INFLUENCE OF FRESHWATER INFLOW IN THE BRAZOS RIVER ESTUARY

by

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Dedication

I dedicate this work to my late maternal grandfather James Mooney, who passed away shortly after my education at University of Houston- Clear Lake began. You were a model for everyone around you through both your military service, and dedication to your family. What I remember most fondly about you is how after a life full of strife and adventure, you were able to find solace and peace in retirement. From the cultivation of your luxurious garden to teaching me how to play dominoes, I never saw you without a smile on your face. I wonder now if all those times you would watch your children and grandchildren play, that you were in fact reminiscing about all your achievements in life and that your smile demonstrated your satisfaction that you could finally sit back and enjoy those achievements like a well-written novel. You had many things to be proud of in your life, but you always seemed most proud of your children and grandchildren. You witnessed all your daughters grow up, achieve a higher education, and start families. You witnessed all your grandchildren excel academically and as individuals, but I regret that the completion of this paper was not something you could enjoy in your lifetime. As the next chapter of my life begins, I look back on your life with the hope that when the story of my life reaches its final chapter, I too can have a life full of family, friends, and frivolity that I can enjoy as much in retirement as I did in the journey.

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ABSTRACT

INFLUENCE OF FRESHWATER INFLOW IN THE BRAZOS RIVER ESTUARY

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The influence of freshwater inflow on estuarine ecology is a topic that receives a lot of attention due to estuaries acting as medians to oceanic and freshwater environments. Freshwater inflow has varying effects depending on the morphology of the estuary, and the Brazos River is one of only three rivers in Texas with a riverine estuary that discharges directly into the Gulf of Mexico. The Environmental Institute of Houston (EIH) has been collecting data to categorize the ecology and hydrology within the estuary since 2012 when the Brazos Basin and Bay Area Stakeholder Committee (BBASC) formally addressed the need for research assessing the impacts of freshwater inflow. Project objectives included: (1) Describing the temporal variation in hydrology in the lower Brazos River, (2) evaluating the relationships between nekton community, freshwater inflow, seasonality and water quality using graphical and statistical methods, (3) characterizing nekton abundance, diversity, and community composition, (4) identifying focal species for different sites, flow tiers and seasons, and (5) identifying any future research needs. Data acquired from the United States Geological Survey (USGS) gage #08116650 was used in order to assess the normal trends of variation in discharge (cfs), as well as determine if data utilized far upstream from the estuary could be used to accurately predict discharge and water quality downstream. Automated monitoring loggers were used to collect long-term data for salinity (psu), temperature (°C), dissolved oxygen (DO) (mg/L), and depth (m) beginning in 2014 in order to create predictive models from daily average discharge. The results indicated that discharge in the Brazos River does exhibit predictable seasonal patterns of increased flow during the spring and reduced flow during the summer, yet still exhibits a huge degree of variation within seasons and between years. The Brazos River is also subject to extreme flow conditions at an increasing rate despite having an average annual discharge of only 7,400 cfs. The regression analysis from the automated loggers and USGS discharge data indicates that salinity and water depth are strongly correlated to flow and react in the form of exponential decay and sigmoidal growth respectively. Temperature proved to not be significantly correlated with flow, but multiple linear regression analysis with DO data demonstrated a complex relationship with flow and temperature. Two-way ANOVAs were used to determine if variations in water quality variables- temperature, salinity, DO, pH, turbidity (NTU), thalweg depth (m), and Secchi disk transparency (m) could be explained by sites, TCEQ flow tiers, or an interaction between both. The results showed that all variables exhibited significant differences ($p \leq 0.05$) between flow tiers and sites- the only exception being temperature. The only two variables tested with a significant interaction effect between flow tier and site were salinity and pH. Principal component analysis was also used to determine whether season, flow tier, or spatial differences could explain the variability in water quality between samples. The results indicated that season is the primary driver of variability due to temperature having the highest eigenvector coefficients for each principal component calculated for surface and bottom profile. Pearson correlation analysis was also used to determine how water quality could be used to predict nekton community diversity. Salinity proved to be the most significantly correlated to nekton communities sampled using both an otter trawl and beam trawl. Nekton community metrics in the form of total catch, species richness, Shannon-Wiener diversity, Shannon evenness, Margalef Richness and catch per unit effort (CPUE) were subjected to nonparametric tests in order to test for significant differences between season, site, and flow tier. The results indicated the larval fish community sampled with the beam trawl near the shore was significantly affected by season, while spatial differences and flow tier explained the variation in nekton communities sampled mid-channel with the otter trawl. The results of this study corroborate many of the conclusions drawn from earlier studies on the ecology of the lower Brazos, as well as provide additional evidence of the highly dynamic nature of the Brazos estuary, while also providing further justification for continued and expanded research.

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INTRODUCTION:

Characteristics of an Estuary

In ecology, the boundaries that separate one distinct biological community from another are seldom abrupt; it is more common to find a transitional community serving as a barrier- this is what is known as an ecotone (Holland 1988). Since ecotones are essentially mixing areas for biotic an abiotic factors for multiple ecosystems, it is not uncommon to find greater diversity in the plant and animal communities than you would find in either habitat the ecotone separates (Gosz 1993). One of the greatest examples of this phenomenon is where rivers and streams meet the ocean to form one of the most important ecosystems on Earth: estuaries (Day et al. 2012). Much of the ecological contribution from estuaries is rooted in the highly specialized vegetation communities that only exist in estuaries. This ecosystem is one of the most productive in the world- primary productivity can yield up to 80 metric tons per hectare of plants (Mitsch and Gosselink 2015). This high primary production also contributes to sediment collection and buildup- a feature that not only allows it to act as a sink for minerals, but also to cope with the onset of rising sea levels. Estuaries can function as sinks, sources, and transformers of nutrients, sediments, and other chemicals depending on the balance freshwater inflow, tidal exchange, underlying geology, and land-use (Day et al. 2012). Inevitably, since everything from the corresponding watershed eventually flows downstream into the estuary, these ecosystems act as sinks for a variety of limiting nutrients out at sea such as nitrogen, but can also function as sinks for limiting nutrients in freshwater systems like phosphorus brought in by rising tides (Day et al. 2012; Mitsch and Gosselink 2015). The occurrence of flooding, heavy rain, large tides, watershed size, land slope, human influence, etc. are all factors which can contribute to the export of these nutrients upstream, out to sea, or to adjacent watersheds (Orlando et al. 1993).

Many of the nutrients that tidal marshes act as sinks for are inorganic in nature, but converted into organic forms before being exported- sulfur, iron, manganese, nitrogen, carbon, phosphorus (Day et al. 2012; Mitsch and Gosselink 2015).

