EARLY LIFE ECOLOGY OF TUNAS IN THE GULF OF MEXICO

A Dissertation

by

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ABSTRACT

Summer ichthyoplankton surveys were conducted in surface waters of the northern Gulf of Mexico from 2007 to 2010 to characterize distribution and abundance of tuna larvae. The assemblage of tuna larvae was comprised of four genera: *Thunnus*, *Auxis*, *Euthynnus,* and *Katsuwonus*. True tunas (genus *Thunnus*) were the most abundant, and four species were detected; Atlantic bluefin tuna (*T. thynnus*), yellowfin tuna (*T. albacares*), bigeye tuna (*T. obesus*), and blackfin tuna (*T. atlanticus*). Intra- and inter-annual variability in distribution and abundance of tuna larvae were observed with higher densities in 2008 and 2009 followed by a decline in abundance in 2010. Principal coordinate analysis (PCoA) and generalized additive models (GAM) based on presence/absence and density were developed to examine the impact of mesoscale features on distribution and abundance on true tuna larvae. Distribution and abundance of true tuna larvae in surface waters were influenced by physicochemical conditions of the water mass, notably sea surface temperature and salinity. Distinct species-specific habitat preferences, were observed and the location of mesoscale oceanographic features influenced larval abundance with higher densities of blackfin tuna, yellowfin tuna, and bigeye tuna associated with convergent zones near the margin of the Loop Current (LC) and other anticyclonic regions (warm core); bluefin tuna was observed in higher densities near cyclonic regions (cold core). Finally, habitat suitability maps were developed based on GAMs and environmental conditions to predict the spatial coverage of suitable habitat of blackfin tuna (2011 and 2015) and yellowfin tuna and bigeye tuna during the Deepwater Horizon oil spill (2010). Habitat suitability maps revealed that the amount of highly suitable habitat of blackfin tuna larvae varied between months (June 6%, July 51%); however, in both months larvae were distributed in similar locations along the continental slope and at the margin of the LC in the northern GoM. Similarly, the extent of highly suitable habitat for yellowfin tuna and bigeye tuna varied between June and July. A larger percentage of highly suitable habitat of bigeye tuna was exposed to surface oil (23-34%) compared to yellowfin tuna (4-26%), indicating that the oil spill might have impacted the two species differently.

DEDICATION

To my mother.

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Contributors

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CHAPTER I

INTRODUCTION

Populations of several Atlantic tunas (family Scombridae) are exploited or overfished due their high economical value with biomass of several stocks near or below the levels to achieve maximum sustainable yield (Juan-Jordá and al. 2011; ICCAT 2016). Effective management of tuna stocks is critical because they play important ecological roles as apex predators in pelagic ecosystems by regulating the productivity and abundance of their prey populations, which can alter the stability of the pelagic ecosystem (Korsmeyer and Dewar 2001; Essington et al. 2002). Thus, indirect effects of tuna fishing may include declines in species diversity, shifts in the species composition of the prey community, and changes in food web structure (Stevens et al. 2000; Essington et al. 2002). Because of their economical and ecological importance, management plans have implemented to ensure the long-term sustainability of tuna stocks in the Atlantic Ocean. However, current assessment tuna populations are largely based on catch data from commercial fishing operations (ICCAT 2016), which are known to be a potential source of error for population estimates because fisheries are typically target a specific size and did not reflect the complex relationships among population dynamics and environmental forcing (Maunder et al. 2006; Rouyer et al. 2008). Lately, fisheries-independent indices based on larval abundance have been developed to assess population dynamics and spawning stock biomass of pelagic fishes (Hiesh et al. 2006; Ingram et al. 2010; Domingues et al. 2016), and this type of data is increasingly used to collect basic information on early life ecology of exploited species for evaluating their stock status.

The Gulf of Mexico (GoM) sustains important commercial and recreational fisheries for true tunas (genus *Thunnus*). Atlantic bluefin tuna (*T. thynnus*), yellowfin tuna (*T. albacares*), and bigeye tuna (*T. obesus*) stocks are of considerable commercially value and despite management plans their stocks are being overfished or are currently experiencing overfishing. Apart from these taxa, blackfin tuna (*T.*

atlanticus) is also an important component of the tuna fishery in this region (NOAA 2014). Because no management plan currently exists for blackfin tuna (ICCAT 2014), its stock status is uncertain. Recently, a fisheries-independent measure of larval abundance for bluefin tuna was developed taking in account spatial and temporal distribution patterns of larvae to determine the population dynamics of this species (Ingram et al. 2010; Domingues et al. 2015). However, larval abundance indices do not exist for other true tunas in the northern GoM, even though this region is an important spawning and nursery areas for these species. To date, information on distribution and abundance of yellowfin tuna and bigeye tuna larvae in the GOM are incomplete while information on early life ecology of blackfin tuna is inexistent. Therefore, determining the influence of environmental conditions on the spatial dynamics of true tuna larvae is fundamental to assess their population status.

The distribution and abundance of true tuna larvae has been related to environmental condition in the GoM (Muhling et al., 2011; Lindo-Atichati et al., 2012; Rooker et al., 2013), which are known to be highly variable to due to the dynamic of the mesoscale oceanographic features (Loop Current and eddies) and the riverine discharges from the Mississippi-Atchafalaya river system. Together, mesoscale oceanographic features and freshwater inflow in the northern GoM likely lead to favorable conditions that improve the growth and survival of true tuna larvae (Lindo-Atichati et al. 2012; Muhling et al. 2013; Rooker et al. 2013). However, the influence of mesoscale features on distribution and abundance of true tunas other than bluefin tuna has not yet been established.

Here, I investigate habitat use of true tunas during their early life stage in the GoM to define spawning and nursery grounds in this region. The effect of dynamic oceanographic conditions on the distribution and abundance of each true tuna species will be examined using habitat-modeling approaches. Species-specific environmental preferences are then combined with environmental data to predict the location and extent coverage of suitable habitat for each species. This information is essential to determine the factors driving existing spatial and temporal patterns of abundance, and also to characterize their critical spawning and/or nursery habitats in the GoM.

CHAPTER II

DISTRIBUTION AND HABITAT ASSOCIATIONS OF TUNA LARVAE IN THE NORTHERN GULF OF MEXICO

Introduction

Tunas (family Scombridae) support an important worldwide fishery and represent a highly prized food resource. Overexploitation of tunas has become an important concern over the past few decades as populations of several species have declined below levels required to achieve maximum sustainable yield (ICCAT 2015, 2016). Declining tuna populations have important economical implications, but also influence the productivity and stability of pelagic ecosystems (Fromentin and Powers 2005; Baum and Worm 2009; Olson et al. 2010). Similar to other pelagic species, tunas consume large amounts of prey to satisfy their high metabolic rates and, in turn, influence biodiversity, community structure, and trophic relationships in pelagic ecosystems (Stevens et al. 2000; Korsmeyer and Dewar 2001; Essington et al. 2002). Because of their economical and ecological importance, understanding the factors that affect the distribution and abundance of tunas is critical information and required to protect and manage their populations.

The dynamic of an exploited population is greatly impacted by recruitment success (Hsiesh et al. 2006); therefore, it is important to understand the causes of recruitment variability to reduce uncertainty in estimates of spawning biomass and population size. Basic information on the abundance and distribution of tuna larvae can be used to determine the timing and location of spawning (Govoni 2005; Rooker et al. 2007; Teo et al. 2007; Richardson et al. 2016). Abundance estimates from early life surveys also represent important fishery independent indices that can be used to predict spawning biomass and the recruitment potential of tuna populations (Ingram et al. 2010). As a variety of biological and physicochemical factors influence growth and survival during early life stages of pelagic fishes, recruitment success may be linked to the quality of the water mass inhabited (Lang et al. 1994; Sponaugle et al. 2005; Wexler et al. 2007; Simms et al. 2010; Rooker et al. 2012). Therefore, density and occurrence data for tunas and other pelagic fish larvae are often combined with environmental data to determine the location of highly suitable habitats or nurseries (Rooker et al. 2013, Kitchens and Rooker 2014).

The Gulf of Mexico (GoM) is known to support important tuna fisheries and it is recognized as an important spawning and nursery habitat for several pelagic species, including tunas (Lindo-Atichati et al. 2012; Rooker et al. 2012, 2013; Kitchens and Rooker 2014). Four genera of tunas are observed in this region (*Thunnus*, *Katsuwonus*, *Euthynnus*, and *Auxis*) and "true tunas" in the genus *Thunnus* represent the most valuable tuna stocks and, in turn, are most vulnerable to overfishing (ICCAT 2015). While several *Thunnus* species are detected in the GoM; *T. thynnus* [bluefin tuna], *T. albacares* [yellowfin tuna], *T. obesus* [bigeye tuna] and *T. atlanticus* [blackfin tuna], investigations of fish-habitat relationships for early life stages of *Thunnus* are incomplete and work to date has centered almost exclusively on one species (*T. thynnus*; e.g., Scott et al. 1993; Ingram et al. 2010; Muhling et al. 2010, 2011; Malca et al. 2015). The distribution and abundance of *Thunnus* larvae has been linked to environmental change of their habitat in the GoM (Muhling et al. 2011; Lindo-Atichati et al. 2012; Rooker et al. 2013); however, our understanding of tuna-habitat associations and the importance of the GoM as spawning and nursery habitat for these species warrants further attention.

The importance of mesoscale features in the distribution and abundance of tunas has been demonstrated in the GoM (Lang et al. 1994; Muhling et al. 2010; Rooker et al. 2013). Spatiotemporal environmental changes in tuna habitat was observed due to the presence of the Loop Current (LC) and its associated eddies that create zones of enhanced primary production, creating favorable early life habitat for *Thunnus* species (Richardson et al. 2010; Lindo-Atichati et al. 2012; Muhling et al. 2013; Rooker et al. 2013). Apart from these mesoscale features, the northern GoM is also heavily influenced by freshwater inflow and nutrient loading from the Mississippi River, which also enhances primary and secondary production (Biggs et al. 2008; Dorado et al. 2012). Together, mesoscale oceanographic features and freshwater inflow in the northern GoM likely lead to favorable environmental conditions that improve the growth and survival of *Thunnus* larvae (Lindo-Atichati et al. 2012; Muhling et al. 2013; Rooker et al. 2013). However, influence of mesoscale features on distribution and abundance of tuna in the northern GoM have not yet been adequately determined at the species level. Here, I provide the first detailed assessment of early life habitats of *Thunnus* (*T. thynnus*, *T. albacares*, *T. atlanticus*, and *T. obesus*) and examine the effect of dynamic oceanographic conditions on the distribution and abundance of each species.

Methods

Sample collection

Surveys were conducted over four years (2007 to 2010) in the northern GoM within a sampling corridor that ranged from 26.5 to 29.0°N latitude and 88.0 to 93.0°W longitude (Figure 1). Sampling was conducted in June and July to correspond with the spawning period of several tunas in this region (Teo et al. 2007; Richardson et al. 2010; Mulhing et al. 2012). Paired neuston nets (2-m width × 1-m height frame) equipped with two different mesh sizes (500 μm and 1200 μm) were towed through surface waters (< 1 m) at approximately 2.5 kt for 10 minutes. Net tows were conducted during the day (ca. 0700 to 1900 h) at stations approximately 15-km apart to ensure coverage of a large area encompassing multiple oceanographic features. In total, 558 stations were sampled with neuston nets over the duration of the study. General Oceanics flowmeters (Model 2030R, Miami, FL) were placed at the opening of each neuston net in order to estimate the volume of water sampled during each tow. This information was then used to calculate the density of tuna larvae collected at each station. Onboard, fish larvae were initially preserved in 70% ethanol, and later transferred to 95% ethanol.

Molecular identification

In the laboratory, each neuston net sample was sorted under a Leica MZ stereomicroscope and tuna larvae were isolated and preserved in 70% ethanol. Four genera were visually identified among tuna larvae using pigmentation and morphological characteristics: *Thunnus* spp., *Auxis* spp., *Katsuwonus pelamis*, and

Euthynnus alletteratus (Richards 2006). *Thunnus* larvae were identified until the species level; however, small *Thunnus* larvae present very similar pigmentation and morphological characteristics making visual identification to the species level difficult. As an alternative, I used high-resolution melting analysis (HRMA), a highly sensitive and fast genotyping method used previously on fishes (Smith et al. 2010; Fitzcharles 2012; Randall et al. 2015), for species identification. I used an unlabeled probe (UP) HRMA assay developed for GoM tuna species genetic identification as described in Smith et al. (submitted). A non-destructive sodium hydroxide DNA isolation method (Alvarado Bremer et al. 2014) was utilized for DNA isolation on each larva. The mitochondrial DNA gene NADH dehydrogenase subunit 4 (ND4) was amplified in 10 µL volumes by asymmetric polymerase chain reactions (PCR) with 10 ng of DNA template, 1 X EconoTaqPlus (Lucigen), and 1 X LC Green Plus (Biofire Diagnostics, Inc.), and 0.200 µM of the forward primer (5'-AGCAGAAAGAGCGGAGGAG-3'), 0.028 µM of the diluted reverse primer (5'-ACAGGCTCAATCTGTCTCCCG-3'), and 0.200 µM of an unlabeled phosphorylated probe (5'-GAGGCTTTACGGGGGGCCCTTATCCTT/3Phos/-3'), which is complementary for *T. maccoyii*. Thermal cycling and HRMA were performed on a LightCycler 480 Real-Time PCR system (Roche Applied Science, USA) with an initial denaturation of 10 min at 95°C followed by 35-45 cycles denaturing for 10 s at 95°C, annealing 30 s at 57 °C, and extension for 10 s at 72 °C. After PCR cycling amplicons were denatured at 95°C for 1 min and then rapidly cooled and incubated at 40°C for 1 min followed by data acquisitions (11/°C) between 48°C and 95°C at a melting ramp rate of 0.02°C/s. Species identification was determined by the unlabeled species probe melts that generated species-specific melting curves corresponding to single nucleotide polymorphisms (i.e., point mutations) in the probe-complementary coding sequences (Figure 2).

Due to the large number of *Thunnus* larvae collected (n=16986), it was not possible to genetically identify to species all larvae collected over the four-year study. HRMA was performed on larvae from a subset of positive stations (*Thunnus* larvae present, n= 5744) from each survey, with molecular identification performed on larvae from 51% of the overall positive stations (range: 38-53% from 2007 to 2009, and 100% in 2010). Positive stations used for HRMA were selected randomly among major zones (e.g. 27° N vs 28° N transect) or mesoscale features to provide broad spatial coverage within each sampling corridor. Positive stations not assessed with HRMA accounted for 28% of the total number of stations sampled, and no attempt was made to extrapolate species composition from HRMA-based stations to remaining positive stations. In response, these stations were excluded from species level descriptions and analyses. If positive stations examined with HRMA contained less than 100 *Thunnus* larvae, each individual was genetically identified to species. If more than 100 *Thunnus* larvae were present, 100 randomly selected larvae were genetically identified and the ratio of species present in this subset was applied to the total number of larvae collected at the station.

Environmental data

At each station, sea surface temperature (°C) and salinity (psu) were collected using a Sonde 6920 Environmental Monitoring System (YSI Inc.). Other environmental data were downloaded and extracted from different datasets using the marine ecology toolbox in ArcGIS v.10. Sea surface height anomaly (SSHA in cm) data were generated every 7 days from merged satellite altimetry measurements using Jason-1, ENVISAT/ERS, Geosat Follow-On and Topex/Poseidon inter- laced (AVISO, www.aviso.oceanobs.com) and data consisted of averaged time periods with 0.25º resolution. Sea surface chlorophyll *a* concentrations (mg m^{-3}) were downloaded from Moderate Resolution Imaging Spectroradiometer (MODIS Aqua, www.oceancolor.gsfc.nasa.gov). Chlorophyll *a* data consisted of 8-d averaged time periods with 0.04º resolution. Water depth (m) at all sampling stations was extracted from GEODAS U.S. Coastal Relief Model with 3 arc-second grids (www.ngdc.noaa.gov).

In addition to environmental data (SST, chlorophyll *a*, and depth) stations were classified based on salinity and SSHA. Over the four sampling years, salinity varied from 20.5 to 39.3 psu and a natural break in salinity data was observed at 35 psu. This break was used to define two different regions depending on salinity: lower salinity regions (≤ 35 psu) and higher salinity regions (> 35 psu). To characterize mesoscale features (Loop Current and eddies) associated with each station, SSHA values < -5cm and > 10cm were defined here as cyclonic and anticyclonic regions, respectively (Leben et al. 2002). Intermediate SSHA values (-5cm < SSHA < 10cm) were defined as open water regions.

Data analysis

Densities at each station were expressed as larvae 1000 m^{-3} and based on pooled catches between the 500 and 1200 µm mesh neuston nets. Moreover, it has been observed that the difference in vertical distribution among tuna genera might influence the catch rate of the *Thunnus* spp., *Auxis* spp., *Euthynnus alletteratus*, and *Katsuwonus pelamis* larvae (Habtes et al. 2014). To determine the influence of the sampling gear in the present study, I compared larval fish collected with both bongo (100 m) and neuston nets (surface waters) in the sampling corridor from 2011 to 2013 (Rooker and Cornic, unpubl. data). No difference in density was observed for *Thunnus* larvae between net gears (Wilcoxon signed rank test p>0.5); however, densities of *Auxis* spp. and *Euthynnus alletteratus* larvae were significantly higher (Wilcoxon signed rank test p>0.5) in bongo nets (6.54 and 1.22 larvae 1000m^{-3}) than in neuston nets (3.23 and 0.31 larvae 1000m^{-3}), while *Katsuwonus pelamis* larvae were rare in my samples. While I acknowledge that the surface sampling gear used for this study may not be suitable characterizing the entire assemblage of tuna larvae, it does provide representative estimates of density for the primary genera (*Thunnus*) under investigation here.

Temporal and spatial variability in densities of *Thunnus* larvae were investigated using PRIMER V6.1.15 (Clarke and Gorley 2006) and permutational multivariate analysis of variance PERMANOVA V1.0.5 (Anderson et al. 2008). PERMANOVA analyses were used because they can handle non-normally distributed data and unbalanced designs (unequal number of stations collected and larvae analyzed per surveys). Statistical significance was calculated by permutations (9999) (Anderson et al. 2001). Prior to the analysis, untransformed densities were used to calculate a Bray-Curtis similarity resemblance matrix for each species and a Euclidean distances matrix was calculated with normalized environmental variables. Densities of each species over the sampling period were compared using PERMANOVA (type-III) performed in a two-way crossed design, with year (4 levels: 2007, 2008, 2009 and 2010) and month (2 levels: June and July) as fixed factors. The relative importance of environmental parameters on the density of each *Thunnus* species was determined using univariate PERMANOVAs (type-I) with environmental data as covariates (SST, salinity, SSHA, chlorophyll *a*, and depth).

The influence of the environmental variables on each species was also investigated using principal coordinate analysis (PCoA). This approach explores the similarities in oceanographic regions and in densities of each species among stations in relation to environmental conditions (Van Oostende et al. 2012). Vector overlays (Pearson correlation) were superimposed onto PCoA plots to show which environmental variables were influencing densities, with the length and the direction of each vector providing information on the degree of correlation and the relationship between the environmental variables and the ordination axes. All statistical analyses were performed with alpha set at 0.05.

Results

A total of 18251 tuna larvae were collected in the GoM including *Thunnus* spp. (93%), *Auxis* spp. (5%), *Euthynnus alletteratus* (<2%), and *Katsuwonus pelamis* (<1%). Variations in occurrence and densities were observed among genera over the four sampling years (Table 1, Figure 3). *Thunnus* spp. were the most common and abundant tuna larvae with percent frequency of occurrence ranging from 63% to 88% and density ranging from 21.3 larvae 1000m^{-3} (2009) to 8.5 larvae 1000m^{-3} (2010). *Auxis* spp. and *Euthynnus alletteratus* larvae were moderately abundant with percent frequency of occurrence ranging from 3 to 23% and 2 to 14%, respectively. Maximum density of *Auxis* spp. was observed in 2009 (0.7 larvae 1000m^{-3}), while *Euthynnus alletteratus* maximum densities were recorded in 2008-2009 (1.1 larvae 1000m^{-3}). For both *Auxis* spp. and *Euthynnus alletteratus*, lowest densities were recorded in 2007 (0.2 and 0.01 larvae 1000m^{-3}). *Katsuwonus pelamis* was the least common tuna genera observed in my samples and was absent in 2007. Highest percent frequency of occurrence and density of *Katsuwonus pelamis* were recorded in 2010 (8% and 0.2 larvae $1000m^{-3}$).

Four species of *Thunnus* larvae were identified in my samples from the GoM with UP-HRMA: *T. atlanticus*, *T. albacares*, *T. obesus*, and *T. thynnus*. The most abundant was *T. atlanticus*, accounting for 81% of the *Thunnus* larvae; *T. albacares* and *T. obesus* comprised 9% and 8% of the *Thunnus* larvae, while *T. thynnus* represented the smallest portion of *Thunnus* at 2% (Figure 4). Temporal variation in density and percent frequency of occurrence of *Thunnus* larvae was also detected, with both inter- and intra-annual effects observed (Table 2; Figure 5). *T. atlanticus* larvae were present at greater than 50% of the stations sampled in each survey except in July 2008 (Table 2). Mean density of *T. atlanticus* larvae across all surveys was 9.7 larvae $1000m^{-3}$ and a significant effect of month (*p(perm)* <0.05), year (*p(perm)* <0.01), and interaction between month and year (*p(perm)* <0.05) was detected (Table 3). Minimum and maximum densities of *T. atlanticus* larvae from surveys were observed in June 2010 (3.3 larvae $1000m^{-3}$) and July 2009 (33.4 larvae $1000m^{-3}$). Maximum density of *T. atlanticus* at a single station was recorded in July 2009 with 402.4 larvae $1000m^{-3}$. *T. obesus* and *T. albacares* larvae were also regularly collected and percent frequency of occurrence ranged from 22 to 79% and 13 to 57% among surveys, respectively (Table 2). *T. obesus* densities varied significantly between months and among years (*p(perm)* <0.01), while *T. albacares* densities varied significantly only among years (*p(perm)* < 0.01) (Table 3). Peak of densities of *T. obesus* (2.7 larvae $1000m^{-3}$) and *T. albacares* (3.5 larvae $1000m^{-3}$) were both observed in July 2009, while the lowest densities were observed in June 2010 for *T. obesus* (0.2 larvae $1000m^{-3}$) and July 2008 for *T. albacares* (0.1 larvae $1000m^{-3}$) (Figure 5). For the two aforementioned species, a significant interaction between month and year (*p(perm)* <0.05) on density was observed (Table 3). *T. thynnus* larvae were absent from all July surveys and percent frequency of occurrence in June surveys ranged from 4 to 25% (Table 2). Mean density of *T. thynnus* larvae in all June surveys was (0.2 larvae $1000m^{-3}$), with the highest density recorded in June 2007 (0.5 larvae $1000m^{-3}$). Similar to the other species, *T. thynnus* densities varied significantly among years (*p(perm)* =

0.03; Table 3), and the lowest recorded density was observed in 2010 with only two larvae caught during this survey (<0.01 larvae $1000m^{-3}$).

Spatial variability in larval densities was observed during the four-year survey in the GoM, with conspicuous species-specific patterns observed for some taxa (Figure 6-7). *T. atlanticus* and *T. obesus* larvae were widely distributed on the continental shelf and the continental slope. *T. albacares* distributions were narrower with peak densities of larvae on the continental slope and in zones impacted by the Mississippi River plume (28°N and 88 to 89°W). In contrast, the distribution of *T. thynnus* was more limited with highest densities observed on the continental slope. In certain years, the presence of anticyclonic eddies and the LC seemed to influence the distribution and abundance of all four *Thunnus* species. Years with the highest northward extension of the LC and associated anticyclonic eddies (2007 and 2009) coincided with peaks in the density of *Thunnus* larvae. Mean densities for *T. atlanticus*, *T. obesus,* and *T. albacares* were greatest in July 2009 during the maximum northward penetration of the LC, with peak densities observed at stations in close proximity to the northern margin of the LC or its associated eddies (Figure 6-7).

PCoA was conducted on all stations sampled to observe the influence of oceanographic conditions on the density of *Thunnus* larvae, with the contribution of environmental variables shown with directional vectors (Figure 8). PCoA axis 1 explained 35.6% of the total variation among stations and was highly correlated to salinity ($|r| = 0.87$), chlorophyll *a* concentration ($|r| = 0.80$), and SST ($|r| = 0.59$), while PCoA axis 2 explained 22.3% of total variation among stations and was highly correlated to SSHA ($|r| = 0.89$). Environmental conditions and oceanographic features varied across the sampling corridor, and distinct physicochemical characteristics were observed in cyclonic, anticyclonic, and open water regions (Figure 8). Cyclonic regions characterized by lower salinity (mean 35.8 psu), lower SST (mean 28.5°C), and higher chlorophyll *a* concentration (mean 0.23 mg m^{-3}), while anticyclonic regions were characterized by higher salinity (mean 36.3 psu), higher SST (mean 29.6°C) and lower chlorophyll *a* concentration (mean 0.11 mg m^{-3}). In addition, open water regions were distinctly different from cyclonic and anticyclonic regions, and characterized by lower salinity (mean 35.2 psu), intermediate SST (mean 29.4°C), and higher chlorophyll *a* concentration (mean 0.27 mg m^{-3}).

The PCoA plots indicated that larval densities of all four *Thunnus* species were influenced by oceanographic conditions (Figure 8). *T. atlanticus* and *T. obesus* were positively associated with SST, SSHA, and chlorophyll *a* concentration (Figure 8). Also, the highest densities of *T. atlanticus* and *T. obesus* were recorded in regions with relatively high salinity (> 36 psu), which are typically found in anticyclonic water masses. *T. albacares* were highly correlated with SST and chlorophyll *a* concentration, with the highest densities recorded in open water and lower salinity regions of survey area (Figure 8). In contrast to other *Thunnus* larvae, *T. thynnus* densities were negatively associated with SSHA, SST, and chlorophyll *a* concentrations and the highest densities were correlated with stations in cyclonic and open waters regions (Figure 8).

Discussion

Larval assemblages of tunas during the course of this study in the northern GoM were dominated by *Thunnus* spp., followed by *Auxis* spp., *Euthynnus alletteratus*, and *Katsuwonus pelamis*. This finding is in accord with previous studies in the GoM (Richardson et al. 2010; Habtes et al. 2014); however, the density of *Thunnus* spp. larvae were higher than previously reported, while *Auxis* spp., *Euthynnus alletteratus* and *Katsuwonus pelamis* densities were lower (Habtes et al. 2014). Although variation in densities was observed among previous studies, *Thunnus* was consistently reported as the dominant tuna taxa in this area (Richards et al. 1993; Rooker et al. 2007; Richardson et al. 2010; Lindo-Atichati et al. 2012; Espinosa-Fuentes et al. 2013). In the present study, *Thunnus* larvae were commonly collected over the four-years sampling with mean densities of three species (9.2, 0.9, 0.8, and 0.2 larvae 1000m^{-3} for *T. atlanticus, T. albacares, T. obesus, T. thynnus*) often comparable or higher than reported values for other putative spawning areas, suggesting that the northern GoM may be a valuable spawning and nursery area. I found that *T. atlanticus* larvae were most abundant followed by *T. albacares* and *T. obesus,* while *T. thynnus* were present in limited numbers in summer surveys. Richards et al. (1990) and Richardson et al. (2010) reported the composition of *Thunnus* larvae from ichthyoplankton surveys in the GoM and observed similar species structure with *T. atlanticus* accounting for 73-95%, *T. albacares* representing 5%, and *T. thynnus* larvae only 1%. Similar to the present study, Richards et al. (1990) detected *T. obesus,* and this species accounted for 4.9% of their *Thunnus* larvae. More recent work by Richardson et al. (2010) did not detect *T. obesus* larvae in their samples, but this may be due the difference in geographic location (Straits of Florida); nevertheless, the general make up of *Thunnus* larvae was similar to the present study with higher occurrence of other *Thunnus* species than *T. thynnus* (Richardson et al., 2010; Habtes et al. 2014).

The presence of tuna larvae can be used to determine the timing and location of tuna spawning in the GoM (Reglero et al. 2014; Richardson et al. 2016), but information on spawning events of each *Thunnus* species in the northern GoM is limited. Moderate to high frequency of occurrence observed in June and July surveys for *T. atlanticus, T. obesus*, and *T. albacares* suggests that each species spawns in the northern GoM in late spring or early summer, and possibly for more protracted periods which could not be determined given the limited temporal extent of the sampling design. Spawning period of *T. albacares* has been defined from May to August in the GoM (Arocha et al. 2001; Richardson et al. 2010), which support my findings and indicate a seasonal periodicity of spawning for *T. albacares* in the northern GoM. In comparison, it has been reported that *T. atlanticus* has a prolonged spawning period with spawning events occurring from April to November with a peak in June and July (Richardson et al. 2010; Mathieu et al. 2013). This study was restricted to summer months but indicates similar results with abundant densities of *T. atlanticus* larvae observed in summer. Basic information on the distribution and abundance of both early life stages and adult *T. obesus* in the GoM is lacking, limiting my ability to compare my findings on the spawning in this region. Previously *T. obesus* larvae were reported in the GoM (Richards 1990); however, no spawning events were identified. Over four-years sampling, I frequently collected *T.*

obesus larvae in both June and July and this species accounted for 5 to 10% of *Thunnus* assemblage, suggesting for the first time the importance of the GoM as spawning habitat. In contrast to the other three species, *T. thynnus* larvae were only encountered in June surveys. This result is in accord with previous studies which indicated that the spawning period of *T. thynnus* is limited from April to June in the GoM (Rooker et al. 2007; Muhling et al. 2010, 2011; Knapp et al. 2014). Thus, lower overall mean densities observed here for *T. thynnus* is likely due in part to the July surveys being conducted at times outside the spawning period of this species.

Significant interannual variation in *Thunnus* larvae abundances was detected with years of high abundances (2007-2009) and years of low abundances (2010) in the GoM, which may be a consequence of habitat changes or/and degradation. For instance, with the exception of *T. albacares,* densities of *Thunnus* larvae and other tuna genera were lowest in 2010, which is the period directly following the Deepwater Horizon (DWH) oil spill that discharged approximately 4.9 million barrels of oil into the northern GoM (Camili et al. 2010; Crone and Tolstoy 2010). Therefore, it is possible that the DWH oil spill impacted the spawning activities of adults and/or the survival of *Thunnus* larvae in the summer of 2010 (Rooker et al. 2013). Shifts in spawning location due to habitat loss or degradation have been observed in other pelagic fishes (Rooker et al. 2013), and it is possible that adult tunas moved away from areas impacted by the DWH oil spill and spawn in different areas. Alternatively, oil near the surface may have impacted survival of tuna larvae as experimental studies have demonstrated that oil causes abnormal cardiac functions in *Thunnus* larvae (Brette et al. 2014; Incardona et al. 2014). Therefore, the presence of oil in the sampling corridor could lead to increased mortality and explained the decrease in larval densities of tunas observed during the present study. Still, temporal changes in environmental conditions due to the presence of Mississippi River plume and the northern penetration of the LC are also known to affect *Thunnus* spawning habitat and the spatiotemporal distribution of adults (Teo et al. 2007) and larvae (Lindo-Atichati et al. 2012; Rooker et al. 2013; Domingues et al. 2016), which may have contributed to the observed variations in the density of *Thunnus* larvae.

The Mississippi river plume is responsible for seasonal freshwater inputs that modify salinity and productivity in the northern GoM (Dagg and Breed 2003) and has been described as a major factor influencing the survival and growth of *Thunnus* larvae (Lang et al., 1994). Along the salinity gradient created by freshwater discharges, a change in biological activity is observed as nutrient-rich riverine waters sustain high primary and secondary production. Regions of confluence between riverine and oceanic waters aggregate fish larvae and nutrients through physical processes and these regions have been described as favorable habitat for fish larvae as food opportunities increase, which in turn supports larval growth, survival, and recruitment (Grimes and Finucane, 1991). Chlorophyll *a* concentration can be used as a proxy to determine the increase of biological productivity due to riverine plume penetration (Walker and Rabalais 2006). In the present study, high chlorophyll *a* concentrations were observed at stations along the northern extent of the sampling corridor (28°N) and most likely corresponded to regions where oceanic waters were impacted by the Mississippi River plume. Over four-year survey, the Mississippi River plume was temporally and spatially variable and changes in the riverine inputs appeared correlated with shifts in the density of *Thunnus* larvae. Increased densities of *T. atlanticus, T. obesus,* and *T. albacares* in the year (2009) with above average chlorophyll *a* concentrations (3.17 mg m^{-3}) and lower salinities (27 psu), potentially indicate that physicochemical conditions associated with the Mississippi River discharges may be favorable to these species. In particular, *T. albacares* larvae were frequently more abundant in lower salinity (2.66 larvae $1000m^{-3}$) than in high salinity (0.43 larvae $1000m^{-3}$) regions of the northern GoM. Lang et al. (1994) reported that the physicochemical conditions associated with freshwater inputs from the Mississippi River positively impacted the growth of *T. albacares* and therefore may enhance early life survival of this species. From 2007 to 2010, *T. atlanticus* and *T. obesus* were detected in a wide range of salinity (28.3-38.6 psu) and chlorophyll *a* concentration (0.02-3.8 mg m^{-3}). The broad salinity tolerance of *T. atlanticus* and *T. obesus* seemed to allow them to take advantages of the highly productive waters associated with the intrusion of the Mississippi River plume in the northern GoM.

However, high densities of *T. atlanticus* and *T. obesus* were also recorded at stations with high salinity (>36 psu) and lower chlorophyll a concentration (0.18 mg m^{-3}), suggesting that the environmental conditions observed in oceanic waters are also favorable to these species. The presence of *T. atlanticus* and *T. obesus* in different water masses indicates that these species were broadly distributed in the northern GoM. *T. thynnus* was the only species absent or in lower abundance close to the areas impacted by the Mississippi River plume or in lower salinity regions. Generally *T. thynnus* larvae were observed in regions with high salinities (>36 psu) and intermediate chlorophyll a concentration (0.15 mg m^{-3}), indicating that this species might be constrained by its salinity tolerance. Similar larval distributions have been previously reported for *T. thynnus* (Richardson et al. 2012; Muhling et al. 2013), supporting the assertion that sudden changes in water mass conditions due to Mississippi River discharges (e.g. lower salinity and SST, turbidity) may negatively impact *T. thynnus* larvae. Consequently, riverine discharges potentially create favorable conditions for certain species (*T. albacares, T. atlanticus, T obesus*) and unfavorable conditions for other species (*T. thynnus*), with habitat quality also being influenced by the presence and location of other mesoscale oceanographic features in the northern GoM, namely the LC and associated features.

Seasonal penetration of the LC and mesoscale eddies are highly variable from year-to-year and are known to influence the spatial distribution of *Thunnus* larvae in the northern GoM (Lindo-Atichati et al. 2012; Rooker et al. 2013). The maximum northward penetration of the LC and associated features during this study was observed in 2007 and 2009 (28°N), which also corresponded to the highest densities of *T. atlanticus*, *T. obesus*, and *T. albacares*. In contrast, the lowest mean densities of several species (*T. atlanticus*, *T. obesus*, and *T. thynnus*) were recorded in 2010 when the northern extent of the LC (26°N) did not reach the study area. The presence of the LC and anticyclonic (warm core) eddies influences the SST in this region by creating areas of higher temperature (>29 ºC). Temperature has been described as an important factor for hatching and larval development of *T. albacares, T. obesus*, and *T. atlanticus*, and the optimal temperature range is 28-29ºC (Wexler et al. 2011; Reglero et al. 2014). Thus, the increase in larval density of these species in the LC and anticyclonic regions (SST >29°C) suggest that these regions offer a favorable environmental conditions to maximize larval growth and survival. Moreover, peaks in density were typically observed at frontal zones, areas of confluence between two eddies, and anticyclonic regions (SSHA>-5 cm). Because, physical processes at the edge of these mesoscale features accumulate both fish larvae and their prey, larvae are often entrained in productive waters where their chance of encountering prey is higher. Thus frontal zones at the margin of the LC and mesoscales eddies likely enhance foraging opportunities and provide high quality habitat for tuna larvae (Grimes and Kingsford 1996; Lamkin 1997; Bakun, 2006; Rooker et al. 2012). In contrast, *T. thynnus* densities were negatively correlated with the years of high northward penetration of the LC, and *T. thynnus* larvae were usually observed in areas of negative or intermediate SSHA corresponding to cyclonic regions (cold core). The affinity of *T. thynnus* larvae to cyclonic regions may be driven by temperature as SST observed in cyclonic regions match their preferred thermal range (22 to 28ºC) in the GoM (Muhling et al. 2010; Reglero et al. 2014). Moreover, cyclonic regions are also associated with upwelling of nutrients and enhanced primary productivity, which can lead to increase condition or growth of fish larvae (Bakun, 2006). Given that all areas outside cyclonic regions in the surveys were generally above to 28ºC, cyclonic regions may provide both favorable thermal conditions and prey resources for *T. thynnus*. My results are in agreement with previous studies that also showed that anticyclonic mesoscale features were more suitable habitat for *T. atlanticus, T. obesus,* and *T. albacares* than *T. thynnus* (Muhling et al. 2010, 2013; Reglero et al. 2014).

