BIODIVERSITY OF PELAGIC ICHTHYOPLANKTON IN THE NORTHERN GULF OF MEXICO

A Thesis

by

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ABSTRACT

Studies on larvae and juvenile fishes during the first few months of life are limited for many pelagic species despite the fact that biological data on these stages are needed to better assess and monitor recruitment variability and population-level processes. An increase in biological diversity in marine environments enhances ecosystem services and stability, increasing the overall health of the ecosystem. The aim of this study was to describe larval fish assemblages in pelagic waters of the northern Gulf of Mexico (NGoM) and identify environmental conditions associated with areas of increased taxonomic richness (T_F) and Shannon diversity (H') (i.e., hotspots). Summer ichthyoplankton surveys were conducted in the NGoM in June and July 2015 and 2016 using neuston net (0-1m) and oblique bongo net (0-100m) tows conducted during the daytime (0700 – 1800 h). Overall, 17,091 fish larvae (N= 9,551 in 2015 and N= 7,540 in 2016) comprised of 99 families were collected over two years of sampling in the NGoM. The catch composition in the upper 1 m of the water column from neuston tows (i.e., surface layer sample) was relatively similar to the catch composition in the upper 100-120 m of the water column from oblique bongo tows (i.e., mixed layer sample), with carangids [jacks], scombrids [mackerels, tunas] and exocoetids [flyingfishes]) being numerically dominant; however, deep pelagic species (e.g. myctophids [lanternfishes], gonostomatids [bristlemouths], and sternoptychids [marine hatchetfishes]) were almost exclusively present in the mixed layer samples. Generalized additive models were used to evaluate the effect of oceanographic conditions on the abundance, T_F, and H'. Several environmental variables (salinity, sea surface height) were found to be influential in

explaining areas of high T_F and H'. Higher larval abundances, T_F, and H' were found in water masses with lower salinity and lower sea surface height, which generally occurred along the northern stations sampled. This study highlights the NGoM as important habitat for larval fishes and suggests that oceanographic conditions are influential in determining assemblage structure in the region.

DEDICATION

To my parents and brother, although they know nothing about fisheries or ecology, their continued support made this possible. I would also like to dedicate this thesis to Rain, my dog, for always cheering me up.

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All other work conducted for the thesis (or) dissertation was completed by the student independently.

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NOMENCLATURE

LC	Loop Current
MARS	Mississippi-Atchafalaya River System
NGoM	Northern Gulf of Mexico
GoM	Gulf of Mexico
SSH	Sea surface height
SST	Sea surface temperature
DO	Dissolved oxygen
SAL	Salinity

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CHAPTER I

INTRODUCTION

Pelagic fishes play an important role in open ocean ecosystems, and changes in their abundances can impact community structure and ecosystem stability (Cury 2000; Myers 2003; Myers and Worm 2003). Declines in the abundances of pelagic fishes are often attributed to overfishing (Ward and Myers 2005) but other types of anthropogenic disturbance (e.g., habitat loss or degradation) and climate change also influence their distribution and abundance (Lehodey et al. 2006; Rijnsdorp et al. 2009). New management approaches that focus on ecosystem-level processes rather than single stocks or species are necessary to effectively mitigate past overexploitation and better understand the drivers of community change in pelagic ecosystems (Pikitch et al. 2004). Identifying biodiversity hotspots is essential to understanding an ecosystem as a whole; taxonomic richness is known to enhance ecosystem services and stability, increasing the overall health and resilience of marine ecosystems (Worm et al. 2006).

The pelagic environment in particular provides unique challenges for locating areas of high diversity as they are constantly in flux and are highly dynamic (Marcheese 2015). As a result, management of pelagic ecosystems requires a multifaceted approach using both ecology and oceanography (Game et al. 2009; Lewison et al. 2015). Despite increased awareness regarding the importance of biodiversity, our understanding of taxonomic diversity in pelagic communities is limited (Mittermeier et al. 2011). Identifying areas of high taxonomic richness and diversity (i.e., hotspots) and the oceanographic conditions that create or maintain them are needed in large marine ecosystems because species rich ecosystems are more stable and less likely to collapse compared to species-poor ecosystems (Bakun 2006; Worm et al. 2006). Increased diversity also has a positive impact on ecosystem services such as higher fisheries yields and enhanced stabilization of communities and ecosystems against regime shifts (Gamfeldt et al. 2014; Rocha et al. 2014). The level of functioning achieved in species-rich marine ecosystems is generally greater than that of species-poor ecosystems, and thus it is crucial to identify biodiversity hotspots and the oceanographic processes driving them to better manage pelagic ecosystems (Gamfeldt et al. 2014).

While the distributions and abundances of adult fishes are fairly well studied, our knowledge of early life history stages of fishes is lacking. Moreover, community level assessments of the larval fish assemblage in the NGoM are remarkably limited, even though this region is an important spawning and nursery areas for a wide range of pelagic taxa (e.g., billfishes, flyingfishes, jacks, tunas). In order to better understand these larval assemblages, determining the influence of environmental drivers on the spatial dynamics of in the NGoM is fundamental for assessing population status. Further, these studies on larval assemblages is necessary to asses changes in the distribution, abundance, and assemblages of ichthyoplankton as they may be indicative of fluctuating environmental conditions, including anthropogenic disturbances such as the Deepwater Horizon oil spill (Kitchens and Rooker 2014).

Here, I quantified the abundance, taxonomic richness (T_F) and Shannon diversity (H') for larval fishes at the family level in shelf and slope waters of the northern Gulf of Mexico (NGoM). The central aim of this study was to identify areas and oceanographic conditions that support increased T_F and H' of larval fishes. In conjunction with epipelagic- mesopelagic coupling, the relative importance of oceanographic conditions on the abundance and diversity of fish larvae was examined using habitat-modeling approaches. In particular, I was interested in determining the influence of the two primary drivers of nutrient availability and primary production—cyclonic eddies and freshwater inflow from Mississippi-Atchafalaya River System (MARS) on the larval fish community in the epipelagic zone (defined here as upper 100 m of the water column) in the NGoM because both are assumed to affect the growth, survival, and recruitment success of pelagic fishes (Lindo-Atichati et al. 2012; Rooker et al. 2013). My working hypothesis is that biodiversity hotspots for larval fishes (high T_F and H') in the NGoM occur primarily in convergence zones (frontal features) identified by areas of lower salinity and cyclonic features (cold core eddies) identified by lower sea surface height because these areas are often associated with upwelling, increased primary productivity, and higher concentrations of planktonic consumers that serve as prey for larval fishes. In addition, I hypothesize larvae of numerically dominant species that are common to the epipelagic zone as adults (e.g., billfishes, flyingfishes, jacks, tunas) will be the primary constituents of the larval fish assemblage in the surface or upper 1 m of the water column, while larvae of numerically dominant species that are common to the mesopelagic zone as adults (e.g., lanternfish, marine hatchetfishs, bristlemouths) will be well represented for the larval fish assemblage in the mixed layer or upper 100 m of the water column. I recognize that vertical migrating species (e.g. lanternfishs, marine hatchetfishs, bristlemouths) are known to move into the epipelagic zone at night but assume that my daytime sampling regime will still include larval stages of these mesopelagic families as they have not yet begun to migrate, therefore may be important determinants of T_F and *H'* for the epipelagic larval fish assemblage.

CHAPTER II

BIODIVERSITY OF PELAGIC ICHTHYOPLANKTON IN THE NORTHERN GULF OF MEXICO

Introduction

Research on the early life stages of pelagic fishes is important because it can provide information on spawning locations, spawning stock biomass, and recruitment variability (Houde 2002). Unfortunately, studies on larvae and juvenile fishes during the first few months of life are limited or nonexistent for many pelagic species despite the fact that biological data on these stages is needed to better assess and monitor recruitment variability and population-level processes. Temporal and spatial trends in the distribution and abundance of fish larvae can be used to identify environmental factors that affect early life survival (Nonaka et al. 2000). Moreover, changes in the distribution, abundance, and assemblage composition can also be indicative of changing environmental conditions (Hernandez Jr et al. 2010; Carassou 2012), including anthropogenic disturbances such as the Deepwater Horizon oil spill (Kitchens and Rooker 2014; Rooker et al. 2013). To date, research on the early life ecology of pelagic fishes in the NGoM and most other regions of the Atlantic Ocean is limited, and such information is needed to fill in gaps about factors that regulate their distribution, abundance, and population dynamics (Richardson 2008).

As a model system, the NGoM offers many advantages for evaluating the diversity and community structure of larval fish assemblages. Most notably, this region is characterized by high overall productivity due to nutrient discharges from the MARS

(Dagg and Breed 2003), which supports primary and secondary production and high fishery yields (Browder 1993). Surrounding the MARS plume, larval fish densities may reach up to 20 times higher than reported for other areas of the GoM (Grimes and Finucane 1991; Richards et al. 1993) along with higher than average densities of larval fishes that are found within plume waters (Giovani et al. 1989; Grimes and Finucane 1991). In addition, the Loop Current is a large mesoscale feature of the NGoM that can concentrate fish eggs and larvae through divergent (cyclonic) and convergent (anticyclonic) features (Richards 1993; Shulzitski et al. 2015). This feature is influential in determining the spatial distribution of ichthyoplankton (Karnauskas et al. 2013), and a higher northern intrusion of the Loop Current has been shown to be associated with a greater abundance of fish larvae in the NGoM (Lindo-Atichati 2012). In addition, the Loop Current frequently sheds eddies that help to bring up nutrient rich waters and can increase larvae abundances (Oey et al. 2003). Specifically, cold core (cyclonic eddies) and areas of confluence between eddies enhance production through upwelling, leading to increased foraging opportunities for fish larvae (Ross 2010). As a result, these area are assumed to serve as critical nursery habitat for several taxa of pelagic fishes (Richardson et al. 2010).

The aim of the proposed research is to assess the value of the NGoM as early life habitat of pelagic fishes, with a special emphasis on identifying locations and environmental conditions that support larval fish assemblages with high taxonomic richness (T_F) and Shannon diversity (H'). Identifying areas of high biodiversity is crucial as species-rich ecosystems are known to have increased rates of recovery and reversibility following detrimental environmental changes (Palumbi et al. 2008). When determining biodiversity of the pelagic environment, it is well recognized that mesopelagic fauna (depth range: 200 to 1,000 m), both invertebrates and fishes, commonly frequent the epipelagic zone (Richards 1993). In response, deep-pelagic fish taxa are likely important determinants of T_F and *H'* in the epipelagic zone, and thus this study will incorporate these taxa. In addition to examining the influence of mesopelagic larvae, I will also examine the influence of oceanographic conditions on T_F and *H'*. The Loop Current intrusion or freshwater inflow from the MARS along with associated biotic (invertebrate biomass, *Sargassum* biomass) and abiotic (salinity, sea surface temperature, dissolved oxygen, sea surface height) factors will be investigated to fully determine their influence on the distribution and abundances of pelagic fish larvae. The research will provide important baseline data on fish larvae common to the epipelagic zone and help elucidate the physicochemical factors that promote biodiversity, which will assist in identifying high priority areas (biodiversity hotspots) for conservation.

Methods

Sample Design

Ichthyoplankton surveys were conducted in June and July of 2015 and 2016 in a sampling corridor that ranged from 26.5 - 29.0°N and 88.0 - 93.0°W. The sampling corridor contained 48 stations located approximately 15-km apart (Figure 1) and represents an area sampled continuously for the past decade to assess recruitment variability of pelagic fish larvae, particularly billfishes, dolphinfishes, and tunas (Cornic et al. 2018; Rooker et al. 2013; Randall et al. 2015). This area was sampled as it interacts with multiple mesoscale features throughout the year, including the Loop Current and MARS, and it covers stations located on the shelf and slope of the NGoM. This corridor is also shown to contain a high spawning stock biomass of pelagic fishes (Rooker et al. 2007, 2012). Near-surface sampling was conducted with a 1x2 m neuston net rigged with a 1200µm mesh. Neuston net tows, referred to as surface samples, were conducted in the top 1 m of the water column at each station and each tow was approximately 10 min in duration. In addition, oblique bongo net tows, referred to as mixed layer samples, were conducted from between 100-120 m to the surface at each station; paired bongo nets were rigged with 333µm mesh and 500µm mesh nets. Although different mesh sizes were used to sample the surface and mixed layers, catch composition is known to be similar between the mesh sizes and gears (Kitchens and Rooker 2014; Randall et al. 2015), allowing for general comparisons of assemblage structure and diversity between the two distinct regions of the water column. All tows were performed at a vessel speed of approximately 2.5 knots, and the volume of water sampled during each tow was determined by equipping each net with General Oceanics flowmeters (Model 2030R, Miami, FL). Once nets were pulled on board, *Sargassum* collected in the nets was separated, weighed, and recorded. Samples from neuston and bongo tows were preserved in a 100% ethanol solution for transport back to the lab.

Sea surface temperature (SST, °C), salinity, and dissolved oxygen (mg/L) were measured at each station using a Sonde 6920 Environmental Monitoring System (YSI Inc.). Other environmental parameters at each station were determined using remotely sensed data accessed through Copernicus Marine Environmental Monitoring Service (http://marine.copernicus.eu/) and the marine geospatial ecology toolbox (version 0.8a44) in ArcGIS (version 10.0). Sea surface height (SSH, cm) data were calculated weekly at a resolution of 1/4 degree using satellite altimetry measurements (GLOBAL_ANALYSIS_PHYS_001_020) from Copernicus (http://marine.copernicus.eu/services-portfolio/access-to-products/). Distance to the Loop Current was estimated by measuring the linear distance from the edge of the feature, based on the 20-cm SSH contour following Randall et al. (2015) using the Spatial Analyst toolbox in ArcGIS. Water depth information for the NGoM was accessed from NOAA National Geophysical Data Center using the GEODAS US Coastal Relief Model Grid with a grid cell size of 6 (http://www.ngdc.noaa.gov/mgg/gdas/gd_designagrid.html).

Samples from each station were sorted out under Leica MZ stereomicroscope in the laboratory and fish larvae were isolated and preserved in 70% ethanol solution. All fish larvae were identified to family level through visual identification following keys in Richards (2006). Identification to the family level was used for biodiversity estimates because of the considerable time, effort, and funds required to conduct genetic assays on all genera/species from the diverse range of families collected (n=99). The use of higher taxonomic categories such as families for assessing trends in biodiversity is common (Gaston et al. 1995; Terlizzi et al. 2009) and more suitable for this type of assessment performed here.

Characteristics used in identifying fish larvae to family were body shape, head shape, mouth shape, myomere count, and pigmentation. Although my thesis addressed family level differences in abundance, T_F and H', genetic approaches were often used to identify individuals to the species level for several families collected, which provided confirmation of assignments to the family level for several taxa in the 2015 and 2016 samples. Issues encountered when sorting that led to unknown sample identification were damaged fishes or individuals too small to accurately identify. Damaged samples had either a significant amount of tissue missing or only part of the body was found. Individuals with a total length of less than 2 mm standard length were too small to accurately identify in some cases.

Data Analysis

Composition of the larval fish assemblage was assessed using two diversity measures and both were based on identification to family as the lowest possible taxon. Species richness (S) is commonly used to represent total number of species per sample but here we estimated taxonomic richness (T_F) as the number of families present in each sample.

Similarly, Shannon diversity (H') was based on diversity at the family level following the equation

$$H' = \frac{n \log n - \sum fi \log fi}{n}$$

where n is the total number of individuals and f_i is the number of individuals for each family.

Diversity measures T_F and H' were used for statistical testing, with each station consisting of a surface sample (0-1 m) collected with a neuston net and a mixed layer sample (0-100+ m) collected with paired bongo nets. A two-way analysis of variance (ANOVA) was used to examine effects of location and date with separate models developed for both T_F and H'. Two-way ANOVAs were also used to examine inter- and intra-annual differences in both T_F and H' for surface, mixed layer, and combined samples. Tukey's honestly significant difference (HSD) test was used to test for *post-hoc* differences among means. All statistical analyses were run using R (version 3.4.2) with alpha set at 0.05.

Generalized additive models (GAMs) were used to examine the influence of environmental factors and month on T_F and H'. Explanatory variables used in GAMs were month, year, sea surface temperature (SST), sea surface height (SSH), distance to Loop Current boundary, salinity (SAL), dissolved oxygen (DO), depth, invertebrate biomass, and *Sargassum* biomass. GAMs are extensions of general linear models and allow fixed effects to be modeled by using a smoothing function (Guisan et al. 2002). General GAM construction follows the equation:

$$E\,[y] = g^{-1}\left(\beta_O + \sum_k S_k\,(x_k)\right)$$

Where $E[y]$ equals the expected values of the response variable (T_F or H'), g represents the link function, β_0 equals the intercept, x represents one of k explanatory variables, and S_k represents the smoothing function of each respective explanatory variable. In addition to environmental data collected at each station described earlier, remotely sensed data (sea surface height, distance to Loop Current) were included as explanatory variables in the GAMs. A manual procedure was used to identify influential variables on T_F and H', and the final model for each diversity measure was based on minimizing the Akaike information criterion (AIC). Collinearity among variables was examined using Spearman's test and variance inflation factor (VIF), ($\rho > 0.60$ and VIF > 5). A manual backward stepwise selection process was used to remove explanatory variables that did not influence T_F or H' based models. Stepwise selection ended when all remaining variables were significant ($p > 0.05$) or the AIC value started to increase when non-significant variables were removed. Percent deviance explained (DE) was calculated for each model to examine overall fit. Once the final model was selected, each variable was removed individually to see the response in ΔAIC and ΔDE in order to assess the relative importance of each predictor variable following Rooker et al. (2012).

Results

Assemblage Composition

A total of 17,091 total larvae (N= 9,551 in 2015 and N= 7,540 in 2016) comprised of 99 families were collected over two years of sampling in the NGoM (Table 1). The top five families by catch percent in the 2015 surface samples (0-1 m) from neuston tows were carangids (jacks) 31.0%, clupeids (herrings) 18.5%, exocoetids (flyingfishes) 16.3%, scombrids (mackerels and tunas) 9.9% and istiophorids (billfishes) 3.0%. In the 2015 mixed layer samples (0-100+ m) collected with bongo tows, the top five families were myctophids (lanternfishes) 16.3%, scombrids 12.9%, carangids 10.9%, gonostomatids (bristlemouths) 7.6%, and gobiids (gobies) 6.6%. The top five families by catch percent in 2016 surface samples were carangids 38.3%, exocoetids 20.6%, scombrids 18.7%, istiophorids 3.6%, and hermiramphids (halfbeaks) 2.5%. Primary families collected in the mixed layer from 2016 consisted of myctophidae 25.6%, carangids 9.1%, scombrids 8.7%, gonostomatids 8.1%, and bregmacerotids (codlets) 7.7%. A small percentage of the fish larvae collected could not be positively identified because of damage or the larvae were too small; 6.5% of the total catch in 2015 and 6.2% of the total catch in 2016.

Seasonal variation (Table 2) was also observed in the samples (Figures 2 and 3). In surface samples from neuston tows, exocoetids accounted for the largest percentage of the total catch in June of 2015 (44.3%) and 2016 (30.9%) compared to July 2015 (6.6%) and 2016 (9.6%), while carangids were most common in surface samples in July of 2015 (37.5%) and 2016 (49.7%) as compared to June 2015 (12.1%) and 2016 (27.6%). July of 2015 had a high composition of clupeids (24.86%) compared in June 2015 (0.1%) and June and July of 2016 (2.6% and 0.3% respectively). Myctophids dominated the mixed layer for all seasons and years sampled (22.6% in June 2015, 31.63% in June 2016, and 17.7% in July 2016) except July of 2015 (10.0%), when scombrids were the dominant taxa in the mixed layer (17.9%). Scombrids had a high presence in other years and months sampled (8.0 in June 2015, 6.3% in June 2016, and 11.9% in July 2016). Carangids were consistently in the top 3 families most frequently caught across all years, months, and net types (9.6% and 12.2% in June and July 2015, 6.8% and 12.1% in June and July 2016).

Of the 99 families collected, the frequency of occurrence for 44 families was greater than 10% frequency in either surface or mixed layers for 2015 or 2016 (Table 1). In surface samples from neuston tows, exoceotids, carangids, scombrids, and hemiramphids were relatively common, with percent frequency of occurrence ranging between 1.16% and 95.83% (Table 1). In 2015, carangids, mullids (goatfishes), cynoglossids (tonguefishes), monacanthids (filefishes), and antennariids (frogfishes) had the highest frequency of occurrence in the surface samples, while the 2016 surface samples had a much higher percent frequency of occurrence of istiophorids and nomeids (driftfishes). In mixed-layer samples, carangids bregmacerotids, gobiids, lutjanids (snappers), and myctophids had the highest percent frequency of occurrence in both years; however, percent frequency of occurrence in 2015 was markedly higher nomeids and sphyraenids (barracudas), while scombrids and sternoptychids (marine hatchetfishes) were higher in 2016.