One of the most recognizable roles that estuaries play is serving as habitat- both temporary and permanent- to a wide variety of organisms. As the waters are very productive, it offers a strong base to the food web, which makes estuaries ideal nurseries for many species of fish (Mitsch et al. 2015). Adapting to the constantly shifting salinity regime for even part of their life is ecologically rewarding for any fish species, as it helps them avoid potential predators that are restricted to upstream or oceanic habitat- providing refuge from both other organisms and adverse environmental conditions. Approximately 95% percent of the commercially harvested species- both bycatch and target species- in the Gulf of Mexico are classified as estuarine-dependent species (Pattillo et al. 1997; USEPA 1999). It is these estuarine-dependent species that contribute to the Western Atlantic Marine Regions high species richness and the 10-13% rate of endemism of fishes in the Gulf of Mexico (Helfman et al. 2009; Hoese and Moore 1977). Many species of fish in the Gulf of Mexico tend to spawn offshore in the summer, allowing the oceanic currents of winter to carry their larvae back towards land and into the estuaries to have a safe place to mature- the Gulf Menhaden (*Brevoortia patronus*) is a prominent example of this reproductive strategy (Sogard et al. 1987). Other fish species spend their entire lives in estuaries in order to mature and reproduce- a notable example is the Saltmarsh Topminnow (*Fundulus jenkinsi*) (Guillen et al. 2015). Fish are not the only animals to benefit from making estuaries part of their lifestyle; the Diamond-backed Terrapin (*Malaclemys terrapin*) are specialist reptiles that thrive only in estuarine waters from the coasts of Texas to Cape Cod, MA (George 2014). The ideal habitat conditions for small fish and vertebrates- as well as the animals the feed on- both seasonally and year-round also provides critical foraging habitat for migratory species. Shorebirds such as the Willet (*Tringa semipalmata*) rely on estuaries as stopovers to feed and rest before proceeding north to their breeding grounds in sub-Arctic Canada and Alaska (Miller 2012).

Having such a pivotal role in the life cycles of many species of animals, diversity of roles in biochemistry, and unique geography, estuaries are also of great interest to humans. Estuaries throughout the world support multiple human activities including fisheries, recreational tourism, agriculture, transportation, urban centers and agriculture (Levinton 1995). A significant proportion of the world's largest cities including Houston and Galveston, TX, have been constructed on estuaries (NOAA 1990). The increased rates of decline of estuarine habitat and loss of fisheries production has inspired ongoing scientific investigations of the relationships of estuarine biodiversity, hydrology, and physiochemistry and how all these factors influence each other over time and during disturbance events- both natural and artificial (Lotze et al. 2006).

Physiological Factors Affecting Estuarine Ecology

Every estuary is unique because its ecological structure responds to a multitude of abiotic factors and environmental processes such as tidal patterns, freshwater inflow, climate, erosion, etc. As a result, this can complicate the application of observed relationships from one system to another even if they are in close geographic proximity. Local climate, freshwater inflow and tidal patterns all interact and influence water quality in an estuary. The scale at which these processes interact within the estuary can also subsequently affect variance in depth, area, and physicochemical variables such as turbidity, salinity and nutrients, which can help further classify estuaries (Engle et al. 2007).

The study of how salinity varies in response to freshwater inflow and how it in turn influences the ecology of estuaries is the topic of many current research projects. Although some factors like turbidity can create broad geochemical "zones" throughout the estuary, the salinity gradient in estuaries tends to be narrow, with most distinguishable zones occurring only around the extremes, namely the areas with high freshwater inflow (0.1-1.0 ppt) and high seawater inflow (≥34 ppt) (Guenther and MacDonald 2012). However, even though these areas tend to be small in comparison to the ecosystem as a whole, the area covered and the distance between them are insignificant when the variation in ecological communities demonstrates correlation with variations in salinity (Able et al. 2001). For example, the Mermentau River Basin in Louisiana has historically displayed stable gradients in salinity with lower freshwater discharge, and while the greatest diversity of species still occurred at the extremes, it was found in the more stable waters of Grand and White Lakes that marine species diversity exceeded that of freshwater species (Gunter 1956). Similar patterns were observed in Old Fort Bayou, Mississippi, where the assemblages of freshwater species were strongly correlated with salinity (Peterson and Ross 1991). Salinity affects organismal distribution, and salinity is in turn affected by changes in tidal patterns and freshwater inflow. The interaction of all these factors and the unique nature of each estuary makes it difficult to classify community structure based on these physiological variables alone. Nevertheless, even a regional understanding of the disparity between community changes between estuaries of similar attributes can prove useful in the future management and study of estuarine habitats (Guenther and MacDonald 2012).

Community composition typically changes gradually within the estuary, but there are also areas that experience rapid rates of change. These areas of rapid community change and environmental conditions are known as ecoclines and are of great scientific interest. In Florida there has been strong evidence to support the idea of identifying ecologically relevant salinity zones by changes in nekton community along the salinity gradients in Tampa Bay and Charlotte Harbor (Greenwood 2007; Greenwood et al. 2007). They found that the most consistent changes in the nekton community composition occurred at the lower end of the salinity gradient which also exhibited the greatest diversity of freshwater species (Greenwood 2007). Within the Alafia River they also observed that increased freshwater inflow would push the tidal-freshwater interface – also known as the salt wedge or halocline- downstream to the mouth of the river with a concurrency of downstream shift in the center of abundance of many transient and marine species. Changes in downstream nekton abundance downstream were attributed more towards changes in salinity rather than freshwater inflow, but negative correlations between inflow and salinity observed suggests that freshwater inflow plays a pivotal role in affecting the locations of the salinity ecotone and therefore how quickly biodiversity changes (Greenwood et al. 2007).

The role that freshwater inflow has on affecting organismal distribution in estuaries appears to be based mostly on individual effects of physical factors on different organisms rather than leading to trophic cascades (Kimmerer 2002a). Dissolved oxygen (DO) concentration is another variable that influences the distribution of estuarine organisms, but unlike salinity, it is more variable throughout not only the estuary, but the entire watershed (Justus et al. 2014). Nevertheless, salinity and DO are both influenced by the mixing of water masses, and can lead to distinct zonation within an estuarine ranging from high velocity and energy areas near river mouths and tidal passes and lower energy areas such as the bay side of barrier islands (Bilotta and Brazier 2008). Stratification of salinity and DO is also possible due to differences in water temperature from the ocean and the freshwater source of the estuary. Water that is less saline and warmer in temperature tends to be less dense and hold less oxygen, than colder, more saline water (Cloern et al. 2017). As the pattern goes, colder and saltier water sinks, and without sufficient mixing from freshwater influx, tides, wind, wave action, etc., sediments will sink to the bottom (Day et al. 2012). During periods where less vertical mixing occurs, debris and nutrients from runoff can settle in the estuary, contributing to phytoplankton and algal blooms. During these periods, photosynthesis can increase, contributing to higher oxygen levels at the surface, as well as increased acidity (Mitsch and Gosselink 2015). However, during phytoplankton die-offs, oxygen levels will plummet as a side effect of decomposition, which can be devastating for all layers of the estuary without vertical mixing (Armstrong 1987).