The diverse group of congeners from the genus *Thunnus* (*T. atlanticus*, *T. obesus*, *T. albacares*, and *T. thynnus*) make up the larval assemblage present in the northern GoM, indicating that this region may represent valuable spawning and/or nursery habitat for *Thunnus* as well as other tuna genera (*Auxis*, *Euthynnus*, *Katsuwonus*). This study clearly demonstrates that the distribution and abundance of

Thunnus larvae were influenced by physicochemical characteristics of the northern GoM, and distinct species-specific habitat preferences observed may reduce resource overlap (i.e., habitat partitioning) among the four congeners examined. Moreover, results indicate that the inclusion of certain environmental variables are necessary to fine tune larval indices, leading to more accurate estimates of population parameters (i.e., spawning stock size/biomass) used in assessment models.

CHAPTER III

INFLUENCE OF OCEANOGRAPHIC CONDITIONS ON DISTRIBUTION AND ABUNDANCE OF BLACKFIN TUNA (*THUNNUS ATLANTICUS*) LARVAE IN THE GULF OF MEXICO

Introduction

The Gulf of Mexico (GoM) supports highly productive commercial and recreational fisheries for tunas (Chesney et al. 2000). Due to overfishing, populations of yellowfin tuna (*Thunnus albacares*), bigeye tuna (*T. obesus*) and Atlantic bluefin tuna (*T. thynnus*) in this region are decreasing in abundance and are considered to be depleted or fully exploited (Majkowski 2007; Juan-Jordá et al. 2011). Apart from these taxa, blackfin tuna (*T. atlanticus*) is also an important component of the offshore tuna fishery in the GoM (NOAA 2014), and despite it numerical dominance relative to other tunas, this species has received considerably less attention by the scientific community. Because directed commercial fisheries for tunas in the GoM and westerns Atlantic Ocean generally target bigeye, bluefin, and yellowfin tuna (ICCAT 2016), the decline of these populations is expected to lead to an increase in fishing pressure on blackfin tuna, which is troubling because no stock assessment or management plan currently exists for this species (ICCAT 2012; 2014).

Understanding the population dynamics of blackfin and other tunas relies on accurate catch or abundance data as well as basic life history information (Fromentin and Fonteneau 2001; Fromentin and Powers 2005; Young et al. 2006). Stock abundance of tunas is often predicted using catch rates from a variety of sources (e.g., survey data, reported landings); however, using catch data to estimate key population parameters (e.g., spawning stock biomass) of tunas is problematic because these data are not necessarily reflective of population size as they represent immediate relative abundance in particular regions (Maunder et al. 2006). Moreover, because most stock assessments are based on fishery-dependent data, environmental and biological factors that affect population dynamics are not included in assessment models which can lead to inaccurate estimates of population size (Rouyer et al. 2008; Taylor et al. 2011). New analytical tools are being developed to create fishery-independent measure of abundance by taking into account spatial and temporal distribution patterns of exploited species (Lehodey et al. 2008, Lamkin et al. 2015). In particular, larval abundance indices are often used as a proxy or indirect means of predicting spawning stock biomass of tunas and other pelagic fishes (Scott et al. 1993; Hsieh et al. 2006; Lehodey et al. 2008, Ingram and al. 2010, 2015). Therefore, determining the influence of environmental conditions - both biotic and abiotic - on the spatial dynamics of blackfin tuna larvae is fundamental to assessing their population status.

Blackfin tuna stock status is uncertain in the GoM, as basic information on the spawning and early life habitat of blackfin tuna is inexistent in this region. Therefore, abundance estimates of blackfin tuna larvae in the GoM can provide critical information that can be used to assess stock status but also determine the timing and location of spawning in this region. It has been observed that potential environmental changes can impact the spatial and temporal dynamic of spawning areas, which influence the distribution and abundance of tuna larvae (Lang et al. 1994; Bakun 2006; Muhling et al. 2010, Lindo-Atichati et al. 2012). The northern GoM has been described as an essential spawning and nursery habitat of blackfin tuna (Rooker et al. 2013; Cornic et al. submitted), and the distribution and abundance of tuna larvae has been related to the seasonal spatiotemporal variations in the geographic position of the Loop Current and the physicochemical conditions associated with this mesoscale feature (Lindo-Atichati et al. 2012; Muhling et al. 2013). Due to the fact that physicochemical conditions of a nursery habitat are known to influence the growth and survival of tuna larvae (Lang et al. 1994; Wexler et al. 2007; Kim et al. 2015), it can be expected that oceanographic conditions and features associated with early life habitats of blackfin tuna will affect their growth, survival, and recruitment. Therefore, defining key components of habitat quality and the location of production hot spots for blackfin tuna in the GoM is essential to understanding the influential drivers of recruitment success for this species.

The objective of this study was to characterize the spatiotemporal patterns in distribution and abundance of blackfin tuna larvae in the northern GoM. Because the distribution and abundance of tuna larvae depend on environmental conditions of their habitat, generalized additive models (GAMs) based on presence-absence (P/A) and density were developed to determine the most influential environmental parameters affecting blackfin tuna larvae. Next, explanatory variables from GAMs were used to predict the probability of distribution of blackfin tuna based on conditions in 2011 and 2015, which were then used to characterize the spatial extent and areal coverage of suitable habitats of blackfin tuna larvae in each year.

Methods

Sampling protocol

Ichthyoplankton surveys were performed in June and July from 2007 to 2011 and 2015 in the northern GoM (Figure 1). Blackfin tuna were collected in surface using neuston nets (1m x 2m frame). From 2007 to 2010 two neuston nets with different mesh size (500 and 1200μm) were used, while only one neuston net (1200μm) was used in 2011 and 2015. Nets were towed at daylight during 10 minutes at an approximate speed of 2.5 knots every 15km in order to sample diverse oceanographic features. Each net was equipped at its center with a General Oceanic flowmeter (Model 2030R, Miami, FL) to estimate the volume of water sampled.

Larval identification

At the laboratory, *Thunnus* larvae were visually sorted using morphological characteristics and pigmentation (Richards et al. 2006). Because *Thunnus* larvae were abundant (n=16986) in my samples, a subset of 6974 *Thunnus* larvae from 62% of the overall positive stations (*Thunnus* present) were selected across the main areas of the sampling corridor (27-28°N transect) and/or oceanographic features for each survey. Then, each larva was genetically identified to the species level using high-resolution melting analysis (HRMA) with unlabelled probe (UP), following the protocol described by Cornic et al. (submitted). At stations with less than 100 *Thunnus* larvae collected during a cruise, all individuals were genetically identified; otherwise, 100 randomly selected individuals were genetically identified and the number of blackfin tuna larvae was extrapolated to the total number of *Thunnu*s larvae collected at the particular station. These thresholds were modified in 2010, 2011, and 2015 because *Thunnus* larvae were less frequent and abundant. Accordingly, all *Thunnus* larvae were identified to species level using UP-HRMA from these years. Moreover, 71% of the overall larvae genetically identified were measured from the tip of the mouth to the end of the notochord to the nearest 0.1mm using image analysis software (Image Pro Plus 7).

Environmental data

Environmental data were recorded on board at each station sea surface temperature (SST, °C) and salinity (psu) using a Sonde 6920 Environmental Monitoring System (YSI Inc.). Also, *Sargassum* biomass (wet weight in kg) collected in neuston nets was recorded at each station.

Additional environmental data at each station were extracted from open access resources using the marine geospatial ecology toolbox in ArcGIS (Roberts et al. 2010). Sea surface height anomaly (SSHA, cm) data were determined from remotely sensed data that match sampling dates and station locations. SSHA data were generated every 7 days from combined satellite altimetry measurements using Jason-1 and 2, ENVISAT/ERS- 1 and 2, Geosat Follow-On and Topex/Poseidon inter- laced (AVISO). Sea surface chlorophyll concentrations (mg m^{-3}) were accessed from NASA Ocean Color Group`s Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite. Chlorophyll a concentration data consisted of 8-d averaged time periods with a 1/24° resolution. Water depth (m) of the northern GoM were obtained from NOAA`s NGDC U.S. Coastal Relief Model. Moreover to generate predicted suitable habitat maps of blackfin tuna larvae in June and July 2011 and 2015, environmental data (SSHA, SST, salinity) were extracted from remotely sensed observations using a grid of 0.0833 degree. SSHA were estimated from AVISO, while SST and salinity were extracted from the Gulf of Mexico Hybrid Coordinate Ocean Model (GoM-HYCOM) added to U.S.

Navy Coupled Ocean Data Assimilation (NCODA) system.

Data analysis

Percent frequency of occurrence was calculated for each survey as the total number of stations containing blackfin tuna larvae divided by the total number of stations with *Thunnus* larvae identified with UP-HRMA plus stations without any *Thunnus* larvae present. Because only a subset of stations could be analyzed with UP-HRMA, other stations with positive *Thunnus* catches (~27%) were not included in the total number of stations sampled during each survey used for percent frequency of occurrence estimates. For each station where larvae were genetically analyzed, densities of blackfin tuna larvae were standardized by number of larvae $1000m^{-3}$. Because density data violated the assumptions of normality and homogeneity of variances, non-parametric tests were carried out with R (R Development Core Team, 2015). The aligned rank transform (ART) for nonparametric factorial ANOVAs test was performed to compare densities among years and months using the package ARTool (Wobbrock et al. 2011). Differences in factor levels of main effects were examined by using the post-hoc interaction analysis using the package phia (De Rosario Martinez, 2015).

Spatiotemporal distribution of blackfin tuna larvae in the northern GoM was visualized using kernel density. Kernel density was based on the densities observed at each positive station from 2007 to 2010. Because the kernel density estimation can be influenced by a skewed statistical distribution of data (Carpentier and Frachaire 2015), a logarithmic+1 transformation was applied to blackfin tuna larvae density before to calculate the kernel density. Kernel density was estimated with a cell size of 0.01 and search radius of 0.8 in ArcGIS spatial analyst tool.

Generalized additive models (GAMs) were developed in R (R Development Core Team, 2015) to examine the influence of environmental conditions on the P/A and density of blackfin tuna larvae. GAMs allow parametric fixed effects to be modeled non-parametrically using additive smoothing functions, and relax the assumptions of normality and linearity inherent in linear regression (Hastie and Tibshirani 1990; Guisan et al. 2002). Models included a suite of environmental parameters (SST, salinity, SSH, depth, surface chlorophyll a, and *Sargassum* biomass standardized by kilogram per kilometer towed), spatial parameters (longitude, latitude), and temporal parameters (hour after the sunrise, year, month). GAMs were built following the equation:

$$E[y] = g^{-1}\,(\beta_0 + \sum_{k} Sk(xk))$$

where $E[y]$ represents the expected value of the response variable, g is the link functions, β_0 equals the intercept, x is one of the k variable, and Sk is the smoothing function of each explanatory variable. Two different models with cubic regression spline and logarithm link function were built; P/A model using binomial distribution (presence =1; absence = 0) and density model using a negative binomial distribution. Degree of freedom of regression splines was penalized with a maximum degree of freedom of 4 to avoid overfitting while estimate the model parameters. The goodness of fit of each model was examined using Akaike information criterion (AIC). Collinearity among variables was examined using Spearman’s test and variance inflation factor (VIF). If variables were highly correlated ($\rho > 0.60$ and VIF > 5), separate GAMs were run with each collinear variable to determine their influence on P/A and density of blackfin tuna larvae. The variable included in the GAM that resulted in the lowest AIC value was kept in the initial model. For both P/A and density models, depth and latitude were collinear therefore latitude was removed from the initial model. For each model a backwards stepwise procedure based on minimizing AIC was used to select explanatory variables influencing the P/A and density of blackfin tuna larvae. Non-significant smoothed variables ($p>0.05$) were removed one by one from the initial model unless their removal involved an increase of AIC value. Final models were selected based on lowest AIC values. To determine the importance of each variable in the final model, variables were removed one by one from the final model and the variation in percent deviance explained (ΔDE) and AIC (ΔAIC) between the two models was calculated (Rooker et al. 2012). For all analyses, alpha was set at 0.05.

Predicted distribution maps were developed to determine the location of suitable habitat of blackfin tuna larvae in the GoM for 2011 and 2015. To predict the probability of density of blackfin tuna larvae in June and July 2011 and 2015, separate GAM for June and July were developed using environmental data and density observed during former sampling period. Because habitat quality of tuna larvae is influenced primarily by the oceanographic conditions of their habitat (Rooker et al. 2013; Cornic et al. submitted), only the most influential physicochemical and/or geophysical parameters (i.e. salinity, SST, SSHA) detected in the density based GAMs developed from 2007 to 2010 were used. Moreover, during the summer 2010 the northern GoM was affected by the Deepwater Horizon oil spill (Crone and Tolstoy, 2010), and this event potentially altered the habitat conditions and survival of blackfin tuna larvae (Rooker et al. 2013; Incardona et al. 2014). As a result, this year was removed and GAMs only included oceanographic conditions observed during the years not affected by the oil spill (2007-2009). Next the explanatory variables from the GAMs were linked to the environmental data recorded in June and July 2011 and 2015 using pred.gam function in the mgcv package in R (Wood 2015). Then, the predicted densities were smoothed using a bilinear interpolation and plotted in ArcGIS to visualize the distribution of blackfin tuna (Rooker et al. 2013) and the percent coverage of highly suitable habitat (>10 larvae $1000m^{-3}$) was estimated for this species.

Results

Catch summary

An overall of 5687 blackfin tuna larvae were identified among six-sampling years. Blackfin tuna larvae ranged from 2.2 mm to 10.2 mm in total length (TL) and nearly all the larvae (99%) were less than 6 mm TL (Figure 9).

Blackfin tuna were the most common tuna accounting for 82% of the *Thunnus* larvae collected and the most abundant (mean density 6.7 larvae $1000m^{-3}$) relative to other *Thunnus* (mean density 2.2 larvae $1000m^{-3}$) (Figure 10). Percent frequency of occurrence for blackfin tuna ranged from a low of 48% (2008) to a high of 92% (2011) (Table 4). Densities of blackfin tuna larvae varied significantly among years (ART test; $p < 0.01$), with mean values ranging from 2.5 larvae $1000m^{-3}$ (2015) to 20.4 larvae per

1000m^{-3} (2009) (Table 4; Figure 10). An intra-annual effect was also observed with overall mean densities lower in June cruises (5.5 larvae 1000m^{-3}) than July cruises (13.7 larvae 1000m^{-3}) (ART test; $p<0.01$). Finally, an interaction between year and month was detected (ART test; $p<0.05$) and the post-hoc interaction analysis test determined that the years of highest densities of blackfin tuna larvae (2007, 2009) were significantly different from the others years ($p<0.01$).

Spatial distribution of blackfin tuna indicated that the larvae were widely distributed in the northern GoM (Figure 11); however, densities of blackfin tuna larvae were higher on the continental slope (depth = 200-2000m). Moreover, different oceanographic features (eddy and the Loop Current) were present in the sampling corridor from 2007 to 2010, and a high number of blackfin tuna larvae (>70%) were observed at the margin of the eddy (2007) and the Loop Current (2008 and 2009), suggesting that the oceanographic features might influence the distribution of blackfin tuna larvae.

Habitat relationships

The final P/A based GAM included 5 variables: hour after the sunrise, SSHA, SST, salinity, and *Sargassum* biomass (Figure 12). The AIC was 389.5 and the deviance explained 15.1%. Hour after the sunrise (ΔAIC = 22.1, ΔDE = 7.3%), SSHA (ΔAIC = 8.1, ΔDE = 3.5%), and *Sargassum* biomass (ΔAIC = 13.2, ΔDE = 5%) were significantly ($p < 0.05$) correlated to the presence of blackfin tuna larvae (Table 5), the two other variables (salinity and SST) were not significant but still included in the final model. Response plots from final P/A based GAM showed that the presence of blackfin tuna larvae increased with negative and positive SSHA (-10 to 20 cm), intermediate to high salinity (31-36 psu), high temperature (>29ºC), and in the evening and early morning (>10h after the sunrise). In contrast, the presence of blackfin tuna larvae was negatively correlated with *Sargassum* biomass.

Finding for the density based GAM were relatively similar with 5 of the 6 variables in this model also present in the P/A model based GAM (Figure 13). Variables in the final density based GAM included: hour after the sunrise, SSHA, SST, salinity, *Sargassum* biomass, and year. The deviance explained was markedly higher for this model (36.6%) relative to the final P/A based GAM. All variables retained in the final density based GAM model were significant ($p<0.01$) and the most influential variables were year (ΔAIC = 55, ΔDE = 6.6%) and SST (ΔAIC = 36.6, ΔDE = 4.7%) (Table 5; Figure 13). Similar to the P/A based GAM, densities of blackfin tuna larvae were positively associated with both negative and positive SSHA (-10 to 20 cm) (ΔAIC = 32, ΔDE = 4%), high SSTs (>30ºC), intermediate to high salinity (> 30 psu) (ΔAIC = 15.1, ΔDE = 2.3%) and period of the day (>10h after the sunrise) (ΔAIC = 33.3, ΔDE = 4.3%), while negatively correlated with *Sargassum* biomass (ΔAIC = 9.8, ΔDE = 1.3%). Moreover, densities of blackfin tuna larvae varied significantly among the years sampled, with a peak in density in 2007 and 2009 followed by a salient decrease in 2010.

Habitat suitability forecasting

Although GAM indicated that the P/A and density of blackfin tuna were influenced by similar environmental parameters (SST, SSHA, salinity), density based GAM represented a better fit of data (DE = 36.6%). Therefore to predict the habitat suitability of blackfin tuna larvae in 2011 and 2015, GAM based on density (2007-2009) were developed using SSHA, SST, and salinity. Final GAM in June (AIC = 614; DE = 21.6%) and July (AIC = 815; DE = 36.6%) retained all environmental variables (SSHA, SST, and salinity) (Table 6, Figure 14). The densities in June and July were influenced by positive SSHA, high SST (>29ºC), and moderate to high salinity (30-36psu). The results of the GAM in June and July were related to the prediction grid and the environmental data (SSHA, SST, and salinity) recorded in 2011 and 2015. Prediction maps indicated that blackfin tuna larvae were predicted to be widely distributed in the northern GoM in 2011 and 2015, with peak in densities on the continental slope (Figure 15). Moreover, the prediction maps indicated that the Loop Current and warm-core eddies location influenced the distribution of blackfin tuna in 2011 and 2015, with areas of low densities detected inside the Loop Current (0-0.2 larvae $1000m^{-3}$) while areas of high densities (>10 larvae $1000m^{-3}$) were detected at the margin of the Loop Current or between oceanographic features. Finally, prediction maps revealed that the availability of highly suitable habitat of blackfin tuna varied among month, with reduced spatial coverage in June (2% and 10%) relative to July (48% and 54%) (Table 7). However, the suitable locations were similar among month and year with higher density along the continental slope of the GoM and at the margin of the Loop Current compare to the central GoM.

Discussion

In the present study, both frequency of occurrence and abundance of blackfin tuna larvae in the GoM were high (82%, 6.7 larvae $1000m^{-3}$) relative to other *Thunnus* species (17-43%, 2.2 larvae $1000m^{-3}$), indicating that blackfin tuna larvae were the most common and abundant for the true tunas in this region. Although age-length relationships for blackfin tuna larvae have not been established, the majority of larvae collected were relatively small (<6mm), and based on growth rates of other *Thunnus* larvae (Lang et al. 1994; Wexler et al. 2007) it appears that 99% of blackfin tuna larvae collected were within 10 days of spawning. This high abundance of small, recently hatched blackfin tuna larvae in June and July surveys indicates that spawning events likely occurred during both late spring and summer in the northern GoM. These results are consistent with other studies on early life ecology of tunas (Richardson et al. 2010; Rooker et al. 2013), which postulate that the GoM is an important spawning and nursery habitat for blackfin tuna.

Inter-annual variability in the abundance tuna larvae in the GoM is common and often attributed to spatially and temporally dynamic mesoscale features and oceanographic conditions (Muhling et al. 2010; Richardson et al. 2010; Rooker et al. 2013). While year was not retained in the P/A model, it was an important explanatory variable in the density model, and mean density per year ranged from a low of 2.4 larvae $1000m^{-3}$ (2010) to a high of 17.6 larvae $1000m^{-3}$ (2009) over six sampling years. The spatial dynamics of the Loop Current are thought to be an important determinant of the temporal variability in abundance of tuna larvae (Lindo-Atichati et al. 2012; Cornic et al. submitted) as it alters environmental conditions and the geographic position of frontal features in this region. In 2009, higher northward penetration of the Loop Current was linked to high densities of blackfin tuna larvae, which were observed at the margin of this mesoscale feature. In contrast, years of lower northward penetration of the Loop Current (2008 and 2010) corresponded to lower densities for this species. My findings suggests that the distribution and abundance of blackfin tuna larvae is dependent on the position of the Loop Current, and this is in accord with previous surveys of pelagic fish larvae in the northern GoM (Rooker et al. 2012, Domingues et al. 2016). Moreover, in 2010 the Deepwater Horizon event discharged large quantities of oil in the northern GoM, impacting large areas of suitable early life habitat tunas and other pelagic species (Crone and Tolstoy 2010; Rooker et al. 2013). Because early life survival of tunas is driven by spatial and temporal differences in habitat quality (Lindo-Atichati et al. 2012), the degradation of spawning and nursery habitat of blackfin tuna in this region could affected their early life survival or even caused adults to spawn in other locations (Rooker et al. 2013; Incardona et al. 2014).

Spatial variability in the distribution of tuna larvae have also been linked to specific physicochemical conditions of the presumed nursery habitat (Muhling et al. 2013; Rooker et al. 2013; Cornic et al. submitted). Salinity was an important predictor of both distribution and abundance of blackfin tuna larvae, indicating that spatial variation in salinity might affect their occurrence and/or survival. In the spring, freshwater discharge from the Mississippi River creates a salinity gradient from the Mississippi Delta to the continental shelf in the northern GoM. Even though blackfin tuna larvae were detected in a wide range of salinities, the probability of occurrence and abundance of larvae both increased at intermediate salinities (30-34 psu), suggesting that marine areas impacted by freshwater inflow may represent highly suitable habitat for blackfin tuna. Furthermore, nutrient loading associated with freshwater inflow from the Mississippi Rivers drives primary and secondary production in the northern GoM (Wawrick and Paul 2004), and thus likely enhances feeding opportunities for blackfin tuna and other pelagic fish larvae (Lohrenz et al. 1997). Therefore, late spring and/or early summer spawning during riverine discharges may maximize the growth potential and survival of blackfin tuna larvae in this region.

Apart from salinity, spatial variability in SST and SSHA was also linked to the distribution and abundance of blackfin tuna larvae. The location of anti-cyclonic (warm-core eddies) and cyclonic (cold-core eddies) circulation features were the primary drivers of spatial variation in both SSHA and SST in the GoM. GAM plots indicated that occurrence and abundance of blackfin tuna larvae were positively associated with higher SST (>29ºC) and positive SSHA (> 10 cm), suggesting that the Loop Current and warm-core eddies might be more suitable habitat for this species compared to cold-core eddies. Tuna larvae are sensitive to temperature which can affect their growth and their ability to swim, escape, and feed (Margulies 1993; Wexler et al. 2011), and several studies have shown that warmer temperatures within anti-cyclonic features are favorable to blackfin tuna larvae (Richardson et al. 2010; Lindo-Atichati et al. 2012; Rooker et al. 2013). Moreover, the margin of the Loop Current and warm-core eddies are often composed of water masses with different physical characteristics than surrounding water (i.e., frontal zones), which can lead to the creation of convergent zones (Bakun 2006). Convergent zones can aggregating particles and influencing the transport of larvae (Bakun 2006), and thus may be responsible for increased blackfin tuna occurrence and density along both cyclonic and anti-cyclonic features. While physical forcing probably determines the distribution of blackfin tuna larvae within convergent zones, it is also likely that the increased larval feeding opportunities encountered in these zones will support growth and therefore survival of tuna larvae (Lamkin 1997; Bakun 2006; Govoni et al. 2010). Still, blackfin tuna larvae were well distributed across a diverse range of SST and SSHA, suggesting that this species is more of a generalist with a high tolerance for environmental conditions common to this region.

GAMs including the three most influential environmental parameters (SST, salinity, and SSHA) on larval densities were used to develop prediction maps for 2011 and 2015. My models predicted a wide distribution of suitable habitat for blackfin tuna larvae for both years. Higher densities were predicted along the continental slope (depth

= 200-2000m) in the north-central and eastern GoM, with peak densities near the margin of the Loop Current and areas of confluence between mesoscale features. The percent coverage of highly suitable habitat for blackfin tuna larvae was significantly higher in July compared to June, which is not unexpected because spawning generally occurs from June to September in the GoM with a peak in midsummer (Mathieu et al. 2013). Therefore, the increase of percent coverage of highly suitable habitat in July suggests that environmental conditions are less favorable for this species in the early summer (June). Subsequently, the spawning period and/or the increase of the nursery habitat quality of blackfin tuna over the summer might explain the higher density recorded in July (13.7 larvae 1000^{-3}) compared to June (5.5 larvae 1000^{-3}) over the six year survey. Moreover, areas of high density observed in 2011 and 2015 often corresponded to the areas of predicted high quality habitat, indicating that geospatial and statistical approaches effectively predicted the spatial distribution of blackfin tuna larvae.

Both occurrence and abundance of blackfin tuna larvae varied during the day, with an increase in abundance at crepuscular periods prior to sunset and just after dawn. These results suggested that blackfin tuna larvae migrate in the water column reaching shallower depth at night. Vertical migrations are common in fish larvae and have been attributed to different factors such as light intensity, turbulence, predator avoidance, and prey concentration (Fortier and Harris 1989; Job and Bellwood 2000; Werner et al. 2001; Höffle et al. 2013). Vertical migrations of fish larvae prey are typically characterized by downward migrations during day and upward migrations at night to avoid predators (Dagg et al. 1989; Loose and Dawidowicz 1994, Spinelli et al. 2015). Because tuna larvae feed principally on zooplankton (appendicularians, copepods and cladocean) and other fish larvae (Llopiz et al. 2010), synchronizing their vertical migrations with the migration of their prey may increase foraging opportunities and survival rates. It is also important to note that the decrease of light intensity from sunset to sunrise may also decrease the ability of larvae to avoid the sampling net. It has been observed that tuna catch can fluctuate between day/night and size of the larvae (Fortier and Harris 1989; Davis et al. 1990; Boehlert et Mundy 1994; Satoh et al. 2008; Habtes et al. 2014), which could have led to greater numbers of larvae caught at the end of the day. To better determine the influence of vertical migrations on the survival (food availability), transport (currents at different depth), or density of blackfin tuna larvae, further research is needed. This information would add valuable environmental parameters (i.e. water column depth and environmental conditions associated) that could improve predictions of blackfin tuna larval distribution in future studies.

Habitat associations of blackfin tuna were influenced by specific physicochemical conditions (moderate to high salinity and high temperature) and the location of the Loop Current, suggesting that the margin of the Loop Current and convergent areas between mesoscale oceanographic features are critical habitat for this species. Results demonstrate the value of the combined statistical models and GIS approach to predict the distribution of blackfin tuna across large-scale features; however, further investigations on the influence of environmental conditions on this species would help to improve the predicted power of these models. Still, spatial and temporal patterns in habitat associations, distribution, and abundance presented here represent important baseline information to the development of management strategies for blackfin tuna in the GoM. These findings can be used to develop accurate larval abundance indices, determine the timing of spawning for blackfin tuna in this region, and improve our understanding of the attributes that define important nursery habitat. Given the recent declines of true tunas in the Atlantic Ocean and the GoM, this information is of considerable importance as exploitation of blackfin tuna may increase over the next decade.

CHAPTER IV

SPATIOTEMPORAL DISTRIBUTION OF YELLOWFIN TUNA AND BIGEYE TUNA LARVAE ACROSS OCEANOGRAPHIC FEATURES IN THE GULF OF MEXICO

Introduction

The quality of spawning and nursery habitats of oceanic pelagic fishes (e.g. billfishes, tunas) is known to influence their population dynamics (Lehodey et al. 2006; Hare 2014), and changes in environmental conditions can effect both early life survival and recruitment (Pepin 1991; Lehodey et al. 2003; Kimura et al. 2010). Therefore, it is essential to determine habitat associations of pelagic fishes during early life as well as identify oceanographic conditions that define suitable nursery areas. Habitat-modeling approaches have been used in recent years to link the spatiotemporal distribution of pelagic fish larvae with environmental conditions to assess fish-habitat relationships and predict the potential impacts of habitat changes on the distribution and abundance of billfishes and tunas (Muhling et al. 2011; Rooker et al. 2012, 2013). These modeling approaches also have been used in recent years to predict the location of key production (spawning) and nursery zones of several taxa of pelagic fishes (Rooker et al. 2012; Kitchens and Rooker 2014; Randall and Rooker 2015).

Tunas (family Scombridae) represent a significant source of food worldwide and support important commercial fisheries due to their high economical values (Juan-Jordá and al. 2011). Despite management plans to ensure the long-term sustainability of tunas stocks in the Atlantic Ocean, several species are considered to be overfished, including the true tunas in the genus *Thunnus* (Juan-Jordá and al. 2011; ICCAT 2015). In the Gulf of Mexico (GoM) *T. thynnus* (Atlantic bluefin tuna), *T. albacares* (yellowfin tuna), and *T. obesus* (bigeye tuna) represent important components of commercial fisheries in the Atlantic Ocean. Management plans for these species are based primarily on fisheries-dependent catch data from commercial operations (ICCAT 2016), which are known to be a potential source of error to estimate the population size of species as fisheries are targeting a specific size (Fromentin and Powers 2005; Juan-Jordá and al. 2011; Maunder and Piner 2014). Given that the assessment of status of tuna populations can be biased by the use of fisheries-dependent indices and increase uncertainty in stock assessment, a greater diversity of data is needed to manage tuna stocks in the GoM.

Recently, fisheries-independent indices of larval abundance have proven useful for assessing the population dynamics of *T. thynnus* in the Gulf of Mexico (Ingram et al. 2010; Muhling et al. 2010, 2011; Domingues et al. 2016). Unfortunately, comparable indices do not exist for other true tunas even though this region is known to be an important spawning area of others species. To date, information on distribution and abundance of *T. albacares* and *T. obesus* larvae in the GoM are scattered and incomplete, and the early life habitat of both species in this region is assumed to be highly variable due to dynamic nature of mesoscale oceanographic features (Loop Current and eddies) and riverine discharges (Mississippi-Atchafalaya River System). These factors likely influence the quality of nursery habitats experienced by *T. albacares* and *T. obesus* larvae, which in turn will likely impact their survival and, in turn, their population dynamics. Because of the complex nature of the oceanography in the GoM and the presumed importance of this region as spawning and nursery habitat of *T. albacares* and *T. obesus* larvae, this region is ideal for evaluating factors influencing the spatial dynamics of *T. albacares* and *T. obesus* larvae.

The aim of this study is to use statistical and geospatial modeling approaches to investigate relationships between the abundance of *T. albacares* and *T. obesus* larvae and environmental conditions in the northern GoM. Generalized additive models (GAMs) were developed to identify oceanographic conditions that were associated with increased catches of *T. albacares* and *T. obesus* larvae. Habitat associations of *T. albacares* and *T. obesus* were then used to identify the location of suitable habitats of each species in outer shelf and slope waters of the GoM. Moreover, the potential impact of oil contamination on *T. albacares* and *T. obesus* larvae was investigated by predicting the probability of occurrence of *T. albacares* and *T. obesus* exposed to the Deepwater Horizon oil spill.

Methods

Samples collection

Tuna larvae were collected during summer ichthyoplankton surveys from 2007-2009. Surveys were conducted during the months of June and July because this period coincides to the spawning peak of several species of *Thunnus* in the northern GoM (Figure 1). Surface net tows were conducted using two neuston nets each with a 1m x 2m rectangular opening and two different mesh sizes (500 µm and 1200 µm). General Oceanic flowmeters were mounted in the center of the mouth of each net to measure the volume of water filtered. Nets were towed in surface during day time for 10 minutes to an approximate speed of 2.5 knots. Stations were spaced every 15km to sample various oceanographic features and all fish larvae were preserved on board in 95% ethanol.

In the laboratory, each tuna larva was visually identified to genus using morphological and pigmentation characters (Richards 2006) and preserved in 70% ethanol. Small *Thunnus* larvae are difficult to visually identify to the species level due to similar pigmentation. Consequently, all *Thunnus* larvae were genetically identified using a highly sensitive genotyping method, high-resolution melting analysis (HRMA) using an unlabeled probe (UP), following the protocol described in Smith et al. (submitted). During the three sampling years, a high number of *Thunnus* larvae (*N*=15,573) were collected. In response, a subset of 163 positive stations (nearly 50% of stations containing *Thunnus* larvae) was selected for further analysis. Because *Thunnus* larvae at several positive stations were present in high numbers (>100), I randomly selected 100 individuals at these stations for UP-HRMA. For these stations, the percent composition of *T. albacares* and *T. obesus* from the 100 larvae was used to assign species identification to the remainder of the *Thunnus* larvae in the sample. At stations with less than 100 individuals, all the larvae were identified with UP-HRMA to the species level.

Moreover, each larva was measured to the nearest 0.1 mm from the tip of the snout to the tip of the notochord using the software Image-Pro Plus 7.0.

Environmental data

Salinity and sea surface temperature were recorded on board at each station from 2007-2009 using a YSI Sonde 6920 Environmental Monitoring System (YSI. Inc). For each survey, supplementary environmental data (depth, sea surface height) were downloaded and extracted from remotely sensed observations (Table 8) using station coordinates and date of sampling. Sea surface height was used as a proxy for the location of the Loop Current boundary (20-cm sea surface height contour; Randall et al. 2015), and then the distance between each station and the Loop Current (LC) was then estimated (distance to LC) in ArcGIS 10.2 (ESRI). All environmental data used to predict habitat suitability in 2010 were extracted from remotely sensed observations (Table 8) with a spatial resolution of approximately 7km and a temporal resolution of one month. Salinity and temperature were determined using Gulf of Mexico Hybrid Coordinate Ocean Model (GoM-HYCOM) added to U.S. Navy Coupled Ocean Data Assimilation (NCODA) system. All remotely sensed environmental data were extracted using the marine geospatial ecology toolbox in ArcGIS 10.2 (Roberts et al. 2010).

Data analysis

For each species, the total number of individuals collected was pooled between both neuston net mesh sizes (500µm, 1200µm) for subsequent calculation of occurrence (presence = 1 and absence = 0) and standardized densities (larvae 1000m^{-3}). The spatial distribution of *T. albacares* and *T. obesus* in June and July from 2007 to 2009 was examined by visualizing the densities of each species in the sampling corridor using ArcGIS 10.2. Variation in larval density among years and between months was investigated using the aligned rank transform (ART) for non-parametric factorial ANOVA test using the package ARTool in R (Wobbrock et al. 2011; R Core 2015). Interaction analysis in package phia (De Rosario Martinez, 2015) was used to evaluate the statistical significance of differences observed between months and among years.

Influence of environmental conditions on the distribution and abundance of *T. albacares* and *T. obesus* were investigated using generalized additive models or GAMs (Hastie and Tibshirani 1990; Wood 2015). GAMs are semiparametric extensions of the generalized linear model (GLM) and frequently used to determine the spatial distribution of fishes (Murase et al. 2009; Reglero et al. 2012; Rooker et al. 2013). Presence-absence (P/A) and density based GAMs were developed using binomial distribution and negative binomial distribution, respectively. All models were built with cubic regression splines restricted to a degree of freedom of 3 and logarithm link function. Explanatory variables used to develop GAMs were salinity, sea surface temperature, sea surface height, depth, and distance to the LC. All models were developed with R (R Development Core Team, 2015) using the mgcv package (Wood 2015).

Overfitting of the models was limited by investigating the multicollinearity between explanatory variables using variance inflation factor (VIF) and Spearman`s correlation test. Explanatory variables with VIF>5 and/or a Spearman`s correlation >0.6 were considered as highly collinear. Multicollinearity tests indicated that distance to the LC and depth were collinear. To determine the most influential variable for P/A- and density-based GAMs, each variable was tested in separate models and the variable that resulted in the lowest Akaike information criterion (AIC) value was included in the initial model. Depth was removed to models, except in the P/A based GAM model in July for *T. obesus* since collinearity was detected (VIF<5; ρ<0.6). To select the explanatory variable influencing the occurrence and densities of *T. albacares* and *T. obesus* larvae, a backwards stepwise procedure based on minimizing AIC was performed. Then, the weight of each explanatory variable in the final model was determined by removing each explanatory variable from the final model and calculated the change in percent deviance explained (ΔDE) and AIC (ΔAIC) between the two models (Rooker et al. 2012).