Taxonomic Richness and Diversity

Taxonomic richness (T_F) in surface samples varied significantly between the two years surveyed (ANOVA, F = 14.681, p < 0.001), with mean T_F per station being significantly higher in 2015 (6.34 ± 2.76) than 2016 (4.62 ± 3.24) (Figure 4). Mean T_F

per station was statistically similar between June (5.91 ± 2.59) and July (5.20 ± 3.50) surveys (ANOVA, F = 2.007, p > 0.05). In the mixed layer, T_F varied significantly between the two years surveyed (ANOVA, F = 6.521 p < 0.01), with mean T_F per station being significantly higher in 2015 (12.36 ± 4.56) than 2016 (10.66 ± 4.73). Mean T_F per station was significantly higher in June (12.90 ± 4.18) than July (10.36 ± 4.85) surveys (ANOVA, F = 13.361, p > 0.001).

Shannon diversity (*H'*) in surface samples (Figure 4) was significantly different between years (ANOVA, F = 40.092, p < 0.001), with mean *H'* per station being higher in 2015 (1.35 ± 0.43) than 2016 (1.21 ± 0.63). Mean *H'* was significantly different between months as well (ANOVA, F = 8.925, p < 0.01), with June (1.26 ± 0.41) being higher than July (1.03 ± 0.63). In the mixed layer, *H'* (Figure 4) varied significantly between the two years surveyed (ANOVA, F = 17.703, p < 0.001), with 2015 (1.99 ± 0.35) being higher than 2016 (1.74 ± 0.45). *H'* was also statistically different between the two months surveyed (ANOVA, F = 4.105, p < 0.05) with June (1.95 ± 0.33) being higher than July (1.81 ± 0.48) in the mixed layer.

Both T_F and *H'* varied spatially in the NGoM with the most pronounced horizontal trend between the north and south sampling transects and in areas impacted by the Mississippi River plume (Figures 5 and 6) where salinity was lower (Figure 7). In general, mean T_F and *H'* was higher along the northern transect across all months and years sampled (Figures 8, 9, and 10). In both 2015 and 2016, the northern transect had higher mean T_F (1.77 and 1.43) and mean *H'* (10.50 and 9.05), compared to T_F (1.59 and 1.23) and *H'* (8.17 and 6.35) for the southern transect. Marked differences were observed in both measures between collections from the surface and mixed layer (Figure 4). In 2015 and 2016, mean T_F (12.36 and 10.88) and *H'* (1.99 and 1.76) were higher in the mixed layer compared to mean T_F (1.36 and 0.92) and *H'* (6.34 and 4.75) from surface samples, which is not surprising given that oblique bongo tows in the mixed layer target are much broader vertical zone of the water column. In 2015, areas of high T_F were associated with the Loop Current boundary (Figure 8). June and July of 2015 had the highest northern intrusion of the Loop Current, while the 2016 July Loop Current had already detached and was a separate feature. In 2015, areas of high T_F and *H'* were located near the Loop Current boundary.

Fish-Habitat Modeling

Final T_F –based (AIC = 835.0, DE = 37.8%) and *H'*-based (AIC = 224.5 DE = 40.9%) GAMs for surface layer samples from neuston tows included all environmental variables tested: sea surface temperature, sea surface height, salinity, dissolved oxygen, invertebrate biomass, distance to Loop Current, and *Sargassum* biomass (Table 3). Based on ΔAIC and ΔDE (%), salinity (ΔAIC = 13.0, ΔDE = 5.0%), *Sargasum* biomass (ΔAIC = 4.6, ΔDE = 4.1%), and invertebrate biomass (ΔAIC = 8.2, ΔDE = 3.7%) were the most influential explanatory variables in the T_F-based GAM. Dissolved oxygen (ΔAIC = 21.2, ΔDE = 7.8%) was again influential in the *H'*-based GAM along with sea surface temperature (ΔAIC = 5.8, ΔDE = 4.1%) and sea surface height (ΔAIC = 5.0, ΔDE = 2.3%), albeit to a lesser degree. Responses plots from GAMs indicated that T_F and *H'* for fish larvae in the surface layer was higher at high sea surface temperatures (>

28°C), lower sea surface heights (0.3- 0.5m), lower salinity, higher invertebrate biomass, farther from the Loop Current, and at lower *Sargassum* biomass (Figures 11 and12).

Similar to models based on surface layer samples, final T_F- (AIC = 995.9, DE = 41.8%) and *H'* - (AIC = 131.6 DE = 42.6%) based GAMs based mixed layer samples from bongo tows included all environmental variables tested (Table 4). Based on ΔAIC and ΔDE (%), salinity (ΔAIC = 12.8, ΔDE = 3.5%), invertebrate biomass (ΔAIC = 10.5, ΔDE = 2.4%), and sea surface temperature (ΔAIC = 6.2, ΔDE = 2.1%) were the most influential explanatory variables in the T_F-based GAM. Sea surface temperature (ΔAIC = 15.8, ΔDE = 6.3%) in the *H'*-based GAM along with sea surface height (ΔAIC = 12.3, ΔDE = 6.1%) and invertebrate biomass (ΔAIC = 4.4, ΔDE = 2.0%) were the most influential variables (Table 4). Responses plots from GAMs indicated that T_F and *H'* for fish larvae in the mixed layer were higher at sea surface temperatures above 28°C, lower sea surface heights (0.3- 0.5m), lower salinity, higher invertebrate biomass, and farther from the Loop Current (Figures 13 and 14).

Discussion

Across all surveys, 99 families of fishes were collected with 29 families comprising at least one percent of the catch at a station during one of the months and years sampled. Larvae of epipelagic and mesopelagic species were collected throughout our sampling corridor in both surface and mixed layer samples. Common epipelagic fishes (e.g. carangids, exocoetids, and scombrids) accounted for almost half of the fish assemblage in surface waters. Observed mean densities in the upper 1 m of the water column for carangids (9.9 larvae $1000m^{-3}$), exocoetids (5.2 larvae $1000m^{-3}$), and scombrids (3.8 larvae $1000m^{-3}$) were markedly higher than any mesopelagic taxa collected (e.g., myctophids 0.1 larvae $1000m^{-3}$). In contrast, mesopelagic fishes, most notably myctophids, bregmacerotids, and gonostomatids, dominated the mixed layer sample, with myctophids alone accounting for 20.92 % of the larval fish assemblage for the upper 100 m of the water column and present at high densities (43.27 larvae $1000m^{3}$). Comparisons with other studies are limited because the majority of surveys using comparable sampling gears focused on specific taxa rather than the entire ichthyoplankton assemblage (e.g. Kitchens and Rooker 2014; Randall et al. 2015; Rooker et al. 2013). However, an earlier study by Richards et al. (1993) did characterize the entire ichthyoplankton assemblage in the NGoM with similar results using bongo net tows to 200 m and overall taxonomic richness at the family level (n = 100). They also reported that myctophids, carangids, and gonostomatids were in the top five most commonly collected taxa, again indicating that larvae of mesopelagic fishes were relatively common in the mixed layer.

Mesopelagic fish larvae, particularly myctophids, bregmacerotids, and gonostomatids, were numerically dominant in our daytime sampling of the upper 100 m of the water column. At night, these taxa are known to migrate from the mesopelagic zone to the epipelagic zone (D'Elia et al. 2016); however, their presence in the upper 100 m during the day suggests that the early life stages remain in the epipelagic zone and have not begun to under go vertical migration (Moku et al. 2003). Several midwater taxa, including species within these three families, hatch in the epipelagic zone and begin migration as they transition from larvae to juveniles (Watanane et al. 2002). Given that most of the individuals collected in our surveys from these two families were relatively small (< 5 mm SL), many specimens in our collections appear to have been recently hatched larvae, which may account for the high numbers of larvae from both families in collections from the upper 100 m of the water column.

Taxonomic richness (T_F) and Shannon diversity (*H'*) varied across my sampling corridor, with high diversity measures generally occurring along the northern transect and in both samples from the surface and mixed layer. It is possible that T_F and *H'* were higher along the northern transect because this region borders the outer continental shelf and thus both oceanic and shelf communities are likely present in this region, with mixed communities leading to higher diversity. Many of the families caught along the northern transect are indicative of continental shelf assemblages (McEachran 2010), and I often observed a greater presence of continental shelf species in collections that were clearly impacted by freshwater inflow (green water, lower salinity, higher turbidity). At the same time, the northern transect included stations that were off the continental shelf where larvae of oceanic taxa (e.g., exocoetids, istiophorids, and scombrids) are known to occur. While the northern transect was essentially a mixed shelf and oceanic assemblage, nearly all of the stations in the southern transect were in oceanic waters, which explains the high abundances of exocoetids and scombrids. As a result, the larval fish assemblage was primarily comprised of oceanic species with limited contribution of continental shelf species, leading to lower overall diversity or reduced T_F and *H'* relative to the northern transect stations.

Assemblage diversity also varied temporally, with T_F and H' generally being higher in June than July in both years sampled. In surface sample of the upper 1 m, exocoetids, mullids, and clupeids comprised a significantly higher percentage of the assemblage in June for both years, while carangids and scombrids were higher in July. In the mixed layer, myctophids and bregmacerotids dominated the June assemblage while carangids and scombrids comprised a greater proportion of the catch in July. Temporal shifts in larval abundance and assemblage composition are often attributed to seasonal patterns of spawning (Sanvicente-Añorve et al. 1998; Mourato et al. 2014; King et al. 2015), but other factors such as the position of mesoscale features or oceanographic conditions are also known to influence presence and distribution of fish larvae (Cowen et al. 2000; Randall et al. 2015; Cornic et al. 2018). Results of the present study are consistent with other studies conducted in the NGoM, which indicate higher densities of exocoetids in June (Randall et al. 2015) and higher densities of scombrids in July (Cornic et al. 2018), with both studies attributing seasonal patterns in larval abundance to temporal variation in spawning activity. Carangids, myctophids, and bregmacerotids are also known to display variable spawning throughout the year (Ditty et al. 2004; Moku et al. 2003; Namiki et al. 2007), and this could also contribute to temporal shifts in the presence of certain taxa in my collections.

Intra- and inter-annual fluctuations in the abundance and diversity of larval fishes are common and often associated with temporal shifts in the location of mesoscale features (Richardson et al. 2010; Rooker et al. 2013). In 2015, a higher northward penetration of the Loop Current corresponded with higher T_F and H'. In contrast, the summer of 2016 was characterized by a reduced northward penetration of the Loop Current and lower T_F and *H'*. This suggests that diversity of the larval fish assemblage in this region is dependent on the northward extension of the Loop Current and these results are consistent with previous studies (Cornic et al. 2018; Rooker et al. 2012).

The intrusion of the MARS into the NGoM is also a seasonal and temporal driver of larval distribution and abundance (Govoni et al. 1989; Grimes and Finucane 1991) and a primary physicochemical indicator of MARS intrusion is salinity. In the present study, salinity was an important factor in both T_F and *H'* measures, indicating that assemblage diversity for larval fishes may be highly dependent on spatial variation in salinity. Freshwater discharge from MARS in the spring creates a salinity gradient in the NGoM that ranges from the river delta to the continental shelf over the summer months (O'Connor et al. 2016; Schiller et al. 2011). Areas with highest diversity of larval fishes corresponded to lower salinity levels, suggesting that areas impacted by freshwater inflow may serve as habitat for a wider range of taxa—both continental shelf and oceanic species. T_F and *H'* are higher in low salinity areas because both oceanic (exocoetids, scombrids, istiophorids) and continental shelf assemblages (serranids, lutjanids, sciaenids) are being caught, leading to higher diversity. Generally, the MARS plume is larger in area and outflow in June than July as the greatest amount of freshwater is discharged in the spring (Aulenbach et al. 2007). The results from this study show higher diversity of larval fishes in June of 2015 and 2016, suggesting the influx of freshwater from the MARS has a considerable impact on assemblage composition and the location of areas with higher T_F and *H'*. Similarly, 2015 had significantly higher diversity measures than 2016, which corresponded with the MARS plume, as there was a greater freshwater discharge in 2015 (896,600 ft^3 s^{-1}) than in 2016 (539,150 ft^3 s^{-1}) (https://waterdata.usgs.gov/). MARS freshwater inflow is also associated with an influx of nutrients that increase primary and secondary productivity (Lohrenz et al. 2008; O'Connor el al. 2016) and likely increases food opportunities for larval fishes. In general, areas of confluence between riverine and oceanic waters are assumed to elevate primary and secondary production, and thus represent favorable habitat for fish larvae as food opportunities increase, which in turn supports larval growth and survival (Grimes and Finucane 1991), which may also contribute to higher T_F and H' observed at stations (i.e. northern) influenced by MARS. .

Spatial variability in sea surface height and sea surface temperature were also important drivers of T_F and H' in this study. GAMs indicated that diversity increased in areas with lower sea surface height (cold-core eddies) and mid-level water temperatures (28- 30 °C). Cold core eddies are associated with upwelling, as cold, nutrient rich waters in these features support higher primary productivity (Biggs et al. 1997). It is expected that feeding opportunities also increase in these areas (Sato et al. 2018), allowing for favorable early life habitat for larval fishes. Convergent zones where two mesoscale features meet are also responsible for aggregating plankton and, therefore, favorable conditions for the survival of fish larvae (Bakun 2006; Erisman et al. 2018), potentially leading to the increased diversity of larval fishes along these features. In addition to the fronts physically transporting larvae to convergent zones, these zones also increase feeding opportunities for larvae, leading to higher survival rates (Bakun 2006; Acha et al. 2018). Results from recent studies in the NGoM of pelagic larval fishes yield similar results, with billfishes, dolphinfishes, and tunas being associated with frontal features and convergent zones (Cornic et al. 2018; Kitchens and Rooker 2014; Rooker et al. 2013).

In summary, biodiversity hotspots of fish larvae in the NGoM were located in areas where continental shelf and oceanic communities co-occur, with T_F and *H'* highest along the northern transect due to the influence of both MARS and oceanic processes. My hypothesis that biodiversity hotspots for larval fishes (high T_F and *H'*) in the NGoM will occur primarily in convergence zones (frontal features) was supported. Additionally, my hypothesis that larvae of numerically dominant species that use the epipelagic zone (istiophorids, carangids, scombrids, exocoetids, etc.) in the NGoM will account for the majority of ichthyoplankton collected during the daytime in the upper 1 m of the water column, while the upper 100m of the water column will have a significant contribution of mesopelagic taxa, was also supported. Mesopelagic families, particularly myctophids and gonostomatids, had a considerable influence on the assemblage composition in the upper 100 m of the water column, highlighting the ecological connectivity that occurs between epipelagic and deep pelagic fish communities in the mixed layer. Given the growing importance of ecosystem based management rather than focusing on a single stock, these findings can be used to develop more accurate larval biodiversity indices for the NGoM and improve the understanding of characteristics of important nursery habitat.

CHAPTER III

CONCLUSIONS

Previous studies on the distribution and abundance on larval fishes are limited in the NGoM and often focus on species-specific distributions rather than communities. This study attempts to characterize assemblages that occupy this region and the temporal and spatial conditions associated with areas of high biodiversity. It was found that mesopelagic families dominated the larval fish assemblages in the mixed layer or upper 100 m of the water column, including myctophids and gonostamatids. In contrast, epipelagic families such as carangids and exocoetids dominated the catch in surface waters. Additionally, my results demonstrate that areas of high biodiversity were generally associated with lower salinity and/or areas of confluence between where continental shelf waters associated with MARS meet oceanic waters. The high abundance and broad distribution of fishes in this region also highlights the importance of the NGoM in early life habitat of many taxa and suggests that this area is an integral component of the pelagic ecosystem.

Taxonomic richness (T_F) and Shannon diversity (H') varied spatially and temporally, with generally higher indices on the northern transect, particularly early season collections (June) and also in the 2015 survey. The freshwater plume associated with MARS likely played an important role in determining the diversity measures as the plume was more present along the northern stations sampled, the freshwater inflow is generally higher in June than July, and MARS had a higher discharge in 2015 than in 2016. Catches in the mixed layer also had generally higher diversity measures, which was attributed to high abundance of mesopelagic fishes along with the common epipelagic families, while very low abundances of mesopelagic fishes occurred in surface waters. Overall, this study demonstrates that larval fish assemblages in the NGoM are extremely diverse with areas of high diversity due to primarily to the presence of mixed communities comprised of continental shelf and oceanic taxa and/or epipelagic and mesopelagic taxa.

Future considerations for studies in the NGoM could be to use a wider approach that integrates all species or families to provide more of an ecosystem perspective on the drivers of population change. Previous studies in this region have generally focused on a specific component (species or family) of the larval fish assemblage, but this study shows that communities in the region are very diverse and a large number of taxa influence the assemblage diversity and structure. Further, I show that diversity measures vary spatially and temporally in the NGoM with salinity and sea surface height being the primary drivers of elevated T_F and H'. Due to the highly dynamic nature of mesoscale features and the influences they have on ichthyoplankton communities, sampling procedures should be wide in scope in order to collect multiple assemblage types in the NGoM.

Given the growing need for ecosystem-based management, there is increased interest in understanding assemblage structure and population dynamics to gain a broader picture of the environment as a whole. Understanding factors that influence distribution and abundance of ichthyoplankton assemblages is important in improving ecosystem management of pelagic ecosystems and can help provide insight into the spatial distribution of pelagic fishes that are both economically and ecologically important. This baseline data on fish larvae common to the epipelagic zone helps identify the physicochemical factors that promote biodiversity in order to more effectively identify high priority areas (biodiversity hotspots) for conservation. Further, this research is crucial as species-rich ecosystems are known to have increased rates of recovery and reversibility following detrimental environmental changes.

REFERENCES

Acha, E. M., Ehrlich, M. D., Muelbert, J. H., Pájaro, M., Bruno, D., Machinandiarena, L., & Cadaveira, M. (2018). Ichthyoplankton Associated to the Frontal Regions of the Southwestern Atlantic. In M. S. Hoffmeyer, M. E. Sabatini, F. P. Brandini, D. L. Calliari, & N. H. Santinelli (Eds.), Plankton Ecology of the Southwestern Atlantic: From the Subtropical to the Subantarctic Realm (pp. 219-246). Springer International Publishing.

Aulenbach, B. T., Buxton, H. T., Battaglin, W. T., & Coupe, RH (2007) Streamflow and nutrient fluxes of the Mississippi-Atchafalaya River Basin and sub basins for the period of record through 2005: U.S. Geological Survey Open-File Report 2007-1080.

Bakun, A. (2006). Fronts and eddies as key structures in the habitat of marine fish larvae: opportunity, adaptive response and competitive advantage. Scientia Marina, 70(S2), 105-122.

Biggs, D. C., Zimmerman, R. A., Gasca, R., SuarezMorales, E., Castellanos, I., & Leben, R. R. (1997). Note on plankton and cold-core rings in the Gulf of Mexico. Fishery Bulletin, 95(2), 369-375.

Browder, J. (1993). A pilot model of the Gulf of Mexico continental shelf. Paper presented at the Trophic models of aquatic ecosystems. ICLARM Conference Proceedings.

Carassou, L. (2012). Cross-shore, seasonal, and depth-related structure of ichthyoplankton assemblages in coastal Alabama. Transactions of the American Fisheries Society, 141(4), 1137.

Chase, J. M. (2010). Stochastic community assembly causes higher biodiversity in more productive environments. Science, 328(5984), 1388-1391.

Cornic, M., Smith, B. L., Kitchens, L. L., Bremer, J. R. A., & Rooker, J. R. (2018). Abundance and habitat associations of tuna larvae in the surface water of the Gulf of Mexico. Hydrobiologia, 806(1), 29-46.

Cowen, R. K., Lwiza, K. M., Sponaugle, S., Paris, C. B., & Olson, D. B. (2000). Connectivity of marine populations: open or closed? Science, 287(5454), 857-859.

Cury, P. (2000). Small pelagics in upwelling systems: patterns of interaction and structural changes in “wasp-waist” ecosystems. ICES Journal of Marine Science, 57(3), 603-618.

Dagg M. J., & Breed G. A. (2003) Biological effects of Mississippi River nitrogen on the northern Gulf of Mexico-a review and synthesis. Journal of Marine Systems 43, 133-152.