Effects of Season and Flow

The combination of physical factors and interactions at the marginal extremes have a dynamic effect on the ecosystem, and quantifying these effects on biota can be useful for establishing criteria for a healthy estuary (Sheaves et al. 2012). In Galveston Bay, TX it has been observed that the distributions of both the Atlantic Rangia (*Rangia cuneata*) and water celery (*Vallisneria americana*) are both strongly correlated to freshwater inflow, and even slight reductions can lead to declines (Parnell et al. 2011). Using this relationship, many studies have used such species as tools for assessing ecosystem health and to set criteria for flow standards in estuaries (Doering et al. 2002). However, many of these previous studies did not address the influence of seasonality on estuarine processes or species composition. Seasonal variation in freshwater inflow, physicochemical variables, tidal patterns and biota often exceeds whatever variability already exists between estuaries (Moskalski et al. 2011). For example, deeper tidal river fish communities within the Myakka and Peace rivers of southern Florida formed distinct seasonal groups with the highest densities overall occurring from June to October, and

November to March (Idelberger and Greenwood 2005). Further studies in the Peace River showed that during periods of low rainfall and decreased flow, fish assemblages in the upper river became more similar to communities in the high salinity regions of the lower river (Stevens et al. 2013). These seasonal reductions in freshwater input can stress oligohaline species that require lower salinities in the estuary, leading to the predictable declines of some of these more sensitive species (Kimmerer 2002b; Tsou and Matheson 2002). In most cases- within the Gulf of Mexico- the reduction of freshwater inflow occurs during summer months when lack of rainfall typically reduces river discharge (Wagner and Austin 1999).

The close coupling of salinity and freshwater inflow has been observed in multiple estuaries across all continents. In the Mediterranean it has been observed that freshwater renewal is most critical during the winter since seasonal recessions tend to occur during the summer (Basterretxea et al. 2017). Marine fish assemblages in the Breede River, South Africa have been shown to change very little in species diversity and abundance even when examined on an interannual time scale and occurrence of freshwater influx events that can account for nearly half of the annual precipitation (James et al. 2018). However, this pattern primarily applies to assemblages consisting mainly of species tolerant to higher salinity conditions. The same response was not observed in oligohaline freshwater and exclusively estuarine species (Lamberth et al. 2008). In the Matla River, India, variations in fish assemblages were significantly different at the river mouth and the upper reaches. Additionally, these differences were consistent when sampling events were grouped into pre-monsoonal, monsoonal, and post-monsoonal seasons (Mukherjee et al. 2013).

Events like monsoons, hurricanes, and seasonal flooding can have a strong effect on coastal ecosystems, but it is unclear how much of the normal seasonal and geospatial patterns in an estuary are disrupted as a result. During flooding, the geomorphology of estuaries that exhibit less vertical mixing can be altered in such a way that changes in water parameters such as salinity can be classified more as disturbance rather than natural swings in biodiversity (Van Diggelen and Montagna 2016). Sampling events in the Matla River after Cyclone Aila revealed the absence of sixteen species but the presence of twelve previously undocumented species (Mukherjee et al. 2012). During the 2004 hurricanes in Tampa Bay and Charlotte Harbor Florida researchers found that any changes or displacement of fish and aquatic vegetation were significant only in the lower portions of the river. However, from a decadal perspective, the fish assemblages appeared to be quite stable and resistant to environmental disturbance (Greenwood et al. 2006). Nevertheless, there are quantifiable changes in water quality after such storm events, and how these changes relate to the sensitive habitat and biota of each individual estuary is difficult to predict (Davis et al. 2004).

The Brazos River and Estuary

The highest point of the Brazos River can be traced to the Blackwater Draw in Curry County, New Mexico from its mouth near Freeport, TX- a total length of approximately 2,060 kilometers (1,280 miles), making it the longest river in Texas (Kimmel 2011; Phillips 2006; USGS 2005). The upper Brazos River passes through an arid region known as the Llano Estacado- which is Spanish for “Staked Plains”- and as a result, many of its tributaries are not perennial (Kimmel 2011). The joining of the Salt Fork and Double Mountain Fork- approximately eight miles northwest of Rule, TX- is often considered the origin of the Brazos River (Figure 51). Despite both streams being classified as ephemeral instead of perennial, the meeting of these two water bodies has a higher rate of continuous flow than contemporary streams of the upper watershed like the Blackwater Draw (Kimmel 2011; Zeng et al. 2011). It is for this reason that the confluence of these two rivers is officially recognized as the headwaters of the Brazos River.

The Brazos River has a mean annual discharge of approximately 7,400 ft^3/s (cfs), with a watershed draining an area of approximately 118,000 km^2 (45,600 mi^2) and encompassing a total of forty-two major reservoirs, making it the largest watershed in Texas (NOAA 1990; Phillips 2006; USGS 2005; USGS 2008). It is home to over seventy native fish species including several endangered species such as the Smalleye Shiner (*Notropis buccala*) and Sharpnose Shiner (*Notropis oxyrhynchus*) (Dahm et al. 2005; Wilde and Durham 2013). Prior to 1929, the river delta was located in present-day Surfside Beach, TX, until it was diverted approximately ten kilometers west by the U.S. Army Corps of Engineers over the span of approximately five years beginning in 1925 (Rodriguez et al. 2000). The purpose of the diversion was for the creation of a large and dependable port for the booming sulfur mining industry, but excessive flooding and sediment loading prior to the early twentieth century stalled efforts for decades (Salvant and McComb 1999; Townsend 2009). A diversion dam was constructed in the northwest portion of Freeport, TX- approximately 7.5 miles upstream from the original mouth- along with a diversion channel re-routing the main river from the dam to an outlet in the Gulf of Mexico- approximately 6.5 miles southwest of the original mouth in Surfside Beach, TX. Upon completion, the old river channel was dredged, and Freeport Harbor soon rose to become one of the largest ports in the United States (Townsend 2009). Though the short-term environmental impacts of the diversion are mostly undocumented, the characterization of the estuary due to its geography has remained relatively unchanged (Rodriguez et al. 2000).