Final GAMs and environmental conditions in June and July 2010 were used to predict the probability of occurrence and density of *T. albacares* and *T. obesus* larvae in the northern GoM (Rooker et al. 2013). The grid points used to extract the environmental data in 2010 were linked to a prediction grid using predict.gam function in the mgcv package in R (Wood 2015). Predicted densities of *T. albacares* and *T. obesus* larvae in June and July 2010 were smoothed using bilinear interpolation to visualize suitable habitats. Areas with larval occurrences greater than 50% were considered to be highly quality habitat. When these habitats were detected, the area of highly quality habitat impacted by the Deepwater Horizon oil spill was calculated. Prediction maps and areal coverage of highly quality habitat were estimated using ArcGIS 10.2.

Results

Catch summary

A total of 341 *T. albacares* and 378 *T. obesus* larvae were genetically identified accounted for 7% and 8% of all *Thunnus* larvae identified at the 163 positive stations (*N*=4901), with *T. atlanticus* (blackfin tuna) numerically dominant and accounting for 83% of the true tunas in my collections. *T. albacares* and *T. obesus* larvae ranged in size from 2.0 to 8.2mm in total length (Figure 16). A higher proportion of smaller *T. albacares* was observed relative to *T. obesus*; however, for both species larvae were of similar size in June and July with a majority of *T. albacares* ranging from 2.0 to 5.0 mm (87%) and a majority of *T. obesus* ranging from 4.0 to 8.0 mm (79%). *T. albacares* and *T. obesus* were common in the sampling corridor with a percent of occurrence ranging from 25 to 76% and 13 to 57%, respectively. Regardless, mean densities of *T. obesus* and *T. albacares* were similar (1.0 and 0.9 larvae $1000m^{-3}$) (Figure 17). Intra- and inter-annual variability in density was observed for *T. albacares* and *T. obesus* (ART, $p<0.01$); with mean density lower in June than July for *T. albacares* (0.8 and 1.0 larvae $1000m^{-3}$) and *T. obesus* (0.5 and 1.2 larvae $1000m^{-3}$). However except for 2009, *T. albacares* mean density was higher in June (1.0 larvae $1000m^{-3}$) than July (0.2 larvae $1000m^{-3}$). Differences in mean density among years were also detected with a maximum density of both *T. albacares* and *T. obesus* observed in 2009 (1.8 larvae $1000m^{-3}$ for both species) with the lowest mean density for each detected in 2008 (0.4 and 0.5 larvae $1000m^{-3}$, respectively).

Both *T. albacares* and *T. obesus* were mostly distributed on the continental slope (depth = 200-2000m) (Figure 18); however, *T. albacares* was also common in zones influenced by the freshwater inputs from the Mississippi River. Moreover, *T. albacares* and *T. obesus* densities were higher during years of higher penetration of the Loop Current (2009) and an associated warm-core eddy (2007), with maximum densities recorded at stations close to the edge of these mesoscale features. In contrast, the lowest mean density for both species was recorded during the year with limited northward penetration of the Loop Current into the northern GoM (2007).

T. albacares GAMs

The June final P/A-based GAM (AIC = 119.5, DE = 19.7%) and density-based GAM (AIC = 185.7, DE = 46.6%) included all the environmental variables tested: distance to the Loop Current, sea surface height, salinity, and sea surface temperature (Table 9). Based on ΔAIC and ΔDE (%), sea surface height (3.4, 3.6%) in the P/A-based GAM and sea surface temperature (20.5, 13.8%) in the density-based GAM were the most influential explanatory variables retained in the final models. Responses plots for larval P/A- and density-based GAM were similar (Figure 19) indicating that the presence and density of *T. albacares* larvae in June were higher farther from the Loop Current, at negative sea surface heights, at higher sea surface temperatures (> 28°C), and at intermediate to high salinity (33-36).

The July final P/A-based GAM (AIC = 145.5, DE = 16.9%) and density-based GAM (AIC = 265, DE = 60.3%) for *T. albacares* retained three similar variables: distance to the LC, sea surface height, and salinity (Table 9). For both models, ΔAIC and ΔDE (%) indicated that the most influential variable retained in the final models was distance to the LC (P/A-based GAM = 7.3, 6.0%; density-based GAM = 11.2, 5.4%). Response plots indicated that the presence and density of *T. albacares* in July were higher closer to the Loop Current, at both negative and positive sea surface heights (-

20cm to 20cm), at higher sea surface temperatures (> 28°C), and at intermediate to high salinity (30-36) (Figure19).

T. obesus GAMs

The June final P/A-based GAM (AIC = 152.7, DE = 15.2%) and density-based GAM (AIC = 239, DE = 22.6%) for *T. obesus* included three similar variables: distance to the LC, salinity, sea surface height (Table 10). Based on ΔAIC and ΔDE (%), sea surface height was the most influential variable retained in both final models (P/A-based June GAM = 6.0, 4.8%; density-based June GAM = 5.9, 5.4%). Response plots for P/A- and density-based GAMs were highly similar (Figure 20) and indicated that the presence and density of *T. albacares* larvae in June were higher farther from the Loop Current, at negative and positive sea surface heights (-15 to 20cm), at higher sea surface temperatures (> 28°C), and at intermediate to high salinity (33-36).

The July final P/A-based GAM (AIC = 165.7, DE = 12.0%) and density-based GAM (AIC = 346.2, DE = 42.2%) for *T. obesus* included two variables observed in the June models: sea surface temperature and salinity (Table 10). Both ΔAIC and ΔDE (%) indicated that the most influential variables retained in the final models were salinity for the P/A-based GAM (6.4, 6.1%) and sea surface temperature for the density-based GAM (35.5, 18.3%). Response plots showed that the presence and density of *T. obesus* larvae were higher closer to the Loop Current, at positive sea surface height (0-25 cm), at higher sea surface temperature (>30°C), and at intermediate to high salinity (31-36). Moreover, the P/A-based GAM was the only model including depth with a higher presence of *T. obesus* on the continental shelf and slope waters (depth <2000m) (Figure 20).

Habitat suitability maps

Predicted distributions of both species in 2010 indicated that highly suitable habitat of *T albacares* in June occurred primarily on continental shelf and slope waters (depth<2000m) with additional suitable areas in the western GoM. In July, *T. albacares* larvae were predicted to be widely distributed throughout eastern and the central regions of the northern GoM (Figure 21). In contrast, highly suitable habitat of *T. obesus* was mostly confined to the continental shelf (depth <200m) but extended across the entire northern GoM in both June and July (Figure 22). In general, distributions of *T. albacares* and *T. obesus* predicted using P/A-based GAMs indicated a wider distribution in the GoM than predicted from density-based GAMs. Areas in the northern GoM predicted to be highly suitable (> 50% occurrence) for *T. albacares* were more constrained in June (18,053 km^2) than July (275,140 km^2), while this trend shifted for *T. obesus* with greater areal coverage of highly suitable habitat in June (263,335 km^2) relative to July (150,215 km^2) (Table 11). The spatial coverage of highly suitable habitat impacted by surface oil was lower in June than July for both species, and overall the amount of highly suitable habitat exposed to surface oil was greater for *T. obesus* (June 23% and July 34%) than *T. albacares* (June 4% and July 26%) (Table 11).

Discussion

The presence of *T. albacares* and *T. obesus* larvae throughout the sampling corridor (39% and 49% frequency of occurrence) indicates that the northern GoM is likely a spawning habitat of both species and possibly an important nursery habitat. In the present study, maximum larval densities (28.8 larvae 1000m^{-3}) of *T. albacares* and *T. obesus* were higher than *T. thynnus* from the same region (9 larvae 1000m^{-3}, Habtes et al. 2014), which is known to represent a key spawning area of this congener. The seasonal penetration of the Loop Current in the GoM can affect larval dispersal and may have transported larvae from the southern GoM (via Yucatan Channel) or into the sampling corridor, increasing the presumed value of this region as a spawning area (Quian et al. 2015); however, recent larval backtracking research using biophysical models conducted during the same period on pelagic fishes indicate that connectivity between the Caribbean Sea and the northern GoM is very limited (A. Vaz, pers.comm.). This combined with presence of numerous recently hatched larvae in my samples (<3 mm or <4 days old; age approximated from Lang et al. 1994) suggest that most of these individuals are likely from spawning in the GoM. While spawning events of *T.*

albacares were previously reported in the GoM (Lang et al. 1994; Richardson et al. 2010), this region has not been yet described as a potential spawning area for *T. obesus* because larvae are not often observed in this area (Richards et al. 1990; Richardson et al. 2010). My results lend further support to the premise that the northern GoM represents a potentially overlooked and important spawning area for both *T. obesus and T. albacares.*

The distribution and abundance of *Thunnus* larvae in the northern GoM are not fixed in space or time, and vary both within and across years (Lindo-Atichati et al. 2012; Cornic et al. submitted). Intra- and inter-annual variation in the occurrence of larvae observed in this study might be explained by changes in the geographic position of mesoscale features in this region, including the Loop Current (Rooker et al. 2012; Richardson et al. 2010; Lindo-Atichati et al. 2012; Randall et al. 2015; Kitchens and Rooker 2014). Observed variation in densities of both *T. albacares* and *T. obesus* was related to the proximity of the station to the margin of the Loop Current or associated eddies, and mean density for both *T. albacares* and *T. obesus* larvae was highest (0.9 and 1.0 larvae $1000m^{-3}$) during years of significant northward penetration of the Loop Current or when strongly defined warm-core eddies were present in the sampling corridor (2007, 2009). In contrast, during the year with the lowest northward penetration of the Loop Current (2008), densities of *T. albacares* and *T. obesus* were lower (0.4 and 0.5 larvae $1000m^{-3}$, respectively). Moreover, GAMs revealed that *T. albacares* and *T. obesus* larvae were typically more common and at greater densities in areas closer to the Loop Current in July, which indicates that these species were positively associated with the seasonal penetration of the Loop Current. Therefore, the strength and geographic position of this mesoscale feature likely influences the distribution and abundance of both *T. albacares* and *T. obesus* larvae. My findings are consistent with results of previous studies showing that the abundance of pelagic fish larvae often increases near anticyclonic or warm core oceanographic features (Richardson et al. 2010; Reglero et al. 2014).

Variability in the spatiotemporal distribution patterns of *T. albacares* and *T. obesus* larvae also can be linked to the hydrodynamic processes and biological production associated with oceanographic features. In the GoM, hydrodynamic processes at the margin of mesoscale features and riverine discharges generate convergent zones that aggregate planktonic organisms and increase productivity (Govoni and Grimes 1992; Bakun 2006). GAMs showed that high occurrence and densities of *T. albacares* and *T. obesus and* were observed in convergent zones, suggesting that hydrodynamic processes affect the distribution and abundance of these species. Alternatively, the concentration of zooplankton in convergent zones might influence the prey availability of *Thunnus* larvae, which in turn has been shown to enhance growth and survival of pelagic fish larvae (Bakun 2006; Simms et al. 2010). Moreover, it has been observed that mechanisms that concentrate fish prey (e.g., cladocerans, copepods) play a role in feeding success of *Thunnus* larvae (Llopiz and Hobday 2015). Therefore, increased availability of prey in the convergent zones might result in increased abundances of *T. albacares* and *T. obesus* in these areas. Since the GoM is an oligotrophic environment, convergent zones at the margin of the mesoscale features and riverine discharges may offer a favorable habitat for *T. albacares* and *T. obesus* larvae by retaining and transporting *Thunnus* larvae along with productive water masses.

Physicochemical such as sea surface height and temperature are known to affect habitat associations of pelagic fishes during early life (Margulies et al. 2007; Wexler et al. 2011; Muhling et al. 2013; Reglero et al. 2014; Kim et al. 2015) and both were also influential in explaining the distribution and abundance of *Thunnus* larvae in the present study. The Loop Current and its associated cold-core and warm-core eddies influence sea surface temperatures in the GoM. Although *T. albacares* and *T. obesus* larvae were detected in different mesoscale features (positive and negative sea surface heights) and a wide range of sea surface temperature (26-33°C), my models showed that highest occurrences and densities were detected in waters close to the Loop Current and warm-core eddies (sea surface height >10cm) as well as high sea surface temperatures (>29°C). Because the optimal thermal range for the development of *T. albacares* and *T. obesus* larvae is between 28 and 31°C (Conan and Richards 1982; Lang et al. 1994; Wexler et al. 2011; Kim et al. 2015), the warmer waters found in the Loop Current and the warm-core eddies may provide more suitable habitat for *T. albacares* and *T. obesus* larvae than cold-core eddies. Therefore, temperature requirements of *T. albacares* and *T. obesus* larvae might explain the distribution of these species in warm mesoscale features, which emphasizes the importance of oceanographic features on the spatial extent of suitable habitat of these species. However, *T. albacares* and *T. obesus* were also present in cold-core eddies which indicate that the high productivity observed in these features might positively affect the distribution and abundance of these species by increasing their prey availability and supporting their growth.

Another important physicochemical factor that affected the distribution and abundance of *Thunnus* larvae was salinity, which is influenced by spatial and temporal dynamics of the Mississippi-Atchafalaya River System in the northern GoM (Lang et al. 1994; Muhling et al. 2010; Lindo-Atichati et al. 2012). The amount of riverine discharge can impact the distribution of waters with lower salinity, which occasionally reaches the outer continental shelf (Amon & Benner 1998). *T. albacares* and *T. obesus* were found in a wide range of salinities (30-36), indicating that these species may be tolerant of conditions observed throughout the northern GoM. Still, peaks in presence and densities of *T. albacares* and *T. obesus* were observed at intermediate salinities (32-34), which corresponds to areas impacted by riverine discharges. Given that intermediate salinities match the optimal salinity conditions required for hatching and early life development of both *T. albacares* and *T. obesus* (Conan and Richards 1982; Margulies et al. 2007; Wexler et al. 2011; Kim et al. 2015), riverine discharges appear to create favorable environmental conditions for these species. Moreover, the mixing of marine and riverine waters often leads to increased primary and secondary productivity (Lohrenz et al. 1997). Because the growth and survival of *Thunnus* larvae are dependent on food availability (Llopiz et al. 2010; Llopiz & Hobday 2015), areas of higher productivity and lower salinity correspond to the optimal conditions for the survival of *T. albacares* and *T. obesus* larvae. This hypothesis is further supported by a previous study showing that *T. albacares* larvae were influenced by Mississippi River inputs in this region, with higher larval abundance and growth rates near the Mississippi River plume (Lang et al.

1994). In the present study, high densities of *T. albacares* and *T. obesus* were observed in 2007 and 2009, which were years of increased Mississippi River discharges (757,950 and 609,100 feet^3 sec^{-1}) compared to 2008 (442,467 feet^3 sec^{-1}) (USACE, www. mvn.usace.army.mil), suggesting that the magnitude of riverine discharges may have major impacts on the distribution and abundance of both species.

The quality of spawning and nursery habitat is critical for the survival of *Thunnus* larvae and the degradation of their habitat can have important repercussions on larval recruitment (Lehodey et al. 2003; Muhling et al. 2011, 2012; Rooker et al. 2013). In 2010, the Deepwater Horizon (DWH) incident discharged the largest oil spill observed in pelagic environment (>4 million barrels), impacting the spawning ground of tunas and other pelagic fishes in the northern GoM (Muhling et al. 2012; Rooker et al. 2013). It has been observed that densities of one species of tuna larvae (*T. atlanticus*) in the northern GoM decreased the summer following the DWH oil spill (Rooker et al. 2013), which is not unexpected given that crude oil has been shown to reduce the survival of tuna larvae (Incardona et al. 2014; Brette et al. 2014). In this study, predictions of highly suitable habitats for *T. albacares* indicated that few larvae were distributed close to, or within, the surface oil slick associated with the DWH event, which explains the lower percent of suitable habitat in areas exposed to surface oil (4-26%) for this species. In fact, areas with the highest amount of suitable habitat were predicted to occur in western and central regions of the northern GoM in areas apparently unaffected by the oil spill. In contrast, a large fraction of the highly suitable habitat of *T. obesus* was predicted to occur on the outer continental shelf and slope in the northern GoM, and a higher percentage of suitable habitat for this species was exposed to surface oil from DWH (23-34%). While exposure to surface oil may have affected larval survival following the DWH event and may possibly explain lower observed densities for both species in summer 2010, the estimated percent coverage of suitable habitat of *T. albacares* and *T. obesus* larvae affected by the oil spill was relatively modest, indicating that the effect of oil on *T. albacares* and *T. obesus* have been mitigated by the large amount of suitable habitat still available. My results are consistent with other studies investigating the impact of the DWH event on tuna spawning and nursery habitat (Muhling et al. 2012; Rooker et al. 2013, Hazen et al. 2016), and suggest that observed differences in the distribution and abundance of *T. albacares* and *T. obesus* in 2010 may be largely due to other factors (i.e. biological, oceanographic features).

Habitat associations of *T. albacares* and *T. obesus* larvae in the northern GoM indicated that several physicochemical influence the spatial distribution of these species (moderate to high salinity, high temperature) and GAMs revealed that oceanographic features (Loop Current and warm-core eddies) influenced the geographic location of suitable habitats for *T. albacares* and *T. obesus*. Although suitable habitats of *T. albacares* and *T. obesus* larvae were affected by the DWH oil spill, the presumed impact was modest and interannual shifts in the abundance of larvae for both species appear likely to be influenced by spatial and temporal variation in environmental conditions in the northern GoM. Given the renewed interest in using fisheries-independent data from ichthyoplankton surveys to estimate important population parameters (i.e., spawning stock biomass; Lamkin et al. 2015), my results provide essential information to refine stock assessments of both species and better predict year-class strength, which is necessary to improve stock recruitment models and promote long-term sustainability of these tuna stocks.

CHAPTER V

CONCLUSIONS

The main objective of my dissertation research was to provide a detailed assessment of early life habitats of true tuna (genus *Thunnus*) in the northern GoM. Summer ichthyoplankton surveys revealed that larval assemblages of tunas in this region were dominated by *Thunnus* spp., followed by *Auxis* spp., *Euthynnus alletteratus*, and *Katsuwonus pelamis*, indicating that this region may represent valuable spawning and/or nursery habitat for several tuna genera. Genetic identification (UP-HRMA) of *Thunnus* larvae indicated that *T. atlanticus* larvae were the most abundant species followed by *T. albacare*s, *T. obesus*, and *T. thynnus*, with the latter species present in limited numbers due in part to July surveys being conducted outside the primary spawning period (April-June) of this species. In contrast, *T. atlanticus*, *T. obesus*, and *T. albacares* were relatively abundant and generally common (moderate to high frequency of occurrence) in both June and July surveys, suggesting that each species spawns in the northern GoM in late spring and summer. It is important to note that the northern GoM has not been previously reported as a spawning ground for *T. obesus*; however over four-years sampling, *T. obesus* larvae were frequently collected in both June and July cruises, indicating for the first time the importance of the GoM as spawning habitat for this species.

Variability in the spatiotemporal distribution of *T. atlanticus*, *T. albacares*, *T. obesus*, and *T. thynnus* larvae was linked to the hydrodynamic processes and biological production associated with oceanographic features. Three species (*T. atlanticus*, *T. albacares*, and *T. obesus*) were more abundant during years of important northward penetration of the Loop Current or associated features in the northern GoM, while *T. thynnus* was typically more abundant during year of low penetration of the Loop Current and commonly observed at the margins of cold-core eddies. Because the sample size was relatively small for *T. thynnus*, only habitat associations of *T. atlanticus*, *T. albacares*, and *T. obesus* were further investigated using generalized additive models (GAMs).

Final models for all three species indicated that salinity, sea surface temperature, and sea surface height were important explanatory variables, with higher densities of *Thunnus* larvae present in areas of intermediate salinities (31-36psu), higher temperatures (>29°C), and positive sea surface height. GAMs also showed that *T. atlanticus*, *T. albacares,* and *T. obesus* were influenced by the geographic position of the Loop Current and associated anticyclonic and cyclonic features, suggesting that the margin of the Loop Current and convergent zones between mesoscale oceanographic features are areas of high abundance or occurrence for these species. Apart from these mesoscale features, distribution of *T. atlanticus, T. albacares,* and *T. obesus* was also influenced by freshwater inflow from the Mississippi River with marine areas impacted by freshwater inflow serving as suitable habitat for all three species during the early life period.

Species-specific environmental preferences determined with GAMs were combined with environmental data (June and July 2010, 2011, and 2015) to predict the spatial coverage of suitable habitat of *T. atlanticus*, *T. albacares,* and *T. obesus* in the GoM. The habitat-modeling approach indicated that the location and the extent of highly suitable habitat of *T. atlanticus, T. albacares,* and *T. obesus* varied over time (year and month) depending on the environmental conditions and the location of mesoscale oceanographic features. Using this approach, I predicted the amount of highly suitable habitat of *T. albacares* and *T. obesus* exposed to the Deepwater Horizon oil spill in 2010. Although suitable habitat of both species was exposed to surface oil, the overall amount of suitable habitat contaminated was modest (ca. 30% for both species). As a result, it is plausible to assume that the oil spill may have played a role in reductions in the distribution and abundance of *T. albacares* and *T. obesus* observed in 2010; however, it is likely that other biological or physicochemical factors (e.g., geographic location of mesoscale features) contributed to the observed pattern.

Overall, findings from this research clearly demonstrate that the northern GoM is a valuable region for the early life stages of *T. atlanticus*, *T. albacares*, *T. obesus*, and *T. thynnus*. The distribution and abundance of these congeners were influenced by physicochemical characteristics often related to the Loop Current and associated features as well as freshwater inflow from the Mississippi River. Distinct species-specific habitat preferences were observed which possibly serves to reduce resource overlap (i.e., habitat partitioning) among *T. thynnus*, *T. albacares, T. obesus*, and *T. atlanticus*. My habitat-modeling approach defined conditions associated with suitable early life habitat of each species, and this information is critical to the development of standardized indices of larval abundance that can be used to assess the population status of tunas in this region. Because fisheries-independent indices are valuable in stock assessment models, a more reliable index of larval abundance for each *Thunnus* species will lead to the development of more reliable and informed population models, which is essential to ensure the long-term suitability of *Thunnus* stocks in the GoM.

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APPENDIX A

TABLES

Table 1: Catch data of tuna larvae in the northern Gulf of Mexico from 2007 to 2010 using neuston nets. Total number of stations sampled, number of larvae caught, and percent of frequency are presented.

			***Thunnus* spp.**		***Euthynnus alletteratus***		***Auxis* spp.**		***Katsuwonus pelamis***	
Year	**Month**	**# Stations**	**n**	**Frequency**	**n**	**Frequency**	**n**	**Frequency**	**n**	**Frequency**
2007	June	59	1381	81%	1	2%	28	7%	0	0%
	July	55	3509	95%	1	2%	0	0%	0	0%
2008	June	72	1343	74%	2	3%	6	8%	2	1%
	July	83	1151	63%	51	8%	296	12%	4	5%
2009	June	92	1242	82%	0	0%	3	3%	0	0%
	July	101	6452	88%	238	29%	370	43%	7	2%
2010	June	48	749	44%	31	10%	170	13%	49	10%
	July	48	1159	81%	0	0%	3	4%	3	6%
Total		558	16986		324		876		65	

Table 2: Catch data of *Thunnus* larvae in the northern Gulf of Mexico from 2007 to 2010 using neuston nets. Total number of stations genetically identified, number of larvae identified, and percent of frequency are presented.

			T. atlanticus		***T. obesus***		***T. albacares***		***T. thynnus***	
Year	Month	# Stations	n	Frequency	n	Frequency	n	Frequency	n	Frequency
2007	June	22	420	79%	32	50%	54	39%	25	25%
	July	22	659	92%	63	79%	16	42%	0	0%
2008	June	25	472	52%	48	40%	82	21%	42	19%
	July	24	531	43%	62	23%	11	13%	0	0%
2009	June	32	623	76%	71	48%	16	19%	31	19%
	July	34	1193	81%	102	55%	162	57%	0	0%
2010	June	28	316	62%	24	22%	157	31%	2	4%
	July	33	464	75%	37	25%	29	25%	0	0%
Total		220	4678		440		527		100	

Table 3: PERMANOVA results showing the temporal difference in densities from *Thunnus* larvae from 2007 to 2010 in the northern Gulf of Mexico using neuston nets. Bold values represent significant differences.

		T. atlanticus			***T. obesus***		
Source of variation	df	MS	Pseudo-F	p	MS	Pseudo-F	p
Ye	3	12516	7.4349	**0.0001**	4964.7	9.5989	**0.001**
Mo	1	9823.7	5.8357	**0.0054**	2931.6	5.668	**0.0104**
Ye * Mo	3	4080.9	2.4242	**0.0311**	1711.6	3.3093	**0.0109**
Residuals	332	1683.4			517.22		

		T. albacares			***T. thynnus***		
Source of variation	df	MS	Pseudo-F	p	MS	Pseudo-F	p
Ye	3	2717	5.1571	**0.0006**	346.21	2.5186	**0.0396**
Mo	1	1424.2	2.7033	0.0797	2573.4	18.72	**0.0001**
Ye * Mo	3	5797.9	11.005	**0.0001**	326.8	2.3773	0.0525
Residuals	332	526.84			137.46		

Table 4: Summary of blackfin tuna larvae catches from 2007 to 2011 and 2015. n corresponds to the number of stations genetically analyzed, count is the number of blackfin tuna larvae identified, and % of blackfin tuna represents the percent of blackfin tuna larvae identified in the *Thunnus* larvae collection. Densities (larvae 1000m^{-3}) and standard error of the mean (SE) are also indicated.

Year	**Cruises**	**n**	**Count**	**% blackfin tuna**	**Frequency of occurrence**	**Densities (SE)**
2007	June	22	420	79	79	5.8 (1.8)
	July	22	659	89	92	13.5 (1.6)
2008	June	25	472	66	52	4.8 (1.7)
	July	24	531	88	43	4.6 (0.6)
2009	June	32	623	84	76	6.0 (1.1)
	July	34	1193	82	81	29.2 (5.7)
2010	June	28	316	63	62	3.7 (1.7)
	July	33	464	87	75	6.3 (0.6)
2011	June	23	407	85	87	4.1 (0.6)
	July	34	166	98	66	1.4 (0.2)
2015	June	25	167	72	50	1.8 (2.9)
	July	23	269	88	48	3.3 (1.4)

Table 5: Variables retained in the final presence-absence (P/A) and density models for blackfin tuna larvae, Akaike Information Criterion (AIC), deviance explained (DE). * $p < 0.05$, ** $p = 0.001$, *** $p < 0.001$

Model	**Variables**	**Δ AIC**	**Δ DE**
Occurrence	Hour after sunrise***	22.1	7.3%
Final AIC: 389.5	SSHA*	8.1	3.5%
Final DE: 15.1%	SST	3.0	1.6%
	Salinity·	9.4	5.1%
	Sargassum biomass*	13.2	5%

Model	**Variables**	**Δ AIC**	**Δ DE**
Density	Year***	55	6.6%
Final AIC: 1840.4	Hour after sunrise***	33.3	4.3%
Final DE: 36.6%	SSHA***	32.0	4%
	SST***	36.2	4.7%
	Salinity***	15.1	2.3%
	Sargassum biomass**	9.8	1.3%

Table 6: Variables retained in the final June and July density models (2007-2009) of blackfin tuna larvae, Akaike Information Criterion (AIC), deviance explained (DE). * $p < 0.05$, ** $p = 0.001$, *** $p < 0.001$.

Model	**Variables**	**Δ AIC**	**Δ DE**
June	SSHA***	25.4	10.6%
Final AIC: 614.6	SST	4.8	3.1%
Final DE: 21.6%	Salinity$^{\cdot}$	-0.4	0.5%

Model	**Variables**	**Δ AIC**	**Δ DE**
July	SSHA***	11.9	3.9%
Final AIC: 815.9	SST***	63.9	15.1%
Final DE: 36.6%	Salinity***	15.7	5.2%

Table 7: Predicted area (km^2) and percent of highly suitable habitat (>10 larvae $1000m^{-3}$) in the overall northern GoM and sampling corridor (black rectangle in Figure 1).

Year	**Month**	**Overall highly suitable habitat (km^2)**	**Overall percent of highly suitable habitat**	**Sampling corridor highly suitable habitat (km^2)**	**Sampling corridor percent of highly suitable habitat**
2011	June	6378	2	0	0
	July	200536	48	15730	42
2015	June	44054	10	0	0
	July	227125	54	36695	98

Table 8: Source and spatial resolution of remotely data sensed extracted to develop generalized additive models.

Variables	**Source**	**Link**	**Spatial resolution**
Sea surface temperature (°C) Salinity (psu)	GoM-HYCOM+NCODA	www.hycom.org	0.04°
Sea surface height (m)	AVISO	www.aviso.oceanobs.com	0.25°
Depth (m)	GEODAS U.S.	www.ngdc.noaa.gov	6 arc-second

Table 9: Akaike information criterion (AIC), deviance explained (DE) and variables retained in the final presence/absence- and density-based generalized additive models for *Thunnus albacares* in June and July. Variation in AIC (Δ AIC), DE (Δ DE), and p values (***p<0.001, **p<0.01, and *p<0.05) are also presented to evaluate the importance of each variable.

Thunnus albacares	**Model**	**Variables**	**Δ AIC**	**Δ DE**
P/A June	Final AIC: 119.5	Distance to LC*	6	6.3
	Final DE: 19.7%	SST*	1.9	2.5
		SSHA*	3.4	3.6
		Salinity*	3.2	2.8
P/A July	Final AIC: 145.5	Distance to LC**	7.3	6
	Final DE: 16.9%	SSHA	4.5	4.6
		Salinity	0.2	2.8
Density June	Final AIC: 185.7	Distance to LC*	4.8	5.3
	Final DE: 46.6%	SST***	20.5	13.8
		SSHA	14.8	11.4
		Salinity**	6.2	4.9
Density July	Final AIC: 265	Distance to LC***	11.2	5.4
	Final DE: 60.3%	SST*	2.9	1.7
		SSHA*	5.3	3.4
		Salinity*	6.44	4.1

Distance to the Loop Current (distance to LC), sea surface temperature (SST), and sea surface height anomaly (SSHA).

Table 10: Akaike information criterion (AIC), deviance explained (DE), and variables retained in the final presence/absence- and density based generalized additive models for *Thunnus obesus* in June and July. Variation in AIC (Δ AIC), DE (Δ DE), and p values (***p<0.001, **p<0.01, and *p<0.05) are also presented to evaluate the importance of each variable.

Thunnus obesus	**Model**	**Variables**	**Δ AIC**	**ΔDE**
P/A June	Final AIC: 152.7	Distance to LC	2.2	2.9
	Final DE: 15.2%	SST	0.7	0.8
		SSHA*	5.9	5.38
		Salinity	0.2	1.3
P/A July	Final AIC: 165.7	Distance to LC	0.4	1.5
	Final DE: 12%	SST*	3.8	3.8
		Salinity*	6.4	6.1
		Depth*	2.3	3.2
Density June	Final AIC: 239	Distance to LC*	3.6	6.1
	Final DE: 22.6%	SSHA*	7.8	11.6
		Salinity	0.1	1.3
Density July	Final AIC: 346.2	SST***	35.5	18.3
	Final DE: 42.2%	SSHA**	6	4.8
		Salinity***	14.5	9.1

Distance to the Loop Current (distance to LC), sea surface temperature (SST), and sea surface height anomaly (SSHA).

Table 11: Estimation of the overall area (km^2) of high quality habitat (50% of occurrence) and high quality habitat exposed to oil in summer 2010 for *Thunnus albacares* and *Thunnus obesus*.

	Thunnus albacares		***Thunnus obesus***	
	Overall high quality habitat (km^2)	**High quality habitat exposed (km^2)**	**Overall high quality habitat (km^2)**	**High quality habitat exposed (km^2)**
June	18 053	745	263 335	59 449
July	275 140	70 367	150 215	50 527

APPENDIX B

FIGURES

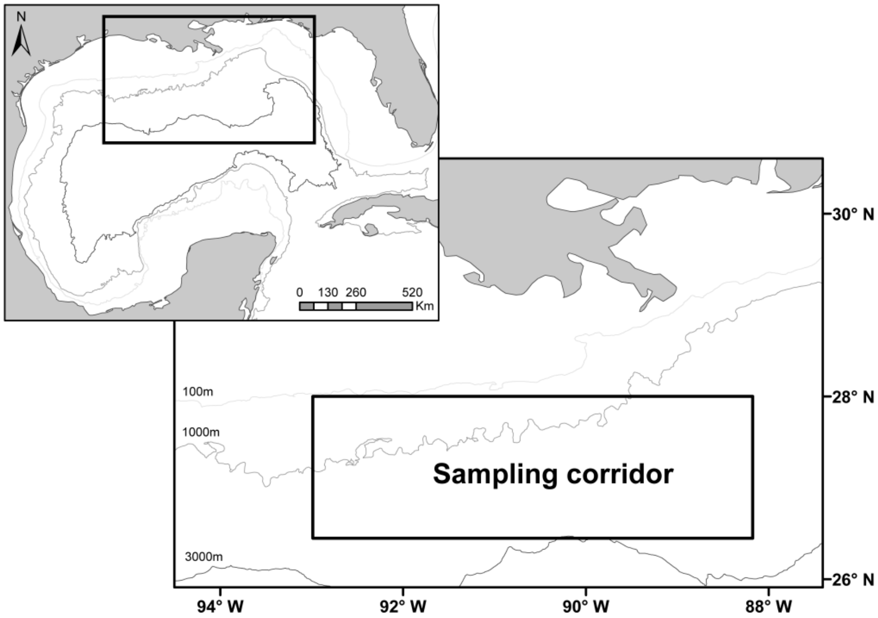

Figure 1: Sampling area (black rectangle) of the June and July ichthyoplankton cruises performed from 2007 to 2011 and 2015 in the northern Gulf of Mexico.

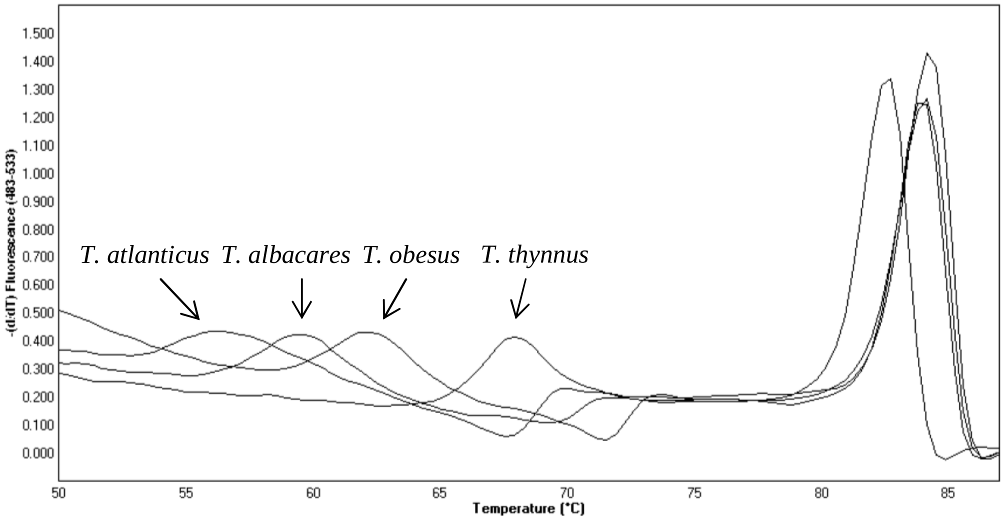

Figure 2: Species- specific derivative melting curves based on UP-HRMA for *Thunnus atlanticus*, *Thunnus obesus*, *Thunnus albacares*, and *Thunnus thynnus* of a ND4 mtDNA gene segment. Labeled peaks correspond to the maximum rate of melting of the PCR product against a *Thunnus maccoyii* specific probe. The portion of each curve melting >80°C corresponds to the entire amplicon and separates *Thunnus thynnus* from the other three species.