D'Elia, M., Warren, J. D., Rodriguez-Pinto, I., Sutton, T. T., Cook, A., & Boswell, K. M. (2016). Diel variation in the vertical distribution of deep-water scattering layers in the Gulf of Mexico. Deep-Sea Research Part I-Oceanographic Research Papers, 115, 91-102.

Ditty, J. G., Shaw, R. F., & Cope, J. S. (2004). Distribution of carangid larvae (Teleostei : Carangidae) and concentrations of zooplankton in the northern Gulf of Mexico, with illustrations of early *Hemicaranx amblyrhynchus* and *Caranx* spp. larvae. Marine Biology, 145(5), 1001-1014.

Erisman, B. , Heyman, W. , Kobara, S. , Ezer, T. , Pittman, S. , Aburto-Oropeza, O. & Nemeth, R. S. (2017), Fish spawning aggregations: where well-placed management actions can yield big benefits for fisheries and conservation. Fish Fisheries, 18, 128-144.

Game, E. T. (2009). Pelagic protected areas: the missing dimension in ocean conservation. Trends in Ecology and Evolution, 24(7), 360.

Gaston, K. J., Williams, P. H., Eggleton, P., & Humphries, C. J. (1995). Large-Scale Patterns of Biodiversity - Spatial Variation in Family Richness. Proceedings of the Royal Society B-Biological Sciences, 260(1358), 149-154.

Grimes, C. B., & Finucane, J. H. (1991) Spatial distribution and abundance of larval and juvenile fish, chlorophyll and macrozooplankton around the Mississippi River discharge plume, and the role of the plume in fish recruitment. Marine Ecology Progress Series 75: 109-119.

Gamfeldt, L. , Lefcheck, J. S., Byrnes, J. E., Cardinale, B. J., Duffy, J. E., &Griffin, J. N. (2015), Marine biodiversity and ecosystem functioning: what's known and what's next? Oikos, 124: 252-265.

Govoni, J. J., Hoss, D. E., & Colby DR (1989) The spatial-distribution of larval fishes about the Mississippi River plume. Limnology and Oceanography 34: 178-187.

Guisan, A., Edwards, T. C., & Hastie, T. (2002). Generalized linear and generalized additive models in studies of species distributions: setting the scene. Ecological Modelling, 157(2-3), 89-100.

Hendriks Iris, E. I. (2006). Biodiversity research still grounded. Science, 312(5781).

Hernandez Jr., F. J., Powers, S. P., & Graham, W. M. (2010) Seasonal variability in ichthyoplankton abundance and assemblage composition in the northern Gulf of Mexico off Alabama. Fishery Bulletin, 108(2), pp. 193-207.

Houde, E. (2002). Mortality. In L. A. Fuiman & R. G. Werner (Eds), Fishery science, the unique contributions of early life stages (pp. 64-87). Blackwell Science, Oxford.

Karnauskas, M., Schirripa, M. J., Kelble, C. R., Cook, G. S., & Craig, J. K. (2013). Ecosystem status report for the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC, 653, 52.

Kitchens, L. L. & Rooker, J. R. (2014), Habitat associations of dolphinfish larvae in the Gulf of Mexico. Fisheries Oceanography, 23, 460-471.

King, A. J., Gwinn, D. C., Tonkin, Z. , Mahoney, J. , Raymond, S. , Beesley, L. & Heino, J. (2016), Using abiotic drivers of fish spawning to inform environmental flow management. Journal of Applied Ecology, 53, 34-43.

Lamkin, J. (1997). The Loop Current and the abundance of larval *C. pauciradiatus* in the Gulf of Mexico: evidence for physical-biological interaction. Fishery Bulletin, 95, 251-267.

Lehodey, P., Alheit, J., Barange, M., Baumgartner, T., Beaugrand, G., Drinkwater, K., & Werner, F. (2006). Climate variability, fish, and fisheries. Journal of Climate, 19(20), 5009-5030.

Lewison, R., Hobday, A. J., Maxwell, S., Hazen, E., Hartog, J. R., Dunn, D. C., & Crowder, L. B. (2015). Dynamic Ocean Management: Identifying the Critical Ingredients of Dynamic Approaches to Ocean Resource Management. BioScience, 65(5), 486-498.

Lindo-Atichati, D. (2012). Varying mesoscale structures influence larval fish distribution in the northern Gulf of Mexico. Marine Ecology Progress Series, MEPS, 463, 245.

Lohrenz, S. E., Fahnenstiel, G. L., Redalje, D. J., Lang, G. A., Chen, X, & Dagg, M. J. (1997). Variations in primary production of northern Gulf of Mexico continental shelf waters linked to nutrient inputs from the Mississippi River. Marine Ecology Progress Series 155, 45-54.

Marchese, C. (2015). Biodiversity hotspots: A shortcut for a more complicated concept. Global Ecology and Conservation, 3: 297.

McEachran, J.D., & Fechhelm J. D. 2010. Fishes of the Gulf of Mexico, Volume 2:

Scorpaeniformes to Tetraodontiformes. University of Texas Press, Austin, Texas, USA.

Mittermeier, R.A., Turner, W.R., Larsen, F.W., Brooks, T.M., & Gascon, C. (2011) Global Biodiversity Conservation: The Critical Role of Hotspots. In: Zachos F., Habel J. (eds) Biodiversity Hotspots. Springer, Berlin, Heidelberg

Moku, M., Tsuda, A., & Kawaguchi, K. (2003). Spawning season and migration of the myctophid fish *Diaphus theta* in the western North Pacific. Ichthyological Research, 50(1), 52-58.

Moser, H. G., & Smith, P. E. (1993). Larval fish assemblages and oceanic boundaries. Bulletin of Marine Science, 53(2), 283-289.

Mourato, B. L., Hazin, F., Bigelow, K., Musyl, M., Carvalho, F., & Hazin, H. (2014), Spatio-temporal trends of sailfish, *Istiophorus platypterus* catch rates in relation to spawning ground and environmental factors in the equatorial and southwestern Atlantic Ocean. Fisheries Oceanography, 23, 32-44.

Myers, R. A. (2003). Rapid worldwide depletion of predatory fish communities. Nature, 423(6937), 280.

Myers, R. A., & Worm, B. (2003). Rapid worldwide depletion of predatory fish communities. Nature, 423(6937), 280-283.

Namiki, C., Bonecker, A. C. T., & De Castro, M. S. (2007). Occurrence and abundance of three larval codlet species (Bregmacerotidae, Teleostei) in the Southwest Atlantic Ocean (12-22 degrees S). Journal of Applied Ichthyology, 23(2), 136-141.

Nonaka, R. H., Matsuura, Y., & Suzuki, K. (2000). Seasonal variation in larval fish assemblages in relation to oceanographic conditions in the Abrolhos Bank region off eastern Brazil. Fishery Bulletin, 98(4), 767-784.

O'Connor, B. S., Muller-Karger, F. E., Nero, R. W., Hu, C. M., & Peebles, E. B. (2016). The role of Mississippi River discharge in offshore phytoplankton blooming in the northeastern Gulf of Mexico during August 2010. Remote Sensing of Environment, 173, 133-144.

Oey, L. Y., Lee, H. C., & Schmitz, W. J. (2003). Effects of winds and Caribbean eddies on the frequency of Loop Current eddy shedding: A numerical model study. Journal of Geophysical Research: Oceans, 108(C10).

Palumbi, S. R., Sandifer, P. A., Allan, J. D., Beck, M. W., Fautin, D. G., Fogarty, M. J., & Wall, D. H. (2009). Managing for ocean biodiversity to sustain marine ecosystem services. Frontiers in Ecology and the Environment, 7(4), 204-211.

Pikitch, E. K., Santora, C., Babcock, E. A., Bakun, A., Bonfil, R., Conover, D. O., Sainsbury, K. J. (2004). Ecology. Ecosystem-based fishery management. Science, 305(5682), 346-347.

Randall, L. L., Smith, B. L., Cowan, J. H., & Rooker, J. R. (2015) Habitat characteristics of bluntnose flyingfish *Prognichthys occidentalis* (Actinopterygii, Exocoetidae), across mesoscale features in the Gulf of Mexico. Hydrobiologia 749, 97-111.

Richards, W. J. (1993). Larval fish assemblages at the Loop Current boundary in the Gulf of Mexico. Bulletin of Marine Science, 53(2), 475.

Richardson, D. E. (2008). Physical and biological characteristics of billfish spawning habitat in the Straits of Florida.

Richardson, D. E., Llopiz, J. K., Guigand, C. M., & Cowen, R. K. (2010). Larval assemblages of large and medium-sized pelagic species in the Straits of Florida. Progress in Oceanography, 86(1-2), 8-20.

Rijnsdorp, A. D., Peck, M. A., Engelhard, G. H., Mollmann, C., & Pinnegar, J. K. (2009). Resolving the effect of climate change on fish populations. ICES Journal of Marine Science, 66(7), 1570-1583.

Rocha, J., Yletyinen, J., Biggs, R., Blenckner, T., & Peterson, G. (2015). Marine regime shifts: drivers and impacts on ecosystems services. Philosophical Transactions of the Royal Society B: Biological Sciences, 370(1659).

Rooker, J. R., Simms, J. R., Wells, R. J. D., Holt, S. A., Holt, G. J., Graves, J. E., & Furey, N. B. (2012) Distribution and habitat associations of billfish and swordfish larvae across mesoscale features in the Gulf of Mexico. PLoS ONE 7: e34180.

Rooker, J. R., Kitchens, L. L., Dance, M. A., Wells, R. J., Falterman, B., & Cornic, M. (2013). Spatial, temporal, and habitat-related variation in abundance of pelagic fishes in the Gulf of Mexico: potential implications of the deepwater horizon oil spill. PLoS ONE, 8(10), e76080.

Ross, S. W. (2010). Species composition and distributions of mesopelagic fishes over the slope of the north-central Gulf of Mexico. Deep Sea Research Part I: Oceanographic Research Papers, 57(21), 1926.

Sanvicente-Añorve, L. (1998). Spatial and seasonal patterns of larval fish assemblages in the southern Gulf of Mexico. Bulletin of Marine Science 62(1): 17.

Sato, M., Barth, J. A., Benoit-Bird, K. J., Pierce, S. D., Cowles, T. J., Brodeur, R. D., & Peterson, W. T. (2018). Coastal upwelling fronts as a boundary for planktivorous fish distributions. Marine Ecology Progress Series, 595, 171-186.

Schiller, R. V., Kourafalou, V. H., Hogan, P., & Walker, N. D. (2011). The dynamics of the Mississippi River plume: Impact of topography, wind and offshore forcing on the fate of plume waters. Journal of Geophysical Research-Oceans, 116(C6).

Shulzitski, K., Sponaugle, S., Hauff, M., Walter, K., D'Alessandro, E. K., & Cowen, R. K. (2015). Close encounters with eddies: oceanographic features increase growth of larval reef fishes during their journey to the reef. Biology Letters, 11(1).

Terlizzi, A., Anderson, M. J., Bevilacqua, S., Fraschetti, S., Włodarska-Kowalczuk, M., & Ellingsen, K. E. (2009). Beta diversity and taxonomic sufficiency: Do higher-level taxa reflect heterogeneity in species composition? Diversity and Distributions, 15(3), 450-458.

Watanabe, H., Kawaguchi, K., & Hayashi, A. (2002). Feeding habits of juvenile surface-migratory myctophid fishes (family Myctophidae) in the Kuroshio region of the western North Pacific. Marine Ecology Progress Series, 236, 263-272.

Ward, P., & Myers, R. A. (2005). Shifts in open-ocean fish communities coinciding with the commencement of commercial fishing. Ecology, 86(4), 835-847.

Worm, B., Barbier, E. B., Beaumont, N., Duffy, J. E., Folke, C., Halpern, B. S., & Watson, R. (2006). Impacts of biodiversity loss on ocean ecosystem services. Science, 314(5800), 787-790.

APPENDIX A

TABLES

Table 1: Catch data of larvae in the northern Gulf of Mexico in 2015 and 2016 from surface (0-1 m with neuston tows) and mixed layer (0-100+ m with oblique bongo tows). Total families collected, density larvae caught by net type, and percent of frequency by net type are presented.

Family	*2015 Surface Density*	*2015 Surface % occurrence*	*2015 Mixed layer Density*	*2015 Mixed % occurrence*	*2016 Surface Density*	*2016 Surface % occurrence*	*2016 Mixed layer Density*	*2016 Mixed layer % occurrence*
Acanthuridae (surgeonfishes)			0.34	9.38				
Acropomatidae (lanternbellies)	1.63	1.42	1.12	27.83			0.71	12.80
Alepisauridae (lancetfish)			0.12	3.13			0.88	2.33
Anguillidae (freshwater eels)			0.37	8.33			0.36	6.98
Antennariidae(frogfishes)	0.65	28.13	0.71	18.75	0.13	1.71	0.48	12.80
Atherinopsidae(New World silversides)	0.38	5.28						
Apogonidae (cardinalfishes)			0.68	2.83			0.44	1.16
Ariommatidae (ariommatids)			0.44	8.33			0.13	2.33
Balistidae (triggerfishes)	0.96	37.50	0.17	5.28	0.22	21.43	0.22	3.49
Bathylagidae (Bathylagidae)			0.68	2.83			0.53	1.47
Belonidae (needlefishes)			0.68	2.83				
Blenniidae (combtooth blennies)	0.56	9.38						
Bothidae (lefteye flounders)			2.34	36.46	0.34	4.76	1.75	25.58
Bramidae (pomfrets)			0.27	7.29			0.66	2.33
Bregmacerotidae (codlets)	0.16	1.42	9.93	58.33			16.92	75.58
Callionymidae (dragonets)			0.85	19.79			0.18	4.65
Caproidae (boarfishes)	0.21	2.83			0.13	1.19	0.44	1.16
Carangidae (jacks)	13.23	71.88	2.49	75.00	6.54	6.71	19.94	62.80
Carapidae (pearlfishes)	0.32	1.42	0.12	3.13			0.44	1.16
Ceratiidae (seadevils)							0.13	3.49
Centrophrynidae (horned lanternfish)			0.34	1.42				
Cetomimidae (flabby whalefishes)			0.12	3.13			0.44	1.16
Chaetodontidae (butterflyfishes)			0.34	1.42				
Chiasmodontidae (snaketooth fishes)			0.14	4.17			0.26	6.98
Chlorophthalmidae (greeneyes)	0.21	1.42	1.60	21.88	0.27	1.19	0.22	4.65
Clupeidae (herrings)	7.90	1.42	8.46	1.42	0.25	13.95	2.63	17.44
Congridae (conger eels)			0.54	1.42	0.74	3.57	0.88	13.95
Coryphaenidae (dolphinfishes)	0.41	1.42	0.34	3.13	0.15	17.86	0.37	23.26
Cynoglossidae (tonguefishes)	0.16	22.92	0.78	17.78			4.51	6.98
Dactylopteridae (flying gurnards)	0.53	4.17	0.44	12.50	0.13	2.39		
Diodontidae (porcupinefishes)			0.34	1.42				
Diretmidae (spinyfins)			0.34	1.42				
Echeneidae (remoras)	0.21	2.83	0.24	5.28	0.67	1.19	0.13	3.49
Ephippidae (spadefishes)					0.67	1.19		
Epigonidae (deepwater cardinalfishes)							0.88	2.33

Family	2015 Surface Density	2015 Surface % occurrence	2015 Mixed layer Density	2015 Mixed % occurrence	2016 Surface Density	2016 Surface % occurrence	2016 Mixed layer Density	2016 Mixed layer % occurrence
Evermannellidae (sabertoothfishes)			0.14	5.28			0.13	3.49
Exocoetidae (flyingfishes)	6.97	93.75	0.61	11.46	3.51	65.48	0.26	4.65
Fistulariidae (cornetfishes)			0.34	1.42				
Gadidae (cods)	0.16	1.42	0.34	1.42				
Gempylidae (snake mackerels)	0.21	2.83	2.72	47.92	0.22	3.57	3.16	44.19
Gerreidae (mojarras)	0.58	9.38			0.17	11.95	0.36	2.33
Gigantactinidae (whipnose anglerfishes)			0.68	2.83				
Giganturidae (telescopefishes)			0.68	2.83				
Gobiidae (gobies)			12.44	52.83			12.98	51.16
Gonostomatidae (bristlemouths)	0.16	1.42	14.24	8.28	0.42	5.95	17.80	8.23
Hemiramphidae (halfbeaks)	1.63	38.54	0.34	1.42	0.42	25.00		
Holocentridae (squirrelfishes)	0.32	2.83	0.44	9.38				
Howellidae (oceanic basslets)			0.44	13.54			0.96	18.65
Istiophoridae (billfishes)	1.26	3.28	0.37	9.38	0.70	27.39		
Kyphosidae (sea chubs)	0.56	22.92	0.12	2.83	0.27	23.90		
Labridae (wrasses and parrotfishes)			2.62	23.96	0.67	1.19	0.22	5.81
Lamprididae (opahs)			0.34	1.42				
Lobotidae (tripletails)	0.85	7.29	0.34	2.83	0.22	3.57		
Lutjanidae (snappers)	0.38	1.42	5.95	42.78	0.67	1.19	4.99	23.26
Malacanthidae (tilefishes)			0.12	3.13				
Melamphaidae (ridgeheads)			0.27	7.29			0.83	15.12
Megalopidae (tarpons)					0.67	1.19		
Melanostomiidae (scaleless black dragonfishes)			0.34	1.42				
Microdesmidae (wormfishes)	0.21	2.83	1.66	13.54			1.18	17.44
Monacanthidae (filefishes)	0.95	38.54	0.27	7.29	0.21	4.76		
Moridae (codlings)			0.12	3.13				
Mugilidae (mullets)	0.12	6.25	0.68	1.42	0.67	1.19		
Mullidae (goatfishes)	1.74	36.46	0.68	1.42	0.15	1.71		
Muraenesocidae (pike congers)							0.44	1.16
Myctophidae (lanternfishes)	0.96	6.25	30.61	95.83	0.13	9.52	55.93	95.35
Nettastomatidae (duckbill eels)			0.37	8.33			0.26	6.98
Nomeidae (driftfishes)	0.19	1.42	1.57	63.54	0.38	25.00	14.55	6.47
Notosudidae (waryfishes)			0.34	1.42			0.44	1.16
Ogcocephalidae (batfishes)							0.44	1.16
Ophichthidae (snake eels)			0.24	2.83			0.88	2.33
Ophidiidae (cusk-eels)	0.21	2.83	0.34	11.46	0.67	1.19	0.71	12.80
Ostraciidae (boxfishes)			0.34	1.42				
Paralepididae (barracudinas and daggertooths)			0.95	2.83			4.00	37.29
Paralichthyidae (sand flounders)			2.28	25.00	0.67	1.19	4.32	25.58

Family	2015 Surface Density	2015 Surface % occurrence	2015 Mixed layer Density	2015 Mixed % occurrence	2016 Surface Density	2016 Surface % occurrence	2016 Mixed layer Density	2016 Mixed layer % occurrence
Percophidae (flatheads)			0.68	2.83			0.44	1.16
Phosichthyidae (lightfishes)			0.54	15.63			2.24	29.70
Phycidae (phycid hakes)							0.44	1.16
Polymixiidae (beardfishes)			0.24	1.42			0.44	1.16
Pomacanthidae (angelfishes)	0.16	1.42	0.68	2.83				
Pomacentridae (damselfishes)	0.19	14.58	0.58	9.38	0.94	13.95	0.26	6.98
Priacanthidae (bigeyes)	0.21	2.83	0.24	5.28				
Scaridae (parrotfishes)	0.16	1.42	1.12	18.75			0.44	1.16
Sciaenidae (drums and croakers)			0.34	2.83			0.18	3.49
Scombridae (tunas and mackerels)	4.30	62.50	24.26	9.63	3.28	53.57	25.95	82.56
Scopelarchidae (pearleyes)			0.17	5.28				
Scorpaenidae (scorpionfishes)			0.61	15.63	0.67	1.19	0.22	3.49
Serranidae (sea basses)			3.26	37.50	0.67	1.19	0.88	15.12
Sparidae (porgies)			0.34	1.42				
Sphyraenidae (barracudas)	0.22	11.46	0.92	21.88	0.19	15.48	0.88	2.33
Sternoptychidae (marine hatchetfishes)			3.64	1.42			1.43	25.58
Stomiidae (dragonfishes)			0.14	5.28			0.44	11.63
Syngnathidae (pipefishes and seahorses)	0.85	7.29					0.22	3.49
Synodontidae (lizardfishes)	0.16	1.42	1.56	14.58			0.57	8.14
Tetraodontidae (puffers)	0.16	9.38	0.58	14.58	0.22	2.39	0.37	8.14
Trachipteridae (ribbonfishes)			0.68	2.83				
Trichiuridae (cutlassfishes)			0.24	4.17			0.88	2.33
Uranoscopidae (stargazers)			0.34	1.42				
Xiphiidae (swordfish)	0.64	4.17	0.34	1.42	0.42	7.14		
Zeidae (dories)			0.34	1.42				
Unknown/Damaged	0.16		11.59		0.42		13.16	

Table 2: Catch data of top 8 larval families in the northern Gulf of Mexico in 2015 and 2015 from surface (0-1 m with neuston tows) and mixed layer (0-100+ m with oblique bongo tows).. Percent total of top families by net type, year, and month are presented.