The Brazos River has a riverine-type estuary, meaning the freshwater discharges directly into the Gulf of Mexico, thereby preventing an extensive and wide delta from forming (Dyer 1997). The Brazos River is one of only three rivers in Texas that possess this type of estuary- the other two include the Colorado and Rio Grande (Miller 2014; White and Calnan 1990). The estuary is also wave-dominated and possesses a short residence time within the tidal portion of the river. This results in the estuary exhibiting oligohaline or low-salinity freshwater conditions even near the mouth (Orlando et al. 1993). It has previously been documented that estuaries with higher freshwater inflow and lower salinity tend to have a higher nutrient load, which can result in eutrophic conditions during warmer months (Palmer et al. 2011).

In 2007, the 80th Texas legislature passed Senate Bill 3 (SB 3), which amended the Texas Water Code §11.1471 in order to establish environmental flow standards for the major bays and rivers of Texas (Quigg and Steichen 2015). This led to the creation of the Brazos Basin and Bay Area Stakeholder Committee (BBASC) and the Brazos Basin and Bay Area Expert Science Team (BBEST) in 2011 in order to develop environmental flow recommendations for the Brazos River Basin and associated bay and estuary system. By March 2012, the BBEST had compiled and analyzed all available data in order to submit an environmental flow recommendation report to the BBASC. After six months of deliberation, the BBASC submitted their stakeholder recommendations report to both the Texas Commission on Environmental Quality (TCEQ) and Environmental Flows Advisory Group (EFAG) in September 2012 (BBASC 2012). The TCEQ then adopted environmental flow standards for the Brazos River Basin, which went into effect beginning March 6, 2014 (TCEQ 2014).

These standards were based on historical hydrological conditions adopted for instream standards at the Rosharon gage due to lack of sufficient biological response data in the lower tidal portion of the river (BBEST 2012). By the time the BBASC submitted their recommendations, a modern study conducted by the Environmental Institute of

Houston (EIH) at University of Houston- Clear Lake (UHCL) was underway in order to characterize the ecology of the Brazos estuary, which meant the most recent ecological data for review was only available from studies conducted in 1973-1975 by the Texas Parks and Wildlife Department (TPWD) and the Dow Chemical Company in 1982 (Emitte 1983; Johnson 1977; Miller 2014). Following the submission of the recommendation report to TCEQ, the BBASC also created a research implementation plan in 2013 in order to address gaps in the knowledge of how biota respond to the changing hydrology and whether any standards approved by the TCEQ would require further change (BBASC 2012; BBASC 2013). In response to the needs of such research, the Environmental Institute of Houston (EIH) at University of Houston-Clear Lake (UHCL) conducted studies in the Brazos River from 2014-2017 (Bonner et al. 2017; Bonner et al. 2015). Bonner et al. (2017) recommended further study and sampling during the summer months, examining stream water inflow effects on nearshore Gulf of Mexico waters, and continued long-term monitoring in order to validate and if necessary recommend alternative flow standards (Bonner et al. 2017; TCEQ 2014). Since the Brazos River estuary lacks a lagoon type estuarine system, the residence time within the tidal portion of the river is very short and results in lower salinities (Bonner et al. 2017). It has been previously documented that estuaries with higher freshwater inflow and lower salinity tend to have a higher nutrient load, which can result in eutrophic conditions during warmer months (Palmer et al. 2011).

Research Objectives

The primary interest of this study was to assess the seasonal and annual variation in freshwater inflow in order to evaluate the physiochemical changes in water quality and biological responses of nekton communities inhabiting the Brazos River estuary. In order to understand this, project objectives included: (1) Describing the temporal variation in hydrology in the lower Brazos River, (2) evaluating the relationships between nekton community, freshwater inflow, seasonality and water quality using graphical and statistical methods, (3) characterizing nekton abundance, diversity, and community composition, (4) identifying focal species for different sites, flow tiers and seasons, and (5) identifying any future research needs.

Data collected by Johnson (1977), Miller (2014), Bonner et al. (2015), Bonner et al. (2017) have shown the Brazos River to be highly dynamic in hydrology and supports a diverse nekton community, but the effects of seasonal variation have yet to be comprehensively investigated since there has been a lack of scientific research conducted during the summer months in recent years (BBASC 2013; Bonner et al. 2017; Bonner et al. 2015; Emitte 1983; Johnson 1977; Miller 2014). The sampling of the current study focused primarily during summer in order address seasonal gaps in data in continuation with the studies conducted by Bonner et al. meant to address the research needs proposed by the BBASC (BBASC 2012; BBASC 2013; Bonner et al. 2017; Bonner et al. 2015).

Data collection for Bonner et al. (2015) began on October 30th, 2014, and concluded on October 19th, 2015. Data analysis during 2015 relied on data collected by Miller (2014) in order to have a larger data set for preliminary ecological and seasonal analysis in the Brazos estuary. The findings in 2015 suggested that the adopted flow tier standards by TCEQ were effective in detecting significant differences in water quality and nekton communities (TCEQ 2014). Time-series modeling between daily average discharge and water quality variables measured with in situ instrumentation helped to visualize how freshwater inflow influences water quality throughout the estuary. Subsequent statistical tests would quantify that influence by detecting significant differences in salinity and dissolved oxygen between different flow tiers. When assessing the relationship of nekton communities and freshwater inflow, it revealed that community assemblages during high flow exhibited a greater spatial gradient from the river mouth to the upper reaches. During periods of decreased flow, species composition was more similar throughout the estuary. Data collection for Bonner et al. (2017) began on November 17th, 2016, and concluded on October 18th, 2017. The behavior of the halocline in the estuary was given greater attention in 2017 than 2015 by evaluating responses of water quality at both the surface and bottom. DO lacked significant differences between sites only at the surface, whereas the results of 2015 suggested there were no significant differences in sites at all due to the usage of all depth-interpolated profile measurements for statistical analysis (Bonner et al. 2015). Greater heterogeneity in sites was observed when examining bottom salinity versus surface salinity during low flow tiers. Weak correlations were observed between nekton community metrics and discharge, but similarity in community assemblages could still be observed when collections were classified by flow tier.

Freshwater inflow directly influences the nekton community through changes in velocity, flow and shoreline inundation and indirectly through changes in water quality including water temperature, salinity, total suspended solids (TSS), dissolved oxygen (DO), and nutrient loads. It seems highly likely that the Brazos River will display these trends given the existing evidence of similar patterns throughout the Gulf of Mexico and other habitats with similar climate patterns (Camacho et al. 2015; Greenwood 2007; Greenwood et al. 2007; Idelberger and Greenwood 2005; Mukherjee et al. 2013; Peterson and Ross 1991; Wagner and Austin 1999). Describing the “normal” range of responses of nekton and water quality to river discharge is important for development of predictive models that incorporate potential changes in freshwater inflow caused by diversions and/or reductions and assessing the reliability of current adopted freshwater inflow standards by the State of Texas (TCEQ 2014).