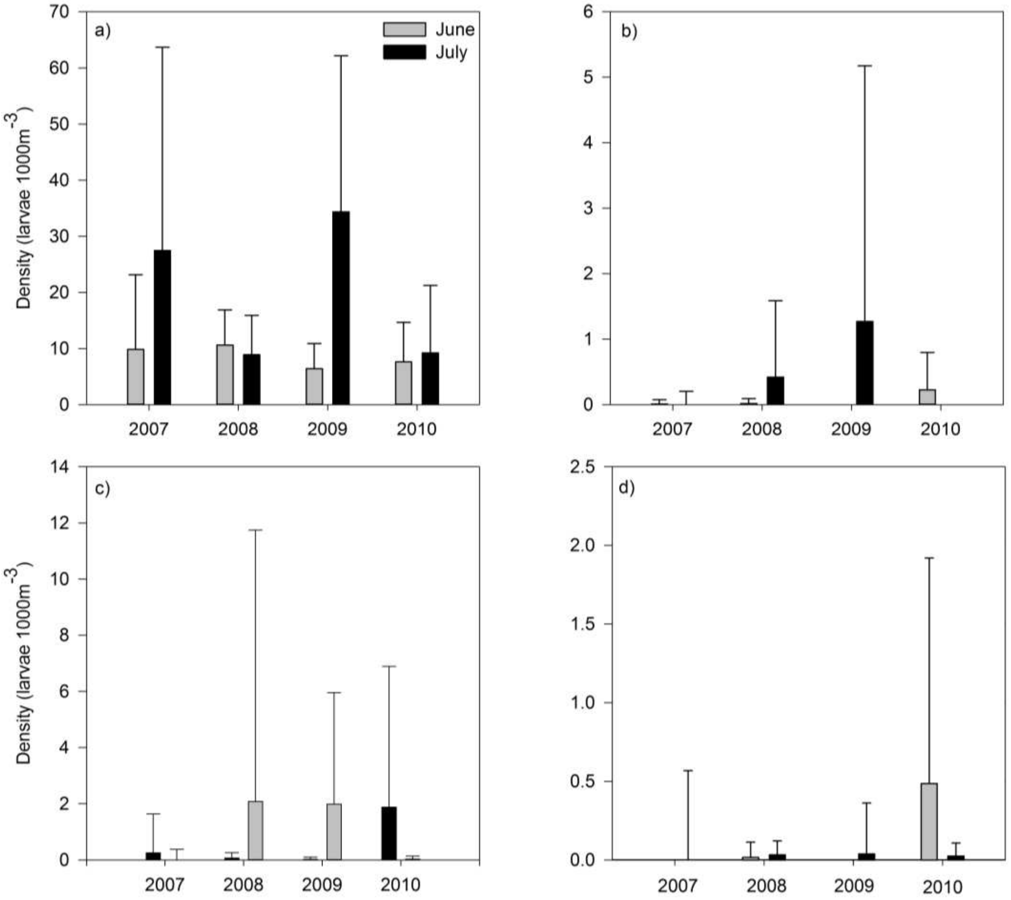

Figure 3: Densities of tuna larvae (larvae 1000m^{-3}), a) *Thunnus* spp., b) *Euthynnus alletteratus*, c) *Auxis* spp., and d) *Katsuwonus pelamis* from 2007 to 2010 in the northern Gulf of Mexico. Error bar represent standard error of the mean.

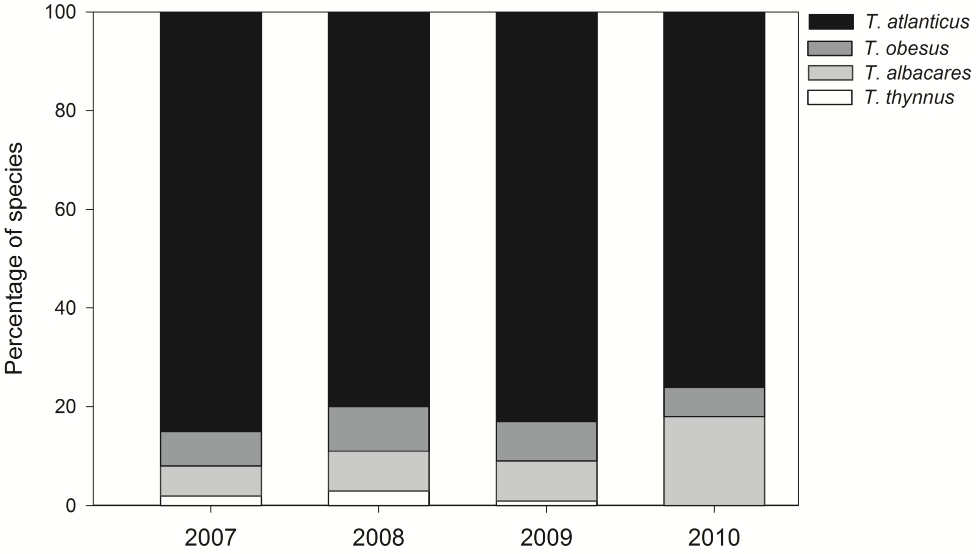

Figure 4: Species composition of *Thunnus* larvae in the northern Gulf of Mexico from 2007 to 2010.

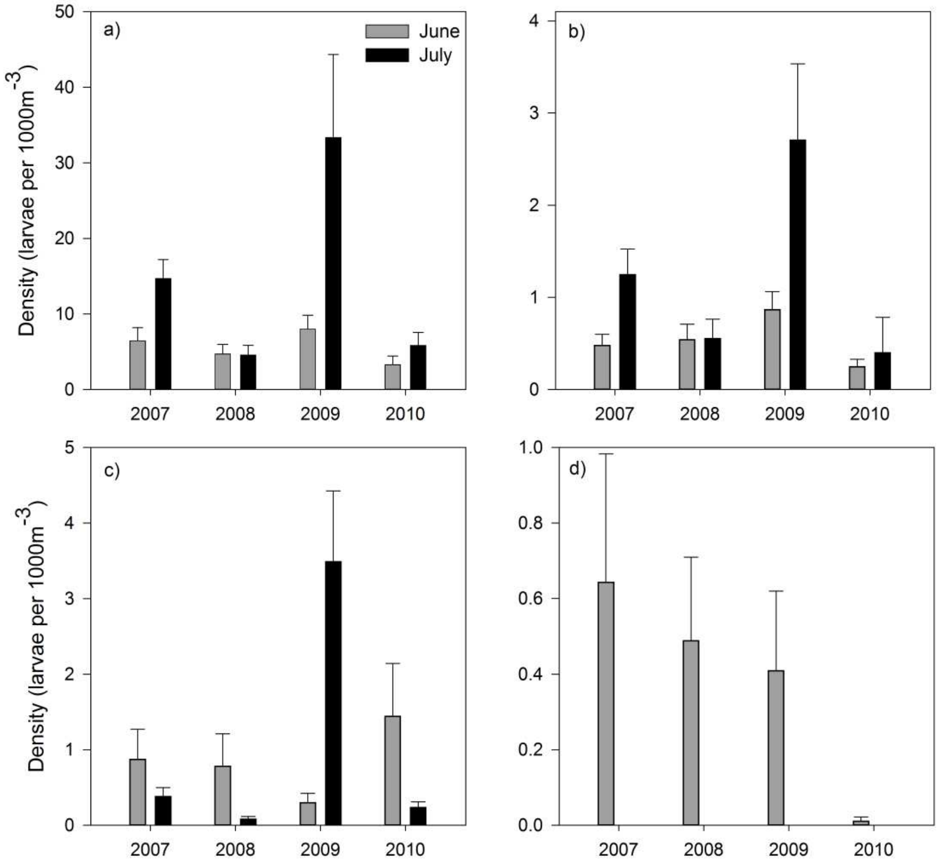

Figure 5: *Thunnus* larvae densities (larvae 1000m^{-3}) in the northern Gulf of Mexico between 2007 and 2010; a) *Thunnus atlanticus*, b) *Thunnus obesus*, c) *Thunnus albacares*, d) *Thunnus thynnus*. Error bars represent standard error of the mean.

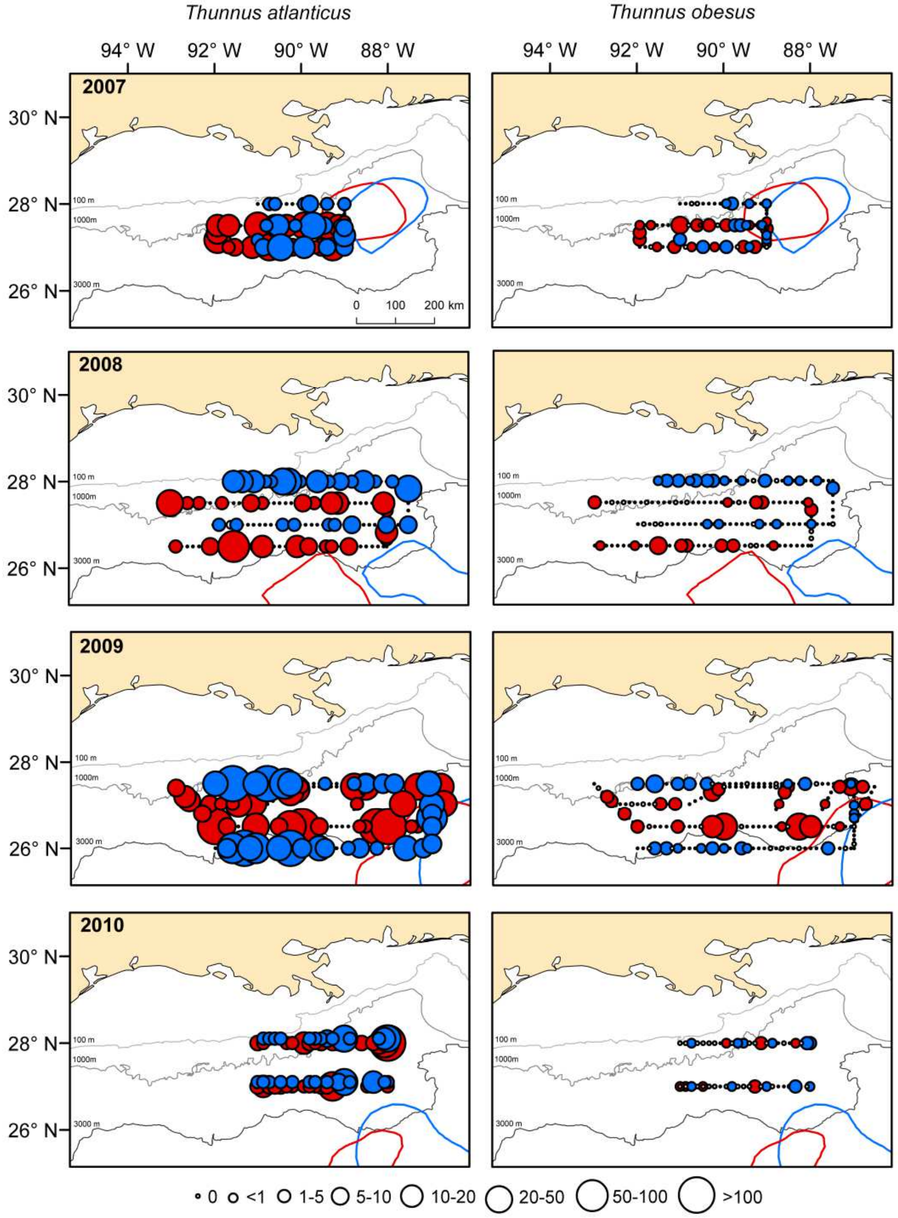

Figure 6: Distribution and abundance of *Thunnus atlanticus* and *Thunnus obesus* larvae in June (blue) and July (red) from 2007 to 2010 in the northern Gulf of Mexico. Circles symbolize densities, scale of *T. atlanticus* and *T. obesus* is from 0 to > 100 larvae 1000m^{-3}. Black dots represented the stations sampled but not genetically analyzed. Location of the LC is represented in June (blue line) and July (red line).

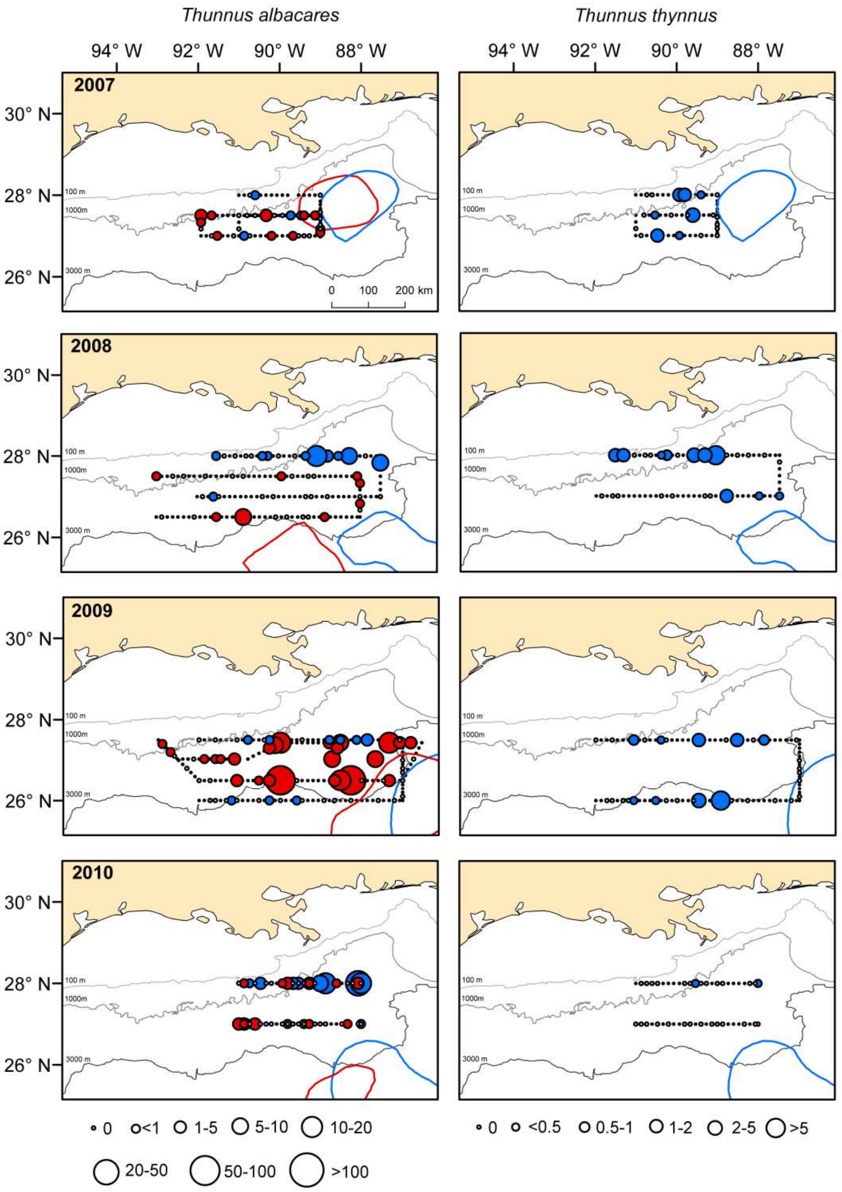

Figure 7: Distribution and abundance of *Thunnus albacares* and *Thunnus thynnus* in June (blue) and July (red) from 2007 to 2010 in the northern Gulf of Mexico. Circles symbolize densities, scale of *T. albacares* is from 0 to >100 larvae 1000m^{-3} and scale of *T. thynnus* from 0 to > 5 larvae 1000m^{-3}. Black dots represented the stations sampled but not genetically analyzed. Location of the LC is represented in June (blue line) and July (red line).

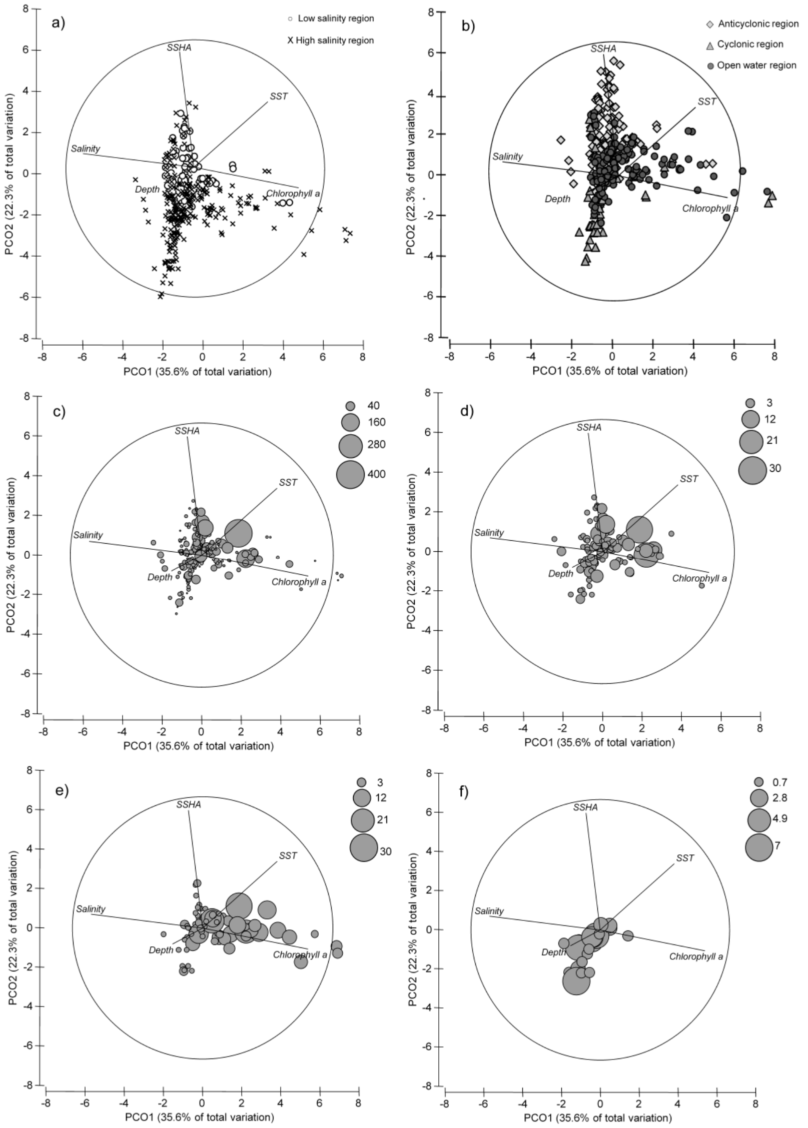

Figure 8: PCO plots of environmental data representing the different regions crossed from 2007 to 2010 in the northern Gulf of Mexico; a) salinity regions, b) oceanographic regions. Bubble plots represent the density of each *Thunnus* species (larvae 1000m^{-3}) depending on the sampling location with, c) *Thunnus atlanticus*, d) *Thunnus obesus*, e) *Thunnus albacares*, f) *Thunnus thynnus*. The circle presents the vector overlay (Pearson correlation) illustrating the contribution of the respective environmental variables to the PCO axes.

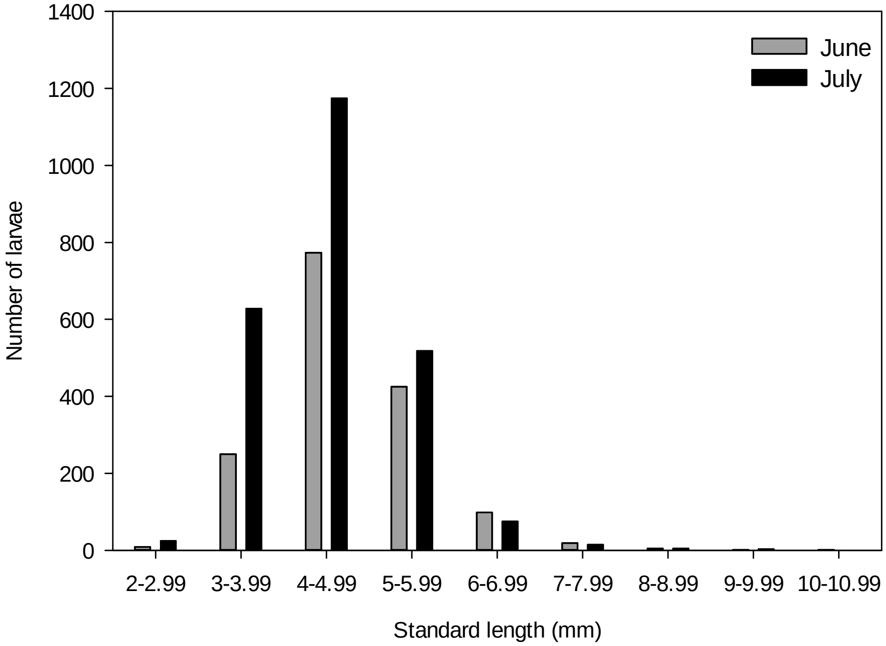

Figure 9: Size distribution of blackfin tuna larvae (standard length, mm) from 2007 to 2010.

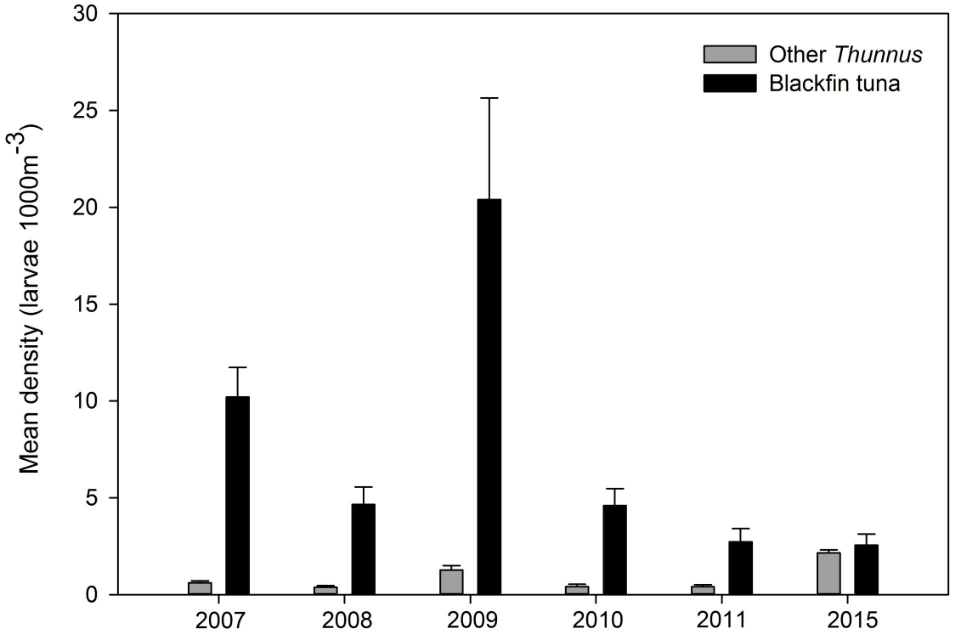

Figure 10 Density (larvae 1000m^{-3}) of blackfin tuna and other *Thunnus* larvae (bluefin tuna, yellowfin tuna, and bigeye tuna) in the northern GoM from 2007 to 2011 and 2015. Error bar represent one standard error of the mean.

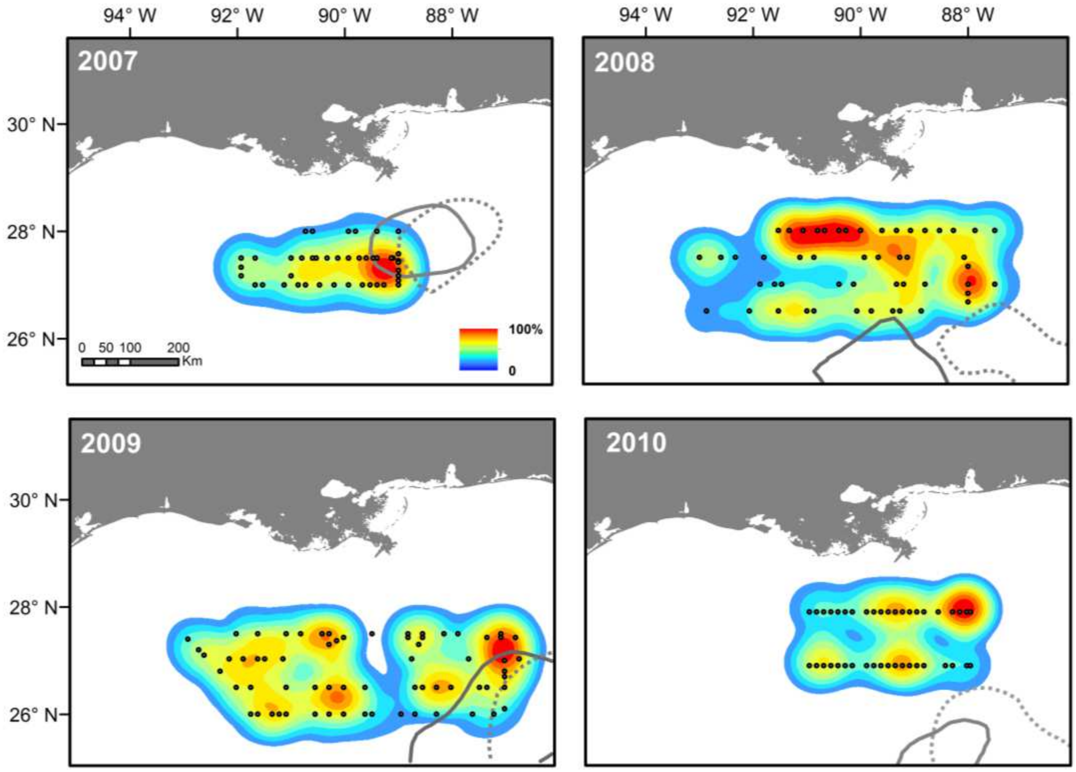

Figure 11: Spatial distribution of blackfin tuna larvae from 2007 to 2010 in the northern GoM, this region corresponds to the sampling corridor represented in Figure 1 (black rectangle). Black dots symbolize the stations genetically identified where blackfin tuna larvae were detected (June and July). Contour of kernel logarithm +1 transformed density (larvae 1000m^{-3}) represent 20 to 100% of the total distribution of larvae. Grey lines represent the location of the Loop Current and anticyclonic features in June (dashed line) and July (plain line).

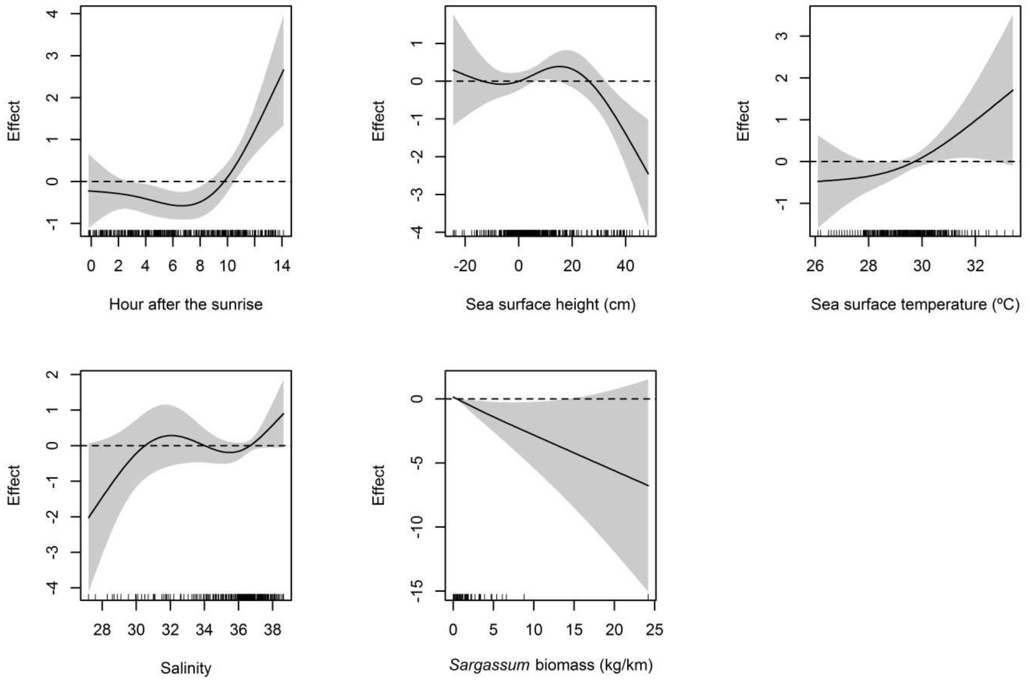

Figure 12: Response plots from final generalized additive models (GAMs) showing the influence of environmental variables on occurrence of blackfin tuna larvae from 2007 to 2010. On x-axis environmental variables and rug plot indicate number of observations, on y-axis the response of the model. Response curves are given by the solid lines and 95% confidence interval by the shaded areas.

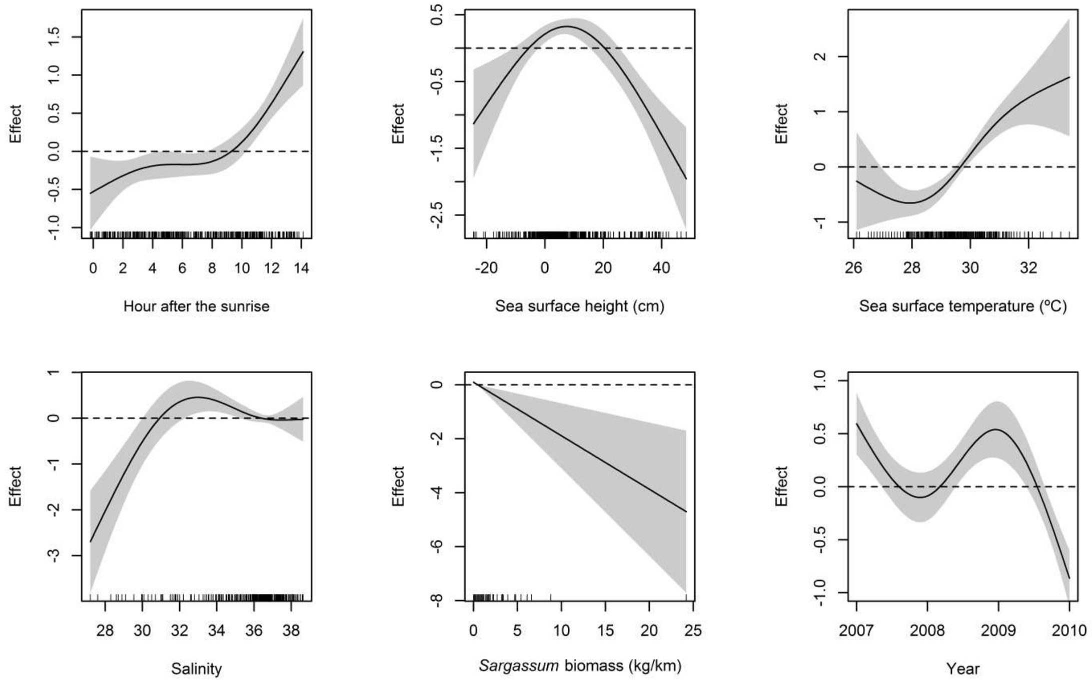

Figure 13: Response plots from final generalized additive models (GAMs) showing the influence of environmental variables on density of blackfin tuna (larvae 1000m^{-3}) from 2007 to 2010. On x-axis environmental variables and rug plot indicate number of observations, on y-axis the response of the model. Response curves are given by the solid lines and 95% confidence interval the shaded areas.

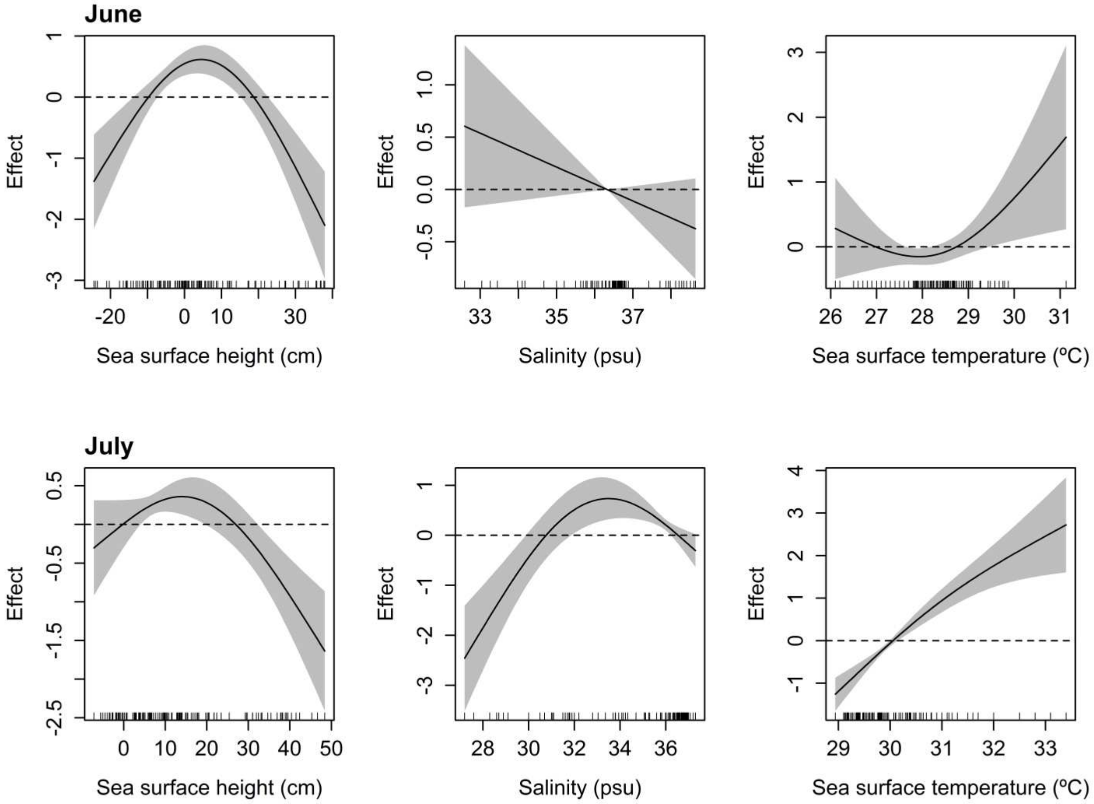

Figure 14: Response plots from final generalized additive models (GAMs) showing the influence of environmental variables on density (larvae 1000m^{-3}) of blackfin tuna larvae from 2007 to 2009 in June (top panel) and July (bottom panel). On x-axis environmental variables and rug plot indicate number of observations, on y-axis the response of the model. Response curves are given by the solid lines and 95% confidence interval by the shaded areas.

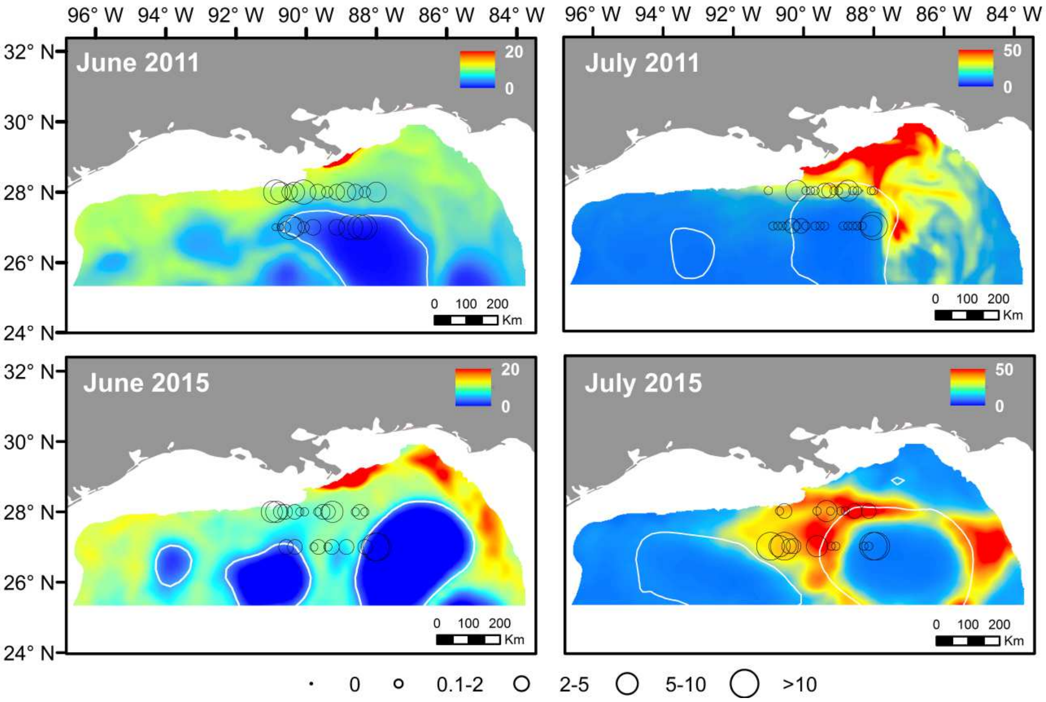

Figure 15: Predictive maps of blackfin tuna larvae densities (larvae 1000m^{-3}) developed based on density GAM models (2007-2009) and environmental conditions in June and July 2011 and 2015. White line indicated the location of the Loop Current and anticyclonic features, black circles symbolized the densities observed during the ichthyoplankton cruises performed in this region in 2011 and 2015 (scale from 0 to >10 larvae 1000m^{-3}).