Surface

Year	Month	Exocoetidae	Carangidae	Scombridae	Mullidae	Clupeidae	Istiophoridae	Hermiramphidae	Nomeidae	Unknown	Other
2015	**June**	44.29	12.09	11.90	5.32	0.10	3.38	2.42	0.87	0.29	19.34
	July	6.63	37.52	9.15	1.54	24.86	2.81	2.51	0.30	0.40	14.27
2016	**June**	30.90	27.63	16.67	1.07	2.59	0.91	3.50	3.65	0.46	12.63
	July	9.56	49.68	21.88	0.65	0.32	6.40	1.38	0.65	0.00	9.48

Mixed Layer

Year	Month	Myctophidae	Carangidae	Scombridae	Bregmacerotidae	Gonostomidae	Gobiidae	Nomeidae	Lutjanidae	Unknown	Other
2015	**June**	22.57	9.58	7.96	8.89	6.26	2.81	8.24	3.02	6.62	24.05
	July	9.95	12.24	17.90	1.63	8.90	10.46	2.43	3.30	5.70	27.49
2016	**June**	31.63	6.79	6.25	9.84	6.68	6.15	9.20	0.53	4.98	17.95
	July	17.72	12.12	11.89	5.00	10.01	4.64	3.35	4.45	7.30	23.51

Table 3: Akaike information criterion (AIC), deviance explained (DE) and variables retained in the final GAMs based on taxonomic richness (T_F) and Shannon diversity (H') for surface samples (0-1 m with neuston tows) collected in 2015 and 2016. 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.

	Model	***Variables***	**Δ *AIC***	**Δ *DE***
T_F	Final AIC: 835.0	SST	0.4	0.8
	Final DE: 37.8%	SSH*	4.6	2.1
		Salinity**	13.0	5.0
		DO	12.8	2.2
		Invert Biomass*	8.2	3.7
		Distance to LC	0.5	0.6
		Sargasum Biomass*	4.6	4.1
H'	Final AIC: 224.5	SST*	5.8	4.1
	Final DE: 40.9%	SSH*	5.0	2.3
		Salinity	0.2	0.9
		DO**	21.2	7.8
		Invert Biomass	0.2	0.6
		Distance to LC	1.3	0.3
		Sargasum Biomass	0.9	0.2

Sea surface temperature (SST), sea surface height (SSH), dissolved oxygen (DO), and Distance to the Loop Current (Distance to LC).

Table 4: Akaike information criterion (AIC), deviance explained (DE) and variables retained in the final taxonomic richness (T_F) and Shannon diversity (*H'*) for mixed layer samples (0-100+ m with oblique bongo tows) collected in 2015 and 2016.. 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.

	Model	***Variables***	**Δ *AIC***	**Δ *DE***
T_F	Final AIC: 995.9	SST**	6.2	2.1
	Final DE: 41.8%	SSH*	5.3	1.8
		Salinity**	12.8	3.5
		DO	9.0	0.9
		Invert Biomass***	10.5	2.4
		Distance to LC	1.8	0.0
H'	Final AIC: 131.6	SST***	15.8	6.3
	Final DE: 42.6%	SSH**	12.3	6.1
		Salinity*	2.4	1.3
		DO	1.6	2.2
		Invert Biomass*	4.4	2.0
		Distance to LC	2.0	0.0

Sea surface temperature (SST), sea surface height (SSH), dissolved oxygen (DO), and Distance to the Loop Current (Distance to LC).

APPENDIX B

FIGURES

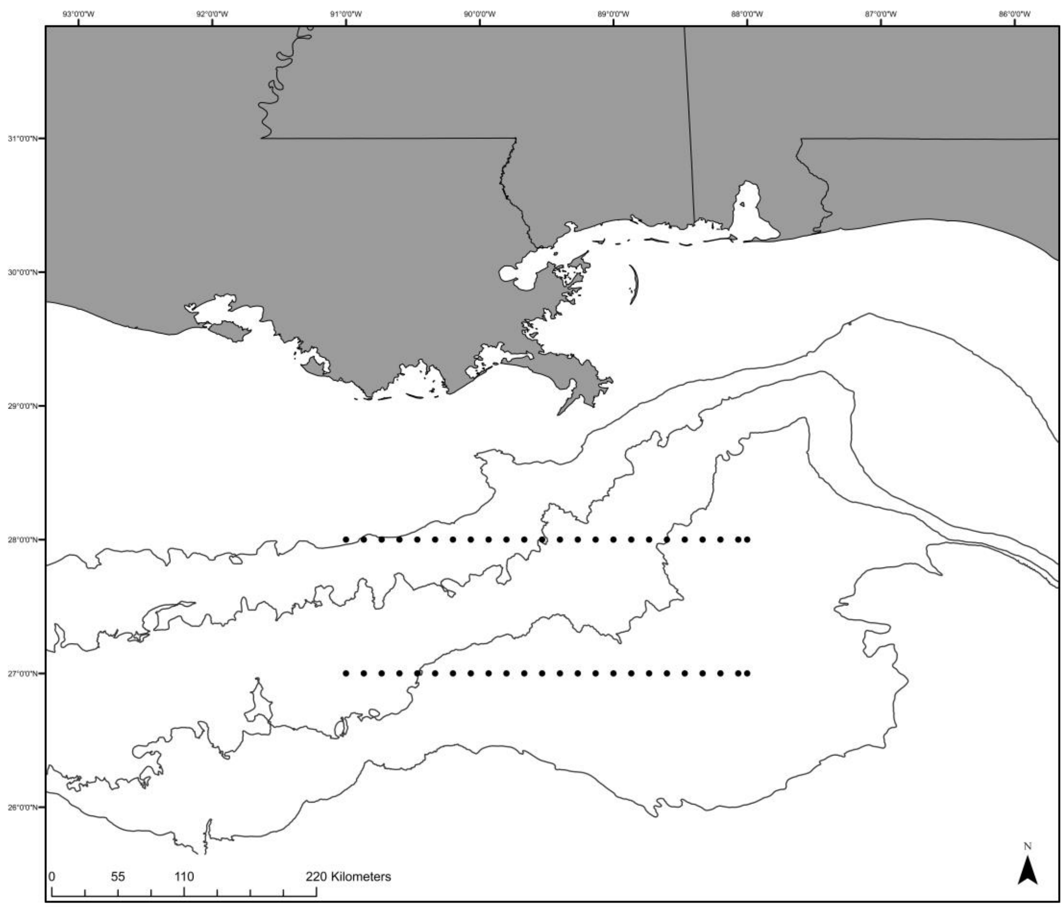

Figure 1: Sampling sites (black dots) of the June and July ichthyoplankton cruises performed in 2015 and 2016 in the northern Gulf of Mexico.

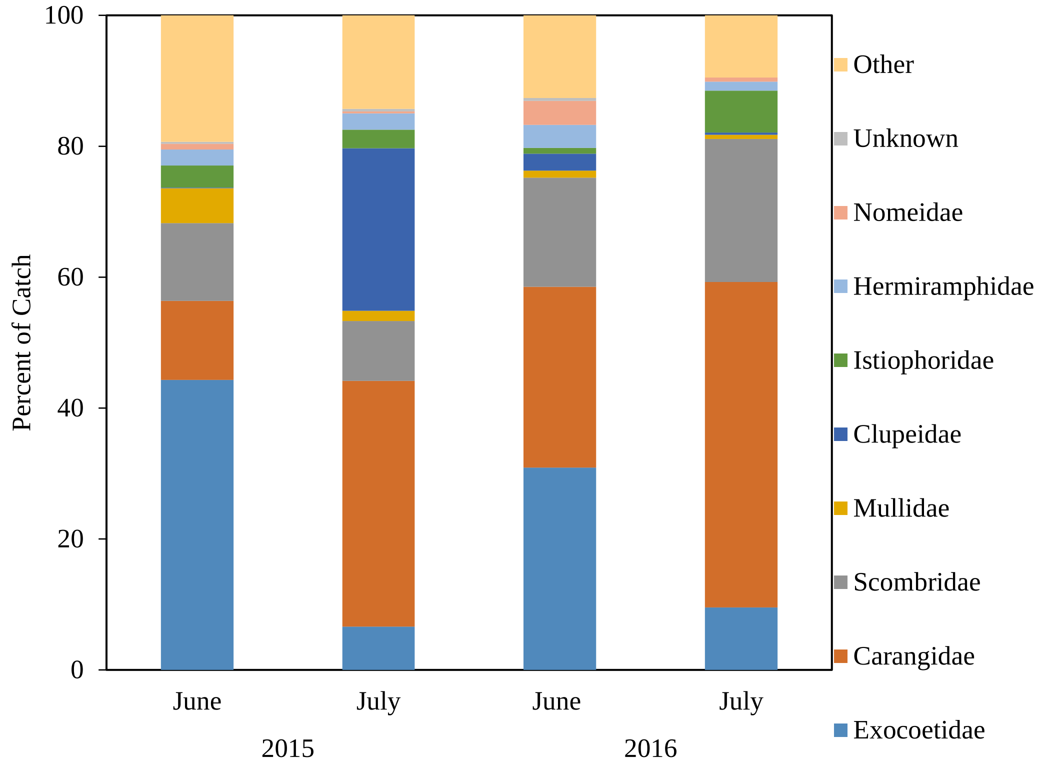

Figure 2: Composition of larvae collected in surface (0-1 m with neuston tows) tows in the northern Gulf of Mexico in 2015 and 2016.

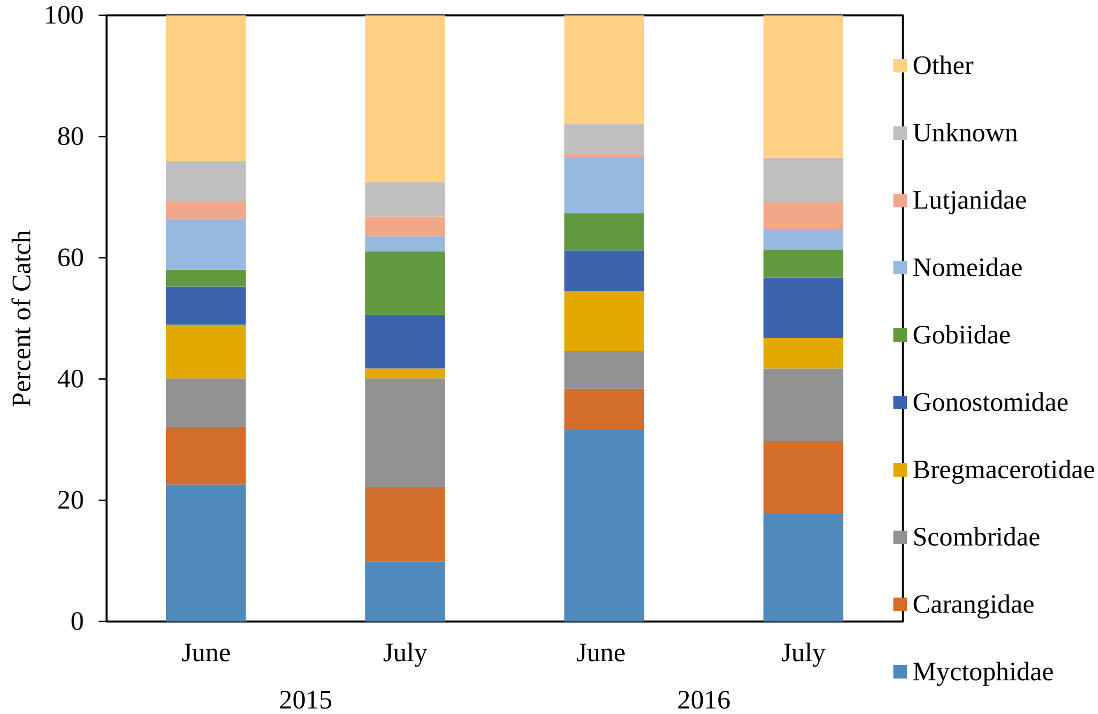

Figure 3: Composition of larvae collected in mixed layer (0-100+ m with oblique bongo tows) samples in the northern Gulf of Mexico in 2015 and 2016.

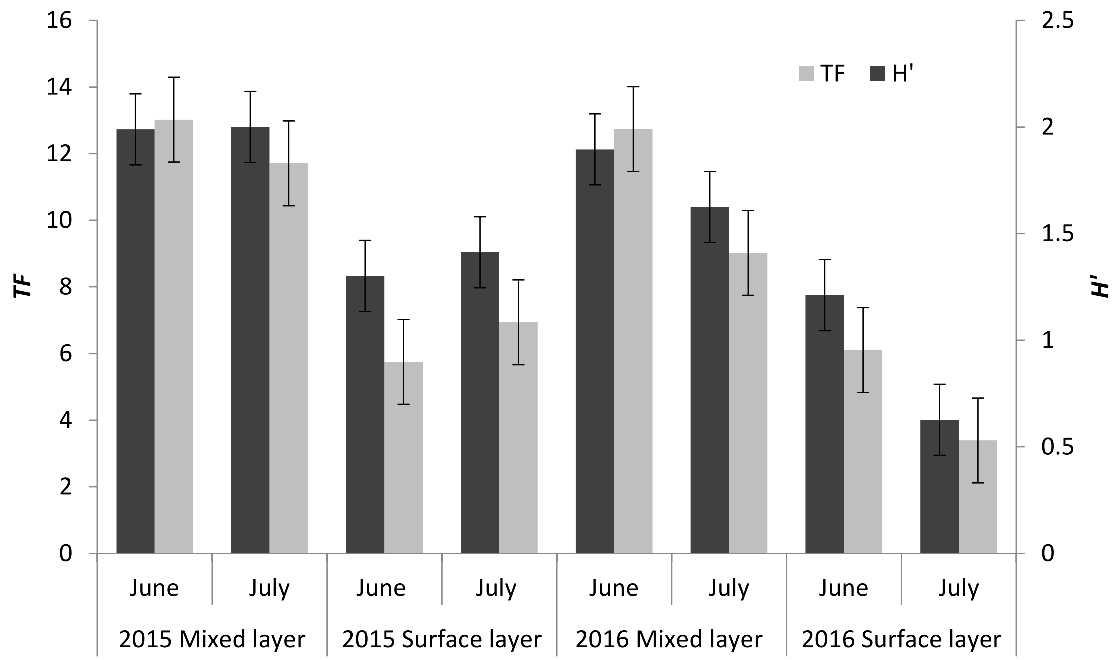

Figure 4: Comparison of taxonomic richness (T_F) and Shannon diversity (H') of all ichthyoplankton collected in the surface (0-1 m with neuston tows) and mixed layer samples (0-100+ m with oblique bongo tows) in 2015 and 2016 in the Northern Gulf of Mexico. Error bars represent standard error of the mean.

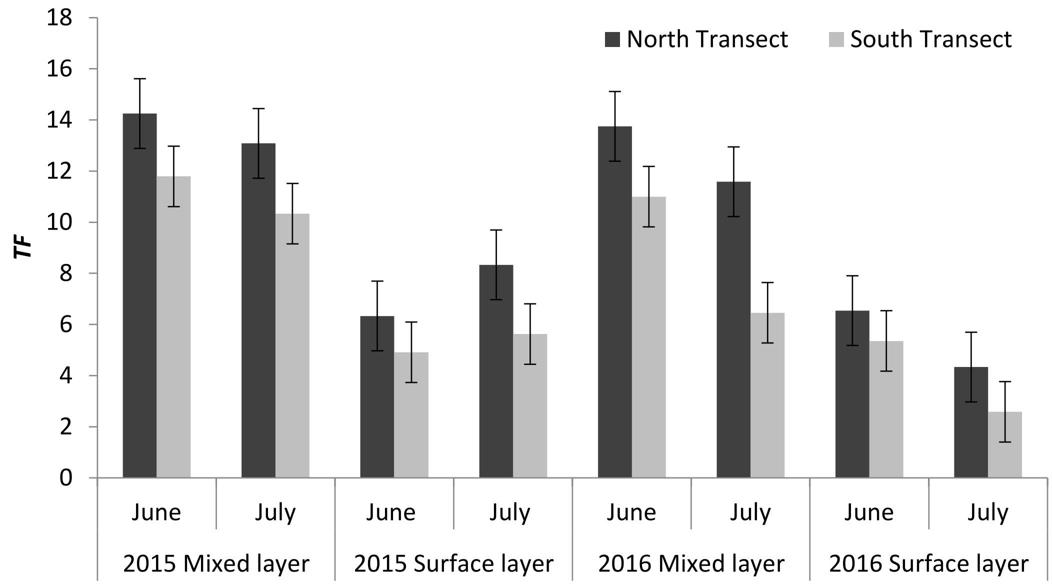

Figure 5: Comparison of taxonomic richness (T_F) between the northern and southern transect of all ichthyoplankton collected in the surface (0-1 m with neuston tows) and mixed layer samples (0-100+ m with oblique bongo tows) in 2015 and 2016 in the Northern Gulf of Mexico. Error bars represent standard error of the mean.

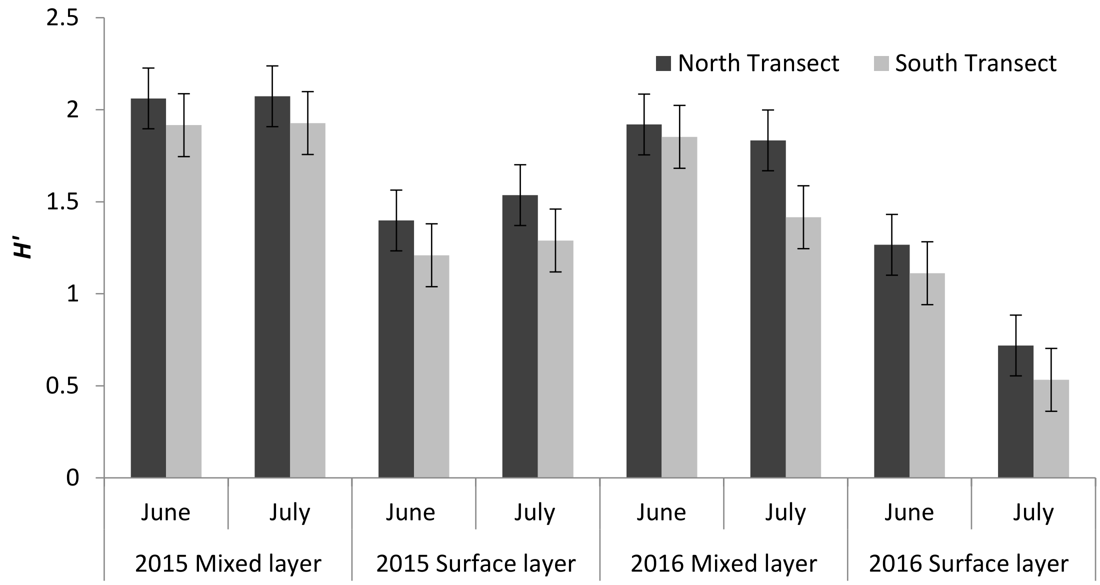

Figure 6: Comparison of taxonomic richness (*H'*) between the northern and southern transect of all ichthyoplankton collected in the surface (0-1 m with neuston tows) and mixed layer samples (0-100+ m with oblique bongo tows) in 2015 and 2016 in the Northern Gulf of Mexico. Error bars represent standard error of the mean.