MATERIALS AND METHODS:

Study Area

The tidal portion of the Brazos River is legally defined as TCEQ segment 1201, which spans from its confluence with the Gulf of Mexico to 40.2 km (25 mi) upstream (TCEQ 2002; TCEQ 2004). Since the Bonner et al. (2015) study, there have been eleven study sites within this segment and one upstream of the segment (Figure 1Figure 1; Table 5). The current study also implemented nine additional sites in the nearshore waters of the Gulf of Mexico (GOM). Prior to 2014, the historical studies had only four primary sample sites, and they correlated closely to the current locations of sites B01, B10, B22 and B42 (Johnson 1977; Miller 2014). Sites were categorized based on the type of data being collected and the corresponding protocols followed in order to collect that data (Table 1). The names of each sample site were based on their location in the Brazos estuary- river or GOM- and their distance from the mouth (Table 5).

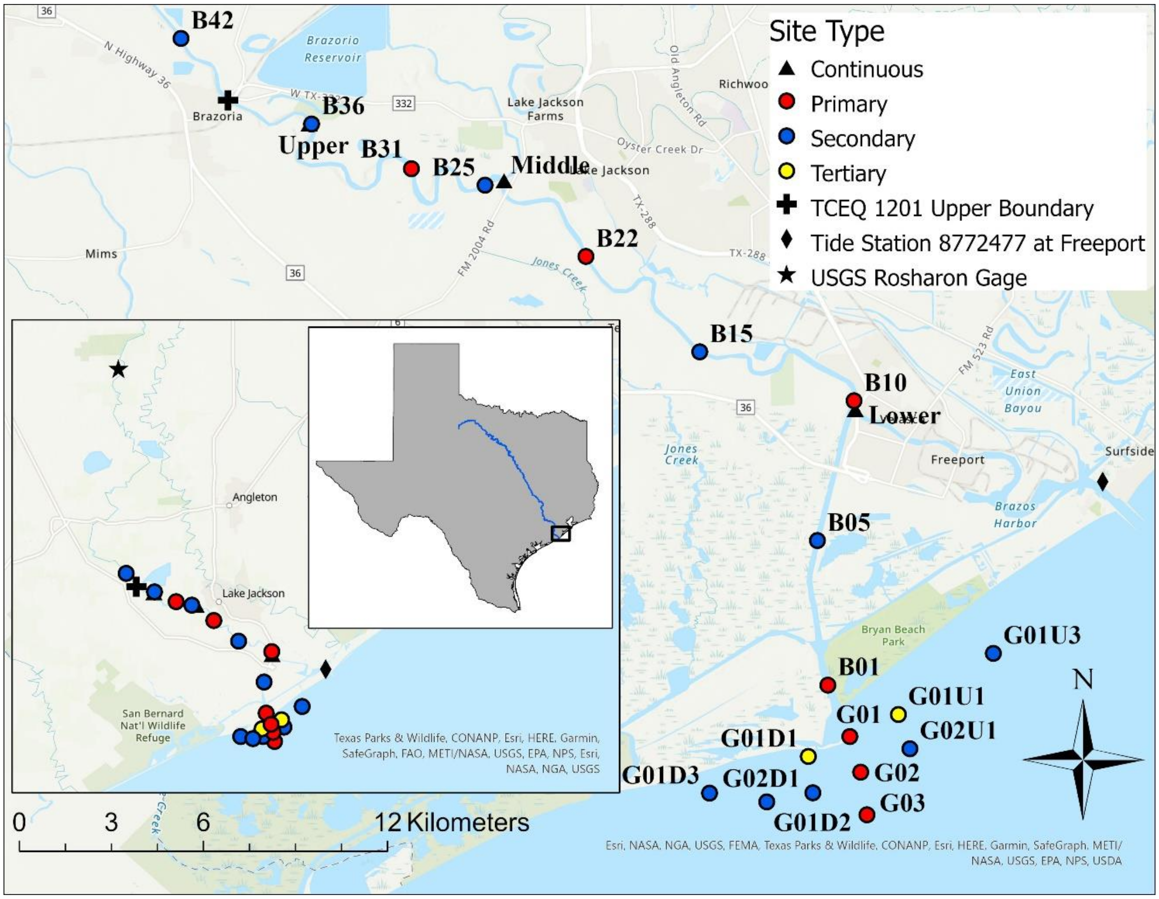


Figure 1. Map of the lower Brazos River depicting the locations of all sampling sites, USGS Gage #08116650 near Rosharon, TX, the boundary of TCEQ segment 1201, and Tide Station 8772477 at Freeport, TX.

Table 1. Site type categories and the data collected for each category.

Site Type	Level TROLL[a]	Baro TROLL[b]	HOBO[c]	Water Quality		Nekton[f]		
				Profile[d]	Grab[e]	BT	OT	ZP[*]
Primary				X	X	X	X	X
Secondary				X				
Tertiary				X			X	
Continuous	X	X	X					

[a] Automated stationary probe paired with Baro TROLL in order to measure water depth.
[b] Automated stationary probe paired with Level TROLL in order to correct measured water depth. Only one Baro TROLL deployed for depth calibration of Level TROLLs; deployed at Middle site.
[c] Includes Temperature and Conductivity U26-001 data loggers and dissolved oxygen sensors.
[d] Vertical profile field measurements of water temperature (°C), specific conductivity (μS/cm), salinity (psu), dissolved oxygen (% saturation and mg/L), pH, total depth (m) and turbidity (NTU).
[e] Nitrate and nitrite nitrogen (mg/L-N), total Kjehldahl nitrogen (TKN; mg/L-N), total phosphorus (total P; mg/L-P), total suspended solids (TSS; mg/L), ammonia, and chlorophyll-a.
[f] BT = Beam Trawl, OT = Otter Trawl, ZP = Zooplankton Trawl.
[*] Conducted only at river sites.

Fieldwork

Fieldwork for the current study commenced on August 3rd, 2018, and officially concluded on December 31st, 2019. As the current study was meant to fill the gap in data between seasons, field sampling for water quality profiles and nekton communities was concentrated during the summer months with at least one sampling event included during spring and winter (Table 2). The primary objective was to examine and record the effects of a wide range of flow tiers during the summer season at the sites previously monitored during 2014-2017.

Hydrology

Daily freshwater inflow data was collected from the United States Geological Survey (USGS) Gage #08116650 located in the upper Brazos River near Rosharon, TX. Data downloaded from this gage included quarter-hourly, daily mean, monthly mean, and annual mean discharge (cfs) (Table 6). Mean daily discharge was the primary form of discharge data used in the final analysis. However, annual and monthly mean discharge were still utilized to visualize long-term trends in flow on different scales. The discharge data on the quarter-hourly scale- also referred to as continuous or instantaneous discharge- was used in order to compare its strength as a predictor of river discharge in the lower Brazos River to the daily average discharge.