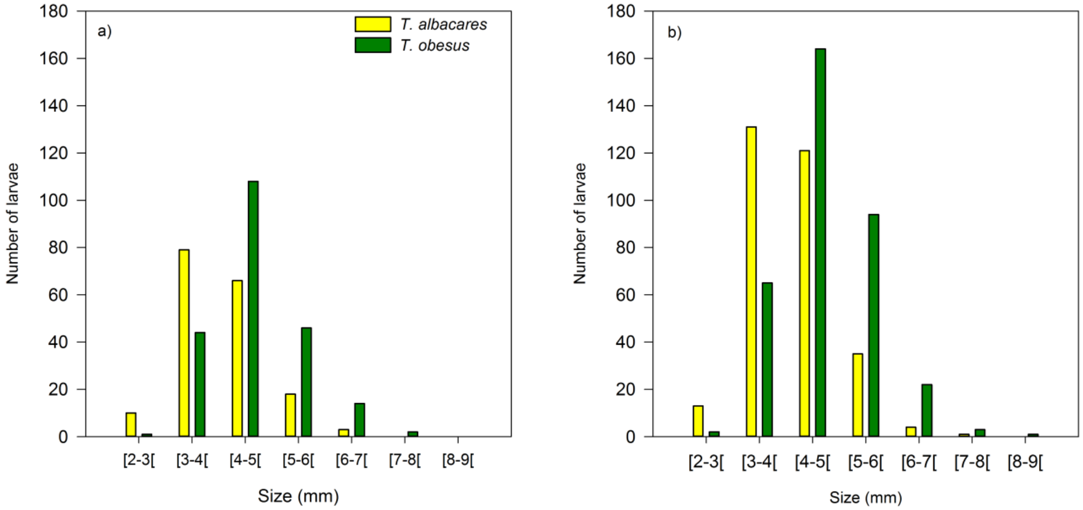

Figure 16: Size frequency of *Thunnus albacares* and *Thunnus obesus* in a) June and b) July from 2007 to 2009.

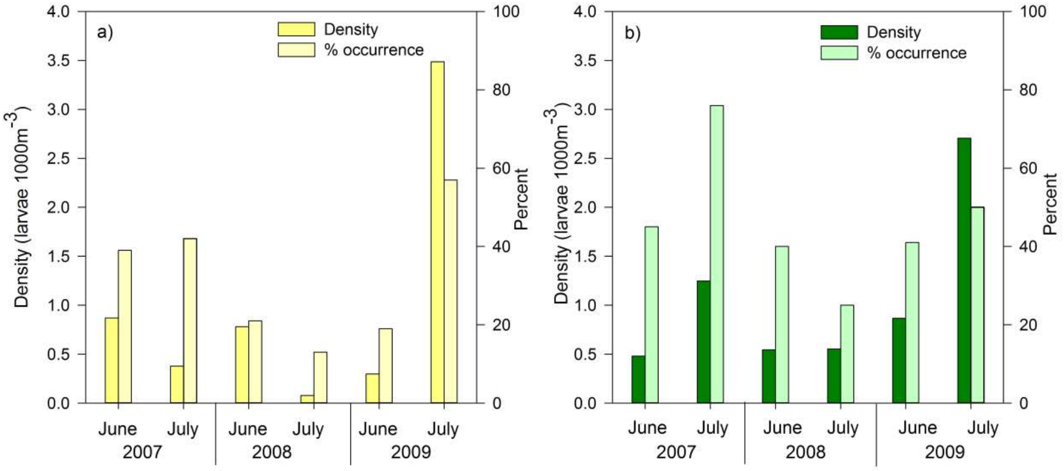

Figure 17: Densities (larvae 1000m^{-3}) and percent frequency of occurrence of a) *Thunnus albacares* and b) *Thunnus obesus* in the northern Gulf of Mexico from 2007 to 2009.

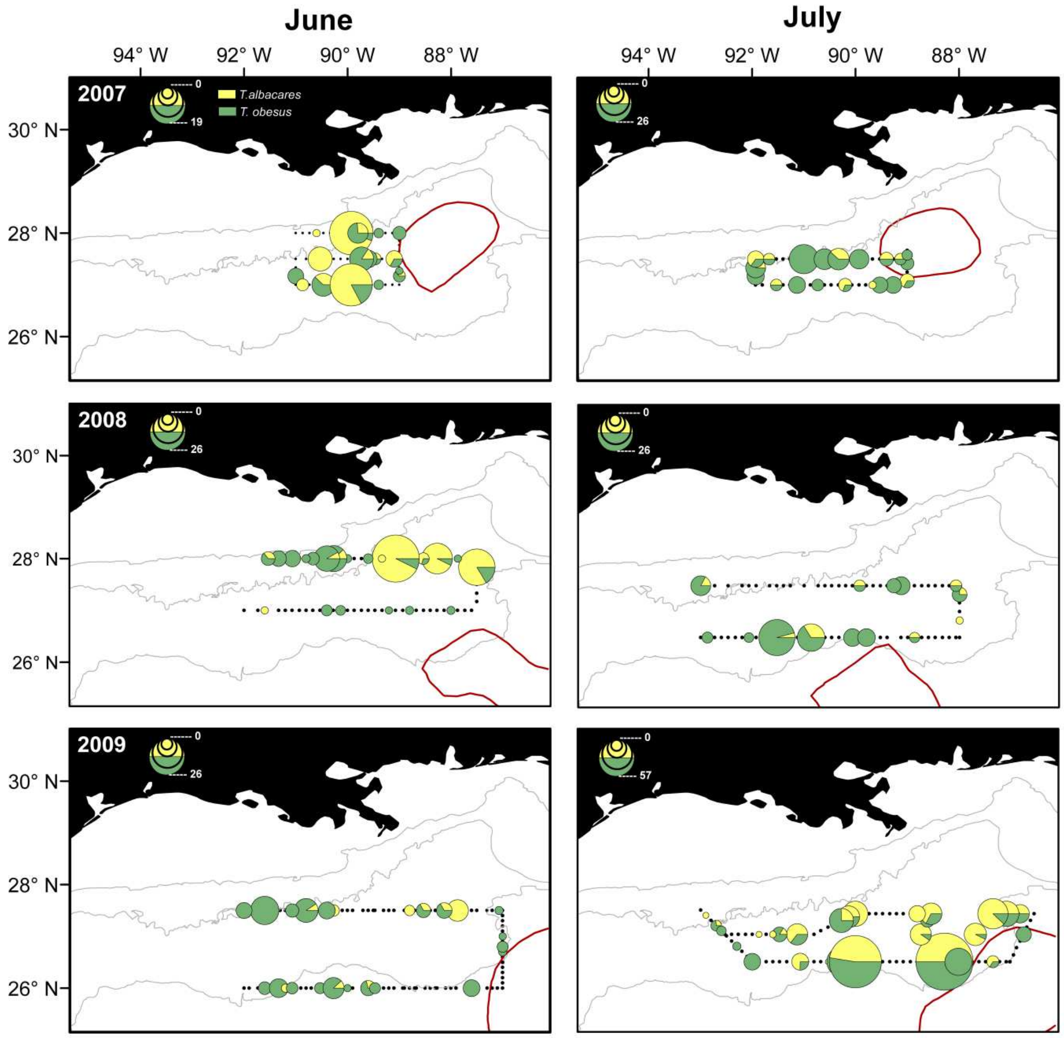

Figure 18: Proportional density (larvae $1000m^{-3}$) of *Thunnus albacares* (yellow) and *Thunnus obesus* (green) in the northern Gulf of Mexico in June (left panel) and July (right panel) from 2007 to 2009. Circles represent the total density of *T. albacares* and *T. obesus* larvae for each station. Red line represents the anticyclonic features (warm-core eddy and/or the Loop Current) and grey lines correspond to depth from the coast to the central Gulf of Mexico (100m, 1000m, 3000m).

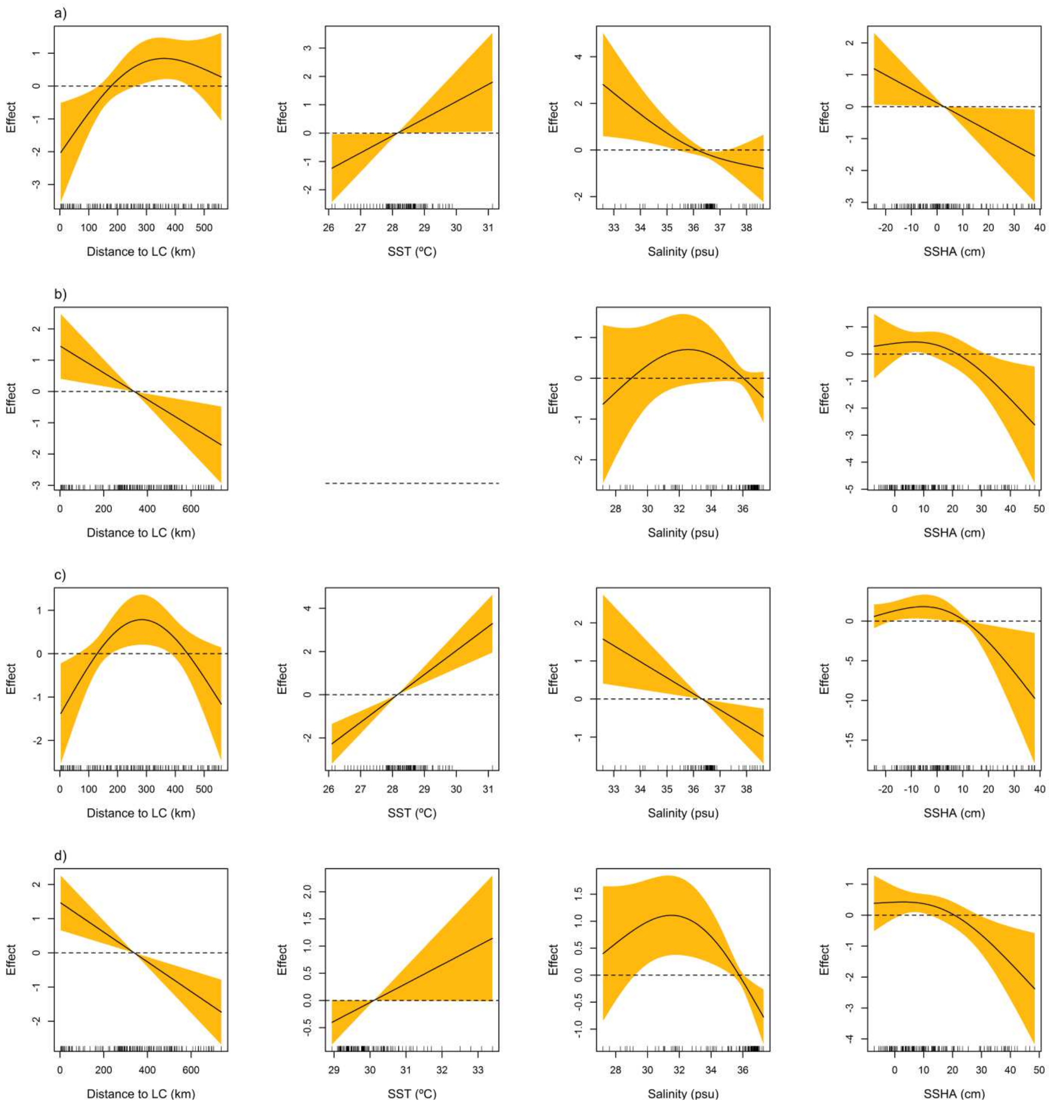

Figure 19: Response plots of generalized additive models showing the effects of environmental data on *Thunnus albacares* larvae, a) presence/absence-based GAM in June, b) presence/absence-based GAM in July, c) density-based GAM in June, d) density-based GAM in July. Variable retained were distance to the Loop Current (distance to LC), sea surface temperature (SST), sea surface height anomaly (SSHA), and salinity. Shaded areas represent 95% confidence intervals and black lines along the x-axis represent the number of observations. Dashed lines indicated that the specific variable has not been retained in the final model.

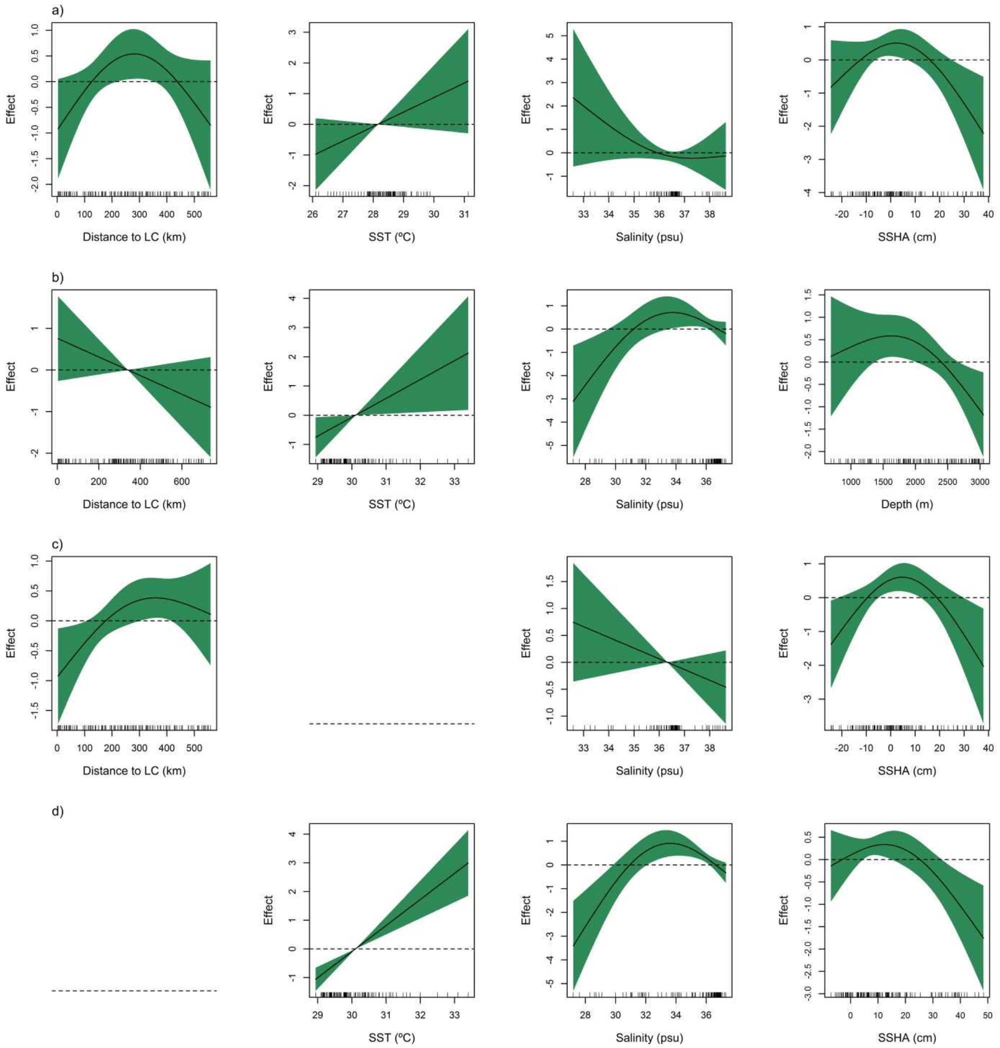

Figure 20: Response plots of generalized additive models showing the effects of environmental data on *Thunnus obesus* larvae, a) presence/absence-based GAM in June, b) presence/absence-based GAM in July, note that depth was retained in the final model, in result the last response plot represents depth and not SSHA, c) density-based GAM in June, d) density-based GAM in July. Variables retained were distance to the Loop Current (distance to LC), sea surface temperature (SST), salinity, sea surface height anomaly (SSHA). Shaded areas represent 95% confidence intervals and black lines along the x-axis represent the number of observations. Dashed lines indicated that the specific variable has not been retained in the final model.

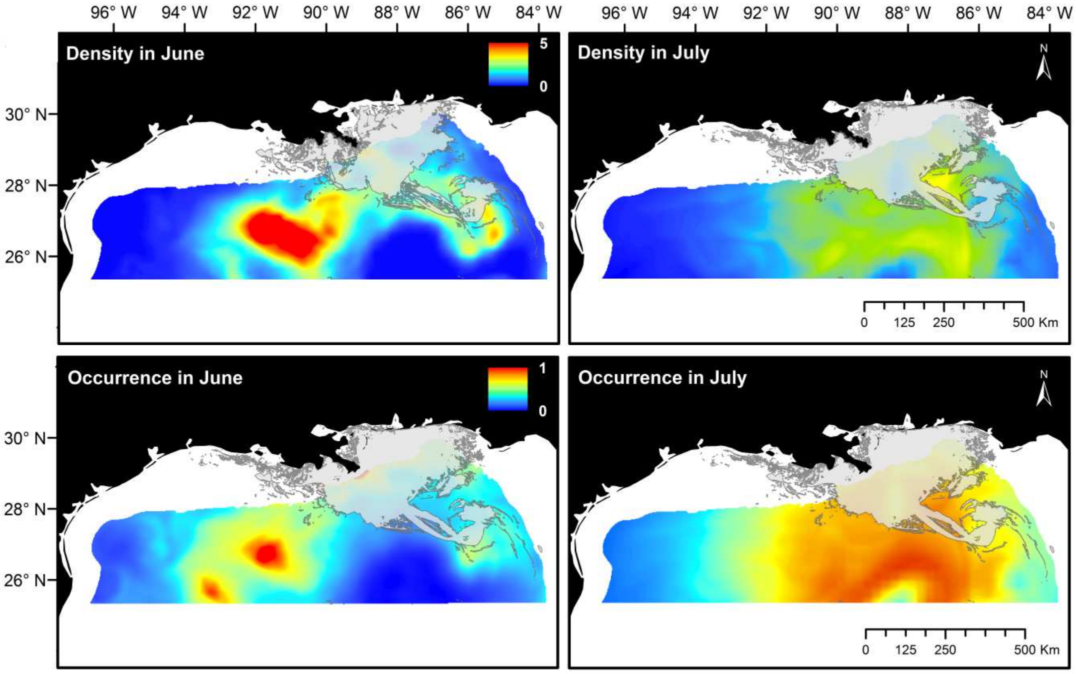

Figure 21: Densities (larvae 1000m^{-3}) and occurrence predictive maps of *Thunnus albacares* in June 2010 (left panel) and July 2010 (right panel) based on environmental data of each month and species-specific environmental preferences from GAMs (2007-2009). Gray shading represents the Deepwater Horizon oil spill.

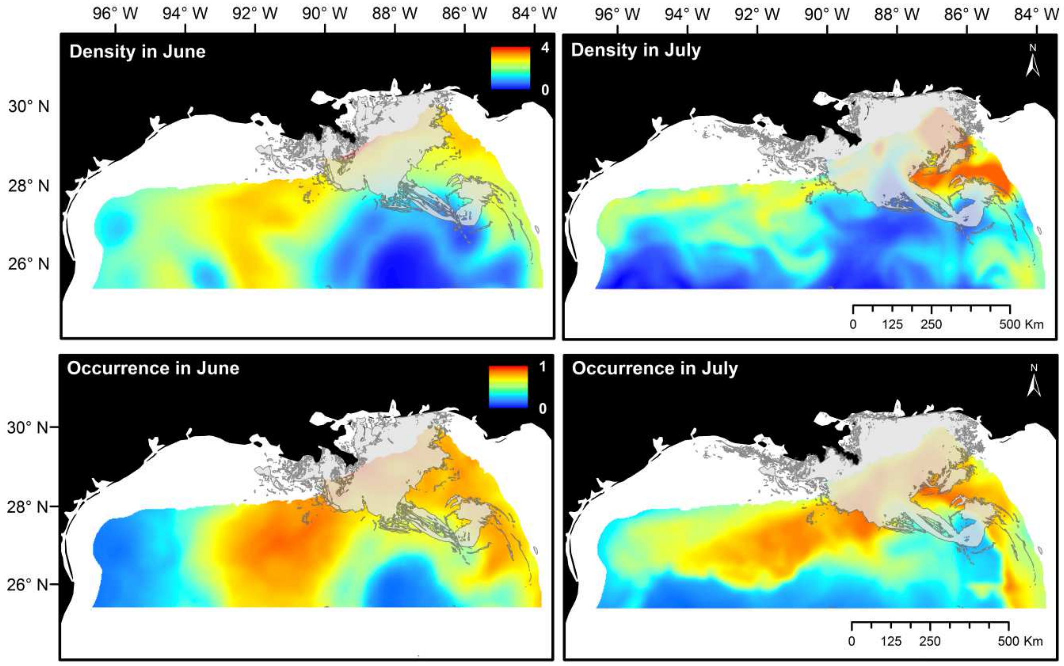

Figure 22: Densities (larvae $1000m^{-3}$) and occurrence predictive maps of *Thunnus obesus* in June 2010 (left panel) and July 2010 (right panel) based on environmental data of each month and species-specific environmental preferences from GAMs (2007-2009). Gray shading represents the Deepwater Horizon oil spill.

APPENDIX C

SUPPLEMENTAL DATA

Density = larvae 1000m^{-3}; BKT = Blackfin tuna; BET = Bigeye tuna; YFT = Yellowfin tuna; BFT = Bluefin tuna; ID = genetically identified; Th = *Thunnus*

Station	**Date**	**Lat**	**Long**	**Station identified**	**BKT density** (500μm)	**BKT density** (1200μm)	**BET density** (500μm)	**BET density** (1200μm)	**YFT density** (500μm)	**YFT density** (1200μm)	**BFT density** (500μm)	**BFT density** (1200μm)
1	6/20/2007	28.0	-91.0	No ID								
2	6/20/2007	28.0	-90.9	No ID								
3	6/20/2007	28.0	-90.7	ID	5.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
4	6/20/2007	28.0	-90.6	ID	0.7	0.0	0.0	0.0	0.0	0.6	0.0	0.0
5	6/20/2007	28.0	-90.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	6/20/2007	28.0	-90.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	6/20/2007	28.0	-90.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	6/20/2007	28.0	-90.1	No ID								
9	6/20/2007	28.0	-89.9	ID	2.2	1.7	1.1	0.0	5.6	9.3	0.0	1.7
10	6/20/2007	28.0	-89.8	No ID								
11	6/20/2007	28.0	-89.8	ID	0.0	11.4	0.0	2.6	0.0	0.9	0.0	6.1
12	6/20/2007	28.0	-89.5	No ID								
13	6/21/2007	28.0	-89.4	ID	5.5	1.2	0.9	0.0	0.0	0.0	0.0	1.2
14	6/21/2007	28.0	-89.3	No ID								
15	6/21/2007	28.0	-89.1	No ID								
16	6/21/2007	28.0	-89.0	ID	7.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
17	6/21/2007	27.9	-89.0	No ID								
18	6/21/2007	27.8	-89.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	6/21/2007	27.7	-89.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	6/21/2007	27.6	-89.0	No ID								
21	6/21/2007	27.5	-89.0	No ID								
22	6/21/2007	27.5	-89.1	ID	7.5	0.8	0.8	0.0	1.7	0.0	0.0	0.0
23	6/21/2007	27.5	-89.2	No ID								
24	6/21/2007	27.5	-89.3	No ID								
25	6/22/2007	27.5	-89.5	ID	5.8	10.2	0.0	1.0	1.1	0.0	0.0	0.0
26	6/22/2007	27.5	-89.6	ID	2.3	2.2	0.0	2.2	0.0	0.0	5.3	0.0
27	6/22/2007	27.5	-89.7	ID	35.2	8.3	1.6	1.7	0.8	0.0	0.0	0.0
28	6/22/2007	27.5	-89.9	No ID								
29	6/22/2007	27.5	-90.0	No ID								
30	6/22/2007	27.5	-90.1	ID	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	6/22/2007	27.5	-90.3	No ID								
32	6/22/2007	27.5	-90.4	No ID								
33	6/22/2007	27.5	-90.5	ID	18.9	0.0	0.0	0.0	5.7	0.0	0.9	0.0
34	6/22/2007	27.5	-90.7	No ID								
35	6/22/2007	27.5	-90.8	ID	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	6/23/2007	27.5	-91.0	No ID								
37	6/23/2007	27.3	-91.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	6/23/2007	27.2	-91.0	ID	7.5	0.0	2.5	0.0	0.0	0.0	0.0	0.0
39	6/23/2007	27.0	-91.0	No ID								
40	6/23/2007	27.0	-90.9	ID	6.7	2.2	0.0	0.0	1.5	0.0	0.0	0.0
41	6/23/2007	27.0	-90.7	No ID								
42	6/23/2007	27.0	-90.6	No ID								
43	6/23/2007	27.0	-90.5	ID	60.5	20.6	3.5	0.0	2.1	0.0	4.2	0.0
44	6/23/2007	27.0	-90.3	No ID								
45	6/23/2007	27.0	-90.2	No ID								
46	6/23/2007	27.0	-90.1	No ID								
47	6/23/2007	27.0	-89.9	ID	16.3	4.9	2.4	0.8	15.5	0.0	0.8	0.0
48	6/23/2007	27.0	-89.8	No ID								
49	6/24/2007	27.0	-89.7	No ID								
51	6/24/2007	27.0	-89.4	ID	7.5	2.4	1.7	0.0	0.0	0.0	0.0	0.0
52	6/24/2007	27.0	-89.3	No ID								
53	6/24/2007	27.0	-89.1	No ID								
54	6/24/2007	27.0	-89.0	ID	10.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0
55	6/24/2007	27.1	-89.0	No ID								
56	6/24/2007	27.2	-89.0	ID	1.6	5.0	0.0	1.0	0.8	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
57	6/24/2007	27.3	-89.0	ID	13.0	5.5	0.5	0.0	0.0	0.0	0.0	0.0
58	6/24/2007	27.3	-89.0	No ID								
59	6/24/2007	27.5	-89.0	ID	9.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0
1	7/20/2007	27.4	-89.0	ID	7.1	0.7	1.9	0.0	0.0	0.0	0.0	0.0
2	7/20/2007	27.3	-89.0	No ID								
3	7/20/2007	27.3	-89.0	No ID								
4	7/20/2007	27.2	-89.0	ID	2.5	5.8	0.0	0.0	0.0	0.0	0.0	0.0
5	7/20/2007	27.1	-89.0	ID	2.2	12.1	0.0	0.8	0.0	1.5	0.0	0.0
6	7/20/2007	27.0	-89.0	No ID								
7	7/20/2007	27.0	-89.1	No ID								
8	7/20/2007	27.0	-89.3	ID	61.2	18.7	3.2	0.0	0.0	0.0	0.0	0.0
9	7/20/2007	27.0	-89.4	No ID								
10	7/21/2007	27.0	-89.5	ID	8.3	2.3	2.3	1.5	0.0	0.0	0.0	0.0
11	7/21/2007	27.0	-89.7	ID	4.9	1.5	0.0	0.0	0.8	0.0	0.0	0.0
12	7/21/2007	27.0	-89.8	No ID								
13	7/21/2007	27.0	-89.9	No ID								
14	7/21/2007	27.0	-90.1	No ID								
15	7/21/2007	27.0	-90.2	ID	9.6	3.5	0.9	0.9	3.5	0.0	0.0	0.0
16	7/21/2007	27.0	-90.3	No ID								
17	7/21/2007	27.0	-90.5	No ID								
18	7/21/2007	27.0	-90.6	No ID								
19	7/21/2007	27.0	-90.7	ID	19.4	25.7	0.8	0.8	0.0	0.0	0.0	0.0
20	7/21/2007	27.0	-90.9	No ID								
21	7/21/2007	27.0	-91.0	No ID								
22	7/21/2007	27.0	-91.1	ID	24.2	0.0	4.2	0.0	0.0	0.0	0.0	0.0
23	7/22/2007	27.0	-91.3	No ID								
24	7/22/2007	27.0	-91.4	No ID								
25	7/22/2007	27.0	-91.5	ID	15.1	0.0	0.9	0.0	0.9	0.0	0.0	0.0
26	7/22/2007	27.0	-91.7	ID	0.8	4.2	0.0	0.0	0.0	0.0	0.0	0.0
27	7/22/2007	27.0	-91.8	No ID								
28	7/22/2007	27.0	-91.9	No ID								
29	7/22/2007	27.2	-91.9	ID	26.8	5.0	2.4	0.0	0.0	0.0	0.0	0.0
30	7/22/2007	27.3	-91.9	ID	38.5	0.0	3.8	0.0	1.9	0.0	0.0	0.0
31	7/22/2007	27.5	-91.9	ID	14.3	17.5	1.0	0.0	2.0	0.0	0.0	0.0
32	7/22/2007	27.5	-91.8	No ID								
33	7/22/2007	27.5	-91.7	ID	8.4	20.3	0.0	0.9	0.0	0.9	0.0	0.0
34	7/23/2007	27.5	-91.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	7/23/2007	27.5	-91.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	7/23/2007	27.5	-91.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	7/23/2007	27.5	-91.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	7/23/2007	27.5	-91.0	ID	49.9	7.7	6.3	1.7	0.0	0.0	0.0	0.0
39	7/23/2007	27.5	-90.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	7/23/2007	27.5	-90.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	7/23/2007	27.5	-90.6	ID	15.1	5.4	5.6	0.0	0.0	0.0	0.0	0.0
42	7/23/2007	27.5	-90.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	7/23/2007	27.5	-90.3	ID	12.5	13.4	0.8	3.1	0.0	2.4	0.0	0.0
44	7/23/2007	27.5	-90.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	7/23/2007	27.5	-90.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7/23/2007	27.5	-89.9	ID	31.8	15.8	4.0	1.2	0.0	0.0	0.0	0.0
47	7/24/2007	27.5	-89.8	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	7/24/2007	27.5	-89.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	7/24/2007	27.5	-89.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	7/24/2007	27.5	-89.4	ID	22.1	5.4	0.8	0.0	0.8	0.0	0.0	0.0
51	7/24/2007	27.5	-89.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	7/24/2007	27.5	-89.1	ID	26.3	1.7	0.9	0.0	0.9	0.0	0.0	0.0
53	7/24/2007	27.5	-89.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
54	7/24/2007	27.6	-89.0	ID	7.0	0.8	0.8	0.8	0.0	0.0	0.0	0.0
55	7/24/2007	27.7	-89.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	6/9/2008	27.0	-92.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	6/9/2008	27.0	-91.9	ID	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	6/9/2008	27.0	-91.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	6/9/2008	27.0	-91.6	ID	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
5	6/9/2008	27.0	-91.5	ID	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	6/9/2008	27.0	-91.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	6/9/2008	27.0	-91.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	6/9/2008	27.0	-91.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	6/9/2008	27.0	-90.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	6/9/2008	27.0	-90.8	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	6/9/2008	27.0	-90.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	6/9/2008	27.0	-90.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	6/9/2008	27.0	-90.4	ID	1.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0
14	6/9/2008	27.0	-90.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	6/9/2008	27.0	-90.1	ID	2.9	3.4	0.7	0.7	0.0	0.0	0.0	0.0
16	6/10/2008	27.0	-90.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	6/10/2008	27.0	-89.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	6/10/2008	27.0	-89.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	6/10/2008	27.0	-89.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	6/10/2008	27.0	-89.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	6/10/2008	27.0	-89.3	ID	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
22	6/10/2008	27.0	-89.2	ID	3.9	2.9	0.0	0.7	0.0	0.0	0.0	0.0
23	6/10/2008	27.0	-89.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	6/10/2008	27.0	-88.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	6/10/2008	27.0	-88.8	ID	1.8	16.1	0.0	0.8	0.0	0.0	0.9	0.8
26	6/10/2008	27.0	-88.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	6/10/2008	27.0	-88.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	6/10/2008	27.0	-88.4	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	6/10/2008	27.0	-88.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	6/11/2008	27.0	-87.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	6/11/2008	27.0	-87.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	6/11/2008	27.0	-87.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	6/11/2008	27.0	-87.5	ID	16.2	4.2	0.0	0.0	0.0	0.0	0.9	0.0
36	6/11/2008	27.2	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	6/11/2008	27.3	-87.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	6/11/2008	27.5	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	6/11/2008	27.7	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	6/11/2008	27.8	-87.5	ID	37.2	8.1	3.0	0.0	14.9	0.0	0.0	0.0
41	6/11/2008	28.0	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	6/11/2008	28.0	-87.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	6/11/2008	28.0	-87.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	6/11/2008	28.0	-87.9	ID	1.0	3.1	0.0	0.8	0.0	0.0	0.0	0.0
45	6/12/2008	28.0	-88.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	6/12/2008	28.0	-88.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	6/12/2008	28.0	-88.3	ID	5.9	0.0	0.8	0.0	10.1	1.5	0.0	0.0
48	6/12/2008	28.0	-88.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	6/12/2008	28.0	-88.5	ID	30.1	2.5	0.0	0.0	1.4	0.0	0.0	0.0
50	6/12/2008	28.0	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	6/12/2008	28.0	-88.8	ID	6.9	0.0	0.0	0.0	3.5	0.0	0.0	0.0
52	6/12/2008	28.0	-88.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	6/12/2008	28.0	-89.1	ID	8.2	2.5	2.5	1.6	24.7	5.8	9.9	1.6
54	6/12/2008	28.0	-89.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	6/12/2008	28.0	-89.3	ID	0.9	0.0	0.0	0.0	0.9	0.0	8.6	0.0
56	6/12/2008	28.0	-89.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
57	6/12/2008	28.0	-89.6	ID	15.2	3.2	1.0	0.0	0.0	0.0	1.9	3.2
58	6/13/2008	28.0	-89.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	6/13/2008	28.0	-89.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	6/13/2008	28.0	-90.0	ID	7.5	0.0	0.9	0.0	0.0	0.0	0.0	0.0
61	6/13/2008	28.0	-90.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	6/13/2008	28.0	-90.3	ID	45.9	11.1	7.4	0.0	0.0	0.0	0.9	0.0
63	6/13/2008	28.0	-90.4	ID	41.6	4.9	7.1	1.6	0.9	0.0	0.9	0.0
64	6/13/2008	28.0	-90.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	6/13/2008	28.0	-90.7	ID	7.1	0.0	2.0	0.0	0.0	0.0	0.0	0.0
66	6/13/2008	28.0	-90.8	ID	5.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0
67	6/13/2008	28.0	-90.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	6/13/2008	28.0	-91.1	ID	28.2	4.7	3.8	0.0	0.0	0.0	0.0	0.0
69	6/13/2008	28.0	-91.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	6/13/2008	28.0	-91.3	ID	8.3	2.8	1.0	0.0	0.0	0.0	0.0	0.9
71	6/13/2008	28.0	-91.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72	6/13/2008	28.0	-91.5	ID	11.8	9.1	0.9	0.9	0.9	0.0	1.8	0.9
1	7/27/2008	26.5	-93.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	7/27/2008	26.5	-92.9	ID	4.5	5.1	0.0	1.4	0.0	0.0	0.0	0.0
3	7/27/2008	26.5	-92.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	7/27/2008	26.5	-92.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	7/27/2008	26.5	-92.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	7/27/2008	26.5	-92.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	7/27/2008	26.5	-92.1	ID	5.8	10.8	0.7	0.8	0.0	0.0	0.0	0.0
9	7/27/2008	26.5	-91.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	7/27/2008	26.5	-91.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	7/27/2008	26.5	-91.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	7/27/2008	26.5	-91.5	ID	56.5	33.3	6.4	8.7	0.0	0.0	0.0	0.0
13	7/27/2008	26.5	-91.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	7/27/2008	26.5	-91.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	7/28/2008	26.5	-91.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	7/28/2008	26.5	-91.0	ID	3.3	1.5	0.8	0.8	0.0	0.0	0.0	0.0
17	7/28/2008	26.5	-90.9	ID	16.7	14.7	1.6	4.4	0.8	2.9	0.0	0.0
18	7/28/2008	26.5	-90.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	7/28/2008	26.5	-90.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	7/28/2008	26.5	-90.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	7/28/2008	26.5	-90.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	7/28/2008	26.5	-90.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	7/28/2008	26.5	-90.1	ID	0.7	21.6	0.0	3.9	0.0	0.0	0.0	0.0
24	7/28/2008	26.5	-89.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	7/28/2008	26.5	-89.8	ID	10.2	0.9	1.5	2.7	0.0	0.0	0.0	0.0
26	7/28/2008	26.5	-89.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	7/28/2008	26.5	-89.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	7/28/2008	26.5	-89.4	ID	0.8	6.5	0.0	0.0	0.0	0.0	0.0	0.0
29	7/28/2008	26.5	-89.3	ID	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	7/29/2008	26.5	-89.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	7/29/2008	26.5	-89.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	7/29/2008	26.5	-88.9	ID	3.0	8.1	0.8	0.0	0.8	0.0	0.0	0.0
33	7/29/2008	26.5	-88.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	7/29/2008	26.5	-88.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	7/29/2008	26.5	-88.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	7/29/2008	26.5	-88.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	7/29/2008	26.5	-88.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	7/29/2008	26.5	-88.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	7/29/2008	26.5	-88.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	7/29/2008	26.7	-88.0	ID	1.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0
41	7/29/2008	26.8	-88.0	ID	26.2	11.1	0.0	0.0	0.7	0.0	0.0	0.0