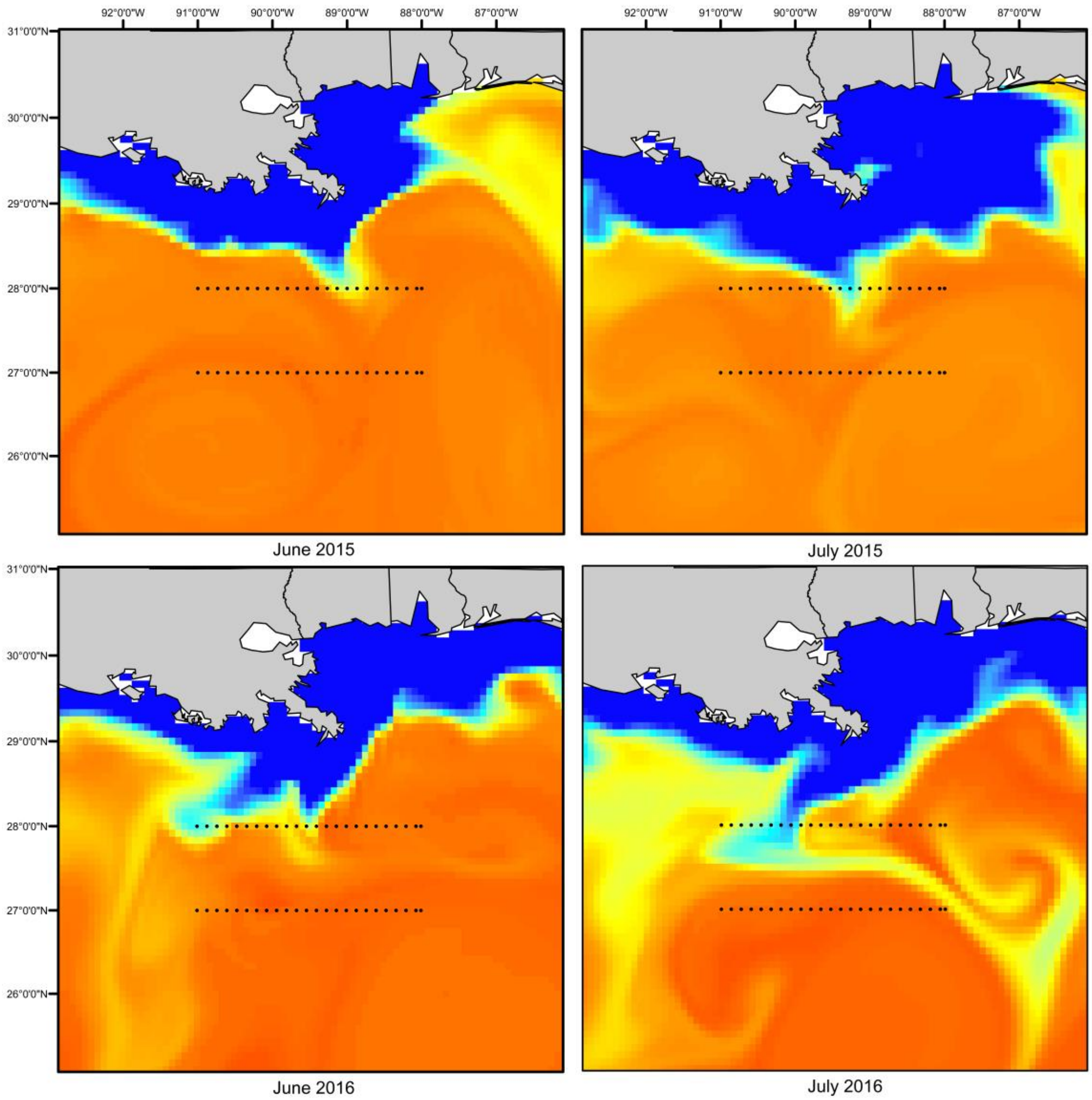

Figure 7: Surface salinity levels in the NGoM for June and July of 2015 and 2016 in the Northern Gulf of Mexico. Low to high salinity is denoted by dark blue to orange colors.

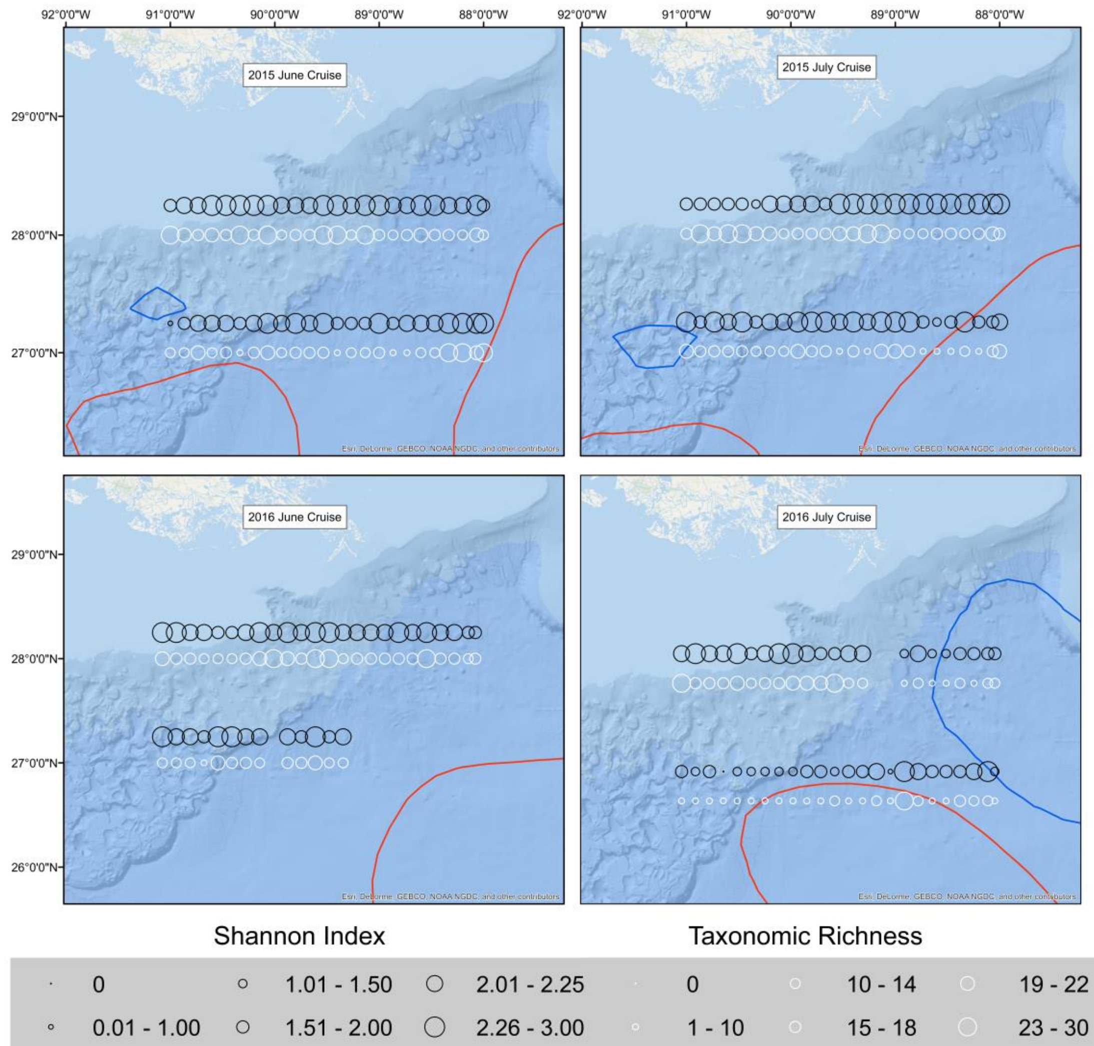

Figure 8: Shannon index (H') (black) and taxonomic richness (T_F) (white) of larvae collected in June and July of 2015 and 2016 in the Northern Gulf of Mexico. Circles represent diversity of larvae per station. Location of the loop current and warm eddies is represented in red and cold core eddies are represented in blue.

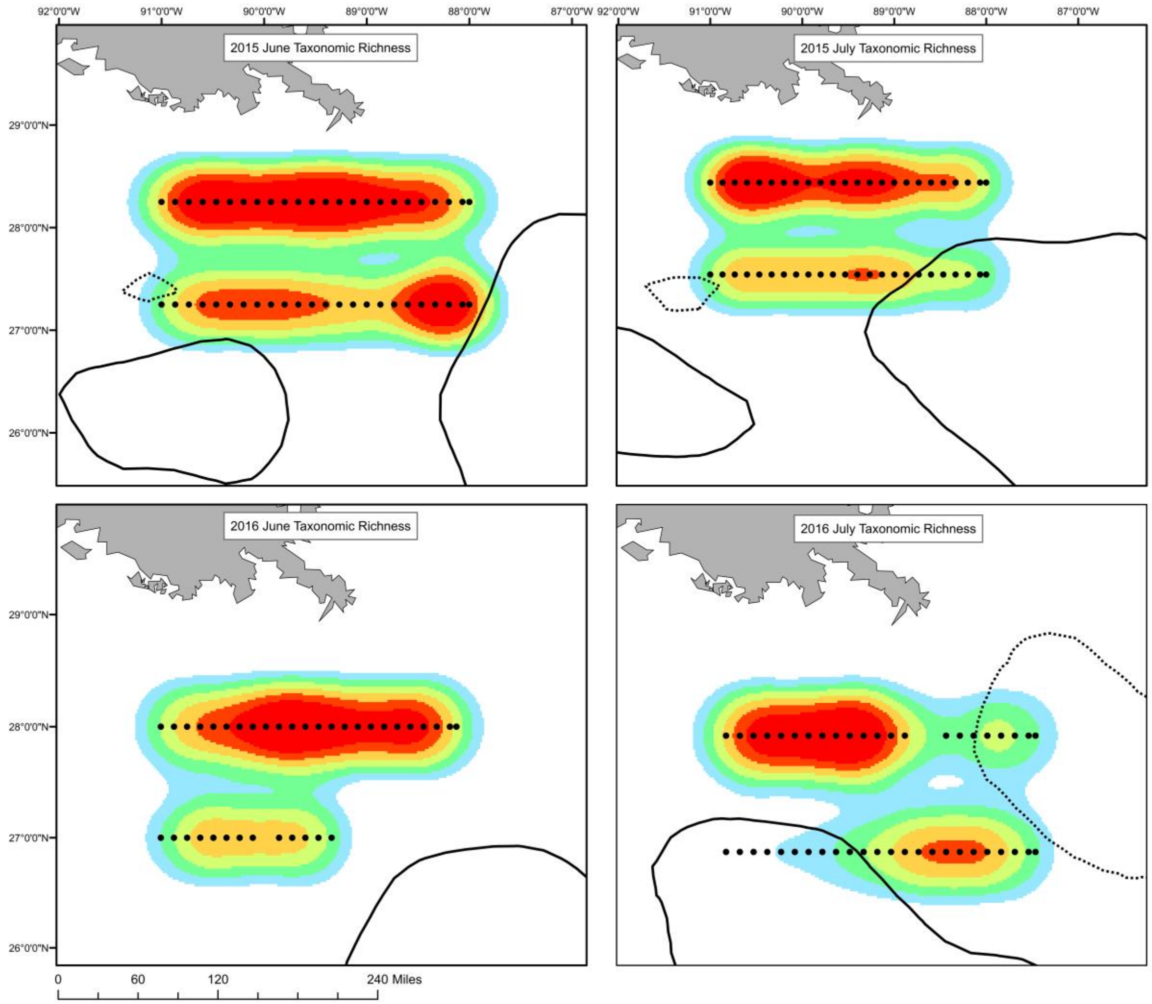

Figure 9: Taxonomic richness (T_F) heat map of larvae collected in June (top left) and July (top right) of 2015 and June (bottom left) and July (bottom right) 2016 in the Northern Gulf of Mexico. Black dots represent sample stations. Location of the loop current and warm eddies is represented in solid black lines and cold core eddies are represented in dashed black lines.

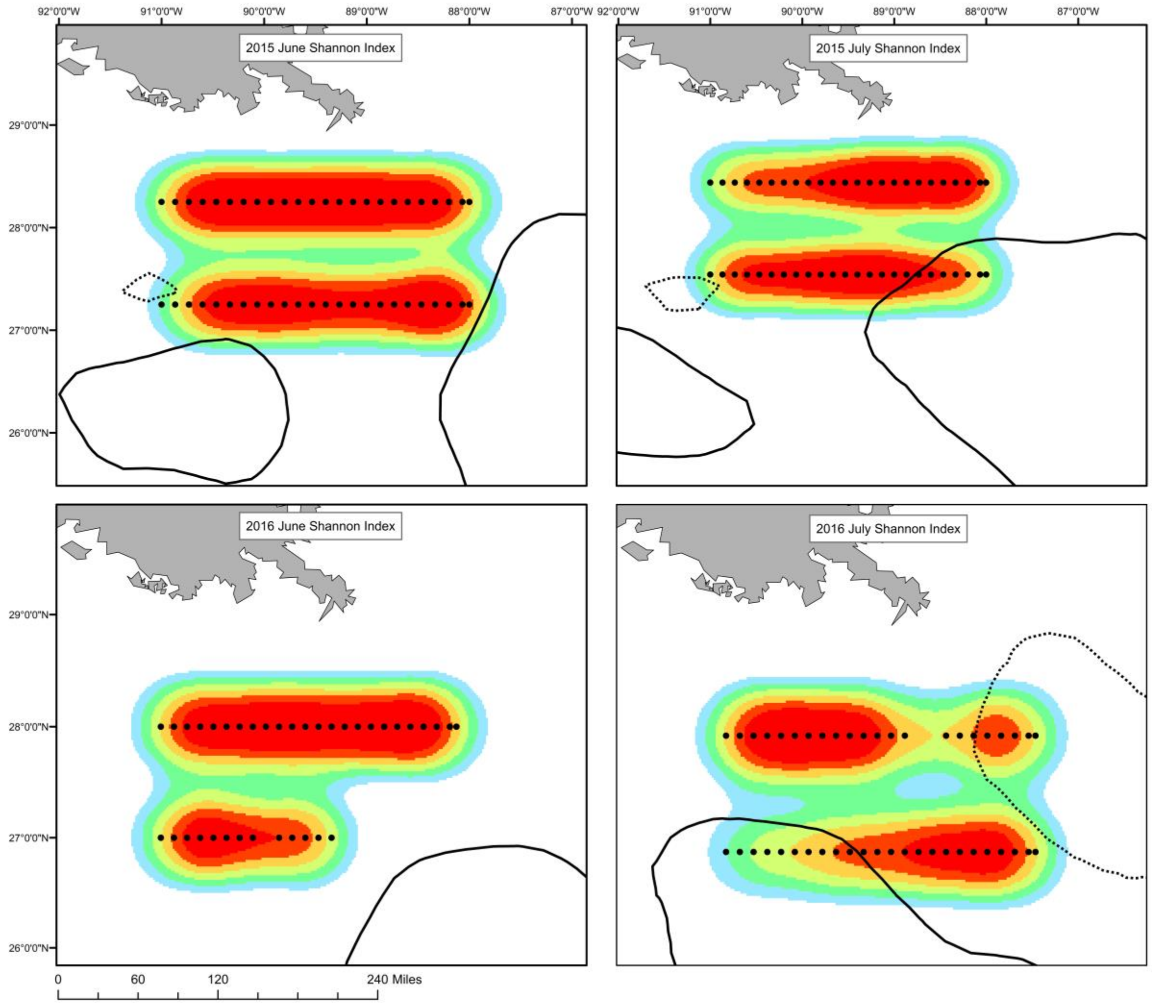

Figure 10: Shannon index (H') heat map of larvae collected in June (top left) and July (top right) of 2015 and June (bottom left) and July (bottom right) 2016 in the Northern Gulf of Mexico. Black dots represent sample stations. Location of the loop current and warm eddies is represented in solid black lines and cold core eddies are represented in dashed black lines.

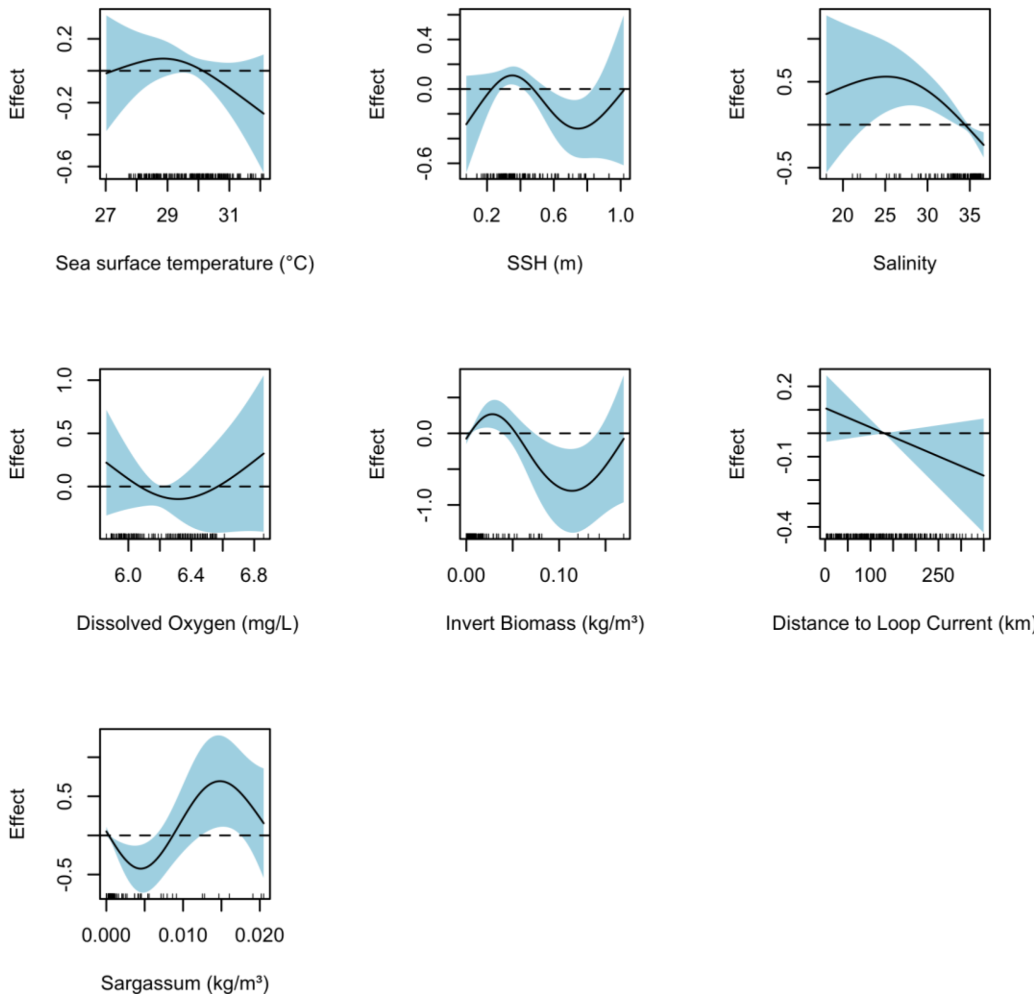

Figure 11: Response plots for oceanographic variable of the surface sample (0-1 m with neuston tows) taxonomic richness (T_F) from full generalized additive model (GAM). Plots include sea surface temperature (°C), sea surface height (m), salinity, dissolved oxygen (mg/L), invertebrate biomass (kg/m^3), distance to loop current (km) and *Sargassum* density (kg/m^3). Solid lines represent smoothed values and the shaded area represents 95% confidence intervals. Dashed line displayed at y=0 on response plots.