Estimates of river discharge in the lower Brazos were performed at site B42 during each sample date since 2014, and were measured using a Sontek River Surveyor S5/M9 Acoustic Doppler Current Profiler (ADCP) (Sontek 2013). This involved attaching the ADCP to a floating hydroboard and towing it across the river roughly perpendicular to the flow multiple times to estimate the water velocity field and net river discharge at the point of measurement (Mueller et al. 2009; Sontek 2013; TCEQ 2012).

Each sample event was categorized by season and flow tier based on the currently adopted environmental flow standards for the lower Brazos River (TCEQ 2014). The assignment of flow tier for any day begins with determining the season. Once the season has been determined, a weighted Palmer Hydrological Drought Index (PHDI) is calculated from the individual PHDI values for the various climatic divisions of Texas, and the geographic weight assigned to each individual PHDI is based on where the USGS gage is located- in this case the lower basin (TCEQ 2014). The PHDI values used in the calculation are from the last month of the previous season and are available online at the Texas Water Development Board (TWDB) Water for Texas website (Table 3; Table 6). Once the weighted PHDI has been calculated, the value is used to determine the hydrological condition. The final step to determining flow tier is based on the mean daily discharge of the sample day (Table 3). Any flow value between 430 (cfs) and the base flow value for the corresponding season and hydrological condition is classified as subsistence. A flow tier is classified as a base flow when it exceeds the listed value for the corresponding season and flow tier. In order to meet the criteria for a pulse flow, the mean daily discharge value in question must be higher than the listed value for the corresponding season and hydrological condition, and it must have remained higher than the listed flow value for a minimum duration of the listed number of days previously. Since 2012, EIH has conducted a total of 39 sample events in the Brazos estuary, encompassing every season, and every possible hydrological condition and flow tier defined by TCEQ (Table 3).

Table 2. Sampling history of the Brazos estuary by EIH with the corresponding TCEQ flow tiers for each sample date and which studies the data collected was first used for (TCEQ 2014). Sample events 21 and 22 were independent surveys conducted by EIH; nekton sampling did not occur during sample event 22.

Sample Event	Sample Date	Season	Flow Tier	Daily Average Discharge (cfs)	Historical Research
1	01/18/2012	Winter	Dry-Base	1280	(Miller 2014)
2	02/14/2012	Winter	Dry-Base	7470	
3	03/12/2012	Spring	Dry-1ps	11500	
4	04/11/2012	Spring	Dry-1ps	10400	
5	05/08/2012	Spring	Dry-Subsistence	1390	
6	06/12/2012	Spring	Dry-Subsistence	304	
7	07/10/2012	Summer	Dry-Subsistence	380	
8	08/14/2012	Summer	Dry-Subsistence	475	
9	09/11/2012	Summer	Dry-Subsistence	710	
10	10/16/2012	Summer	Dry-Subsistence	920	
11	11/13/2012	Winter	Dry-Subsistence	275	
12	12/13/2012	Winter	Dry-Subsistence	350	
13	11/11/2014	Winter	Average-Subsistence	1160	(Bonner et al. 2015)
14	12/9/2014	Winter	Average-Subsistence	1050	
15	1/6/2015	Winter	Average-Base	4230	
16	2/4/2015	Winter	Average-Base	5740	
17	2/18/2015	Winter	Average-Subsistence	2090	
18	4/1/2015	Spring	Average-3ps	7080	
19	4/29/2015	Spring	Average-3ps	13100	
20	5/6/2015	Spring	Average-3ps	10500	
21	8/12/2015	Summer	Wet-2ps	6120	(Bonner et al. 2017)
22	8/25/2015	Summer	Wet-Base	4550	(Bonner et al. 2017)
23	12/1/2016	Winter	Wet-Subsistence	3250	(Bonner et al. 2017)
24	12/20/2016	Winter	Wet-Subsistence	3670	
25	1/31/2017	Winter	Wet-Base	9400	
26	3/15/2017	Spring	Wet-Base	6040	
27	5/1/2017	Spring	Wet-Base	9750	
28	5/24/2017	Spring	Wet-Subsistence	3110	
29	6/27/2017	Spring	Wet-Base	5720	
30	7/31/2017	Summer	Average-Base	1810	
31	9/20/2017	Summer	Average-3ps	5950	
32	10/18/2017	Summer	Average-3ps	3490	
33	09/27/2018	Summer	Average-Subsistence	1400	Current
34	03/12/2019	Spring	Wet-Base	6100	
35	07/11/2019	Summer	Wet-2ps	8120	
36	07/31/2019	Summer	Wet-Base	4070	
37	09/05/2019	Summer	Wet-Subsistence	2020	
38	10/17/2019	Summer	Wet-Subsistence	944	
39	12/05/2019	Winter	Average-Subsistence	836	

Table 3. Environmental flow standards for the Brazos River based on mean daily discharge (cfs) at USGS Gage #08116650 near Rosharon, TX (TCEQ 2014). Available online at: https://www.tceq.texas.gov/assets/public/legal/rules/rules/pdflib/298g.pdf.

<table>
<tr><th>Season</th><th>Months</th><th>Subsistence Flow (cfs[a])</th><th>Hydrological Conditions</th><th>Base Flow (cfs)</th><th>Dry Hydrological Conditions Pulse(s) per Season (ps)</th><th>Average Hydrological Conditions Pulse(s) per Season (ps)</th><th>Wet Hydrological Conditions Pulse(s) per Season (ps)</th></tr>
<tr><td rowspan="3">Winter</td><td rowspan="3">Nov-Feb</td><td rowspan="3">430</td><td>Dry</td><td>1140</td><td rowspan="3">Pulse(s): 1
Qp[b]: 9090
Volume: 94700 af[c]
Duration[d]: 12</td><td rowspan="3">Pulse(s): 3
Qp: 9090
Volume: 94700 af
Duration: 12</td><td rowspan="3">Pulse(s): 2
Qp: 13600
Volume: 168000 af
Duration: 16</td></tr>
<tr><td>Average</td><td>2090</td></tr>
<tr><td>Wet</td><td>4700</td></tr>
<tr><td rowspan="3">Spring</td><td rowspan="3">Mar-Jun</td><td rowspan="3">430</td><td>Dry</td><td>1250</td><td rowspan="3">Pulse(s): 1
Qp: 6580
Volume: 58500 af
Duration: 10</td><td rowspan="3">Pulse(s): 3
Qp: 6580
Volume: 58500 af
Duration: 10</td><td rowspan="3">Pulse(s): 2
Qp: 14200
Volume: 184000 af
Duration: 18</td></tr>
<tr><td>Average</td><td>2570</td></tr>
<tr><td>Wet</td><td>4740</td></tr>
<tr><td rowspan="3">Summer</td><td rowspan="3">Jul-Oct</td><td rowspan="3">430</td><td>Dry</td><td>930</td><td rowspan="3">Pulse(s): 1
Qp: 6580
Volume: 58500 af
Duration: 10</td><td rowspan="3">Pulse(s): 3
Qp: 2490
Volume: 14900 af
Duration: 6</td><td rowspan="3">Pulse(s): 2
Qp: 4980
Volume: 39100 af
Duration: 9</td></tr>
<tr><td>Average</td><td>1420</td></tr>
<tr><td>Wet</td><td>2630</td></tr>
<tr><td colspan="8">Weighted Palmer Hydrological Drought Index (PHDI) = ∑ (geographic weight * climatic division PHDI value from last month of previous season) = (0.619 * North Central PHDI) + (0.147*East Texas PHDI) + (0.057*Edwards Plateau PHDI) + (0.132 * South Central PHDI) + (0.045* Upper Coast PHDI).