Station	**Date**	**Lat**	**Long**	**Station identified**	**BKT density (500µm)**	**BKT density (1200µm)**	**BET density (500µm)**	**BET density (1200µm)**	**YFT density (500µm)**	**YFT density (1200µm)**	**BFT density (500µm)**	**BFT density (1200µm)**
42	7/29/2008	27.0	-88.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	7/30/2008	27.2	-88.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	7/30/2008	27.3	-88.0	ID	8.3	1.3	0.0	2.0	0.0	0.7	0.0	0.0
45	7/30/2008	27.5	-88.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7/30/2008	27.5	-88.1	ID	17.2	17.8	0.0	1.0	0.0	1.0	0.0	0.0
47	7/30/2008	27.5	-88.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	7/30/2008	27.5	-88.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	7/30/2008	27.5	-88.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	7/30/2008	27.5	-88.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	7/30/2008	27.5	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	7/30/2008	27.5	-88.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	7/30/2008	27.5	-89.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	7/30/2008	27.5	-89.1	ID	11.4	14.1	3.3	0.0	0.0	0.0	0.0	0.0
55	7/30/2008	27.5	-89.3	ID	13.3	9.5	3.1	0.0	0.0	0.0	0.0	0.0
56	7/30/2008	27.5	-89.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	7/31/2008	27.5	-89.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	7/31/2008	27.5	-89.7	ID	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0
59	7/31/2008	27.5	-89.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	7/31/2008	27.5	-89.9	ID	8.7	1.6	0.9	0.0	0.9	0.0	0.0	0.0
61	7/31/2008	27.5	-90.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	7/31/2008	27.5	-90.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	7/31/2008	27.5	-90.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	7/31/2008	27.5	-90.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	7/31/2008	27.5	-90.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	7/31/2008	27.5	-90.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	7/31/2008	27.5	-90.9	ID	5.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0
68	7/31/2008	27.5	-91.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
69	7/31/2008	27.5	-91.1	ID	3.5	2.7	0.0	0.0	0.0	0.0	0.0	0.0
70	7/31/2008	27.5	-91.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	8/1/2008	27.5	-91.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72	8/1/2008	27.5	-91.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	8/1/2008	27.5	-91.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	8/1/2008	27.5	-91.8	ID	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	8/1/2008	27.5	-91.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	8/1/2008	27.5	-92.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	8/1/2008	27.5	-92.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78	8/1/2008	27.5	-92.3	ID	1.3	1.4	0.0	0.0	0.0	0.0	0.0	0.0
79	8/1/2008	27.5	-92.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	8/1/2008	27.5	-92.6	ID	6.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
81	8/1/2008	27.5	-92.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82	8/1/2008	27.5	-92.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	8/1/2008	27.5	-93.0	ID	36.9	22.6	3.5	0.8	0.9	0.0	0.0	0.0
1	6/3/2009	26.0	-92.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	6/3/2009	26.0	-91.9	ID	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	6/3/2009	26.0	-91.7	ID	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0
4	6/3/2009	26.0	-91.6	ID	14.6	3.3	0.0	1.6	0.0	0.0	0.0	0.0
5	6/3/2009	26.0	-91.5	No iD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	6/3/2009	26.0	-91.3	ID	23.2	11.1	3.4	2.0	0.0	0.0	0.0	0.0
7	6/3/2009	26.0	-91.2	ID	96.4	0.9	6.0	0.0	6.0	0.0	0.0	0.0
8	6/3/2009	26.0	-91.1	ID	76.7	4.2	2.6	1.0	0.0	0.0	0.0	1.0
9	6/3/2009	26.0	-90.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	6/3/2009	26.0	-90.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	6/4/2009	26.0	-90.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	6/4/2009	26.0	-90.5	ID	7.0	2.3	1.7	0.0	0.0	0.0	0.9	0.0
13	6/4/2009	26.0	-90.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	6/4/2009	26.0	-90.3	ID	38.8	16.3	3.4	2.3	0.0	0.8	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
15	6/4/2009	26.0	-90.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	6/4/2009	26.0	-90.0	ID	3.3	0.8	0.0	0.8	0.0	0.0	0.0	0.0
17	6/4/2009	26.0	-89.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	6/4/2009	26.0	-89.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	6/4/2009	26.0	-89.6	ID	26.7	0.0	3.9	0.0	1.6	0.0	0.0	0.0
20	6/4/2009	26.0	-89.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	6/4/2009	26.0	-89.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	6/4/2009	26.0	-89.2	ID	1.5	1.6	0.8	0.0	0.0	0.0	2.3	3.1
23	6/4/2009	26.0	-89.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	6/4/2009	26.0	-88.9	ID	0.0	0.9	0.0	0.0	0.0	0.0	4.7	6.0
25	6/4/2009	26.0	-88.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	6/5/2009	26.0	-88.7	ID	0.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0
27	6/5/2009	26.0	-88.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	6/5/2009	26.0	-88.4	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	6/5/2009	26.0	-88.3	ID	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
30	6/5/2009	26.0	-88.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	6/5/2009	26.0	-88.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	6/5/2009	26.0	-87.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	6/5/2009	26.0	-87.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	6/5/2009	26.0	-87.6	ID	13.0	4.7	2.4	1.6	0.0	0.0	0.0	0.0
35	6/5/2009	26.0	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	6/5/2009	26.0	-87.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37	6/5/2009	26.0	-87.2	ID	4.3	4.7	0.0	0.0	0.0	0.0	0.0	0.0
38	6/5/2009	26.0	-87.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	6/5/2009	26.0	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	6/5/2009	26.1	-87.0	ID	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
41	6/6/2009	26.2	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	6/6/2009	26.3	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	6/6/2009	26.4	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	6/6/2009	26.5	-87.0	ID	2.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0
45	6/6/2009	26.6	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	6/6/2009	26.7	-87.0	ID	19.1	7.9	0.9	0.0	0.0	0.0	0.0	0.0
47	6/6/2009	26.8	-87.0	ID	4.5	0.0	0.9	0.0	0.0	0.0	0.0	0.0
48	6/6/2009	26.9	-87.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	6/6/2009	27.0	-87.0	ID	13.6	4.0	0.9	0.0	0.0	0.0	0.0	0.0
50	6/6/2009	27.1	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	6/6/2009	27.2	-87.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	6/6/2009	27.3	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	6/6/2009	27.4	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54	6/6/2009	27.5	-87.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	6/6/2009	27.5	-87.1	ID	5.9	8.2	0.8	0.0	0.0	0.0	0.0	0.0
56	6/6/2009	27.5	-87.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	6/6/2009	27.5	-87.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	6/7/2009	27.5	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
59	6/7/2009	27.5	-87.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	6/7/2009	27.5	-87.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
61	6/7/2009	27.5	-87.9	ID	2.5	0.9	0.0	0.0	5.0	0.0	0.8	0.0
62	6/7/2009	27.5	-88.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	6/7/2009	27.5	-88.1	ID	3.8	1.6	1.9	0.0	1.0	0.0	0.0	0.0
65	6/7/2009	27.5	-88.4	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	6/7/2009	27.5	-88.5	ID	5.1	3.4	1.7	0.0	0.8	0.0	2.5	0.0
67	6/7/2009	27.5	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
68	6/7/2009	27.5	-88.8	ID	0.0	0.8	0.0	0.0	0.0	0.8	0.0	0.0
69	6/7/2009	27.5	-88.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70	6/7/2009	27.5	-89.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
71	6/7/2009	27.5	-89.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
72	6/8/2009	27.5	-89.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
73	6/8/2009	27.5	-89.5	ID	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0
74	6/8/2009	27.5	-89.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	6/8/2009	27.5	-89.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	6/8/2009	27.5	-89.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	6/8/2009	27.5	-90.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
78	6/8/2009	27.5	-90.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
79	6/8/2009	27.5	-90.3	ID	7.4	0.0	0.0	0.0	0.8	0.8	0.0	0.0
80	6/8/2009	27.5	-90.4	ID	14.8	16.8	0.8	2.3	0.0	0.0	0.0	0.8
81	6/8/2009	27.5	-90.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82	6/8/2009	27.5	-90.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	6/8/2009	27.5	-90.8	ID	36.7	28.5	3.7	4.1	0.9	0.0	0.0	0.0
84	6/8/2009	27.5	-90.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85	6/8/2009	27.5	-91.1	ID	4.6	13.3	2.8	0.0	0.0	0.0	1.8	0.0
86	6/8/2009	27.5	-91.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87	6/9/2009	27.5	-91.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	6/9/2009	27.5	-91.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	6/9/2009	27.5	-91.6	ID	65.4	7.6	8.1	2.5	0.0	0.0	0.0	0.0
90	6/9/2009	27.5	-91.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
91	6/9/2009	27.5	-91.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
92	6/9/2009	27.5	-92.0	ID	7.4	5.0	2.5	0.8	0.0	0.0	0.0	0.0
1	7/22/2009	27.5	-93.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	7/22/2009	27.4	-92.9	ID	10.4	0.9	0.0	0.0	0.9	0.0	0.0	0.0
3	7/22/2009	27.3	-92.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	7/22/2009	27.2	-92.7	ID	22.7	3.9	2.8	0.0	0.9	0.0	0.0	0.0
5	7/22/2009	27.1	-92.6	ID	23.7	4.9	2.8	0.0	0.0	0.0	0.0	0.0
6	7/22/2009	27.0	-92.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	7/22/2009	26.9	-92.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	7/22/2009	26.8	-92.3	ID	8.8	0.0	1.8	0.0	0.0	0.0	0.0	0.0
9	7/22/2009	26.7	-92.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	7/22/2009	26.6	-92.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	7/22/2009	26.5	-92.0	ID	90.8	8.3	4.1	0.0	0.0	0.0	0.0	0.0
12	7/22/2009	26.5	-91.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	7/22/2009	26.5	-91.7	ID	5.1	3.9	0.0	0.0	0.0	0.0	0.0	0.0
14	7/23/2009	26.5	-91.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	7/23/2009	26.5	-91.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	7/23/2009	26.5	-91.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	7/23/2009	26.5	-91.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	7/23/2009	26.5	-91.1	ID	45.3	0.0	2.0	0.0	6.0	0.0	0.0	0.0
19	7/23/2009	26.5	-90.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	7/23/2009	26.5	-90.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	7/23/2009	26.5	-90.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	7/23/2009	26.5	-90.5	ID	10.9	0.0	0.0	0.0	1.1	0.0	0.0	0.0
23	7/23/2009	26.5	-90.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	7/23/2009	26.5	-90.3	ID	52.4	8.3	8.7	1.8	2.2	0.9	0.0	0.0
25	7/23/2009	26.5	-90.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	7/23/2009	26.5	-90.0	ID	89.5	0.0	12.3	0.0	11.2	0.0	0.0	0.0
27	7/23/2009	26.5	-89.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	7/24/2009	26.5	-89.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	7/24/2009	26.5	-89.6	ID	9.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0
30	7/24/2009	26.5	-89.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	7/24/2009	26.5	-89.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	7/24/2009	26.5	-89.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	7/24/2009	26.5	-89.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	7/24/2009	26.5	-88.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	7/24/2009	26.5	-88.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500μm)	BKT density (1200μm)	BET density (500μm)	BET density (1200μm)	YFT density (500μm)	YFT density (1200μm)	BFT density (500μm)	BFT density (1200μm)
36	7/24/2009	26.5	-88.7	ID	4.7	0.0	1.2	0.0	5.9	0.0	0.0	0.0
37	7/24/2009	26.5	-88.5	ID	6.0	0.9	0.0	0.0	23.9	0.0	0.0	0.0
38	7/24/2009	26.5	-88.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	7/24/2009	26.5	-88.3	ID	69.8	22.6	3.4	2.6	6.8	0.0	0.0	0.0
40	7/24/2009	26.5	-88.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	7/24/2009	26.5	-88.0	ID	72.4	8.4	7.4	0.0	0.0	0.0	0.0	0.0
42	7/24/2009	26.5	-87.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	7/25/2009	26.5	-87.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	7/25/2009	26.5	-87.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	7/25/2009	26.5	-87.5	ID	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	7/25/2009	26.5	-87.3	ID	0.0	2.4	0.0	0.8	0.0	1.6	0.0	0.0
47	7/25/2009	26.5	-87.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	7/25/2009	26.5	-87.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	7/25/2009	26.5	-87.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	7/25/2009	26.6	-86.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	7/25/2009	26.8	-86.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	7/25/2009	26.9	-86.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	7/25/2009	27.0	-86.7	ID	32.5	10.1	3.4	0.8	0.0	0.0	0.0	0.0
54	7/25/2009	27.2	-86.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	7/25/2009	27.3	-86.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
56	7/25/2009	27.4	-86.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	7/26/2009	27.4	-86.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	7/26/2009	27.4	-86.8	ID	87.3	0.0	7.1	0.0	4.1	0.0	0.0	0.0
59	7/26/2009	27.4	-86.9	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	7/26/2009	27.4	-87.1	ID	100.0	0.0	10.2	0.0	6.8	0.0	0.0	0.0
61	7/26/2009	27.4	-87.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
62	7/26/2009	27.4	-87.3	ID	55.8	1.0	3.5	0.0	25.6	0.0	0.0	0.0
63	7/26/2009	27.4	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
64	7/26/2009	27.3	-87.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65	7/26/2009	27.2	-87.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
66	7/26/2009	27.0	-87.7	ID	42.6	4.4	1.1	0.0	14.6	0.0	0.0	0.0
67	7/26/2009	26.9	-87.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
74	7/27/2009	26.9	-88.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75	7/27/2009	27.0	-88.7	ID	5.3	0.0	1.1	0.0	9.5	0.0	0.0	0.0
76	7/27/2009	27.2	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	7/27/2009	27.3	-88.6	ID	0.0	0.0	1.1	0.0	1.1	0.0	0.0	0.0
78	7/27/2009	27.4	-88.5	ID	63.6	0.0	5.1	0.0	10.3	0.0	0.0	0.0
79	7/27/2009	27.4	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	7/27/2009	27.4	-88.8	ID	37.4	0.0	0.0	0.0	7.7	0.0	0.0	0.0
81	7/27/2009	27.4	-88.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
82	7/27/2009	27.4	-89.1	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	7/27/2009	27.4	-89.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
84	7/27/2009	27.4	-89.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85	7/27/2009	27.4	-89.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86	7/27/2009	27.4	-89.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87	7/27/2009	27.4	-89.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88	7/28/2009	27.4	-89.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
89	7/28/2009	27.4	-90.0	ID	0.0	2.0	0.0	0.0	4.6	5.0	0.0	0.0
90	7/28/2009	27.4	-90.1	ID	53.0	0.0	3.2	0.0	12.7	0.0	0.0	0.0
91	7/28/2009	27.3	-90.3	ID	19.3	3.2	0.0	6.5	2.3	0.0	0.0	0.0
92	7/28/2009	27.2	-90.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
93	7/28/2009	27.2	-90.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
94	7/28/2009	27.1	-90.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95	7/28/2009	27.0	-90.8	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96	7/28/2009	27.0	-91.1	ID	51.4	9.2	5.1	0.0	9.3	0.0	0.0	0.0
97	7/28/2009	27.0	-91.2	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
98	7/28/2009	27.0	-91.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99	7/28/2009	27.0	-91.5	ID	31.2	15.6	5.6	0.0	1.1	1.0	0.0	0.0
100	7/28/2009	27.0	-91.6	ID	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101	7/29/2009	27.0	-91.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
102	7/29/2009	27.0	-91.9	ID	6.4	1.0	0.0	0.0	1.1	0.0	0.0	0.0
103	7/29/2009	27.0	-92.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
104	7/29/2009	27.0	-92.1	ID	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105	7/29/2009	27.0	-92.3	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106	7/29/2009	27.0	-92.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
107	7/29/2009	27.0	-92.5	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	6/15/2010	28.0	-91.0	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	6/15/2010	28.0	-90.9	ID	3.0	0.0	0.6	0.0	0.6	0.0	0.0	0.0
3	6/15/2010	28.0	-90.7	ID	6.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0
4	6/15/2010	28.0	-90.6	ID	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	6/15/2010	28.0	-90.5	ID	0.8	0.0	0.0	0.0	0.8	0.0	0.0	0.0
6	6/15/2010	28.0	-90.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	6/15/2010	28.0	-90.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	6/15/2010	28.0	-90.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	6/15/2010	28.0	-89.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	6/15/2010	28.0	-89.8	ID	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	6/15/2010	28.0	-89.7	ID	0.8	0.5	0.3	0.0	2.0	0.0	0.0	0.0
12	6/16/2010	28.0	-89.5	ID	3.9	2.1	0.8	0.0	5.5	4.2	0.0	0.0
13	6/16/2010	28.0	-89.4	ID	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	6/16/2010	28.0	-89.3	ID	1.7	0.0	0.0	0.0	6.9	0.0	0.0	0.0
15	6/16/2010	28.0	-89.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	6/16/2010	28.0	-89.0	ID	2.4	0.0	0.0	0.0	0.8	0.0	0.0	0.0
17	6/16/2010	28.0	-88.9	ID	5.6	0.0	1.4	0.0	21.6	0.0	0.0	0.0
18	6/16/2010	28.0	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	6/16/2010	28.0	-88.6	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	6/16/2010	28.0	-88.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	6/16/2010	28.0	-88.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	6/16/2010	28.0	-88.2	ID	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	6/16/2010	28.0	-88.1	ID	39.4	3.2	2.8	0.0	54.5	0.0	0.0	0.0
24	6/16/2010	28.0	-88.0	ID	68.9	6.3	4.2	0.0	24.4	0.0	0.8	0.0
25	6/17/2010	27.0	-88.0	ID	11.6	0.0	2.0	0.0	2.0	0.0	0.0	0.0
26	6/17/2010	27.0	-88.1	ID	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	6/17/2010	27.0	-88.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	6/17/2010	27.0	-88.3	ID	17.5	3.6	2.6	0.0	0.0	0.0	0.0	0.0
29	6/17/2010	27.0	-88.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	6/17/2010	27.0	-88.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	6/17/2010	27.0	-88.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	6/17/2010	27.0	-88.9	ID	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	6/17/2010	27.0	-89.0	ID	14.2	1.8	0.6	0.0	0.0	0.0	0.0	0.0
34	6/17/2010	27.0	-89.1	ID	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	6/17/2010	27.0	-89.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	6/17/2010	27.0	-89.4	ID	4.2	1.7	0.0	0.0	0.2	0.0	0.0	0.0
37	6/18/2010	27.0	-89.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	6/18/2010	27.0	-89.7	ID	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	6/18/2010	27.0	-89.8	ID	3.8	0.0	1.1	0.0	0.5	0.0	0.0	0.0
40	6/18/2010	27.0	-89.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	6/18/2010	27.0	-90.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	6/18/2010	27.0	-90.2	ID	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
43	6/18/2010	27.0	-90.3	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	6/18/2010	27.0	-90.5	ID	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	6/18/2010	27.0	-90.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	6/18/2010	27.0	-90.7	ID	4.9	0.0	0.6	0.0	0.6	0.0	0.0	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
47	6/18/2010	27.0	-90.9	ID	0.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0
48	6/18/2010	27.0	-91.0	ID	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0
1	7/27/2010	28.0	-91.0	ID	7.0	0.0	0.6	0.0	0.6	0.0	0.0	0.0
2	7/27/2010	28.0	-90.9	ID	2.9	0.7	0.7	0.0	1.4	0.0	0.0	0.0
3	7/27/2010	28.0	-90.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	7/27/2010	28.0	-90.6	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	7/27/2010	28.0	-90.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	7/27/2010	28.0	-90.3	ID	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	7/27/2010	28.0	-90.2	ID	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	7/27/2010	28.0	-90.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	7/27/2010	28.0	-89.9	ID	30.6	0.0	1.6	0.0	3.1	0.0	0.0	0.0
10	7/27/2010	28.0	-89.8	ID	13.9	0.0	0.0	0.0	3.3	0.0	0.0	0.0
11	7/27/2010	28.0	-89.7	ID	5.4	1.2	0.7	0.6	0.7	0.0	0.0	0.0
12	7/27/2010	28.0	-89.5	ID	14.5	3.5	0.0	0.0	0.8	0.0	0.0	0.0
13	7/28/2010	28.0	-89.4	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	7/28/2010	28.0	-89.3	ID	45.6	4.2	7.9	0.0	0.0	0.0	0.0	0.0
15	7/28/2010	28.0	-89.1	ID	12.4	0.0	1.3	1.2	0.0	0.0	0.0	0.0
16	7/28/2010	28.0	-89.0	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	7/28/2010	28.0	-88.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	7/28/2010	28.0	-88.7	No ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	7/28/2010	28.0	-88.6	ID	7.0	0.0	0.6	0.0	1.3	0.0	0.0	0.0
20	7/28/2010	28.0	-88.5	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	7/28/2010	28.0	-88.3	ID	6.3	1.8	0.0	1.2	0.6	0.0	0.0	0.0
22	7/28/2010	28.0	-88.2	ID	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	7/28/2010	28.0	-88.1	ID	53.8	0.0	4.0	0.0	3.4	0.0	0.0	0.0
24	7/28/2010	28.0	-88.0	ID	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	7/29/2010	27.0	-88.0	ID	0.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0
26	7/29/2010	27.0	-88.1	ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	7/29/2010	27.0	-88.2	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	7/29/2010	27.0	-88.3	ID	0.6	0.0	0.0	0.0	0.6	0.0	0.0	0.0
29	7/29/2010	27.0	-88.5	ID	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	7/29/2010	27.0	-88.6	ID	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	7/29/2010	27.0	-88.7	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32	7/29/2010	27.0	-88.9	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33	7/29/2010	27.0	-89.0	ID	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	7/29/2010	27.0	-89.1	ID	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0
35	7/29/2010	27.0	-89.3	ID	28.2	2.3	1.3	0.6	0.7	0.0	0.0	0.0
36	7/29/2010	27.0	-89.4	ID	6.7	0.6	0.0	0.0	0.0	0.0	0.0	0.0
37	7/29/2010	27.0	-89.5	ID	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38	7/30/2010	27.0	-89.7	ID	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	7/30/2010	27.0	-89.8	ID	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	7/30/2010	27.0	-89.9	ID	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	7/30/2010	27.0	-90.1	No Th	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	7/30/2010	27.0	-90.2	ID	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	7/30/2010	27.0	-90.3	ID	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	7/30/2010	27.0	-90.5	ID	5.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0
45	7/30/2010	27.0	-90.6	ID	0.7	0.0	0.0	0.0	0.7	0.0	0.0	0.0
46	7/30/2010	27.0	-90.7	ID	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
47	7/30/2010	27.0	-90.9	ID	7.3	9.9	0.0	0.6	0.0	0.6	0.0	0.0
48	7/30/2010	27.0	-91.0	ID	4.3	2.4	0.6	0.0	1.2	0.6	0.0	0.0
1	6/14/2011	27.0	-91.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
2	6/14/2011	27.0	-90.9	ID	Na	0.6	Na	0.0	Na	0.0	Na	0.0
3	6/14/2011	27.0	-90.7	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
4	6/14/2011	27.0	-90.6	ID	Na	1.3	Na	0.0	Na	0.0	Na	0.0
5	6/14/2011	27.0	-90.5	ID	Na	12.8	Na	1.2	Na	0.0	Na	0.0
6	6/14/2011	27.0	-90.3	ID	Na	9.0	Na	3.0	Na	0.7	Na	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
7	6/14/2011	27.0	-90.2	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
8	6/15/2011	27.0	-90.1	ID	Na	0.9	Na	0.9	Na	0.0	Na	0.0
9	6/15/2011	27.0	-89.9	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
10	6/15/2011	27.0	-89.8	ID	Na	0.9	Na	0.0	Na	0.0	Na	0.0
11	6/15/2011	27.0	-89.7	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
12	6/15/2011	27.0	-89.5	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
13	6/15/2011	27.0	-89.4	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
14	6/15/2011	27.0	-89.3	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
15	6/15/2011	27.0	-89.1	ID	Na	4.3	Na	0.0	Na	0.0	Na	0.0
16	6/15/2011	27.0	-89.0	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
17	6/15/2011	27.0	-88.9	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
18	6/15/2011	27.0	-88.7	ID	Na	78.0	Na	5.6	Na	5.6	Na	0.0
19	6/15/2011	27.0	-88.6	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
20	6/15/2011	27.0	-88.5	ID	Na	16.2	Na	3.4	Na	0.0	Na	0.0
21	6/15/2011	27.0	-88.3	ID	Na	30.9	Na	8.4	Na	0.0	Na	0.0
22	6/16/2011	27.0	-88.2	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
23	6/16/2011	27.0	-88.1	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
24	6/16/2011	27.0	-88.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
25	6/16/2011	28.0	-88.0	ID	Na	11.3	Na	0.8	Na	0.8	Na	0.0
26	6/16/2011	28.0	-88.1	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
27	6/16/2011	28.0	-88.2	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
28	6/16/2011	28.0	-88.3	ID	Na	3.7	Na	0.0	Na	0.0	Na	0.0
29	6/16/2011	28.0	-88.5	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
30	6/16/2011	28.0	-88.6	ID	Na	9.7	Na	0.0	Na	6.2	Na	0.7
31	6/17/2011	28.0	-88.7	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
32	6/17/2011	28.0	-88.9	ID	Na	5.8	Na	0.6	Na	0.6	Na	0.0
33	6/17/2011	28.0	-89.0	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
34	6/17/2011	28.0	-89.1	ID	Na	0.7	Na	0.0	Na	0.7	Na	0.0
35	6/17/2011	28.0	-89.3	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
36	6/17/2011	28.0	-89.4	ID	Na	0.7	Na	0.0	Na	0.7	Na	0.0
37	6/17/2011	28.0	-89.5	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
38	6/17/2011	28.0	-89.7	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
39	6/17/2011	28.0	-89.8	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
40	6/17/2011	28.0	-89.9	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
41	6/17/2011	28.0	-90.1	ID	Na	32.0	Na	0.9	Na	0.0	Na	0.0
42	6/17/2011	28.0	-90.2	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
43	6/18/2011	28.0	-90.3	ID	Na	8.2	Na	0.0	Na	0.0	Na	0.0
44	6/18/2011	28.0	-90.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
45	6/18/2011	28.0	-90.6	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
46	6/18/2011	28.0	-90.7	ID	Na	10.0	Na	1.1	Na	0.0	Na	0.0
47	6/18/2011	28.0	-90.9	ID	Na	26.3	Na	0.8	Na	0.0	Na	0.0
48	6/18/2011	28.0	-91.0	No ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
1	7/17/2011	27.0	-91.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
2	7/17/2011	27.0	-90.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
3	7/17/2011	27.0	-90.7	ID	Na	1.6	Na	0.0	Na	0.0	Na	0.0
4	7/17/2011	27.0	-90.6	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
5	7/17/2011	27.0	-90.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
6	7/17/2011	27.0	-90.3	ID	Na	7.6	Na	0.5	Na	0.0	Na	0.0
7	7/17/2011	27.0	-90.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
8	7/17/2011	27.0	-90.1	ID	Na	5.9	Na	0.5	Na	0.0	Na	0.0
9	7/17/2011	27.0	-89.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
10	7/17/2011	27.0	-89.8	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
11	7/17/2011	27.0	-89.7	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
12	7/17/2011	27.0	-89.5	ID	Na	0.5	Na	0.0	Na	0.0	Na	0.0
13	7/18/2011	27.0	-89.4	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
14	7/18/2011	27.0	-89.3	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
15	7/18/2011	27.0	-89.1	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
16	7/18/2011	27.0	-89.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
17	7/18/2011	27.0	-88.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
18	7/18/2011	27.0	-88.7	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
19	7/18/2011	27.0	-88.6	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
20	7/18/2011	27.0	-88.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
21	7/18/2011	27.0	-88.3	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
22	7/18/2011	27.0	-88.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
23	7/18/2011	27.0	-88.1	ID	Na	8.5	Na	0.9	Na	0.9	Na	0.0
24	7/18/2011	27.0	-88.0	ID	Na	26.7	Na	0.9	Na	0.0	Na	0.0
25	7/19/2011	28.0	-88.0	ID	Na	1.7	Na	0.0	Na	0.0	Na	0.0
26	7/19/2011	28.0	-88.1	ID	Na	2.7	Na	0.0	Na	0.0	Na	0.0
27	7/19/2011	28.0	-88.2	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
28	7/19/2011	28.0	-88.3	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
29	7/19/2011	28.0	-88.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
30	7/19/2011	28.0	-88.6	ID	Na	1.2	Na	0.0	Na	0.0	Na	0.0
31	7/19/2011	28.0	-88.7	ID	Na	8.1	Na	0.0	Na	0.0	Na	0.0
32	7/19/2011	28.0	-88.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
33	7/19/2011	28.0	-89.0	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
34	7/19/2011	28.0	-89.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
35	7/19/2011	28.0	-89.3	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
36	7/20/2011	28.0	-89.4	ID	Na	0.7	Na	0.0	Na	0.0	Na	0.0
37	7/20/2011	28.0	-89.5	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
38	7/20/2011	28.0	-89.7	ID	Na	0.7	Na	0.0	Na	0.0	Na	0.0
39	7/20/2011	28.0	-89.8	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
40	7/20/2011	28.0	-89.9	ID	Na	0.8	Na	0.0	Na	0.0	Na	0.0
41	7/20/2011	28.0	-90.1	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
42	7/20/2011	28.0	-90.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
43	7/20/2011	28.0	-90.3	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
44	7/20/2011	28.0	-90.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
45	7/20/2011	28.0	-90.6	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
46	7/20/2011	28.0	-90.7	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
47	7/20/2011	28.0	-90.9	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
48	7/20/2011	28.0	-91.0	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
1	6/6/2015	27.0	-91.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
2	6/6/2015	27.0	-90.9	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
3	6/6/2015	27.0	-90.7	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
4	6/6/2015	27.0	-90.6	ID	Na	2.1	Na	0.0	Na	0.0	Na	0.0
5	6/6/2015	27.0	-90.4	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
6	6/6/2015	27.0	-90.3	ID	Na	2.1	Na	0.0	Na	0.0	Na	1.0
7	6/6/2015	27.0	-90.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
8	6/6/2015	27.0	-90.1	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
9	6/6/2015	27.0	-89.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
10	6/6/2015	27.0	-89.8	ID	Na	0.8	Na	0.0	Na	0.0	Na	0.0
11	6/6/2015	27.0	-89.7	ID	Na	3.2	Na	0.0	Na	0.0	Na	0.0
12	6/6/2015	27.0	-89.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
13	6/7/2015	27.0	-89.4	ID	Na	0.9	Na	0.0	Na	0.9	Na	1.9
14	6/7/2015	27.0	-89.3	ID	Na	3.0	Na	3.0	Na	0.0	Na	0.0
15	6/7/2015	27.0	-89.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
16	6/7/2015	27.0	-89.0	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
17	6/7/2015	27.0	-88.9	ID	Na	2.1	Na	0.0	Na	0.0	Na	2.1
18	6/7/2015	27.0	-88.7	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
19	6/7/2015	27.0	-88.6	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
20	6/7/2015	27.0	-88.5	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
21	6/7/2015	27.0	-88.3	ID	Na	1.7	Na	0.9	Na	0.0	Na	0.0
22	6/7/2015	27.0	-88.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
23	6/7/2015	27.0	-88.0	ID	Na	10.8	Na	0.9	Na	0.0	Na	0.0
24	6/7/2015	27.0	-88.0	ID	Na	11.7	Na	2.3	Na	0.0	Na	0.0
25	6/8/2015	28.0	-88.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
26	6/8/2015	28.0	-88.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
27	6/8/2015	28.0	-88.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
28	6/8/2015	28.0	-88.3	ID	Na	1.9	Na	0.0	Na	0.0	Na	0.0
29	6/8/2015	28.0	-88.5	ID	Na	2.9	Na	0.0	Na	0.0	Na	0.0
30	6/8/2015	28.0	-88.6	ID	Na	1.0	Na	0.0	Na	0.0	Na	0.0
31	6/8/2015	28.0	-88.7	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
32	6/8/2015	28.0	-88.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
33	6/8/2015	28.0	-89.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
34	6/8/2015	28.0	-89.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
35	6/8/2015	28.0	-89.3	ID	Na	5.4	Na	0.8	Na	0.0	Na	1.5
36	6/8/2015	28.0	-89.4	ID	Na	2.3	Na	1.5	Na	0.0	Na	10.7
37	6/9/2015	28.0	-89.5	ID	Na	3.6	Na	0.0	Na	0.0	Na	1.8
38	6/9/2015	28.0	-89.7	ID	Na	1.2	Na	0.0	Na	0.0	Na	0.0
39	6/9/2015	28.0	-89.8	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
40	6/9/2015	28.0	-89.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
41	6/9/2015	28.0	-90.1	ID	Na	1.9	Na	0.0	Na	0.0	Na	0.0
42	6/9/2015	28.0	-90.2	ID	Na	1.9	Na	0.0	Na	0.0	Na	0.0
43	6/9/2015	28.0	-90.3	ID	Na	2.8	Na	0.0	Na	0.0	Na	0.0
44	6/9/2015	28.0	-90.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
45	6/9/2015	28.0	-90.6	ID	Na	2.7	Na	0.0	Na	0.0	Na	0.0
46	6/9/2015	28.0	-90.7	ID	Na	4.7	Na	0.8	Na	0.0	Na	0.0
47	6/9/2015	28.0	-90.9	ID	Na	5.7	Na	2.9	Na	0.0	Na	0.0
48	6/9/2015	28.0	-91.0	ID	Na	9.1	Na	0.0	Na	0.0	Na	0.0
1	7/20/2015	27.0	-91.0	ID	Na	15.0	Na	0.0	Na	0.0	Na	0.0
2	7/21/2015	27.0	-90.9	ID	Na	0.0	Na	1.8	Na	0.9	Na	0.0
3	7/21/2015	27.0	-90.7	ID	Na	6.1	Na	0.9	Na	0.0	Na	0.0
4	7/21/2015	27.0	-90.6	ID	Na	19.7	Na	2.4	Na	0.0	Na	0.0
5	7/21/2015	27.0	-90.5	ID	Na	4.4	Na	0.0	Na	0.0	Na	0.0
6	7/21/2015	27.0	-90.3	ID	Na	4.6	Na	0.0	Na	0.0	Na	0.0
7	7/21/2015	27.0	-90.2	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
8	7/21/2015	27.0	-90.1	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
9	7/21/2015	27.0	-89.9	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
10	7/21/2015	27.0	-89.8	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
11	7/21/2015	27.0	-89.7	ID	Na	8.1	Na	0.0	Na	0.0	Na	0.0
12	7/21/2015	27.0	-89.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
13	7/21/2015	27.0	-89.4	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
14	7/22/2015	27.0	-89.3	ID	Na	1.4	Na	0.0	Na	0.0	Na	0.0
15	7/22/2015	27.0	-89.1	ID	Na	1.9	Na	0.0	Na	0.0	Na	0.0
16	7/22/2015	27.0	-89.0	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
17	7/22/2015	27.0	-88.9	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
18	7/22/2015	27.0	-88.7	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
19	7/22/2015	27.0	-88.6	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
20	7/22/2015	27.0	-88.5	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
21	7/22/2015	27.0	-88.3	ID	Na	2.4	Na	0.0	Na	0.0	Na	0.0
22	7/22/2015	27.0	-88.2	ID	Na	1.6	Na	0.0	Na	0.0	Na	0.0
23	7/22/2015	27.0	-88.1	ID	Na	12.5	Na	2.6	Na	0.5	Na	0.0
24	7/22/2015	27.0	-88.0	ID	Na	19.5	Na	1.1	Na	0.6	Na	0.0
25	7/23/2015	28.0	-88.0	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
26	7/23/2015	28.0	-88.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
27	7/23/2015	28.0	-88.2	ID	Na	2.2	Na	0.0	Na	0.0	Na	0.0
28	7/23/2015	28.0	-88.3	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
29	7/23/2015	28.0	-88.4	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
30	7/23/2015	28.0	-88.6	ID	Na	3.6	Na	0.9	Na	0.0	Na	0.0