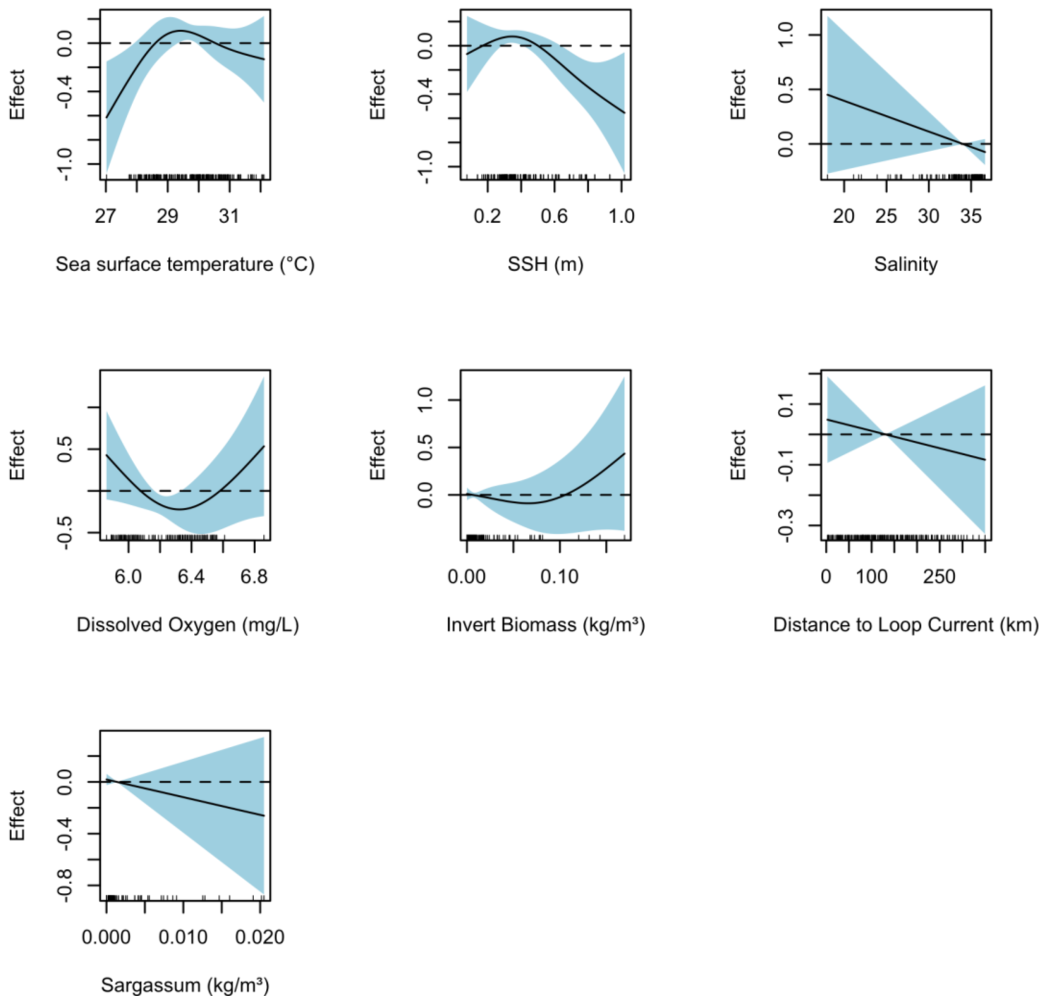

Figure 12: Response plots for oceanographic variable of the surface sample (0-1 m with neuston tows) Shannon diversity (*H'*) from full generalized additive model (GAM). Plots include sea surface temperature (°C), sea surface height (m), salinity, dissolved oxygen (mg/L), invertebrate biomass (kg/m^3), distance to loop current (km) and *Sargassum* density (kg/m^3). Solid lines represent smoothed values and the shaded area represents 95% confidence intervals. Dashed line displayed at y=0 on response plots.

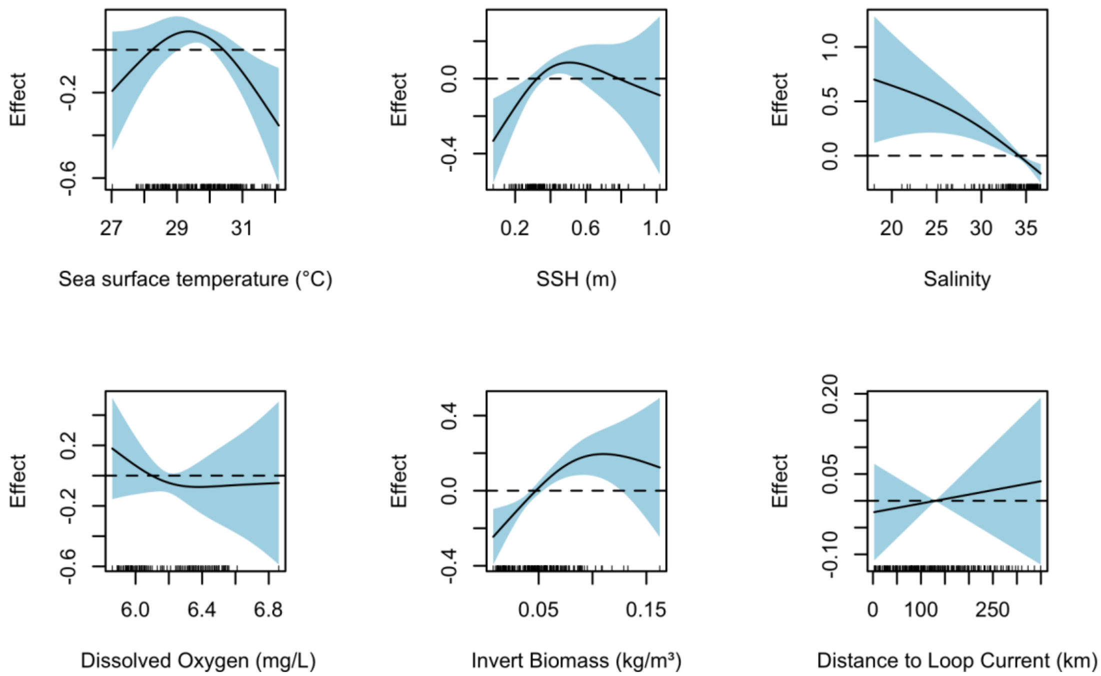

Figure 13: Response plots for oceanographic variable of the bongo net taxonomic richness (T_F) from full generalized additive model (GAM). Plots include sea surface temperature (°C), sea surface height (m), salinity, dissolved oxygen (mg/L), invertebrate biomass (kg/m^3), and distance to loop current (km). Solid lines represent smoothed values and the shaded area represents 95% confidence intervals. Dashed line displayed at y=0 on response plots.

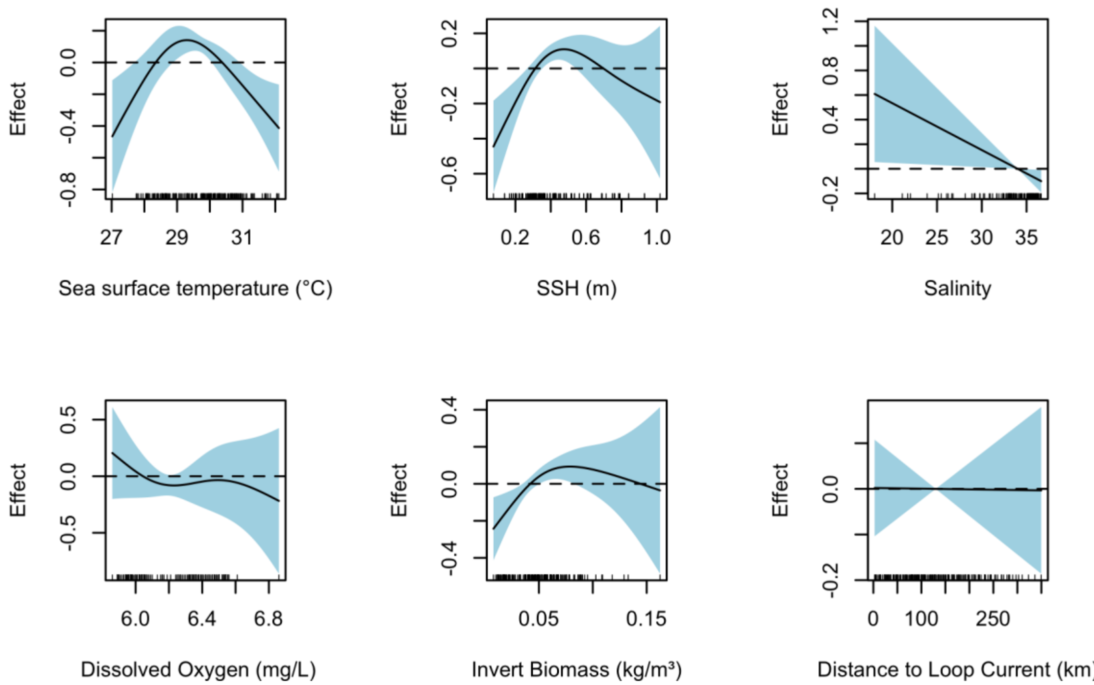

Figure 14: Response plots for oceanographic variable of the bongo net Shannon diversity (*H'*) from full generalized additive model (GAM). Plots include sea surface temperature (°C), sea surface height (m), salinity, dissolved oxygen (mg/L), invertebrate biomass (kg/m^3), and distance to loop current (km). Solid lines represent smoothed values and the shaded area represents 95% confidence intervals. Dashed line displayed at y=0 on response plots.

APPENDIX C

SUPPLEMENTAL DATA

*NN refers to neuston net, BN refers to bongo net, *H'* refers to Shannon's Index, T_F refers to taxonomic richness.

Cruise	***Date***	***Station***	***Latitude***	***Longitude***	***Net Type***	***H'***	T_F
LF2015A	6/6/15	1	27 00	91 00	NN	1.24	5
LF2015A	6/6/15	2	27 00	90 52	NN	0.00	1
LF2015A	6/6/15	3	27 00	90 44	NN	1.63	7
LF2015A	6/6/15	4	27 00	90 36	NN	1.43	6
LF2015A	6/6/15	5	27 00	90 28	NN	1.17	4
LF2015A	6/6/15	6	27 00	90 20	NN	1.29	5
LF2015A	6/6/15	7	27 00	90 12	NN	1.67	6
LF2015A	6/6/15	8	27 00	90 04	NN	1.20	5
LF2015A	6/6/15	9	27 00	89 56	NN	1.07	4
LF2015A	6/6/15	10	27 00	89 48	NN	1.25	5
LF2015A	6/6/15	11	27 00	89 40	NN	1.24	5
LF2015A	6/6/15	12	27 00	89 32	NN	0.90	6
LF2015A	6/7/15	13	27 00	89 24	NN	1.48	6
LF2015A	6/7/15	14	27 00	89 16	NN	0.83	5
LF2015A	6/7/15	15	27 00	89 08	NN	1.08	4
LF2015A	6/7/15	16	27 00	89 00	NN	1.27	4
LF2015A	6/7/15	17	27 00	88 52	NN	1.40	5
LF2015A	6/7/15	18	27 00	88 44	NN	1.04	3
LF2015A	6/7/15	19	27 00	88 36	NN	0.67	2
LF2015A	6/7/15	20	27 00	88 28	NN	0.94	4
LF2015A	6/7/15	21	27 00	88 20	NN	1.86	8
LF2015A	6/7/15	22	27 00	88 12	NN	1.43	5
LF2015A	6/7/15	23	27 00	88 04	NN	1.71	8
LF2015A	6/7/15	24	27 00	88 00	NN	1.82	12

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015A	6/8/15	25	28 00	88 00	NN	0.73	4
LF2015A	6/8/15	26	28 00	88 04	NN	1.29	7
LF2015A	6/8/15	27	28 00	88 12	NN	1.05	5
LF2015A	6/8/15	28	28 00	88 20	NN	1.50	8
LF2015A	6/8/15	29	28 00	88 28	NN	1.09	4
LF2015A	6/8/15	30	28 00	88 36	NN	1.67	6
LF2015A	6/8/15	31	28 00	88 44	NN	1.55	5
LF2015A	6/8/15	32	28 00	88 52	NN	1.03	4
LF2015A	6/8/15	33	28 00	89 00	NN	1.83	7
LF2015A	6/8/15	34	28 00	89 08	NN	1.86	9
LF2015A	6/8/15	35	28 00	89 16	NN	1.21	4
LF2015A	6/8/15	36	28 00	89 24	NN	1.42	7
LF2015A	6/9/15	37	28 00	89 32	NN	1.99	10
LF2015A	6/9/15	38	28 00	89 40	NN	1.81	8
LF2015A	6/9/15	39	28 00	89 48	NN	1.35	7
LF2015A	6/9/15	40	28 00	89 56	NN	0.68	4
LF2015A	6/9/15	41	28 00	90 04	NN	1.56	6
LF2015A	6/9/15	42	28 00	90 12	NN	0.90	3
LF2015A	6/9/15	43	28 00	90 20	NN	1.77	8
LF2015A	6/9/15	44	28 00	90 28	NN	0.95	3
LF2015A	6/9/15	45	28 00	90 36	NN	1.79	8
LF2015A	6/9/15	46	28 00	90 44	NN	1.05	5
LF2015A	6/9/15	47	28 00	90 52	NN	1.64	8
LF2015A	6/9/15	48	28 00	91 00	NN	1.11	11
LF2015B	7/20/15	1	27 00	91 00	NN	1.81	7
LF2015B	7/21/15	2	27 00	90 52	NN	1.66	8
LF2015B	7/21/15	3	27 00	90 44	NN	1.55	8

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015B	7/21/15	4	27 00	90 36	NN	1.60	10
LF2015B	7/21/15	5	27 00	90 28	NN	1.91	8
LF2015B	7/21/15	6	27 00	90 20	NN	1.42	8
LF2015B	7/21/15	7	27 00	90 12	NN	1.40	5
LF2015B	7/21/15	8	27 00	90 04	NN	1.29	5
LF2015B	7/21/15	9	27 00	89 56	NN	2.08	9
LF2015B	7/21/15	10	27 00	89 48	NN	1.91	8
LF2015B	7/21/15	11	27 00	89 40	NN	1.49	6
LF2015B	7/21/15	12	27 00	89 32	NN	1.33	4
LF2015B	7/21/15	13	27 00	89 24	NN	1.68	6
LF2015B	7/22/15	14	27 00	89 16	NN	1.05	3
LF2015B	7/22/15	15	27 00	89 08	NN	1.33	4
LF2015B	7/22/15	16	27 00	89 00	NN	1.07	4
LF2015B	7/22/15	17	27 00	88 52	NN	0.00	1
LF2015B	7/22/15	18	27 00	88 44	NN	0.69	2
LF2015B	7/22/15	19	27 00	88 36	NN	0.00	1
LF2015B	7/22/15	20	27 00	88 28	NN	0.50	2
LF2015B	7/22/15	21	27 00	88 20	NN	1.42	5
LF2015B	7/22/15	22	27 00	88 12	NN	1.05	3
LF2015B	7/22/15	23	27 00	88 04	NN	1.58	7
LF2015B	7/22/15	24	27 00	88 00	NN	1.62	11
LF2015B	7/23/15	25	28 00	88 00	NN	2.04	10
LF2015B	7/23/15	26	28 00	88 04	NN	1.75	7
LF2015B	7/23/15	27	28 00	88 12	NN	1.56	6
LF2015B	7/23/15	28	28 00	88 20	NN	1.84	7
LF2015B	7/23/15	29	28 00	88 28	NN	1.93	9
LF2015B	7/23/15	30	28 00	88 36	NN	1.43	6

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015B	7/23/15	31	28 00	88 44	NN	1.01	3
LF2015B	7/23/15	32	28 00	88 52	NN	1.99	8
LF2015B	7/23/15	33	28 00	89 00	NN	1.80	7
LF2015B	7/24/15	34	28 00	89 08	NN	1.64	6
LF2015B	7/24/15	35	28 00	89 16	NN	1.50	5
LF2015B	7/24/15	36	28 00	89 24	NN	1.98	12
LF2015B	7/24/15	37	28 00	89 32	NN	1.36	7
LF2015B	7/24/15	38	28 00	89 40	NN	1.03	8
LF2015B	7/24/15	39	28 00	89 48	NN	1.67	10
LF2015B	7/24/15	40	28 00	89 56	NN	1.33	4
LF2015B	7/24/15	41	28 00	90 04	NN	1.85	7
LF2015B	7/24/15	42	28 00	90 12	NN	1.53	9
LF2015B	7/24/15	43	28 00	90 20	NN	0.83	10
LF2015B	7/24/15	44	28 00	90 28	NN	1.20	9
LF2015B	7/25/15	45	28 00	90 36	NN	1.48	16
LF2015B	7/25/15	46	28 00	90 44	NN	1.22	10
LF2015B	7/25/15	47	28 00	90 52	NN	1.25	13
LF2015B	7/25/15	48	28 00	91 00	NN	1.09	9
LF2015A	6/6/15	1	27 00	91 00	BN	1.59	9
LF2015A	6/6/15	2	27 00	90 52	BN	1.71	12
LF2015A	6/6/15	3	27 00	90 44	BN	1.69	13
LF2015A	6/6/15	4	27 00	90 36	BN	2.00	9
LF2015A	6/6/15	5	27 00	90 28	BN	1.81	11
LF2015A	6/6/15	6	27 00	90 20	BN	1.47	8
LF2015A	6/6/15	7	27 00	90 12	BN	2.07	10
LF2015A	6/6/15	8	27 00	90 04	BN	2.18	17
LF2015A	6/6/15	9	27 00	89 56	BN	1.99	10

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015A	6/6/15	10	27 00	89 48	BN	2.16	12
LF2015A	6/6/15	11	27 00	89 40	BN	2.23	12
LF2015A	6/6/15	12	27 00	89 32	BN	2.28	14
LF2015A	6/7/15	13	27 00	89 24	BN	1.00	5
LF2015A	6/7/15	14	27 00	89 16	BN	1.59	8
LF2015A	6/7/15	15	27 00	89 08	BN	1.59	10
LF2015A	6/7/15	16	27 00	89 00	BN	2.08	13
LF2015A	6/7/15	17	27 00	88 52	BN	1.54	7
LF2015A	6/7/15	18	27 00	88 44	BN	1.75	7
LF2015A	6/7/15	19	27 00	88 36	BN	1.80	9
LF2015A	6/7/15	20	27 00	88 28	BN	1.62	7
LF2015A	6/7/15	21	27 00	88 20	BN	2.45	20
LF2015A	6/7/15	22	27 00	88 12	BN	2.67	25
LF2015A	6/7/15	23	27 00	88 04	BN	2.43	19
LF2015A	6/7/15	24	27 00	88 00	BN	2.27	16
LF2015A	6/8/15	25	28 00	88 00	BN	2.03	9
LF2015A	6/8/15	26	28 00	88 04	BN	1.90	13
LF2015A	6/8/15	27	28 00	88 12	BN	1.99	9
LF2015A	6/8/15	28	28 00	88 20	BN	1.76	9
LF2015A	6/8/15	29	28 00	88 28	BN	1.87	13
LF2015A	6/8/15	30	28 00	88 36	BN	1.83	15
LF2015A	6/8/15	31	28 00	88 44	BN	2.07	13
LF2015A	6/8/15	32	28 00	88 52	BN	1.96	11
LF2015A	6/8/15	33	28 00	89 00	BN	2.17	11
LF2015A	6/8/15	34	28 00	89 08	BN	2.27	17
LF2015A	6/8/15	35	28 00	89 16	BN	1.82	11
LF2015A	6/8/15	36	28 00	89 24	BN	2.61	22

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015A	6/9/15	37	28 00	89 32	BN	2.28	21
LF2015A	6/9/15	38	28 00	89 40	BN	1.91	12
LF2015A	6/9/15	39	28 00	89 48	BN	1.87	9
LF2015A	6/9/15	40	28 00	89 56	BN	1.18	9
LF2015A	6/9/15	41	28 00	90 04	BN	2.44	18
LF2015A	6/9/15	42	28 00	90 12	BN	2.36	15
LF2015A	6/9/15	43	28 00	90 20	BN	2.50	20
LF2015A	6/9/15	44	28 00	90 28	BN	2.41	16
LF2015A	6/9/15	45	28 00	90 36	BN	2.29	14
LF2015A	6/9/15	46	28 00	90 44	BN	2.33	16
LF2015A	6/9/15	47	28 00	90 52	BN	2.08	17
LF2015A	6/9/15	48	28 00	91 00	BN	1.56	22
LF2015B	7/20/15	1	27 00	91 00	BN	2.20	15
LF2015B	7/21/15	2	27 00	90 52	BN	1.72	9
LF2015B	7/21/15	3	27 00	90 44	BN	2.04	11
LF2015B	7/21/15	4	27 00	90 36	BN	1.69	9
LF2015B	7/21/15	5	27 00	90 28	BN	2.13	12
LF2015B	7/21/15	6	27 00	90 20	BN	1.76	7
LF2015B	7/21/15	7	27 00	90 12	BN	1.77	8
LF2015B	7/21/15	8	27 00	90 04	BN	1.57	6
LF2015B	7/21/15	9	27 00	89 56	BN	1.77	13
LF2015B	7/21/15	10	27 00	89 48	BN	1.87	10
LF2015B	7/21/15	11	27 00	89 40	BN	2.53	14
LF2015B	7/21/15	12	27 00	89 32	BN	1.75	7
LF2015B	7/21/15	13	27 00	89 24	BN	2.30	12
LF2015B	7/22/15	14	27 00	89 16	BN	2.10	9
LF2015B	7/22/15	15	27 00	89 08	BN	2.61	17