Hydrological Condition Assessment for Lower Basin
Dry = Weighted PHDI < -1.73
Average = -1.73 ≤ Weighted PHDI ≤ 2.13
Wet = Weighted PHDI > 2.13</td></tr>
<tr><td colspan="8">Data Source: waterdatafortexas.org/drought/phdi/monthly?time=2018-06
[a] cfs = cubic feet per second
[b] Qp = Flow (cfs)
[c] af = acre-feet
[d] Duration = days</td></tr>
</table>

Water Quality

Continuous

The continuous monitoring sites were equipped with temperature and conductivity Onset U26-001 HOBO data loggers and dissolved oxygen sensors. The conductivity loggers measured conductivity (μS/cm), and temperature (°C) while the dissolved oxygen logger measured dissolved oxygen concentration [DO (mg/L)]. Both types of loggers measured the corresponding data every fifteen minutes until their retrieval. These data loggers were checked approximately once a month in order to ensure the battery life was still good, check for fouling, damage, and proper data logging. Prior to retrieval and launching of the data loggers, a YSI ProDSS sonde was used to take side-by-side measurements of salinity (psu), specific conductivity (μS/cm), conductivity (μS/cm), DO (mg/L), temperature (°C), depth of the loggers (m), and total depth (m). These side-by-side measurements would later be used to validate and correct the raw HOBO data in HOBOware (v 3.7.22). Prior to and after sampling, the sonde was calibrated according to TCEQ Surface Water Quality Monitoring quality assurance standards (TCEQ 2012). Once the data was downloaded and the HOBO loggers were reactivated, they would be given a protective layer of plastic wrapping, housed in polyvinyl chloride (PVC) tubes, and secured to a wood piling using a metal cable and lock (Figure 2).

After the data was downloaded and the loggers were redeployed, the conductivity data was converted to salinity using HOBOware Conductivity Assistant and the side-by-side specific conductivity readings from the deploy and retrieval date in order to calibrate the salinity conversion. The converted salinity data would then be used to adjust the DO data using Dissolved Oxygen Assistant and the side-by-side DO readings. After each retrieval, the data would be scrutinized for any suspect readings such as severe fluctuations or zero values that would indicate the loggers were not submerged or buried in sediment. These values were flagged and removed with final approval from EIH Associate Director Jenny Oakley, Ph.D.

Additionally, In-Situ model water depth probes (m)- Level TROLL 300- were deployed at all continuous sites while a barometric pressure probe (mm Hg)- Baro Troll- was deployed at the Middle site (Table 1; Table 5; Figure 1; Figure 2). The Level TROLLs were deployed next to the HOBO loggers in contact with the river bottom, while the Baro TROLL was deployed on a light post where it could not be submerged by water (Figure 2). Both types of probes were given a protective layer of plastic wrapping to help prevent fouling and growth and were also housed in a hollow tube made of PVC. The PVC housing was secured to a wood piling using a screw near the top of the housing, and plastic zip ties near the bottom. To decrease the odds of theft, a metal cable was secured through the top of the probe and looped through an eye ring drilled into the same piling.

Like the HOBO loggers, the TROLL probes logged their corresponding data every fifteen minutes and were checked approximately once per month to download data and ensure the equipment was still functioning properly. The data from both TROLL probes was downloaded via the software program Win-Situ 5. In order to ensure the accuracy of relative depth readings by the Level TROLL 300, they required correction in the software package Win-Situ Baro-Merge (v 1.4.3) using synchronized barometric pressure readings from the Baro TROLL (In-Situ 2013).