Station	Date	Lat	Long	Station identified	BKT density (500µm)	BKT density (1200µm)	BET density (500µm)	BET density (1200µm)	YFT density (500µm)	YFT density (1200µm)	BFT density (500µm)	BFT density (1200µm)
31	7/23/2015	28.0	-88.7	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
32	7/23/2015	28.0	-88.9	ID	Na	2.0	Na	0.0	Na	0.0	Na	0.0
33	7/23/2015	28.0	-89.0	ID	Na	1.3	Na	0.0	Na	0.0	Na	0.0
34	7/24/2015	28.0	-89.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
35	7/24/2015	28.0	-89.3	ID	Na	0.9	Na	0.0	Na	0.0	Na	0.0
36	7/24/2015	28.0	-89.4	ID	Na	9.3	Na	0.7	Na	0.0	Na	0.0
37	7/24/2015	28.0	-89.5	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
38	7/24/2015	28.0	-89.7	ID	Na	1.1	Na	0.0	Na	1.1	Na	0.0
39	7/24/2015	28.0	-89.8	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
40	7/24/2015	28.0	-89.9	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
41	7/24/2015	28.0	-90.1	ID	Na	0.0	Na	0.0	Na	0.0	Na	0.0
42	7/24/2015	28.0	-90.2	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
43	7/24/2015	28.0	-90.3	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
44	7/24/2015	28.0	-90.5	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0
45	7/25/2015	28.0	-90.6	ID	Na	3.1	Na	0.0	Na	1.6	Na	0.0
46	7/25/2015	28.0	-90.7	ID	Na	1.5	Na	0.0	Na	0.0	Na	0.0
47	7/25/2015	28.0	-90.9	ID	Na	0.0	Na	0.7	Na	0.0	Na	0.0
48	7/25/2015	28.0	-91.0	No Th	Na	0.0	Na	0.0	Na	0.0	Na	0.0

Station	**Year**	**Month**	**Lat**	**Long**	**HAS (h)**	**SSH (cm)**	**Dist LC (km)**	**DO (mg/L)**	**Chl*a* (mg/m^3)**	**SST (°C)**	**Sal (psu)**	**Depth (m)**	**Sarg (kg)**
1	2007	6	28.0	-91.0	2.3	1.9	580.9	6.8	0.1	27.8	36.4	162.0	0.5
2	2007	6	28.0	-90.9	3.1	1.3	570.1	6.7	0.2	28.3	36.6	296.5	0.5
3	2007	6	28.0	-90.7	3.9	0.9	559.4	6.7	0.1	28.3	36.6	229.0	0.0
4	2007	6	28.0	-90.6	5.1	0.6	548.8	6.7	0.1	27.9	37.9	256.9	1.8
5	2007	6	28.0	-90.5	6.0	0.3	538.4	6.7	0.2	28.0	37.9	346.2	1.6
6	2007	6	28.0	-90.3	7.2	0.2	528.0	6.6	0.3	28.1	37.4	445.0	0.7
7	2007	6	28.0	-90.2	8.4	0.1	517.8	6.6	0.4	28.6	36.3	509.7	0.0
8	2007	6	28.0	-90.1	9.5	-0.2	507.8	6.7	0.4	29.3	34.1	590.6	0.0
9	2007	6	28.0	-89.9	10.6	-0.6	497.7	6.6	0.5	29.8	34.0	594.0	0.0
10	2007	6	28.0	-89.8	11.6	-0.8	487.6	6.6	0.4	29.5	34.4	783.4	0.0
11	2007	6	28.0	-89.8	12.8	-0.8	487.6	6.5	0.4	28.5	37.7	783.4	0.5
12	2007	6	28.0	-89.5	13.9	0.3	467.4	6.6	0.1	28.1	37.8	957.0	0.5
13	2007	6	28.0	-89.4	0.7	3.5	457.5	6.4	0.1	28.0	38.0	1232.0	2.0
14	2007	6	28.0	-89.3	1.5	7.6	447.8	6.6	0.1	28.2	38.2	1337.5	2.0
15	2007	6	28.0	-89.1	2.4	12.4	438.3	6.5	0.1	28.7	38.3	1259.2	1.1
16	2007	6	28.0	-89.0	3.4	19.3	429.0	6.4	0.1	28.7	38.3	1305.0	0.0
17	2007	6	27.9	-89.0	5.2	16.5	417.3	6.4	0.1	29.1	38.1	1430.3	0.0
18	2007	6	27.8	-89.0	6.8	12.7	410.9	6.2	0.1	29.5	38.2	1550.1	0.0
19	2007	6	27.7	-89.0	7.8	7.4	402.2	5.9	0.1	29.7	38.2	1705.4	0.0
20	2007	6	27.6	-89.0	9.0	4.2	397.3	5.5	0.1	29.7	38.3	1737.0	0.0
21	2007	6	27.5	-89.0	10.0	0.0	391.4	6.0	0.1	29.3	38.3	1810.8	0.0
22	2007	6	27.5	-89.1	10.8	-5.2	399.0	6.0	0.1	29.6	38.4	1672.0	0.5
23	2007	6	27.5	-89.2	11.9	-8.6	406.7	5.8	0.1	29.6	38.3	1771.1	0.0
24	2007	6	27.5	-89.3	13.2	-8.6	416.7	6.7	0.1	29.4	38.3	1752.7	4.2
25	2007	6	27.5	-89.5	2.1	-8.5	426.8	6.5	0.1	28.4	38.6	1849.8	0.2
26	2007	6	27.5	-89.6	3.4	-6.8	436.9	6.2	0.1	28.7	38.6	1763.9	1.1
27	2007	6	27.5	-89.7	4.2	-4.6	447.2	5.7	0.1	29.0	38.5	1332.8	1.4
28	2007	6	27.5	-89.9	5.7	-2.7	457.7	5.6	0.1	29.2	38.3	1287.2	2.4
29	2007	6	27.5	-90.0	6.7	-2.0	468.3	5.3	0.1	29.2	38.0	1190.7	0.5
30	2007	6	27.5	-90.1	7.7	-1.2	479.1	5.2	0.1	29.3	38.1	1123.4	0.7
31	2007	6	27.5	-90.3	8.8	-1.1	490.0	5.5	0.1	29.1	38.2	1196.1	0.9
32	2007	6	27.5	-90.4	9.9	-1.3	501.0	5.3	0.1	28.9	38.3	1146.3	0.8
33	2007	6	27.5	-90.5	10.9	-1.2	512.1	7.0	0.1	29.0	36.5	1026.8	0.5
34	2007	6	27.5	-90.7	12.2	-0.8	523.3	6.9	0.1	28.9	36.6	1302.6	0.5
35	2007	6	27.5	-90.8	13.3	-0.4	534.5	7.2	0.1	29.0	36.7	1012.1	8.8
36	2007	6	27.5	-91.0	0.1	0.3	551.4	6.5	0.1	28.5	36.6	1124.0	0.0
37	2007	6	27.3	-91.0	1.4	-0.1	542.3	6.2	0.1	28.4	36.7	1330.3	0.0
38	2007	6	27.2	-91.0	2.6	-0.8	533.7	6.8	0.1	28.7	36.5	1563.3	0.7
39	2007	6	27.0	-91.0	3.9	-1.5	525.6	6.8	0.1	28.7	36.2	1692.4	0.5
40	2007	6	27.0	-90.9	4.9	-1.4	513.7	6.9	0.1	29.1	36.3	1701.1	0.5
41	2007	6	27.0	-90.7	6.0	-1.7	501.8	7.2	0.1	29.6	36.3	1628.0	1.1
42	2007	6	27.0	-90.6	6.9	-2.1	490.0	7.6	0.1	30.4	36.3	1557.7	0.0
43	2007	6	27.0	-90.5	7.9	-2.5	478.2	7.1	0.1	31.1	36.0	1958.8	0.5
44	2007	6	27.0	-90.3	8.9	-2.5	466.6	7.5	0.1	30.2	36.6	2016.9	1.1
45	2007	6	27.0	-90.2	9.9	-2.6	455.1	7.3	0.1	29.6	36.7	2353.8	1.4
46	2007	6	27.0	-90.1	10.9	-3.4	443.6	7.9	0.1	29.1	36.7	2423.4	0.5
47	2007	6	27.0	-89.9	12.0	-4.4	432.3	7.5	0.1	29.1	36.6	2360.9	0.7
48	2007	6	27.0	-89.8	12.9	-6.2	421.1	7.3	0.1	29.3	36.6	2413.1	0.0
49	2007	6	27.0	-89.7	1.0	-9.8	409.9	6.8	0.1	28.9	36.7	2366.1	0.5
50	2007	6	27.0	-89.5	2.0	-13.5	398.8	7.3	0.1	28.6	36.6	2476.0	7.3
51	2007	6	27.0	-89.4	3.0	-16.6	387.8	7.7	0.1	28.6	36.6	2548.9	0.0
52	2007	6	27.0	-89.3	4.0	-19.4	376.9	7.7	0.1	28.7	36.7	2501.1	0.5
53	2007	6	27.0	-89.1	4.9	-20.3	366.3	8.0	0.1	28.7	36.7	2433.9	0.5
54	2007	6	27.0	-89.0	6.0	-15.9	355.8	7.7	0.1	28.7	36.7	2371.8	0.5
55	2007	6	27.1	-89.0	6.9	-14.5	361.6	6.7	0.1	28.6	36.7	2258.2	1.8
56	2007	6	27.2	-89.0	7.5	-12.7	367.6	6.9	0.1	28.5	36.8	2169.8	0.5
57	2007	6	27.3	-89.0	8.1	-10.5	374.8	6.9	0.1	28.6	36.8	1993.6	0.0
58	2007	6	27.3	-89.0	9.1	-8.5	379.6	6.6	0.1	28.6	36.8	1937.6	1.8
59	2007	6	27.5	-89.0	9.8	-2.5	387.8	6.7	0.1	28.6	36.6	1845.4	0.0
1	2007	7	27.4	-89.0	6.0	38.3	268.1	6.5	0.0	30.4	36.6	1898.0	0.2
2	2007	7	27.3	-89.0	6.8	33.2	262.8	6.5	0.0	30.4	36.6	1937.8	0.0
3	2007	7	27.3	-89.0	7.7	27.1	257.8	6.5	0.1	30.7	36.6	2029.0	0.0
4	2007	7	27.2	-89.0	8.5	20.6	252.9	6.5	0.0	30.7	36.6	2169.8	0.0
5	2007	7	27.1	-89.0	9.4	14.0	248.3	6.6	0.1	30.8	36.5	2258.2	4.5

Station	**Year**	**Month**	**Lat**	**Long**	**HAS (h)**	**SSH (cm)**	**Dist LC (km)**	**DO (mg/L)**	**Chl*a* (mg/m^3)**	**SST (°C)**	**Sal (psu)**	**Depth (m)**	**Sarg (kg)**
6	2007	7	27.0	-89.0	10.3	7.8	244.0	6.5	0.1	31.0	36.5	2371.7	0.9
7	2007	7	27.0	-89.1	11.2	7.2	255.9	6.6	0.1	30.9	36.3	2434.1	0.0
8	2007	7	27.0	-89.3	12.0	6.2	267.9	6.5	0.1	30.6	36.3	2501.2	3.5
9	2007	7	27.0	-89.4	12.9	5.0	280.0	6.5	0.1	30.8	36.4	2548.9	0.0
10	2007	7	27.0	-89.5	1.7	4.0	292.2	6.4	0.0	30.3	36.5	2476.0	0.0
11	2007	7	27.0	-89.7	2.7	3.7	304.4	6.5	0.1	30.5	35.8	2366.2	0.9
12	2007	7	27.0	-89.8	3.6	3.4	316.5	6.6	0.1	30.4	36.6	2413.1	0.5
13	2007	7	27.0	-89.9	4.6	3.8	328.6	6.5	0.1	30.5	36.5	2360.9	1.1
14	2007	7	27.0	-90.1	5.6	4.4	340.9	6.6	0.1	30.3	36.3	2423.4	0.0
15	2007	7	27.0	-90.2	6.6	5.2	353.2	6.5	0.1	30.0	36.5	2353.8	0.0
16	2007	7	27.0	-90.3	7.6	6.5	365.6	6.6	0.1	30.3	36.5	2016.3	0.0
17	2007	7	27.0	-90.5	8.6	7.9	378.0	6.6	0.1	30.7	34.7	1959.0	0.0
18	2007	7	27.0	-90.6	9.6	8.8	390.6	6.5	0.1	30.5	35.4	1557.7	0.0
19	2007	7	27.0	-90.7	10.5	9.6	403.1	6.5	0.1	30.6	36.8	1628.0	0.0
20	2007	7	27.0	-90.9	11.8	10.1	415.7	6.5	0.1	30.2	36.6	1701.1	0.0
21	2007	7	27.0	-91.0	12.7	9.6	428.4	6.5	0.1	30.3	36.8	1692.4	1.1
22	2007	7	27.0	-91.1	13.7	9.1	441.0	6.5	0.1	30.2	36.7	1745.5	5.2
23	2007	7	27.0	-91.3	0.8	8.4	453.8	6.3	0.1	29.9	36.8	2353.0	5.7
24	2007	7	27.0	-91.4	1.7	7.6	466.5	6.3	0.1	29.8	36.7	1801.8	0.0
25	2007	7	27.0	-91.5	2.9	6.8	479.3	6.4	0.1	29.8	36.8	2208.6	0.7
26	2007	7	27.0	-91.7	4.1	5.9	492.1	6.5	0.1	29.8	36.7	1822.5	0.2
27	2007	7	27.0	-91.8	5.2	5.1	504.9	6.5	0.1	29.9	36.7	1567.1	0.5
28	2007	7	27.0	-91.9	6.3	4.2	517.8	6.5	0.1	30.1	36.0	1726.0	0.0
29	2007	7	27.2	-91.9	8.3	3.8	522.4	6.6	0.1	30.5	35.1	1533.6	0.0
30	2007	7	27.3	-91.9	9.7	3.6	527.6	6.7	0.1	30.1	35.3	1396.3	0.2
31	2007	7	27.5	-91.9	11.2	4.0	533.5	6.8	0.1	30.2	35.8	817.1	10.1
32	2007	7	27.5	-91.8	12.4	4.3	521.1	6.6	0.1	30.3	35.4	922.1	0.0
33	2007	7	27.5	-91.7	13.5	4.8	508.7	6.5	0.1	30.3	35.3	1020.7	0.0
34	2007	7	27.5	-91.5	0.8	5.3	496.4	6.4	0.1	30.0	34.8	949.2	0.0
35	2007	7	27.5	-91.4	1.6	6.0	484.1	6.4	0.1	30.1	35.6	991.4	4.9
36	2007	7	27.5	-91.3	2.6	6.7	471.9	6.5	0.1	30.0	35.7	1370.5	1.6
37	2007	7	27.5	-91.1	3.6	7.4	459.7	6.5	0.1	30.0	35.7	1261.6	4.0
38	2007	7	27.5	-91.0	4.6	8.2	447.6	6.6	0.1	30.0	35.8	1124.1	0.9
39	2007	7	27.5	-90.9	5.6	9.0	435.5	6.6	0.1	30.2	35.7	1305.6	0.9
40	2007	7	27.5	-90.7	6.6	9.9	423.3	6.5	0.1	31.0	36.7	963.6	0.0
41	2007	7	27.5	-90.6	7.6	10.9	411.2	6.5	0.1	31.1	36.5	1149.9	0.0
42	2007	7	27.5	-90.5	8.6	11.9	399.1	6.7	0.1	30.8	35.8	1049.6	0.0
43	2007	7	27.5	-90.3	9.6	13.1	387.1	6.7	0.1	30.6	36.5	1175.1	0.0
44	2007	7	27.5	-90.2	10.6	14.2	375.2	6.8	0.1	30.6	36.5	1196.7	0.0
45	2007	7	27.5	-90.1	11.7	15.9	363.4	6.8	0.1	30.7	35.7	1160.5	1.8
46	2007	7	27.5	-89.9	12.8	17.6	351.7		0.1	30.4	36.0	1279.2	0.9
47	2007	7	27.5	-89.8	2.5	19.8	340.1	6.5	0.1	30.1	36.3	1279.4	5.0
48	2007	7	27.5	-89.7	3.5	23.1	328.6	6.5	0.1	29.9	36.4	1595.8	2.5
49	2007	7	27.5	-89.5	4.6	26.5	317.3	6.6	0.0	29.9	36.4	1834.4	1.4
50	2007	7	27.5	-89.4	5.7	31.0	306.1	6.6	0.0	29.8	36.2	1923.5	2.7
51	2007	7	27.5	-89.3	6.8	36.0	295.1	6.5	0.0	29.9	36.4	1763.4	0.2
52	2007	7	27.5	-89.1	8.2	40.4	284.3	6.6	0.0	29.7	36.2	1710.6	0.0
53	2007	7	27.5	-89.0	11.6	43.3	273.7	6.6	0.1	29.8	36.4	1810.8	1.4
54	2007	7	27.6	-89.0	12.5	48.4	279.4	6.5	0.0	29.8	36.4	1737.0	0.0
55	2007	7	27.7	-89.0	13.3	50.5	285.3	6.5	0.0	29.8	36.4	1691.7	0.0
1	2008	6	27.0	-92.0	0.4	20.7	349.2	6.6	0.1	27.9	36.6	1428.0	0.0
2	2008	6	27.0	-91.9	1.5	25.6	336.5	6.7	0.1	27.9	36.6	1543.6	0
3	2008	6	27.0	-91.7	2.5	29.4	323.8	6.9	0.1	27.8	36.6	1610.5	0
4	2008	6	27.0	-91.6	3.4	32.7	311.2	7.0	0.1	27.8	36.6	1996.1	0
5	2008	6	27.0	-91.5	4.3	35.5	298.6	7.0	0.1	27.9	36.6	1808.9	1.25
6	2008	6	27.0	-91.3	5.2	36.7	286.0	7.0	0.1	27.9	36.6	2108.0	1.02
7	2008	6	27.0	-91.2	6.1	37.9	273.6	7.2	0.1	28.0	36.6	1741.7	1.7
8	2008	6	27.0	-91.1	7.0	37.7	261.3	7.3	0.1	28.1	36.7	2026.9	0.79
9	2008	6	27.0	-90.9	7.9	36.9	248.9	7.0	0.1	28.2	36.6	1662.8	2.83
10	2008	6	27.0	-90.8	8.8	35.8	236.6	7.1	0.1	28.1	36.7	1671.9	0.45
11	2008	6	27.0	-90.7	9.7	33.4	224.3	7.0	0.1	28.2	36.7	1568.0	0
12	2008	6	27.0	-90.5	10.6	31.0	212.0	7.1	0.1	28.1	36.7	1511.4	0
13	2008	6	27.0	-90.4	11.5	27.4	199.7	7.0	0.1	28.2	36.7	2255.8	0.68
14	2008	6	27.0	-90.3	12.4	23.4	187.4	6.8	0.1	28.1	36.7	1876.4	0.79

Station	**Year**	**Month**	**Lat**	**Long**	**HAS (h)**	**SSH (cm)**	**Dist LC (km)**	**DO (mg/L)**	**Chl*a* (mg/m^3)**	**SST (°C)**	**Sal (psu)**	**Depth (m)**	**Sarg (kg)**
15	2008	6	27.0	-90.1	13.3	19.0	175.0	6.7	0.1	28.1	36.7	2375.4	0.23
16	2008	6	27.0	-90.0	0.2	14.0	162.8	6.4	0.1	28.0	36.9	2420.2	0.45
17	2008	6	27.0	-89.9	1.1	9.0	150.7	6.6	0.1	28.1	36.8	2365.9	0.45
18	2008	6	27.0	-89.7	2.1	4.2	138.7	6.7	0.1	28.0	36.5	2326.5	5.78
19	2008	6	27.0	-89.6	2.9	-0.4	127.2	6.8	0.1	28.1	36.6	2409.2	6.35
20	2008	6	27.0	-89.5	3.8	-4.5	115.9	6.9	0.1	28.3	36.7	2528.3	0.34
21	2008	6	27.0	-89.3	4.7	-7.3	105.1	6.9	0.1	28.2	36.5	2536.0	0.45
22	2008	6	27.0	-89.2	5.6	-10.1	95.0	6.9	0.1	28.3	36.5	2473.6	0
23	2008	6	27.0	-89.1	6.4	-10.5	85.7	6.9	0.1	28.3	36.6	2310.0	4.54
24	2008	6	27.0	-88.9	7.3	-10.1	77.6	6.9	0.1	28.4	36.6	2201.1	0
25	2008	6	27.0	-88.8	8.1	-9.2	70.5	6.9	0.1	28.6	36.8	2199.9	0
26	2008	6	27.0	-88.7	8.9	-6.6	63.5	6.9	0.1	28.5	36.6	2286.5	0
27	2008	6	27.0	-88.5	9.8	-4.0	56.1	7.0	0.1	28.3	36.5	2463.8	0
28	2008	6	27.0	-88.4	10.7	-1.4	48.9	7.0	0.1	28.6	36.5	2592.4	0
29	2008	6	27.0	-88.3	11.7	1.1	42.3	6.8	0.1	28.7	36.6	2655.7	0
30	2008	6	27.0	-88.1	12.4	3.9	35.0	6.5	0.1	28.5	36.5	2702.2	0
31	2008	6	27.0	-88.0	13.2	7.0	28.5	6.5	0.1	28.5	36.6	2749.2	0
32	2008	6	27.0	-87.9	0.4	10.1	22.3	6.2	0.1	28.1	36.6	2793.7	0
33	2008	6	27.0	-87.7	1.2	12.9	16.3	6.3	0.1	28.3	36.6	2817.3	0
34	2008	6	27.0	-87.6	2.0	15.4	10.3	6.4	0.1	28.2	36.6	2856.8	0
35	2008	6	27.0	-87.5	2.7	17.4	6.6	6.5	0.1	28.4	36.8	2878.4	0
36	2008	6	27.2	-87.5	4.2	10.1	25.2	6.6	0.1	28.7	36.4	2876.8	1.36
37	2008	6	27.3	-87.5	5.6	3.3	43.6	6.6	0.1	28.5	36.5	2833.1	8.16
38	2008	6	27.5	-87.5	7.1	0.2	62.2	6.6	0.1	28.8	36.5	2916.2	0.23
39	2008	6	27.7	-87.5	8.5	-1.2	80.8	6.7	0.1	29.3	36.6	2864.6	0
40	2008	6	27.8	-87.5	9.9	0.6	99.2	6.5	0.2	29.9	33.3	2868.2	0
41	2008	6	28.0	-87.5	11.1	3.6	117.8	6.4	0.3	30.0	32.5	2780.1	0
42	2008	6	28.0	-87.6	11.8	3.8	118.2	6.4	0.3	30.0	31.5	2718.2	0.23
43	2008	6	28.0	-87.7	12.7	4.0	120.0	6.3	0.3	29.6	33.0	2686.5	0.57
44	2008	6	28.0	-87.9	13.5	4.2	123.2	6.3	0.3	29.8	33.0	2563.2	4.54
45	2008	6	28.0	-88.0	0.3	4.4	127.7	6.1	0.4	28.9	33.6	2417.7	0
46	2008	6	28.0	-88.1	1.3	4.6	133.4	6.4	0.5	29.0	32.7	2418.7	0
47	2008	6	28.0	-88.3	2.2	4.6	139.3	6.4	0.4	29.0	32.6	2195.0	0.23
48	2008	6	28.0	-88.4	3.2	4.7	145.2	6.4	0.4	29.0	32.9	2143.8	1.59
49	2008	6	28.0	-88.5	4.1	4.6	151.2	6.7	0.4	29.4	34.2	2083.0	0.23
50	2008	6	28.0	-88.7	5.0	4.5	157.7	6.6	0.2	29.3	32.6	1938.9	0
51	2008	6	28.0	-88.8	5.9	4.3	164.2	6.5	0.3	29.3	33.5	1683.2	0
52	2008	6	28.0	-88.9	6.9	4.1	171.1	6.5	0.2	29.0	34.1	1464.4	0
53	2008	6	28.0	-89.1	9.1	4.0	178.1		0.2	28.8	36.2	1309.9	0.11
54	2008	6	28.0	-89.2	10.2	3.9	185.0	6.3	0.2	28.6	36.2	1311.3	1.36
55	2008	6	28.0	-89.3	11.2	4.0	192.4	6.3	0.2	28.5	36.5	1235.1	0.34
56	2008	6	28.0	-89.5	12.1	4.1	199.6	6.3	0.2	28.4	36.7	1057.2	0.57
57	2008	6	28.0	-89.6	13.1	4.4	206.6	6.3	0.1	28.3	36.4	888.9	0.45
58	2008	6	28.0	-89.7	-0.3	4.7	213.8	6.0	0.1	28.1	36.5	728.4	2.95
59	2008	6	28.0	-89.9	0.7	5.1	221.7	6.1	0.1	28.2	36.6	706.1	1.02
60	2008	6	28.0	-90.0	1.7	5.5	230.0	6.4	0.1	28.2	36.6	560.9	0
61	2008	6	28.0	-90.1	2.8	5.8	238.7	6.5	0.1	28.2	35.8	554.4	0
62	2008	6	28.0	-90.3	3.8	6.2	247.9	7.1	0.1	28.4	35.7	447.6	0
63	2008	6	28.0	-90.4	5.0	6.6	257.4	7.2	0.2	28.5	35.6	437.9	0
64	2008	6	28.0	-90.5	6.0	7.1	267.2	7.1	0.2	28.6	35.6	362.8	0
65	2008	6	28.0	-90.7	6.9	7.9	277.4	7.1	0.1	28.6	35.8	236.7	0
66	2008	6	28.0	-90.8	7.9	8.6	287.7	7.0	0.2	28.9	36.1	260.0	0
67	2008	6	28.0	-90.9	8.9	9.5	298.2	7.0	0.2	28.8	36.1	173.8	0.45
68	2008	6	28.0	-91.1	9.9	10.4	309.1	6.4	0.3	28.7	36.2	143.4	0.23
69	2008	6	28.0	-91.2	11.0	11.1	320.0	7.0	0.1	28.9	36.1	142.5	0.23
70	2008	6	28.0	-91.3	12.0	11.6	331.1	6.9	0.2	28.8	34.7	191.6	0.45
71	2008	6	28.0	-91.5	13.0	12.0	342.4	6.9	0.2	28.6	34.9	124.0	0
72	2008	6	28.0	-91.5	13.5	12.0	348.1	6.9	0.2	28.6	35.9	196.4	0
1	2008	7	26.5	-93.0	-0.2	37.9	694.8	6.2	0.1	29.2	37.0	1736.0	0.9
2	2008	7	26.5	-92.9	0.7	39.5	682.3	6.3	0.1	29.2	37.0	1839.2	0.8
3	2008	7	26.5	-92.7	1.6	39.2	669.8	6.3	0.1	29.1	36.9	2296.8	0.5
4	2008	7	26.5	-92.6	2.5	38.2	657.3	6.3	0.1	29.2	37.0	1816.1	0.3
5	2008	7	26.5	-92.5	3.4	36.9	644.8	6.4	0.1	29.3	37.0	1869.1	0.0
6	2008	7	26.5	-92.3	4.4	34.7	632.5	6.3	0.1	29.5	37.0	1974.6	2.7

Station	**Year**	**Month**	**Lat**	**Long**	**HAS (h)**	**SSH (cm)**	**Dist LC (km)**	**DO (mg/L)**	**Chl*a* (mg/m^3)**	**SST (°C)**	**Sal (psu)**	**Depth (m)**	**Sarg (kg)**
7	2008	7	26.5	-92.2	5.4	32.4	620.1	6.3	0.1	29.6	37.0	2533.5	0.2
8	2008	7	26.5	-92.1	6.4	29.6	607.8	6.3	0.1	29.9	37.0	2439.7	0.5
9	2008	7	26.5	-91.9	7.4	26.6	595.5	6.3	0.1	30.1	36.6	1839.0	0.0
10	2008	7	26.5	-91.8	8.6	23.3	583.3	6.2	0.1	30.5	36.8	1851.9	1.0
11	2008	7	26.5	-91.7	9.6	19.2	571.2	6.1	0.1	30.5	36.9	2471.0	4.2
12	2008	7	26.5	-91.5	10.8	15.1	559.1	6.1	0.1	30.4	36.9	2129.3	0.7
13	2008	7	26.5	-91.4	11.8	11.0	547.0	6.1	0.1	29.8	35.8	2242.2	3.4
14	2008	7	26.5	-91.3	12.8	6.8	535.0	6.2	0.1	29.8	34.1	2255.4	0.5
15	2008	7	26.5	-91.1	-0.1	3.0	523.0	5.8	0.1	29.7	33.0	2016.9	2.4
16	2008	7	26.5	-91.0	1.0	0.6	511.1	5.9	0.1	29.6	33.4	2076.3	0.1
17	2008	7	26.5	-90.9	2.0	-1.8	499.3	6.0	0.3	29.4	34.2	2061.7	0.0
18	2008	7	26.5	-90.7	3.0	-1.9	487.5	6.1	0.4	29.3	34.2	2256.3	0.2
19	2008	7	26.5	-90.6	4.0	-1.3	475.8	6.1	0.1	29.1	35.1	2752.4	0.9
20	2008	7	26.5	-90.5	5.0	-0.1	464.2	6.2	0.1	28.9	36.4	2787.0	0.6
21	2008	7	26.5	-90.3	6.0	2.9	452.7	6.2	0.1	29.1	36.7	2884.6	0.6
22	2008	7	26.5	-90.2	7.0	5.8	441.3	6.2	0.1	29.3	36.7	2965.4	0.6
23	2008	7	26.5	-90.1	7.9	9.6	430.0	6.3	0.1	29.6	36.6	2913.3	2.0
24	2008	7	26.5	-89.9	8.9	13.8	418.8	6.3	0.1	29.5	37.0	2948.0	19.8
25	2008	7	26.5	-89.8	10.0	17.9	407.3	6.1	0.1	29.5	37.1	2930.4	0.1
26	2008	7	26.5	-89.7	10.8	22.0	395.8	6.1	0.1	29.5	36.8	2927.4	0.0
27	2008	7	26.5	-89.5	11.7	26.2	384.5	6.1	0.1	29.5	36.3	2922.6	0.3
28	2008	7	26.5	-89.4	12.5	29.3	373.4	6.1	0.1	29.8	36.7	2896.3	0.3
29	2008	7	26.5	-89.3	13.3	31.9	362.3	6.1	0.1	29.6	36.9	2835.9	0.5
30	2008	7	26.5	-89.1	0.3	33.9	351.5	5.7	0.1	29.5	36.7	2810.6	0.2
31	2008	7	26.5	-89.0	1.1	33.5	340.8	6.0	0.1	29.5	36.8	2799.4	0.9
32	2008	7	26.5	-88.9	2.0	33.1	330.2	6.2	0.1	29.4	36.8	2666.1	0.2
33	2008	7	26.5	-88.7	2.7	29.7	318.9	6.1	0.1	29.4	36.8	2585.7	0.0
34	2008	7	26.5	-88.6	3.7	25.4	307.8	6.2	0.1	29.4	36.8	2557.9	0.2
35	2008	7	26.5	-88.5	4.6	20.4	296.9	6.2	0.1	29.4	36.8	2567.4	0.2
36	2008	7	26.5	-88.3	5.4	13.5	286.2	6.3	0.1	29.4	36.8	2605.4	0.5
37	2008	7	26.5	-88.2	6.3	6.6	275.8	6.2	0.1	29.4	36.6	2668.1	0.0
38	2008	7	26.5	-88.1	7.2	-0.8	265.6	6.3	0.1	29.2	36.8	2702.5	0.5
39	2008	7	26.5	-88.0	7.7	-4.5	260.5	6.3	0.1	29.6	36.6	2724.5	1.1
40	2008	7	26.7	-88.0	9.5	-2.7	271.2	6.1	0.1	29.6	36.7	2713.9	0.3
41	2008	7	26.8	-88.0	11.0	-0.3	282.6	6.1	0.1	29.8	36.7	2782.4	0.2
42	2008	7	27.0	-88.0	12.5	2.3	294.6	6.3	0.2	29.4	33.0	2749.2	0.0
43	2008	7	27.2	-88.0	-0.1	4.8	307.3	5.9	0.2	29.6	29.2	2725.0	0.2
44	2008	7	27.3	-88.0	1.1	7.2	320.6	6.0	0.2	29.5	31.1	2616.4	0.0
45	2008	7	27.5	-88.0	2.3	8.5	334.3	6.1	0.1	29.7	32.9	2537.8	0.2
46	2008	7	27.5	-88.1	3.1	9.4	338.7	6.1	0.1	29.3	35.1	2489.4	0.0
47	2008	7	27.5	-88.2	4.3	11.0	347.6	6.1	0.1	29.8	30.9	2383.4	0.0
48	2008	7	27.5	-88.3	5.3	12.1	356.8	6.1	0.1	29.8	32.2	2183.6	0.0
49	2008	7	27.5	-88.5	6.3	13.3	366.3	6.1	0.1	29.7	36.2	2082.8	0.0
50	2008	7	27.5	-88.6	7.3	13.8	376.0	6.2	0.1	29.6	36.9	1966.7	0.5
51	2008	7	27.5	-88.7	8.3	14.0	385.9	6.2	0.1	29.4	36.8	2065.3	0.5
52	2008	7	27.5	-88.9	9.5	13.9	396.1	6.2	0.1	29.4	36.8	1901.3	4.8
53	2008	7	27.5	-89.0	10.6	12.8	406.4	6.8	0.1	29.5	36.8	1810.8	6.7
54	2008	7	27.5	-89.1	11.7	11.6	416.8	6.5	0.1	29.4	36.7	1710.6	0.2
55	2008	7	27.5	-89.3	12.6	9.7	427.5	6.6	0.1	29.5	36.7	1763.4	0.0
56	2008	7	27.5	-89.4	13.5	7.4	438.2	6.7	0.1	29.4	36.6	1923.5	1.1
57	2008	7	27.5	-89.5	-0.2	5.1	448.7	6.4	0.1	29.2	36.7	1834.5	0.7
58	2008	7	27.5	-89.7	0.8	2.6	459.0	6.6	0.2	29.2	36.7	1595.8	2.0
59	2008	7	27.5	-89.8	1.8	0.1	469.5	6.7	0.2	26.2	36.5	1279.4	0.9
60	2008	7	27.5	-89.9	2.8	-1.6	480.1	6.8	0.1	29.3	36.0	1279.2	0.5
61	2008	7	27.5	-90.1	3.9	-3.0	490.8	6.8	0.1	29.4	33.3	1160.5	0.0
62	2008	7	27.5	-90.2	5.0	-3.9	501.7	6.8	0.1	29.8	31.8	1196.7	0.0
63	2008	7	27.5	-90.3	6.2	-3.3	512.7		0.1	30.0	32.8	1175.1	0.0
64	2008	7	27.5	-90.5	7.3	-2.6	523.7	6.6	0.1	30.1	33.9	1049.6	0.0
65	2008	7	27.5	-90.6	8.3	-1.0	534.5	6.6	0.1	29.7	36.4	1149.9	7.9
66	2008	7	27.5	-90.7	9.3	0.8	545.3	6.8	0.2	29.8	33.8	963.6	0.0
67	2008	7	27.5	-90.9	10.4	2.7	556.1	6.7	0.2	29.4	34.3	1305.6	0.0
68	2008	7	27.5	-91.0	11.5	4.5	567.1	6.6	0.5	29.3	34.8	1124.1	0.0
69	2008	7	27.5	-91.1	12.5	6.2	578.1	6.6	0.4	29.4	36.0	1261.5	0.1
70	2008	7	27.5	-91.3	13.5	7.9	589.2	6.6	0.3	29.5	35.9	1370.5	0.0