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015B	7/22/15	16	27 00	89 00	BN	2.47	19
LF2015B	7/22/15	17	27 00	88 52	BN	2.38	15
LF2015B	7/22/15	18	27 00	88 44	BN	1.88	8
LF2015B	7/22/15	19	27 00	88 36	BN	1.25	6
LF2015B	7/22/15	20	27 00	88 28	BN	1.63	6
LF2015B	7/22/15	21	27 00	88 20	BN	1.93	8
LF2015B	7/22/15	22	27 00	88 12	BN	1.31	8
LF2015B	7/22/15	23	27 00	88 04	BN	1.81	9
LF2015B	7/22/15	24	27 00	88 00	BN	1.80	10
LF2015B	7/23/15	25	28 00	88 00	BN	1.84	8
LF2015B	7/23/15	26	28 00	88 04	BN	2.15	13
LF2015B	7/23/15	27	28 00	88 12	BN	2.05	12
LF2015B	7/23/15	28	28 00	88 20	BN	1.33	4
LF2015B	7/23/15	29	28 00	88 28	BN	1.61	5
LF2015B	7/23/15	30	28 00	88 36	BN	2.40	13
LF2015B	7/23/15	31	28 00	88 44	BN	2.09	12
LF2015B	7/23/15	32	28 00	88 52	BN	1.91	7
LF2015B	7/23/15	33	28 00	89 00	BN	2.03	9
LF2015B	7/24/15	34	28 00	89 08	BN	2.87	19
LF2015B	7/24/15	35	28 00	89 16	BN	2.76	23
LF2015B	7/24/15	36	28 00	89 24	BN	2.03	10
LF2015B	7/24/15	37	28 00	89 32	BN	2.14	16
LF2015B	7/24/15	38	28 00	89 40	BN	1.86	10
LF2015B	7/24/15	39	28 00	89 48	BN	1.90	11
LF2015B	7/24/15	40	28 00	89 56	BN	1.90	13
LF2015B	7/24/15	41	28 00	90 04	BN	1.88	11
LF2015B	7/24/15	42	28 00	90 12	BN	2.42	17

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2015B	7/24/15	43	28 00	90 20	BN	2.38	16
LF2015B	7/24/15	44	28 00	90 28	BN	2.13	21
LF2015B	7/25/15	45	28 00	90 36	BN	2.16	18
LF2015B	7/25/15	46	28 00	90 44	BN	1.92	16
LF2015B	7/25/15	47	28 00	90 52	BN	1.81	17
LF2015B	7/25/15	48	28 00	91 00	BN	2.18	13
LF2016A	6/9/16	1	27 00	91 00	NN	1.04	3
LF2016A	6/9/16	2	27 00	90 52	NN	0.00	1
LF2016A	6/9/16	3	27 00	90 44	NN	0.64	2
LF2016A	6/9/16	4	27 00	90 36	NN	0.50	2
LF2016A	6/9/16	5	27 00	90 28	NN	1.73	7
LF2016A	6/9/16	6	27 00	90 20	NN	1.04	3
LF2016A	6/9/16	7	27 00	90 12	NN	1.43	7
LF2016A	6/9/16	8	27 00	90 04	NN	1.34	7
LF2016A	6/9/16	9	27 00	89 56	NN	1.34	5
LF2016A	6/9/16	10	27 00	89 48	NN	1.10	8
LF2016A	6/9/16	11	27 00	89 40	NN	1.43	7
LF2016A	6/10/16	12	27 00	89 32	NN	1.56	7
LF2016A	6/10/16	13	27 00	89 24	NN	0.61	5
LF2016A	6/10/16	14	27 00	89 16	NN	0.91	5
LF2016A	6/30/16	25	28 00	88 00	NN	1.94	9
LF2016A	6/30/16	26	28 00	88 04	NN	1.47	6
LF2016A	6/30/16	27	28 00	88 12	NN	1.46	8
LF2016A	6/30/16	28	28 00	88 20	NN	1.04	3
LF2016A	6/30/16	29	28 00	88 28	NN	1.64	6
LF2016A	6/30/16	30	28 00	88 36	NN	2.18	12
LF2016A	6/30/16	31	28 00	88 44	NN	1.67	6

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2016A	6/30/16	32	28 00	88 52	NN	1.25	8
LF2016A	6/30/16	33	28 00	89 00	NN	1.22	7
LF2016A	6/30/16	34	28 00	89 08	NN	0.73	6
LF2016A	6/30/16	35	28 00	89 16	NN	0.69	4
LF2016A	6/30/16	36	28 00	89 24	NN	1.13	9
LF2016A	7/1/16	37	28 00	89 32	NN	1.51	16
LF2016A	7/1/16	38	28 00	89 40	NN	1.38	5
LF2016A	7/1/16	39	28 00	89 48	NN	1.34	6
LF2016A	7/1/16	40	28 00	89 56	NN	1.22	11
LF2016A	7/1/16	41	28 00	90 04	NN	1.00	3
LF2016A	7/1/16	42	28 00	90 12	NN	1.35	5
LF2016A	7/1/16	43	28 00	90 20	NN	0.96	3
LF2016A	7/1/16	44	28 00	90 28	NN	0.84	4
LF2016A	7/1/16	45	28 00	90 36	NN	0.76	3
LF2016A	7/1/16	46	28 00	90 44	NN	1.38	7
LF2016A	7/1/16	47	28 00	90 52	NN	1.34	7
LF2016A	7/1/16	48	28 00	91 00	NN	1.87	9
LF2016B	7/23/16	1	27 00	91 00	NN	0.96	3
LF2016B	7/23/16	2	27 00	90 52	NN	0.00	0
LF2016B	7/23/16	3	27 00	90 44	NN	0.00	0
LF2016B	7/23/16	4	27 00	90 36	NN	0.00	0
LF2016B	7/23/16	5	27 00	90 28	NN	0.00	0
LF2016B	7/23/16	6	27 00	90 20	NN	0.00	1
LF2016B	7/23/16	7	27 00	90 12	NN	0.00	0
LF2016B	7/23/16	8	27 00	90 04	NN	0.64	2
LF2016B	7/23/16	9	27 00	89 56	NN	0.41	2
LF2016B	7/23/16	10	27 00	89 48	NN	0.56	2

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2016B	7/23/16	11	27 00	89 40	NN	0.70	6
LF2016B	7/23/16	12	27 00	89 32	NN	0.69	6
LF2016B	7/23/16	13	27 00	89 24	NN	0.82	4
LF2016B	7/23/16	14	27 00	89 16	NN	1.03	4
LF2016B	7/24/16	15	27 00	89 08	NN	1.52	9
LF2016B	7/24/16	16	27 00	89 00	NN	0.11	2
LF2016B	7/24/16	17	27 00	88 52	NN	1.25	5
LF2016B	7/24/16	18	27 00	88 44	NN	0.69	2
LF2016B	7/24/16	19	27 00	88 36	NN	0.69	2
LF2016B	7/24/16	20	27 00	88 28	NN	0.00	1
LF2016B	7/24/16	21	27 00	88 20	NN	1.39	4
LF2016B	7/24/16	22	27 00	88 12	NN	0.80	3
LF2016B	7/24/16	23	27 00	88 04	NN	0.69	2
LF2016B	7/24/16	24	27 00	88 00	NN	0.00	1
LF2016B	7/25/16	25	28 00	88 00	NN	0.77	4
LF2016B	7/25/16	26	28 00	88 04	NN	0.69	2
LF2016B	7/25/16	27	28 00	88 12	NN	0.69	2
LF2016B	7/25/16	28	28 00	88 20	NN	0.00	1
LF2016B	7/25/16	29	28 00	88 28	NN	0.00	1
LF2016B	7/25/16	30	28 00	88 36	NN	0.00	0
LF2016B	7/25/16	31	28 00	88 44	NN	0.00	1
LF2016B	7/25/16	32	28 00	88 52	NN	0.00	1
LF2016B	7/25/16	35	28 00	89 16	NN	1.91	7
LF2016B	7/25/16	36	28 00	89 24	NN	0.79	3
LF2016B	7/28/16	37	28 00	89 32	NN	0.84	9
LF2016B	7/28/16	38	28 00	89 40	NN	0.45	6
LF2016B	7/28/16	39	28 00	89 48	NN	0.78	8

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2016B	7/28/16	40	28 00	89 56	NN	1.11	8
LF2016B	7/28/16	41	28 00	90 04	NN	1.36	5
LF2016B	7/28/16	42	28 00	90 12	NN	0.24	2
LF2016B	7/28/16	43	28 00	90 20	NN	0.33	2
LF2016B	7/28/16	44	28 00	90 28	NN	1.01	3
LF2016B	7/28/16	45	28 00	90 36	NN	1.17	6
LF2016B	7/28/16	46	28 00	90 44	NN	1.02	5
LF2016B	7/28/16	47	28 00	90 52	NN	1.07	6
LF2016B	7/28/16	48	28 00	91 00	NN	1.63	13
LF2016A	6/9/16	1	27 00	91 00	BN	1.92	9
LF2016A	6/9/16	2	27 00	90 52	BN	1.97	12
LF2016A	6/9/16	3	27 00	90 44	BN	2.07	12
LF2016A	6/9/16	4	27 00	90 36	BN	1.55	7
LF2016A	6/9/16	5	27 00	90 28	BN	2.00	15
LF2016A	6/9/16	6	27 00	90 20	BN	2.13	13
LF2016A	6/9/16	7	27 00	90 12	BN	1.88	12
LF2016A	6/9/16	8	27 00	90 04	BN	1.98	10
LF2016A	6/9/16	9	27 00	89 56	BN	0.69	2
LF2016A	6/9/16	10	27 00	89 48	BN	2.02	12
LF2016A	6/9/16	11	27 00	89 40	BN	2.07	14
LF2016A	6/10/16	12	27 00	89 32	BN	2.09	16
LF2016A	6/10/16	13	27 00	89 24	BN	1.78	10
LF2016A	6/10/16	14	27 00	89 16	BN	1.80	10
LF2016A	6/30/16	25	28 00	88 00	BN	1.48	11
LF2016A	6/30/16	26	28 00	88 04	BN	1.59	11
LF2016A	6/30/16	27	28 00	88 12	BN	1.78	12
LF2016A	6/30/16	28	28 00	88 20	BN	1.74	16

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2016A	6/30/16	29	28 00	88 28	BN	2.04	20
LF2016A	6/30/16	30	28 00	88 36	BN	1.30	11
LF2016A	6/30/16	31	28 00	88 44	BN	2.34	12
LF2016A	6/30/16	32	28 00	88 52	BN	1.95	13
LF2016A	6/30/16	33	28 00	89 00	BN	1.80	11
LF2016A	6/30/16	34	28 00	89 08	BN	1.98	14
LF2016A	6/30/16	35	28 00	89 16	BN	2.10	13
LF2016A	6/30/16	36	28 00	89 24	BN	2.10	20
LF2016A	7/1/16	37	28 00	89 32	BN	2.14	19
LF2016A	7/1/16	38	28 00	89 40	BN	1.98	13
LF2016A	7/1/16	39	28 00	89 48	BN	2.11	15
LF2016A	7/1/16	40	28 00	89 56	BN	2.13	20
LF2016A	7/1/16	41	28 00	90 04	BN	2.24	17
LF2016A	7/1/16	42	28 00	90 12	BN	1.95	14
LF2016A	7/1/16	43	28 00	90 20	BN	1.70	11
LF2016A	7/1/16	44	28 00	90 28	BN	1.71	10
LF2016A	7/1/16	45	28 00	90 36	BN	1.95	11
LF2016A	7/1/16	46	28 00	90 44	BN	1.88	11
LF2016A	7/1/16	47	28 00	90 52	BN	2.07	12
LF2016A	7/1/16	48	28 00	91 00	BN	2.02	13
LF2016B	7/23/16	1	27 00	91 00	BN	0.90	3
LF2016B	7/23/16	2	27 00	90 52	BN	1.01	3
LF2016B	7/23/16	3	27 00	90 44	BN	1.68	6
LF2016B	7/23/16	4	27 00	90 36	BN	0.00	1
LF2016B	7/23/16	5	27 00	90 28	BN	1.28	4
LF2016B	7/23/16	6	27 00	90 20	BN	1.16	4
LF2016B	7/23/16	7	27 00	90 12	BN	1.42	5

Cruise	Date	Station	Latitude	Longitude	Net Type	H'	T_F
LF2016B	7/23/16	8	27 00	90 04	BN	1.19	4
LF2016B	7/23/16	9	27 00	89 56	BN	1.47	5
LF2016B	7/23/16	10	27 00	89 48	BN	1.05	3
LF2016B	7/23/16	11	27 00	89 40	BN	0.00	1
LF2016B	7/23/16	12	27 00	89 32	BN	1.70	8
LF2016B	7/23/16	13	27 00	89 24	BN	1.43	6
LF2016B	7/23/16	14	27 00	89 16	BN	1.47	5
LF2016B	7/24/16	15	27 00	89 08	BN	1.49	5
LF2016B	7/24/16	16	27 00	89 00	BN	1.81	8
LF2016B	7/24/16	17	27 00	88 52	BN	2.49	21
LF2016B	7/24/16	18	27 00	88 44	BN	2.10	10
LF2016B	7/24/16	19	27 00	88 36	BN	1.85	9
LF2016B	7/24/16	20	27 00	88 28	BN	1.45	7
LF2016B	7/24/16	21	27 00	88 20	BN	1.70	11
LF2016B	7/24/16	22	27 00	88 12	BN	2.01	13
LF2016B	7/24/16	23	27 00	88 04	BN	1.99	9
LF2016B	7/24/16	24	27 00	88 00	BN	1.33	4
LF2016B	7/25/16	25	28 00	88 00	BN	1.64	9
LF2016B	7/25/16	26	28 00	88 04	BN	1.73	10
LF2016B	7/25/16	27	28 00	88 12	BN	1.49	5
LF2016B	7/25/16	28	28 00	88 20	BN	1.67	11
LF2016B	7/25/16	29	28 00	88 28	BN	1.32	5
LF2016B	7/25/16	30	28 00	88 36	BN	1.23	5
LF2016B	7/25/16	31	28 00	88 44	BN	1.83	14
LF2016B	7/25/16	32	28 00	88 52	BN	1.27	6
LF2016B	7/25/16	33	28 00	89 00	BN	1.55	9
LF2016B	7/25/16	34	28 00	89 08	BN	1.76	8

Cruise	*Date*	*Station*	*Latitude*	*Longitude*	*Net Type*	*H'*	T_F
LF2016B	7/25/16	35	28 00	89 16	BN	1.36	8
LF2016B	7/25/16	36	28 00	89 24	BN	1.84	11
LF2016B	7/28/16	37	28 00	89 32	BN	2.16	17
LF2016B	7/28/16	38	28 00	89 40	BN	1.99	16
LF2016B	7/28/16	39	28 00	89 48	BN	2.36	15
LF2016B	7/28/16	40	28 00	89 56	BN	2.27	16
LF2016B	7/28/16	41	28 00	90 04	BN	2.28	14
LF2016B	7/28/16	42	28 00	90 12	BN	2.26	15
LF2016B	7/28/16	43	28 00	90 20	BN	1.67	10
LF2016B	7/28/16	44	28 00	90 28	BN	2.44	19
LF2016B	7/28/16	45	28 00	90 36	BN	1.97	13
LF2016B	7/28/16	46	28 00	90 44	BN	2.01	12
LF2016B	7/28/16	47	28 00	90 52	BN	2.33	15
LF2016B	7/28/16	48	28 00	91 00	BN	1.56	15

*NN refers to neuston net, BN refers to bongo net, LCrefers to Loop Current

Cruise	Date	Station	Latitude	Longitude	Sea Surface Temp (°C) (YSI)	Salinity (YSI)	Dissolved Oxygen (mg/L) (YSI)	Depth (m)	NN Sargassum (kg)	NN Invert Biomass (g)	BN Invert Biomass (g)	Distance to LC (km)	Sea Surface Height (m)
LF2015A	6/6/15	1	27 00	91 00	26.66	38.18	4.99	1660	0.5	11.8	3.1	310.52	0.56
LF2015A	6/6/15	2	27 00	90 52	28.50	37.11	10.65	1660	0.5	9.5	3.6	296.07	0.56
LF2015A	6/6/15	3	27 00	90 44	28.30	36.05	5.95	1629	0.5	3.3	3.1	281.67	0.61
LF2015A	6/6/15	4	27 00	90 36	28.43	36.12	5.96	1549	0.5	6.4	4.7	267.31	0.61
LF2015A	6/6/15	5	27 00	90 28	28.52	36.12	5.95	2170	3	12.1	5.9	253.01	0.62
LF2015A	6/6/15	6	27 00	90 20	27.78	35.52	6.05	1968	0.5	1.8	4.6	238.77	0.62
LF2015A	6/6/15	7	27 00	90 12	28.89	35.67	6.03	2384	16.5	61.9	10.4	224.61	0.59
LF2015A	6/6/15	8	27 00	90 04	28.69	36.19	6.02	2450	6	17.4	10	210.55	0.59
LF2015A	6/6/15	9	27 00	89 56	28.65	36.11	6.05	2367	0.5	8.3	4.9	196.60	0.51
LF2015A	6/6/15	10	27 00	89 48	28.79	35.90	6.04	2433	1	7.4	9	182.80	0.51
LF2015A	6/6/15	11	27 00	89 40	28.88	35.60	6.02	2381	0.5	4.1	5.8	169.16	0.43
LF2015A	6/6/15	12	27 00	89 32	28.56	35.35	6.03	2510	11.5	22.6	18.8	155.63	0.43
LF2015A	6/7/15	13	27 00	89 24	27.96	35.40	6.13	2553	1	8.2	11	141.95	0.33
LF2015A	6/7/15	14	27 00	89 16	28.08	36.21	6.01	2519	4	3.6	12.9	128.20	0.33
LF2015A	6/7/15	15	27 00	89 08	28.11	36.28	5.92	2375	5	23.8	20.9	114.49	0.24
LF2015A	6/7/15	16	27 00	89 00	28.24	36.26	5.98	2292	0	13.9	11.2	100.83	0.18
LF2015A	6/7/15	17	27 00	88 52	28.48	36.18	6.00	2192	0.5	2.4	16.1	87.54	0.18
LF2015A	6/7/15	18	27 00	88 44	28.54	36.10	6.05	2265	3	15.9	37	74.45	0.20
LF2015A	6/7/15	19	27 00	88 36	28.59	36.06	6.04	2412	2	6.5	17.7	61.42	0.20
LF2015A	6/7/15	20	27 00	88 28	28.97	36.19	5.97	2578	3	16.8	10.6	48.84	0.34
LF2015A	6/7/15	21	27 00	88 20	28.96	36.54	5.96	2637	1	2.1	14	36.07	0.34
LF2015A	6/7/15	22	27 00	88 12	29.43	36.16	5.97	2685	1.5	1.5	5.5	22.99	0.53
LF2015A	6/7/15	23	27 00	88 04	29.83	36.12	5.93	2745	1.5	3.6	3.5	9.92	0.53
LF2015A	6/7/15	24	27 00	88 00	29.59	36.25	5.86	2773	18	4.1	3.3	3.34	0.71
LF2015A	6/8/15	25	28 00	88 00	28.06	36.14	6.08	2444	2.5	4.5	2.4	48.03	0.43
LF2015A	6/8/15	26	28 00	88 04	28.17	36.05	6.07	2292	2.5	9.8	11.9	54.59	0.30
LF2015A	6/8/15	27	28 00	88 12	28.38	36.15	6.06	2396	4	10.7	15.4	67.78	0.30
LF2015A	6/8/15	28	28 00	88 20	28.27	36.24	6.03	2189	0	1.2	13.2	80.99	0.22
LF2015A	6/8/15	29	28 00	88 28	28.64	36.31	6.04	2208	1	2	21.4	94.55	0.22
LF2015A	6/8/15	30	28 00	88 36	29.99	36.32	6.02	2006	0.5	1.6	19.1	108.44	0.21
LF2015A	6/8/15	31	28 00	88 44	29.96	36.64	5.99	1926	4.5	10.7	12.2	122.41	0.21
LF2015A	6/8/15	32	28 00	88 52	30.14	36.40	5.98	1579	1.5	8.8	15.2	136.25	0.24
LF2015A	6/8/15	33	28 00	89 00	29.81	36.29	6.00	1330	1.5	4.5	16.5	150.08	0.24
LF2015A	6/8/15	34	28 00	89 08	29.46	36.24	6.05	1225	6	22.3	13.7	163.95	0.28
LF2015A	6/8/15	35	28 00	89 16	29.33	35.40	6.02	1347	0	28.8	24.4	177.94	0.32
LF2015A	6/8/15	36	28 00	89 24	29.38	34.77	6.09	1244	0.5	54.3	21	191.92	0.32
LF2015A	6/9/15	37	28 00	89 32	28.66	35.69	6.07	980	1.5	14.3	23.7	205.39	0.34
LF2015A	6/9/15	38	28 00	89 40	28.40	36.24	6.06	761	3	12.8	14.6	218.84	0.34
LF2015A	6/9/15	39	28 00	89 48	28.32	36.21	6.05	800	1.5	10.4	16.4	232.24	0.35
LF2015A	6/9/15	40	28 00	89 56	28.74	36.21	6.04	666	2	17.4	19.7	245.58	0.35
LF2015A	6/9/15	41	28 00	90 04	28.63	36.22	5.98	599	5	17.8	19.4	258.73	0.36
LF2015A	6/9/15	42	28 00	90 12	28.41	36.22	5.98	505	0	1	15.2	271.45	0.36
LF2015A	6/9/15	43	28 00	90 20	28.98	36.32	6.10	472	0	2.6	11.8	284.19	0.36
LF2015A	6/9/15	44	28 00	90 28	29.24	36.28	6.00	421	0.5	2.1	10.1	297.13	0.36
LF2015A	6/9/15	45	28 00	90 36	29.37	35.80	6.00	306	1	6.8	12	310.20	0.36
LF2015A	6/9/15	46	28 00	90 44	29.23	35.39	6.01	247	0	10.3	17.3	323.29	0.36
LF2015A	6/9/15	47	28 00	90 52	28.97	35.51	6.04	407	0.5	10.2	20.6	336.43	0.36
LF2015A	6/9/15	48	28 00	91 00	27.02	35.93	5.98	178	0	18.5	27.4	349.72	0.36