Station	Year	Month	Lat	Long	HAS (h)	SSH (cm)	Dist LC (km)	DO (mg/L)	Chl*a* (mg/m^3)	SST (°C)	Sal (psu)	Depth (m)	Sarg (kg)
71	2008	8	27.5	-91.4	-0.2	9.5	600.5	6.3	0.2	29.3	35.8	991.4	0.0
72	2008	8	27.5	-91.5	0.8	11.0	611.8	6.5	0.1	29.2	36.4	949.0	0.2
73	2008	8	27.5	-91.7	2.2	12.3	623.2	6.7	0.8	28.9	36.5	1019.6	6.4
74	2008	8	27.5	-91.8	3.3	13.5	634.6	6.7	0.1	29.1	37.0	922.1	0.5
75	2008	8	27.5	-91.9	4.4	14.3	645.9	7.0	0.1	28.9	36.7	817.1	1.1
76	2008	8	27.5	-92.1	5.4	14.9	657.2	6.8	0.1	29.0	36.8	823.8	0.2
77	2008	8	27.5	-92.2	6.4	15.4	668.6	6.7	0.1	29.0	36.8	953.7	0.9
78	2008	8	27.5	-92.3	7.6	15.4	680.0	6.7	0.1	29.2	36.9	1016.2	1.1
79	2008	8	27.5	-92.5	8.6	15.4	691.5	6.5	0.1	29.9	36.7	945.8	5.4
80	2008	8	27.5	-92.6	9.6	14.9	703.1	6.6	0.1	29.2	36.6	690.2	0.1
81	2008	8	27.5	-92.7	10.8	14.1	714.7	6.6	0.1	29.4	36.6	723.6	0.3
82	2008	8	27.5	-92.9	11.9	13.1	726.4	6.6	0.1	29.3	36.6	771.9	0.2
83	2008	8	27.5	-93.0	12.9	11.5	738.2	6.5	0.1	29.4	36.6	835.4	0.0
1	2009	6	26.0	-92.0	3.9	49.5	472.8		0.0			2401.2	0.0
2	2009	6	26.0	-91.9	4.8	47.0	459.5		0.0			2340.7	0.0
3	2009	6	26.0	-91.7	5.7	43.2	446.2		0.0			2268.7	0.0
4	2009	6	26.0	-91.6	6.7	38.9	432.8	9.6	0.0	25.7		2304.1	0.0
5	2009	6	26.0	-91.5	7.7	34.2	419.5	9.0	0.1	26.0		2480.5	0.9
6	2009	6	26.0	-91.3	8.8	28.2	406.2	8.7	0.1	26.2		3068.1	0.0
7	2009	6	26.0	-91.2	9.8	22.1	392.9	8.4	0.1	26.4		3388.1	0.0
8	2009	6	26.0	-91.1	10.8	15.3	379.5	8.6	0.1	26.5		3369.4	0.0
9	2009	6	26.0	-90.9	11.8	8.3	366.2	8.5	0.1	26.5		3375.7	0.0
10	2009	6	26.0	-90.8	12.8	1.9	352.9		0.1	26.4		3380.6	0.9
11	2009	6	26.0	-90.7	0.2	-2.5	339.6	8.6	0.1	26.4	37.0	3365.3	0.9
12	2009	6	26.0	-90.5	1.2	-6.9	326.2	8.4	0.1	26.2	36.5	3349.0	0.0
13	2009	6	26.0	-90.4	2.2	-8.4	312.9	8.5	0.1	26.1	35.0	3336.3	0.0
14	2009	6	26.0	-90.3	3.3	-9.0	299.6	9.2	0.1	26.1	35.0	3315.4	0.5
15	2009	6	26.0	-90.1	4.3	-9.3	286.3	9.0	0.1	26.5	36.2	3239.8	0.0
16	2009	6	26.0	-90.0	5.3	-9.2	272.9	9.3	0.1	27.0	35.8	3206.4	0.5
17	2009	6	26.0	-89.9	6.3	-9.0	259.6	9.3	0.1	27.3	35.6	3200.1	1.2
18	2009	6	26.0	-89.7	7.3	-10.0	246.3	8.8	0.1	27.3	35.5	3185.6	0.0
19	2009	6	26.0	-89.6	8.3	-11.4	232.9	9.4	0.1	27.5	36.0	3167.0	0.0
20	2009	6	26.0	-89.5	9.2	-13.1	219.6	9.5	0.1	27.6	36.5	3153.6	1.1
21	2009	6	26.0	-89.3	10.2	-15.4	206.3	9.6	0.1	27.6	36.3	3139.3	0.0
22	2009	6	26.0	-89.2	11.1	-17.7	193.0	9.8	0.1	27.6	36.3	3119.7	0.0
23	2009	6	26.0	-89.1	12.0	-19.5	179.7	9.7	0.1	27.3	36.3	3093.7	0.9
24	2009	6	26.0	-88.9	13.0	-21.0	166.4	9.4	0.1	27.1	36.5	3051.8	0.0
25	2009	6	26.0	-88.8	13.9	-22.5	153.1	10.2	0.1	27.0	36.4	3010.0	0.0
26	2009	6	26.0	-88.7	0.4	-23.5	139.9	9.8	0.1	26.6	36.3	3000.5	0.0
27	2009	6	26.0	-88.5	1.5	-24.6	126.6	9.8	0.1	26.8	36.6	3002.9	0.7
28	2009	6	26.0	-88.4	2.5	-24.5	113.2	9.9	0.1	26.5	36.5	3027.1	0.5
29	2009	6	26.0	-88.3	3.6	-24.0	99.9		0.1	27.6	36.3	3005.8	0.0
30	2009	6	26.0	-88.1	4.6	-22.5	86.5		0.1	27.6	36.3	3003.8	0.0
31	2009	6	26.0	-88.0	5.5	-17.5	73.1		0.1	27.9	36.4	3016.9	2.4
32	2009	6	26.0	-87.9	6.6	-12.6	59.7		0.1	28.6	36.3	3038.9	0.1
33	2009	6	26.0	-87.7	7.7	-5.4	46.3		0.1	28.9	36.2	3088.6	0.0
34	2009	6	26.0	-87.6	8.6	2.6	32.9		0.1	28.9	36.2	3120.5	0.0
35	2009	6	26.0	-87.5	9.5	10.3	19.6		0.1	29.0	36.1	3145.5	0.0
36	2009	6	26.0	-87.3	10.4	16.9	6.2		0.1	28.9	36.2	3164.6	0.0
37	2009	6	26.0	-87.2	11.4	23.5	7.2		0.1	28.3	36.2	3185.4	0.0
38	2009	6	26.0	-87.1	12.3	28.3	20.6		0.1	27.9	36.1	3188.5	0.0
39	2009	6	26.0	-87.0	12.9	30.4	27.3		0.1	27.7	36.1	3205.5	0.0
40	2009	6	26.1	-87.0	13.8	30.7	25.7		0.1	27.9	36.1	2969.8	0.0
41	2009	6	26.2	-87.0	0.3	30.4	23.4		0.1	28.1	36.1	3001.5	0.6
42	2009	6	26.3	-87.0	1.2	29.9	21.5		0.1	28.4	36.2	3007.2	0.0
43	2009	6	26.4	-87.0	2.0	29.5	18.5		0.1	28.6	36.1	3049.2	0.0
44	2009	6	26.5	-87.0	2.7	27.2	13.0		0.0	28.7	36.1	2985.2	0.0
45	2009	6	26.6	-87.0	3.5	24.4	7.5		0.1	28.8	36.1	2967.5	0.0
46	2009	6	26.7	-87.0	4.2	21.7	2.9		0.1	28.8	36.1	2936.6	0.1
47	2009	6	26.8	-87.0	4.9	17.2	4.1		0.1	28.7	36.2	2915.5	0.0
48	2009	6	26.9	-87.0	5.7	12.3	11.3		0.1	28.7	36.2	2957.1	0.0
49	2009	6	27.0	-87.0	6.4	7.4	18.9		0.1	27.9	36.3	2959.8	0.0
50	2009	6	27.1	-87.0	7.2	2.7	26.7		0.1	28.2	36.2	2969.8	0.0
51	2009	6	27.2	-87.0	8.1	-1.8	34.7		0.1	27.5	36.2	3001.5	0.0

Station	**Year**	**Month**	**Lat**	**Long**	**HAS (h)**	**SSH (cm)**	**Dist LC (km)**	**DO (mg/L)**	**Chl*a* (mg/m^3)**	**SST (°C)**	**Sal (psu)**	**Depth (m)**	**Sarg (kg)**
52	2009	6	27.3	-87.0	9.0	-6.4	42.6		0.1	27.8	36.1	3007.2	0.3
53	2009	6	27.4	-87.0	9.8	-8.4	51.1		0.1	27.5	36.3	3013.6	0.6
54	2009	6	27.5	-87.0	10.7	-10.0	59.6		0.1	27.3	36.3	3054.5	0.0
55	2009	6	27.5	-87.1	11.4	-11.2	63.9		0.1	27.3	36.3	3039.1	0.0
56	2009	6	27.5	-87.2	12.4	-13.2	72.5		0.1	27.8	36.4	3012.9	2.8
57	2009	6	27.5	-87.3	13.4	-14.1	81.7		0.1	27.8	36.3	2978.7	0.0
58	2009	6	27.5	-87.5	0.2	-15.0	90.9		0.1	27.1	36.2	2910.7	0.0
59	2009	6	27.5	-87.6	1.1	-15.4	100.4		0.1	27.1	36.2	2897.8	0.2
60	2009	6	27.5	-87.7	2.1	-15.5	110.2		0.1	27.2	36.2	2797.7	0.5
61	2009	6	27.5	-87.9	3.1	-15.6	120.1		0.1	27.3	36.2	2663.4	0.5
62	2009	6	27.5	-88.0	4.1	-15.5	130.3		0.1	27.3	36.2	2537.8	0.5
63	2009	6	27.5	-88.1	5.1	-15.4	140.6		0.1	27.3	36.2	2438.6	0.2
64	2009	6	27.5	-88.3	6.1	-15.0	151.2		0.1	27.4	36.2	2258.7	0.0
65	2009	6	27.5	-88.4	7.1	-14.5	162.3		0.1	27.0	35.7	2082.0	0.0
66	2009	6	27.5	-88.5	8.1	-13.9	173.6		0.1	27.0	35.0	2050.3	0.0
67	2009	6	27.5	-88.7	9.3	-13.0	185.2		0.1	27.2	34.6	1933.1	1.2
68	2009	6	27.5	-88.8	10.3	-12.1	197.0		0.1	27.2	35.9	1906.8	0.0
69	2009	6	27.5	-88.9	11.3	-11.1	208.9		0.1	27.0	35.9	1865.5	0.0
70	2009	6	27.5	-89.1	12.3	-10.1	220.7		0.1	27.4	36.1	1685.8	0.6
71	2009	6	27.5	-89.2	13.3	-8.9	232.3		0.1	27.3	36.1	1771.1	0.5
72	2009	6	27.5	-89.3	0.0	-7.3	243.9		0.1	27.0	36.0	1752.7	0.5
73	2009	6	27.5	-89.5	1.0	-5.7	255.7		0.1	26.9	35.9	1849.9	0.3
74	2009	6	27.5	-89.6	1.9	-3.8	267.6		0.1	26.9	35.9	1764.0	0.3
75	2009	6	27.5	-89.7	3.0	-1.9	279.6		0.1	26.7	35.8	1333.6	0.5
76	2009	6	27.5	-89.9	4.0	-0.2	291.8		0.1	26.8	36.0	1287.2	0.0
77	2009	6	27.5	-90.0	5.0	0.9	303.9		0.1	26.8	36.0	1190.7	0.2
78	2009	6	27.5	-90.1	6.0	2.0	316.1		0.1	26.6	35.9	1123.4	0.0
79	2009	6	27.5	-90.3	7.0	2.3	328.4		0.1	26.8	35.7	1196.1	0.2
80	2009	6	27.5	-90.4	7.9	2.2	340.8		0.1	27.0	35.8	1146.3	0.0
81	2009	6	27.5	-90.5	9.0	2.1	353.2		0.1	26.8	35.6	1026.8	0.0
82	2009	6	27.5	-90.7	10.1	1.7	365.7		0.1	27.0	35.7	1302.6	0.2
83	2009	6	27.5	-90.8	11.0	1.2	378.2		0.1	27.1	35.8	1012.1	0.2
84	2009	6	27.5	-90.9	12.0	1.1	390.8		0.1	27.3	35.6	1134.2	0.0
85	2009	6	27.5	-91.1	13.0	1.0	403.4		0.1	27.4	35.7	1253.4	0.0
86	2009	6	27.5	-91.2	14.0	1.2	416.1		0.1	27.2	35.3	1135.9	6.7
87	2009	6	27.5	-91.3	-0.1	1.9	428.8		0.1	26.9	35.2	880.7	2.5
88	2009	6	27.5	-91.5	1.2	2.6	441.5		0.1	27.0	35.1	941.4	0.7
89	2009	6	27.5	-91.6	2.5	3.5	454.2		0.2	26.5	34.1	1131.1	0.3
90	2009	6	27.5	-91.7	3.5	4.4	467.0		0.1	27.2	35.2	987.0	0.8
91	2009	6	27.5	-91.9	4.6	5.3	479.8		0.2	27.1	35.4	834.1	4.5
92	2009	6	27.5	-92.0	5.8	5.7	492.6		0.2	27.7	36.0	772.3	3.2
1	2009	7	27.5	-93.0	0.0	14.9	372.7		0.1	29.7	36.9	835.4	0.0
2	2009	7	27.4	-92.9	1.5	16.7	365.5		0.1	29.8	36.9	739.3	0.0
3	2009	7	27.3	-92.8	2.6	18.8	358.9	6.0	0.1	29.9	36.7	1088.9	0.0
4	2009	7	27.2	-92.7	3.7	20.1	352.8	5.9	0.1	29.9	36.7	1057.6	0.0
5	2009	7	27.1	-92.6	4.8	21.7	347.2	6.2	0.1	30.1	36.8	1309.6	0.0
6	2009	7	27.0	-92.5	5.9	23.5	342.2	5.8	0.1	30.3	36.8	1376.7	0.0
7	2009	7	26.9	-92.4	7.0	23.4	337.6	5.8	0.1	30.6	36.9	1498.2	0.1
8	2009	7	26.8	-92.3	8.1	23.4	333.0	5.7	0.1	30.9	36.8	1869.7	0.2
9	2009	7	26.7	-92.2	9.1	23.6	328.8	5.8	0.1	30.8	36.7	1938.3	0.2
10	2009	7	26.6	-92.1	10.1	23.2	325.2	5.7	0.1	31.5	36.9	1801.1	0.1
11	2009	7	26.5	-92.0	11.1	22.4	322.3	6.0	0.1	31.1	36.8	1826.6	0.0
12	2009	7	26.5	-91.9	12.1	20.7	363.7	5.8	0.1	31.7	36.8	1869.7	0.8
13	2009	7	26.5	-91.7	13.1	18.1	357.0	6.0	0.3	31.1	31.6	2351.0	0.0
14	2009	7	26.5	-91.6	0.0	15.3	350.4	6.0	0.3	29.8	30.7	2138.1	0.0
15	2009	7	26.5	-91.5	1.1	12.5	343.8	5.9	0.3	29.9	32.8	2493.4	9.5
16	2009	7	26.5	-91.3	2.2	9.8	324.1	6.2	0.4	30.3	30.9	2284.8	0.3
17	2009	7	26.5	-91.2	3.2	7.1	311.2	5.9	0.4	30.0	30.9	2165.1	0.0
18	2009	7	26.5	-91.1	4.1	4.7	298.4	5.8	0.4	30.4	31.1	2038.1	1.5
19	2009	7	26.5	-90.9	5.1	2.4	285.7	5.9	0.5	30.7	30.9	2114.9	0.2
20	2009	7	26.5	-90.8	6.0	0.2	272.9	5.8	0.4	31.2	30.5	2200.9	0.5
21	2009	7	26.5	-90.7	7.0	-1.6	260.2	6.0	0.4	31.2	31.5	2777.7	0.0
22	2009	7	26.5	-90.5	8.1	-3.5	247.4	6.0	0.5	31.7	30.0	2726.9	0.0
23	2009	7	26.5	-90.4	9.1	-4.6	234.8	5.8	0.5	33.5	30.1	2881.3	0.0
24	2009	7	26.5	-90.3	10.1	-5.5	222.2	5.7	0.5	32.8	32.0	2950.6	0.0

Station	**Year**	**Month**	**Lat**	**Long**	**HAS (h)**	**SSH (cm)**	**Dist LC (km)**	**DO (mg/L)**	**Chl*a* (mg/m^3)**	**SST (°C)**	**Sal (psu)**	**Depth (m)**	**Sarg (kg)**
25	2009	7	26.5	-90.1	11.1	-6.1	209.7	5.7	0.4	32.9	32.2	2965.8	0.5
26	2009	7	26.5	-90.0	12.1	-5.5	197.3	5.7	0.4	32.0	31.9	2923.8	0.2
27	2009	7	26.5	-89.9	13.1	-5.0	185.1	5.7	0.4	32.3	32.3	2953.9	0.0
28	2009	7	26.5	-89.7	0.1	-3.9	173.0	6.0	0.4	30.5	33.0	2915.9	0.1
29	2009	7	26.5	-89.6	1.2	-2.8	161.1	5.8	0.6	30.2	31.8	2930.6	0.0
30	2009	7	26.5	-89.5	2.2	-1.8	149.4	6.0	0.8	29.6	27.5	2914.5	0.0
31	2009	7	26.5	-89.3	3.3	-1.2	138.0	6.0	0.9	30.4	27.6	2868.0	0.0
32	2009	7	26.5	-89.2	4.3	-0.6	126.9	6.2	0.9	30.7	29.3	2817.8	2.9
33	2009	7	26.5	-89.1	5.3	0.5	115.7	6.0	0.8	31.4	27.2	2800.5	0.0
34	2009	7	26.5	-88.9	6.2	1.7	104.7	6.3	0.7	32.5	28.3	2734.7	0.0
35	2009	7	26.5	-88.8	7.1	3.1	94.4	6.0	0.4	32.5	27.8	2618.0	0.0
36	2009	7	26.5	-88.7	8.0	4.7	84.2	5.9	0.3	33.4	28.9	2561.7	0.0
37	2009	7	26.5	-88.5	8.9	6.4	74.1	5.8	0.1	33.1	28.6	2561.2	0.0
38	2009	7	26.5	-88.4	9.8	8.3	64.1	5.9	0.1	32.4	29.1	2589.3	0.0
39	2009	7	26.5	-88.3	10.7	10.3	55.2	5.9	0.1	32.5	32.2	2633.2	0.0
40	2009	7	26.5	-88.1	11.6	12.9	47.0	5.7	0.1	31.5	36.2	2688.9	4.8
41	2009	7	26.5	-88.0	12.5	17.2	38.9	5.7	0.1	31.6	36.3	2724.5	0.0
42	2009	7	26.5	-87.9	13.3	21.5	31.8	5.6	0.1	31.1	36.3	2771.3	0.0
43	2009	7	26.5	-87.7	1.6	26.2	24.1	5.7	0.1	30.4	36.1	2815.0	0.0
44	2009	7	26.5	-87.6	2.3	31.0	15.2	5.7	0.1	30.5	36.2	2879.1	0.0
45	2009	7	26.5	-87.5	3.2	35.5	5.9	5.7	0.1	30.5	36.2	2919.5	0.0
46	2009	7	26.5	-87.3	4.0	38.9	3.1	5.6	0.1	30.6	36.1	2923.6	0.0
47	2009	7	26.5	-87.2	4.8	42.4	11.7	5.9	0.1	31.0	36.2	2968.9	0.0
48	2009	7	26.5	-87.1	5.6	45.3	20.7	5.6	0.1	31.5	35.3	2989.7	0.9
49	2009	7	26.5	-87.0	6.0	46.6	28.9	5.6	0.1	31.5	36.2	2985.2	0.0
50	2009	7	26.6	-86.9	7.1	44.0	36.9	5.7	0.1	30.9	36.2	2991.4	0.0
51	2009	7	26.8	-86.9	8.2	41.5	44.5	5.9	0.0	30.9	36.2	3049.1	0.0
52	2009	7	26.9	-86.8	9.3	37.8	52.5	5.8	0.1	30.8	35.6	3048.8	0.0
53	2009	7	27.0	-86.7	10.3	33.3	56.5	5.7	0.1	31.3	36.1	3050.3	0.2
54	2009	7	27.2	-86.7	11.4	28.1	49.3	5.8	0.1	30.7	36.1	3069.1	1.5
55	2009	7	27.3	-86.6	12.5	22.5	42.8	5.8	0.4	30.7	34.1	3084.8	0.0
56	2009	7	27.4	-86.5	13.6	17.0	37.4	5.8	0.5	30.7	31.8	3141.4	0.0
57	2009	7	27.4	-86.7	0.9	16.6	31.4	5.9	0.4	30.7	35.3	3089.1	0.5
58	2009	7	27.4	-86.8	2.2	16.3	20.5	5.8	0.5	30.4	33.7	3054.1	0.0
59	2009	7	27.4	-86.9	3.4	13.5	6.6	5.7	0.6	30.9	34.0	3034.6	0.0
60	2009	7	27.4	-87.1	4.6	9.8	7.6	5.8	0.5	30.9	33.8	3019.4	0.0
61	2009	7	27.4	-87.2	5.8	6.1	8.9	5.8	0.3	31.1	31.3	3011.1	0.0
62	2009	7	27.4	-87.3	6.9	2.2	10.6	5.9	0.4	31.1	28.7	2977.6	0.0
63	2009	7	27.4	-87.5	8.0	-1.7	14.7	5.7	0.4	30.5	29.5	2895.4	0.0
64	2009	7	27.3	-87.5	9.2	-1.3	23.7	5.8	0.6	30.8	29.1	2818.2	0.0
65	2009	7	27.2	-87.6	10.4	1.6	32.8	5.9	0.8	31.1	28.7	2844.4	0.0
66	2009	7	27.0	-87.7	11.7	4.5	42.0	5.7	0.6	30.9	30.7	2832.3	0.0
67	2009	7	26.9	-87.7	13.1	8.6	51.6	5.9	0.1	30.7	28.0	2816.9	0.0
74	2009	7	26.9	-88.8	0.0	1.3	45.9	6.3	1.1	29.1	29.9	2279.4	0.0
75	2009	7	27.0	-88.7	1.2	0.3	38.7	5.8	3.2	29.1	31.7	2225.9	0.0
76	2009	7	27.2	-88.7	2.3	-2.0	30.9	5.7	0.7	29.2	31.2	2306.3	0.0
77	2009	7	27.3	-88.6	3.5	-5.1	22.5	5.8	0.2	29.2	31.0	2395.2	0.0
78	2009	7	27.4	-88.5	4.7	-7.2	90.4	5.8	0.1	29.5	31.5	2154.6	0.0
79	2009	7	27.4	-88.7	5.8	-3.8	99.2	5.9	0.2	29.6	29.9	2147.3	0.0
80	2009	7	27.4	-88.8	6.8	-0.4	105.2	5.7	0.2	30.3	30.0	1990.7	0.0
81	2009	7	27.4	-88.9	7.8	2.5	111.9	5.8	0.5	30.6	29.1	1918.0	0.0
82	2009	7	27.4	-89.1	8.7	5.2	118.4	5.6	0.9	30.8	29.4	1797.0	0.0
83	2009	7	27.4	-89.2	9.7	7.5	127.4	5.8	1.2	30.8	29.5	1874.7	0.0
84	2009	7	27.4	-89.3	10.7	8.7	135.9	5.8	1.4	30.6	29.4	1912.5	0.0
85	2009	7	27.4	-89.5	11.7	9.8	144.8	5.8	1.2	30.5	27.6	1990.2	0.0
86	2009	7	27.4	-89.6	12.7	10.1	154.2	5.8	1.1	30.7	27.3	1911.5	0.0
87	2009	7	27.4	-89.7	13.6	10.1	161.7	5.8	1.1	30.5	27.2	1502.7	0.0
88	2009	7	27.4	-89.9	-0.2	10.0	169.5	5.9	1.0	30.3	27.6	1427.3	0.0
89	2009	7	27.4	-90.0	0.8	9.8	177.6	5.7	1.1	30.1	28.3	1212.9	0.0
90	2009	7	27.4	-90.1	1.8	8.7	185.7	5.6	0.9	30.4	31.8	1324.3	0.0
91	2009	7	27.3	-90.3	2.9	7.7	194.1	5.7	0.6	30.1	31.8	1289.6	2.5
92	2009	7	27.2	-90.4	4.0	6.4	203.0	5.7	0.6	30.3	31.5	1389.1	0.1
93	2009	7	27.2	-90.5	5.1	5.3	212.2	5.7	0.6	30.1	32.3	1304.7	0.0
94	2009	7	27.1	-90.7	6.2	4.5	217.1	5.7	0.5	30.2	31.3	1473.5	0.0

Station	Year	Month	Lat	Long	HAS (h)	SSH (cm)	Dist LC (km)	DO (mg/L)	Chl*a* (mg/m^3)	SST (°C)	Sal (psu)	Depth (m)	Sarg (kg)
95	2009	7	27.0	-90.8	7.4	4.2	222.5	5.7	0.6	30.1	31.1	1646.4	0.0
96	2009	7	27.0	-91.1	9.7	6.5	227.9	5.8	0.3	30.2	34.7	1857.7	0.0
97	2009	7	27.0	-91.2	10.2	7.2	234.0	5.5	0.3	30.3	35.0	1720.7	0.0
98	2009	7	27.0	-91.3	11.4	8.9	240.9	5.6	0.4	30.2	36.2	2118.3	0.0
99	2009	7	27.0	-91.5	12.5	10.6	248.1	5.6	0.1	30.2	37.3	1736.3	0.0
100	2009	7	27.0	-91.6	13.5	12.9	276.7	5.5	0.1	30.1	37.2	1664.0	0.0
101	2009	7	27.0	-91.7	-0.2	15.5	282.5		0.2	30.1	37.3	1574.9	0.0
102	2009	7	27.0	-91.9	0.8	17.9	294.3	5.7	0.2	30.1	37.3	1523.0	0.0
103	2009	7	27.0	-92.0	1.9	19.8	306.1	5.6	0.1	30.2	37.3	1445.5	0.1
104	2009	7	27.0	-92.1	2.9	21.8	318.1	5.6	0.1	30.3	37.3	1890.0	0.1
105	2009	7	27.0	-92.3	4.0	22.5	330.2	5.6	0.1	30.3	37.3	1536.7	0.0
106	2009	7	27.0	-92.4	5.0	22.9	342.4	5.6	0.1	30.3	37.3	1547.0	0.5
107	2009	7	27.0	-92.5	6.1	22.9	354.7	5.5	0.1	30.3	37.3	1344.5	1.2
1	2010	6	28.0	-91.0	3.4	9.9	320.7		0.1	29.1	36.2	162.0	0.9
2	2010	6	28.0	-90.9	4.5	10.9	309.7		0.1	29.4	36.5	296.5	0.1
3	2010	6	28.0	-90.7	5.3	11.6	298.9		0.1	29.3	36.6	229.0	0.0
4	2010	6	28.0	-90.6	6.2	12.3	288.3		0.2	29.3	34.7	256.9	0.0
5	2010	6	28.0	-90.5	7.2	12.5	278.0		0.2	29.8	35.6	346.2	0.1
6	2010	6	28.0	-90.3	8.3	11.5	267.7		0.2	29.5	35.9	445.0	0.0
7	2010	6	28.0	-90.2	9.4	10.4	257.6		0.2	30.4	35.4	509.7	0.0
8	2010	6	28.0	-90.1	10.4	8.7	247.8		0.3	30.3	34.5	590.6	0.0
9	2010	6	28.0	-89.9	11.3	6.9	238.2		0.5	30.7	33.5	594.0	0.0
10	2010	6	28.0	-89.8	12.3	5.2	229.0		1.4	30.9	32.6	783.4	0.0
11	2010	6	28.0	-89.7	13.3	4.1	219.8		2.5	31.4	30.1	746.4	0.0
12	2010	6	28.0	-89.5	0.9	3.1	211.1		3.4	30.8	29.5	956.9	0.0
13	2010	6	28.0	-89.4	1.7	2.4	202.9		3.7	30.9	30.0	1232.0	0.0
14	2010	6	28.0	-89.3	2.8	1.9	195.2		3.8	30.4	30.3	1337.5	0.0
15	2010	6	28.0	-89.1	3.8	1.3	188.2		3.2	30.5	32.6	1259.2	0.0
16	2010	6	28.0	-89.0	4.8	0.4	180.5		2.5	31.3	33.6	1305.0	0.0
17	2010	6	28.0	-88.9	5.7	-0.5	172.8		0.6	31.4	34.5	1565.3	0.0
18	2010	6	28.0	-88.7	6.6	-1.2	165.3		0.2	32.0	34.2	1893.4	0.0
19	2010	6	28.0	-88.6	7.5	-1.9	158.6		0.1	31.9	34.3	1896.2	0.1
20	2010	6	28.0	-88.5	8.5	-2.5	152.7		0.2	32.0	34.3	2169.9	0.1
21	2010	6	28.0	-88.3	9.5	-2.4	147.8		0.1	32.3	36.0	2149.0	0.0
22	2010	6	28.0	-88.2	10.3	-2.3	143.9		0.1	32.4	35.8	2305.0	0.7
23	2010	6	28.0	-88.1	11.3	-2.0	140.8		0.1	31.9	36.3	2426.3	0.0
24	2010	6	28.0	-88.0	12.3	-1.9	139.3		0.1	32.1	36.4	2417.7	1.7
25	2010	6	27.0	-88.0	0.8	4.3	32.6		0.1	29.8	37.6	2749.2	0.3
26	2010	6	27.0	-88.1	1.4	2.5	36.4		0.1	29.7	37.2	2726.8	0.6
27	2010	6	27.0	-88.2	2.4	-0.9	44.2		0.1	29.8	37.7	2675.2	0.7
28	2010	6	27.0	-88.3	3.5	-3.8	52.1		0.1	30.0	37.9	2633.5	0.2
29	2010	6	27.0	-88.5	4.7	-6.6	59.0		0.1	30.3	36.4	2520.9	0.3
30	2010	6	27.0	-88.6	5.9	-7.2	66.8		0.1	30.7	34.3	2357.2	1.6
31	2010	6	27.0	-88.7	7.0	-7.2	75.9		0.1	30.7	33.9	2244.3	0.0
32	2010	6	27.0	-88.9	8.2	-6.8	85.3		0.1	30.9	36.8	2183.4	0.0
33	2010	6	27.0	-89.0	9.5	-5.6	95.4		0.1	30.9	37.3	2371.7	0.0
34	2010	6	27.0	-89.1	10.4	-4.4	105.8		0.1	30.7	37.4	2433.9	0.1
35	2010	6	27.0	-89.3	11.4	-3.4	116.6		0.1	30.4	37.5	2501.2	0.1
36	2010	6	27.0	-89.4	12.5	-2.6	127.7		0.1	30.8	37.4	2548.9	0.0
37	2010	6	27.0	-89.5	0.3	-1.8	138.8		0.1	29.9	37.1	2476.0	1.4
38	2010	6	27.0	-89.7	1.3	-0.9	150.0		0.1	29.7	37.0	2366.1	0.2
39	2010	6	27.0	-89.8	2.3	0.0	161.2		0.1	29.7	37.3	2413.1	0.3
40	2010	6	27.0	-89.9	3.3	1.0	172.5		0.1	30.3	37.3	2360.9	0.9
41	2010	6	27.0	-90.1	4.1	2.0	183.7		0.1	30.3	37.2	2423.4	0.2
42	2010	6	27.0	-90.2	5.1	2.8	195.2		0.1	30.6	37.2	2353.8	0.0
43	2010	6	27.0	-90.3	5.9	3.0	206.8		0.1	31.2	37.2	2016.8	0.0
44	2010	6	27.0	-90.5	7.3	3.2	218.6		0.1	31.0	37.2	1958.9	0.3
45	2010	6	27.0	-90.6	7.6	2.5	230.6		0.1	30.9	37.5	1557.7	0.0
46	2010	6	27.0	-90.7	8.5	1.7	242.7		0.1	30.8	37.5	1628.0	0.2
47	2010	6	27.0	-90.9	9.4	0.7	254.9		0.1	30.7	37.5	1701.1	0.2
48	2010	6	27.0	-91.0	10.2	-0.7	267.3		0.1	30.8	37.6	1692.4	0.2

Station	Year	Month	Lat	Long	HAS (h)	SSH (cm)	Dist LC (km)	DO (mg/L)	Chl*a* (mg/m^3)	SST (°C)	Sal (psu)	Depth (m)	Sarg (kg)
1	2010	7	28.0	-91.0	3.0	7.4	325.1	6.3	0.1	29.5	35.1	162.0	0.0
2	2010	7	28.0	-90.9	4.0	7.9	316.4	6.2	0.2	29.6	34.8	296.5	0.0
3	2010	7	28.0	-90.7	5.0	8.6	308.0	6.3	0.2	30.0	35.0	229.0	0.0
4	2010	7	28.0	-90.6	6.0	9.3	300.0	6.2	0.2	29.9	35.0	256.9	1.0
5	2010	7	28.0	-90.5	7.1	10.0	292.4	6.2	0.1	30.1	34.4	346.2	0.0
6	2010	7	28.0	-90.3	8.1	10.5	285.1	6.3	0.2	29.9	34.6	445.0	0.0
7	2010	7	28.0	-90.2	9.1	10.9	278.3	6.4	0.1	30.2	34.8	509.7	0.0
8	2010	7	28.0	-90.1	10.1	11.0	272.0	6.2	0.1	30.0	35.6	590.6	0.0
9	2010	7	28.0	-89.9	11.1	11.0	265.8	6.2	0.1	30.3	34.7	594.0	0.0
10	2010	7	28.0	-89.8	12.3	10.8	258.6	6.5	0.1	30.1	35.3	783.4	0.0
11	2010	7	28.0	-89.7	13.4	10.0	251.0	6.1	0.1	30.0	35.4	746.4	0.0
12	2010	7	28.0	-89.5	12.8	9.2	243.9	6.2	0.1	29.7	35.4	956.9	0.0
13	2010	7	28.0	-89.4	1.9	7.9	237.3	6.2	0.1	29.9	35.7	1232.0	0.0
14	2010	7	28.0	-89.3	2.9	6.4	231.0	6.1	0.1	30.1	35.9	1337.5	0.0
15	2010	7	28.0	-89.1	3.8	4.9	225.1	6.2	0.1	30.2	36.1	1259.2	0.0
16	2010	7	28.0	-89.0	4.9	3.5	219.8	6.1	0.0	30.1	36.2	1305.0	1.4
17	2010	7	28.0	-88.9	5.8	2.1	215.1	6.2	0.1	30.2	36.0	1565.3	0.0
18	2010	7	28.0	-88.7	6.7	1.4	211.2	6.1	0.1	30.3	36.1	1893.4	0.0
19	2010	7	28.0	-88.6	7.7	0.9	208.1	6.0	0.1	30.4	36.2	1896.2	0.0
20	2010	7	28.0	-88.5	8.8	0.7	205.8	6.0	0.1	30.5	36.3	2169.9	0.0
21	2010	7	28.0	-88.3	9.8	1.0	203.9	5.7	0.1	30.5	36.1	2149.0	0.0
22	2010	7	28.0	-88.2	10.9	1.4	201.8	6.0	0.1	30.4	36.2	2305.0	0.0
23	2010	7	28.0	-88.1	11.9	1.5	200.3	6.0	0.1	30.2	36.3	2426.3	0.0
24	2010	7	28.0	-88.0	12.6	1.5	199.6	5.6	0.1	30.2	36.1	2417.7	0.0
25	2010	7	27.0	-88.0	0.6	-4.3	89.2	6.2	0.1	29.6	36.2	2749.2	1.1
26	2010	7	27.0	-88.1	1.3	-3.9	90.0	6.2	0.1	29.6	36.1	2726.8	0.0
27	2010	7	27.0	-88.2	2.2	-3.6	92.1	6.2	0.0	29.9	36.4	2675.2	2.0
28	2010	7	27.0	-88.3	3.2	-4.1	94.1	6.4	0.0	29.9		2633.5	1.9
29	2010	7	27.0	-88.5	4.2	-4.6	97.3	6.5	0.0	29.8		2520.9	1.5
30	2010	7	27.0	-88.6	5.0	-5.1	102.2	6.3	0.1	29.8		2357.2	0.7
31	2010	7	27.0	-88.7	5.9	-5.5	108.2	6.4	0.1	30.0		2244.3	0.0
32	2010	7	27.0	-88.9	6.8	-5.6	114.8	6.4	0.1	30.1	38.1	2183.4	0.0
33	2010	7	27.0	-89.0	7.7	-4.9	122.3	6.4	0.1	30.1	38.0	2371.7	0.0
34	2010	7	27.0	-89.1	8.6	-4.3	129.8	6.4	0.0	30.1	37.2	2433.9	1.1
35	2010	7	27.0	-89.3	9.6	-3.0	136.8	6.3	0.0	30.1	37.5	2501.2	3.3
36	2010	7	27.0	-89.4	10.5	-1.4	143.2	6.2	0.1	30.1	37.8	2548.9	0.8
37	2010	7	27.0	-89.5	11.4	0.4	149.3	6.3	0.1	30.0	37.3	2476.0	0.3
38	2010	7	27.0	-89.7	1.4	2.8	156.2	6.3	0.1	29.5	37.6	2366.1	0.3
39	2010	7	27.0	-89.8	2.5	5.2	163.8	6.1	0.1	29.6	38.1	2413.1	0.0
40	2010	7	27.0	-89.9	4.1	7.3	172.2	6.1	0.1	29.3	37.9	2360.9	2.8
41	2010	7	27.0	-90.1	6.9	9.2	181.1	6.2	0.1	28.8	37.1	2423.4	4.4
42	2010	7	27.0	-90.2	7.8	10.7	190.6	6.1	0.0	29.1	38.2	2353.8	0.0
43	2010	7	27.0	-90.3	8.7	10.5	200.5	6.0	0.0	28.9	37.6	2016.8	0.7
44	2010	7	27.0	-90.5	9.7	10.4	210.6	6.1	0.1	28.7	37.7	1958.9	0.0
45	2010	7	27.0	-90.6	10.8	9.3	221.1	6.1	0.1	29.0	37.9	1557.7	0.0
46	2010	7	27.0	-90.7	11.8	7.9	231.9	6.1	0.1	29.1	37.9	1628.0	0.0
47	2010	7	27.0	-90.9	13.0	6.7	242.9	6.0	0.1	29.3	37.8	1701.1	0.0
48	2010	7	27.0	-91.0	14.1	6.1	254.1	6.0	0.1	29.2	37.6	1692.4	0.0