Cruise	Date	Station	Latitude	Longitude	Sea Surface Temp (°C) (YSI)	Salinity (YSI)	Dissolved Oxygen (mg/L) (YSI)	Depth (m)	NN Sargassum (kg)	NN Invert Biomass (g)	BN Invert Biomass (g)	Distance to LC (km)	Sea Surface Height (m)
LF2015B	7/20/15	1	27 00	91 00	29.59	34.27	5.94	1685	0.5	2.9	8	192.00	0.34
LF2015B	7/21/15	2	27 00	90 52	27.75	34.20	5.96	1660	0.5	6.2	10.5	177.54	0.34
LF2015B	7/21/15	3	27 00	90 44	29.81	34.48	5.97	1634	0.5	1.6	12.4	163.15	0.32
LF2015B	7/21/15	4	27 00	90 36	29.60	34.51	5.97	1538	0.5	1.7	9.6	148.85	0.32
LF2015B	7/21/15	5	27 00	90 28	29.95	34.47	5.95	2065	0.5	1	21.3	134.67	0.33
LF2015B	7/21/15	6	27 00	90 20	30.40	34.81	5.94	1968	1.5	8.3	23.7	120.60	0.33
LF2015B	7/21/15	7	27 00	90 12	30.63	35.15	5.96	2384	0.5	2.7	22.3	106.51	0.36
LF2015B	7/21/15	8	27 00	90 04	30.81	35.43	5.91	2450	0	1.3	21.1	92.23	0.36
LF2015B	7/21/15	9	27 00	89 56	31.13	35.50	5.94	2367	3	10.3	19.6	78.07	0.41
LF2015B	7/21/15	10	27 00	89 48	29.93	36.12	5.94	2433	13	8.4	18.8	64.20	0.41
LF2015B	7/21/15	11	27 00	89 40	30.37	36.11	5.98	2381	1	5.1	29.4	50.42	0.49
LF2015B	7/21/15	12	27 00	89 32	29.81	36.17	5.98	2510	12	40.5	24.7	36.64	0.49
LF2015B	7/21/15	13	27 00	89 24	29.89	36.08	5.93	2553	7	26.8	7.6	23.59	0.56
LF2015B	7/22/15	14	27 00	89 16	29.05	36.10	5.97	2520	4	10	15.9	12.27	0.56
LF2015B	7/22/15	15	27 00	89 08	29.31	35.96	5.97	2414	1.2	41.8	19.8	2.68	0.63
LF2015B	7/22/15	16	27 00	89 00	29.36	36.02	5.98	2292	12.5	32.2	32.2	6.60	0.69
LF2015B	7/22/15	17	27 00	88 52	29.76	35.91	5.95	2192	18	32	20.9	14.49	0.69
LF2015B	7/22/15	18	27 00	88 44	30.46	36.16	5.89	2265	1.5	2.5	5	23.27	0.76
LF2015B	7/22/15	19	27 00	88 36	30.64	36.19	5.90	2412	2	7.7	7.4	33.45	0.76
LF2015B	7/22/15	20	27 00	88 28	30.93	36.10	5.89	2578	1	1.1	6.5	42.64	0.84
LF2015B	7/22/15	21	27 00	88 20	30.82	36.17	5.90	2637	1.5	0.5	4.4	51.49	0.84
LF2015B	7/22/15	22	27 00	88 12	30.95	36.01	5.89	2685	0	1.7	4.5	61.20	0.93
LF2015B	7/22/15	23	27 00	88 04	30.76	36.19	5.89	2741	0	1.5	4.2	68.17	0.93
LF2015B	7/22/15	24	27 00	88 00	30.73	36.13	5.90	2773	0.5	2.1	6.2	69.83	1.02
LF2015B	7/23/15	25	28 00	88 00	30.02	35.48	5.90	2444	16	4.1	14.6	40.93	0.46
LF2015B	7/23/15	26	28 00	88 04	30.16	35.33	5.95	2314	11.5	8.6	15.1	41.68	0.47
LF2015B	7/23/15	27	28 00	88 12	30.14	35.23	5.95	2420	3	4.8	15	43.37	0.47
LF2015B	7/23/15	28	28 00	88 20	30.18	35.74	5.89	2189	11	44.6	14.5	47.02	0.49
LF2015B	7/23/15	29	28 00	88 28	29.79	36.14	5.96	2212	1	4.3	10.2	50.74	0.49
LF2015B	7/23/15	30	28 00	88 36	30.46	36.21	5.95	2098	0.5	0.8	16.8	57.01	0.49
LF2015B	7/23/15	31	28 00	88 44	30.96	36.08	5.95	1937	11.5	20.3	9.5	63.87	0.49
LF2015B	7/23/15	32	28 00	88 52	30.33	36.17	5.97	1610	3	9	14.4	71.62	0.47
LF2015B	7/23/15	33	28 00	89 00	30.10	36.30	6.04	1352	6	17.9	26	81.19	0.47
LF2015B	7/24/15	34	28 00	89 08	29.30	36.19	5.96	1261	11	40.1	24.4	90.97	0.45
LF2015B	7/24/15	35	28 00	89 16	29.32	36.18	6.03	1340	5	18.7	33.1	99.66	0.42
LF2015B	7/24/15	36	28 00	89 24	29.94	32.75	5.98	1244	0	3.8	42.5	108.75	0.42
LF2015B	7/24/15	37	28 00	89 32	30.74	28.90	6.06	980	0	1.4	18.4	118.83	0.40
LF2015B	7/24/15	38	28 00	89 40	31.31	25.46	6.16	737	0	1.2	21	127.16	0.40
LF2015B	7/24/15	39	28 00	89 48	31.60	21.12	6.30	800	0	2.3	28.4	135.83	0.38
LF2015B	7/24/15	40	28 00	89 56	31.72	18.03	6.61	606	0	5.4	16.8	145.23	0.38
LF2015B	7/24/15	41	28 00	90 04	31.35	21.71	6.24	599	0	3.4	8.3	154.58	0.37
LF2015B	7/24/15	42	28 00	90 12	31.78	22.04	6.21	505	0	5.2	19	164.45	0.37
LF2015B	7/24/15	43	28 00	90 20	31.73	23.90	6.31	472	0	9.1	17.7	175.02	0.36
LF2015B	7/24/15	44	28 00	90 28	31.68	25.16	6.19	421	0	22.4	30.1	186.14	0.36
LF2015B	7/25/15	45	28 00	90 36	30.23	26.07	6.25	343	0	6.5	27.4	197.45	0.35
LF2015B	7/25/15	46	28 00	90 44	30.79	26.25	6.15	247	0	1.9	23.3	209.13	0.35
LF2015B	7/25/15	47	28 00	90 52	30.85	26.65	6.16	407	0	11.2	41.6	221.20	0.35
LF2015B	7/25/15	48	28 00	91 00	30.91	26.79	6.17	178	0	3.3	17.9	233.59	0.35
LF2016A	6/9/16	1	27 00	91 00	27.90	35.52	6.54	1660	0	0.7	8.9	244.64	0.26
LF2016A	6/9/16	2	27 00	90 52	27.82	35.20	6.54	1660	0	1.1	12.3	231.55	0.26
LF2016A	6/9/16	3	27 00	90 44	28.06	35.21	6.55	1629	0	0	12.7	218.51	0.27
LF2016A	6/9/16	4	27 00	90 36	28.13	35.47	6.55	1549	0	2.5	11.7	205.50	0.27

Cruise	Date	Station	Latitude	Longitude	Sea Surface Temp (°C) (YSI)	Salinity (YSI)	Dissolved Oxygen (mg/L) (YSI)	Depth (m)	NN Sargassum (kg)	NN Invert Biomass (g)	BN Invert Biomass (g)	Distance to LC (km)	Sea Surface Height (m)
LF2016A	6/9/16	5	27 00	90 28	28.62	35.44	6.52	2170	0	1.4	14.5	192.56	0.29
LF2016A	6/9/16	6	27 00	90 20	28.71	35.00	6.56	1968	1	2.2	14.8	179.92	0.29
LF2016A	6/9/16	7	27 00	90 12	28.93	35.50	6.55	2384	1	2.8	14.4	167.44	0.29
LF2016A	6/9/16	8	27 00	90 04	28.68	35.36	6.53	2450	0	2	12.2	154.89	0.29
LF2016A	6/9/16	9	27 00	89 56	28.76	35.39	6.54	2367	0	2.2	1.8	142.20	0.29
LF2016A	6/9/16	10	27 00	89 48	28.53	35.49	6.56	2433	0	6.6	20.8	129.51	0.29
LF2016A	6/9/16	11	27 00	89 40	28.55	35.59	6.50	2381	0	9.1	21.7	117.21	0.28
LF2016A	6/10/16	12	27 00	89 32	28.12	35.15	6.53	2510	0	2.8	22.9	105.01	0.28
LF2016A	6/10/16	13	27 00	89 24	28.11	35.48	6.50	2553	1	2.1	18.6	92.92	0.30
LF2016A	6/10/16	14	27 00	89 16	28.33	35.68	6.50	2519	0	0.9	19.6	81.04	0.30
LF2016A	6/30/16	25	28 00	88 00	29.07	33.83	6.42	2444	0	3.8	21	123.52	0.08
LF2016A	6/30/16	26	28 00	88 04	29.178	33.49	6.46	2292	0	4.5	16.8	124.41	0.14
LF2016A	6/30/16	27	28 00	88 12	29.133	33.61	6.48	2396	0	8.1	26.1	126.42	0.14
LF2016A	6/30/16	28	28 00	88 20	29.57	33.74	6.43	2189	0	1.9	31.6	128.74	0.20
LF2016A	6/30/16	29	28 00	88 28	29.24	33.60	6.54	2208	0	1.7	17.3	132.13	0.20
LF2016A	6/30/16	30	28 00	88 36	28.97	31.69	6.86	2006	0	2.2	14.9	135.63	0.24
LF2016A	6/30/16	31	28 00	88 44	29.32	35.05	6.47	1926	0	1.8	15.5	139.83	0.24
LF2016A	6/30/16	32	28 00	88 52	29.11	33.27	6.53	1579	0	9.6	20.3	144.85	0.27
LF2016A	6/30/16	33	28 00	89 00	29.29	33.17	6.52	1330	0	144.5	14.1	151.09	0.27
LF2016A	6/30/16	34	28 00	89 08	29.31	33.11	6.52	1225	0	44.4	14.8	158.06	0.29
LF2016A	6/30/16	35	28 00	89 16	28.87	31.65	6.54	1347	0	51.3	21.9	165.37	0.30
LF2016A	6/30/16	36	28 00	89 24	28.90	32.38	6.54	1244	0	20	21.3	173.63	0.30
LF2016A	7/1/16	37	28 00	89 32	29.06	32.70	6.48	980	0	58.6	25.5	182.18	0.30
LF2016A	7/1/16	38	28 00	89 40	28.04	33.10	6.50	761	0	13.6	8.4	190.82	0.30
LF2016A	7/1/16	39	28 00	89 48	29.60	32.98	6.48	800	0	2.8	16.5	200.19	0.31
LF2016A	7/1/16	40	28 00	89 56	29.49	32.49	6.54	666	0	1.6	23.1	210.14	0.31
LF2016A	7/1/16	41	28 00	90 04	29.46	32.75	6.49	599	0	0.4	11.4	220.64	0.31
LF2016A	7/1/16	42	28 00	90 12	29.54	33.07	6.46	505	0	20.9	13.5	231.61	0.31
LF2016A	7/1/16	43	28 00	90 20	29.89	33.21	6.49	472	0	4.6	13.4	242.97	0.31
LF2016A	7/1/16	44	28 00	90 28	30.02	33.03	6.47	421	0	2.8	12.3	254.67	0.31
LF2016A	7/1/16	45	28 00	90 36	30.04	33.07	6.47	306	0	2.7	11.2	266.58	0.31
LF2016A	7/1/16	46	28 00	90 44	29.98	33.27	6.41	247	0	9.8	9.2	278.46	0.31
LF2016A	7/1/16	47	28 00	90 52	29.75	33.03	6.40	407	0	8.4	9.4	290.43	0.31
LF2016A	7/1/16	48	28 00	91 00	29.88	33.34	6.36	178	0	24.5	12	302.62	0.31
LF2016B	7/23/16	1	27 00	91 00	30.05	35.78	6.32	1685	0.4	1.3	2.7	31.74	0.76
LF2016B	7/23/16	2	27 00	90 52	29.78	35.60	6.34	1660	0	0.6	2	31.80	0.76
LF2016B	7/23/16	3	27 00	90 44	30.04	35.68	6.33	1634	0	1.7	2.8	30.16	0.79
LF2016B	7/23/16	4	27 00	90 36	30.12	35.81	6.33	1538	0	0.4	1.1	28.74	0.79
LF2016B	7/23/16	5	27 00	90 28	30.15	35.35	6.34	2065	0	0.3	2.1	27.03	0.78
LF2016B	7/23/16	6	27 00	90 20	30.57	35.73	6.32	1968	0.4	2.1	2.8	25.33	0.78
LF2016B	7/23/16	7	27 00	90 12	30.88	35.80	6.32	2384	0	0.4	2.4	22.97	0.75
LF2016B	7/23/16	8	27 00	90 04	32.07	35.71	6.27	2450	0	0.2	3.3	19.09	0.75
LF2016B	7/23/16	9	27 00	89 56	32.04	35.61	6.26	2367	0	1	3.8	13.63	0.69
LF2016B	7/23/16	10	27 00	89 48	32.11	35.70	6.27	2433	0	1.8	6.5	5.00	0.69
LF2016B	7/23/16	11	27 00	89 40	31.85	35.56	6.26	2381	0.4	2.1	1.7	4.74	0.61
LF2016B	7/23/16	12	27 00	89 32	31.36	35.70	6.28	2510	0	2.7	3.5	15.31	0.61
LF2016B	7/23/16	13	27 00	89 24	31.03	35.25	6.36	2553	0	3.2	10.7	25.84	0.52
LF2016B	7/23/16	14	27 00	89 16	31.00	35.45	6.25	2520	0.8	1.7	4.3	35.79	0.52
LF2016B	7/24/16	15	27 00	89 08	30.26	35.12	6.32	2414	0	5.6	2.1	46.33	0.44
LF2016B	7/24/16	16	27 00	89 00	30.27	33.53	6.34	2292	0	6.1	10.1	56.84	0.40
LF2016B	7/24/16	17	27 00	88 52	30.29	33.77	6.36	2192	0	5.3	12.6	66.40	0.40
LF2016B	7/24/16	18	27 00	88 44	30.66	32.93	6.32	2265	0	0.4	7.2	76.27	0.37

Cruise	Date	Station	Latitude	Longitude	Sea Surface Temp (°C) (YSI)	Salinity (YSI)	Dissolved Oxygen (mg/L) (YSI)	Depth (m)	NN Sargassum (kg)	NN Invert Biomass (g)	BN Invert Biomass (g)	Distance to LC (km)	Sea Surface Height (m)
LF2016B	7/24/16	19	27 00	88 36	30.69	33.51	6.35	2412	0	0.5	9.5	86.43	0.37
LF2016B	7/24/16	20	27 00	88 28	31.26	33.33	6.36	2578	0	0.1	3.5	96.12	0.34
LF2016B	7/24/16	21	27 00	88 20	31.29	34.69	6.36	2637	0	0.1	11.6	99.78	0.34
LF2016B	7/24/16	22	27 00	88 12	30.94	34.38	6.34	2685	0	0.4	12.1	101.61	0.31
LF2016B	7/24/16	23	27 00	88 04	30.30	32.38	6.44	2741	0	0	11.3	103.40	0.31
LF2016B	7/24/16	24	27 00	88 00	30.54	33.89	6.36	2773	0	0.3	3.7	104.51	0.28
LF2016B	7/25/16	25	28 00	88 00	30.23	33.58	6.33	2444	0	0	6.4	213.66	0.17
LF2016B	7/25/16	26	28 00	88 04	30.31	33.32	6.38	2314	0	1.4	7.9	208.95	0.19
LF2016B	7/25/16	27	28 00	88 12	30.06	33.51	6.37	2420	0	1	10.4	198.48	0.19
LF2016B	7/25/16	28	28 00	88 20	30.31	33.47	6.38	2189	1	0.3	8.5	188.07	0.22
LF2016B	7/25/16	29	28 00	88 28	30.28	33.60	6.40	2212	0	1.9	10.3	178.06	0.22
LF2016B	7/25/16	30	28 00	88 36	31.68	33.13	6.40	2098	0	0.2	5.1	167.46	0.27
LF2016B	7/25/16	31	28 00	88 44	30.68	34.04	6.42	1937	0	0.4	14.5	156.89	0.27
LF2016B	7/25/16	32	28 00	88 52	31.09	34.33	6.35	1610	0.6	0.1	4.6	146.67	0.32
LF2016B	7/25/16	33	28 00	89 00	30.79	35.17	6.35	1352	*NA*	*NA*	5.2	137.31	0.32
LF2016B	7/25/16	34	28 00	89 08	30.59	32.19	6.50	1261	*NA*	*NA*	9.8	128.77	0.36
LF2016B	7/25/16	35	28 00	89 16	30.70	31.91	6.50	1340	0	12.9	5.5	120.10	0.40
LF2016B	7/25/16	36	28 00	89 24	30.42	32.89	6.29	1244	0	11.2	7.8	112.40	0.40
LF2016B	7/28/16	37	28 00	89 32	29.76	32.40	6.36	980	0	17	13.8	106.10	0.42
LF2016B	7/28/16	38	28 00	89 40	29.85	30.18	6.44	737	0	7.8	14.8	100.81	0.42
LF2016B	7/28/16	39	28 00	89 48	30.17	29.77	6.37	800	0	11.9	16.1	95.49	0.43
LF2016B	7/28/16	40	28 00	89 56	29.72	29.22	6.45	606	0	9.7	14.4	91.77	0.43
LF2016B	7/28/16	41	28 00	90 04	30.00	29.14	6.50	599	0	1.9	13.9	89.34	0.43
LF2016B	7/28/16	42	28 00	90 12	30.24	28.15	6.53	505	0	5.9	17.8	86.96	0.43
LF2016B	7/28/16	43	28 00	90 20	30.64	29.23	6.42	472	0	1.2	9.2	85.27	0.42
LF2016B	7/28/16	44	28 00	90 28	30.85	29.81	6.44	421	0	1.4	17.7	83.55	0.42
LF2016B	7/28/16	45	28 00	90 36	30.44	30.33	6.39	343	0	7	12.6	82.02	0.42
LF2016B	7/28/16	46	28 00	90 44	30.48	30.83	6.38	247	0	4.4	12.1	80.42	0.42
LF2016B	7/28/16	47	28 00	90 52	30.33	30.96	6.32	407	0	4.7	11.1	79.30	0.43
LF2016B	7/28/16	48	28 00	91 00	30.37	31.21	6.39	178	0	7.4	15.8	79.29	0.43