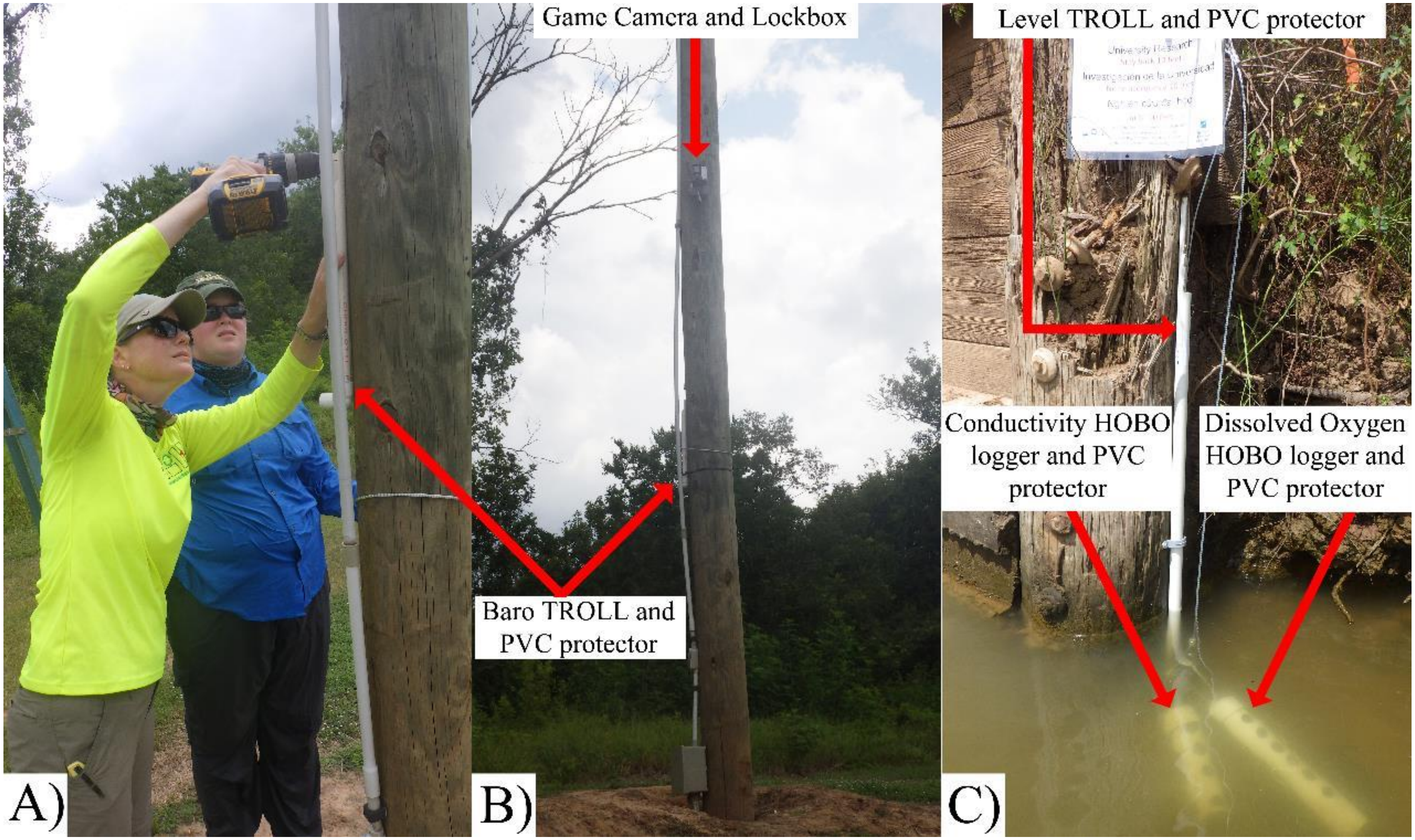


Figure 2. Continuous monitoring gear setup. A) Jenny Oakley and Natasha Zarnstorff securing Baro TROLL and its PVC protector to light post at Middle Site. B) Baro TROLL and game camera deployed at Middle site. C) HOBO loggers and Level TROLL in their PVC protectors deployed at Upper site.

A new addition to the protocol at the continuous sites was the deployment of Ltl Acorn trail cameras at the Lower and Middle Site. These cameras were drilled to a nearby tree or wooden pole and secured in a lockbox approximately four meters off the ground in order to actively photograph the changes in water levels for the duration of the study (Figure 2). The purpose of this was to provide additional evidence for the correlation- or lack of- between the quarter-hourly and daily average discharge at the Rosharon gage and the relative water depth at the continuous sites. The distance between the Rosharon gage and the TCEQ boundary is over 100 kilometers, so there is reason to question the accuracy of the instantaneous measurements as a predictor of river discharge in the estuary at the same time. Each camera was set to take a photograph once every hour with a timestamp, and each month had the pictures downloaded from the SD card before redeployment. During the duration of the camera deployment, the Rosharon gage was carefully monitored in order to identify days where pulse events occurred. These are classified as a rapid increase in water levels and river discharge over a short period of time- several hours to a few days. These types of events were needed for cross-referencing the photos with instantaneous data from USGS because it was only during events such as these when a rapid influx of water could offset any changes in water height due to tidal cycles.

Profile

Vertical profiles of the Brazos River water quality were collected using a 21’ JH Performance during each sampling event at the thalweg of all sample sites except the continuous sites (Table 1; Table 5). Variables measured included water temperature (°C), specific conductivity (µS/cm), salinity (psu), DO (% saturation and mg/L), pH, turbidity (nephelometric turbidity unit [NTU]), and water depth (m). All the previously listed variables were recorded using a YSI 600XLM multiprobe sonde with a cable range of ten meters (YSI, Inc., of Yellow Springs, Ohio). A two-pound weight was attached to the sonde during measurements in order to minimize drag due to the flow of the river. Prior to and after sampling, the sonde was calibrated according to TCEQ Surface Water Quality Monitoring quality assurance standards (TCEQ 2012).

Each water-quality variable was measured at the surface (0.3 m), 25% of total depth, 50% of total depth, 75% of total depth, and the bottom (0.3 m above the bottom substrate), along with the corresponding sample depth (meters) recorded for each depth percentage group. In addition, mid-channel total depth and Secchi disk transparency (depth: meters) were recorded at each site- except during 2014-2015 where Secchi disk transparency was only recorded at the primary sites (Bonner et al. 2015). The water quality profile for each site was taken at the thalweg in order to ensure the most representative profile- specifically at the bottom and an accurate mid-channel total depth. Vertical water quality profiles were also conducted at nine sites in the GOM during two collection dates using the same protocols (Table 1;Table 5). Tide data taken from NOAA tide station 8772447 at Freeport, TX to determine tide stage and tidal height (ft) at the time the water quality profile was taken for each site (Table 6).

Surface Water Grab

Surface water grab samples were collected at all primary sites during each sampling event following protocol outlined in TCEQ (2012) (Table 1;Table 5). These samples were then submitted to the Eastex Environmental Laboratories of Houston, Texas and subjected to laboratory analysis. The chemical parameters of interest for analysis include Nitrate and nitrite nitrogen (mg/L-N), total Kjehldahl nitrogen (TKN; mg/L-N), total phosphorus (total P; mg/L-P), total suspended solids (TSS; mg/L), ammonia, Total Organic Carbon (TOC) and chlorophyll-a. Additional surface water grab samples were collected at three GOM sites (Table 1). All water samples were collected and stored in sterile, 1-Liter Nalgene bottles apart from the chlorophyll sample which was stored in a 4-Liter Nalgene bottle. The sample bottles were rinsed three times with water from the corresponding site before filling. Once the bottles had been filled, they were put on ice until they could be collected by Eastex. The results of these laboratory tests are reported in Appendix F but were not utilized in any of the analyses.

Nekton

The extensive summer monitoring period for estuarine nekton is due to the absence of appropriate monitoring during previous studies of the Brazos River and the higher probability for lower flow tiers and hypoxic water conditions. Certain documented species of nekton are proven to move between different sections of the river seasonally due to available food sources or for breeding purposes, which also necessitated the increase of samples representing the summer months (Day et al. 2012). Site B42 was omitted from nekton sampling events for the current study since previous studies revealed it consisted primarily of freshwater species (Bonner et al. 2017; Bonner et al. 2015; Miller 2014). The most recent nekton sampling occurred from B31 to B01 in order to be more selective of species that would be considered estuarine- species that utilize the estuary to complete at least one stage of their life cycle. Nekton sampling occurred during the same day as the water quality profiles except during 2014-2015 when nekton sampling prior to August 12th, 2015, occurred the day proceeding the day the water quality profile was taken at each site. However, the need for paired water quality data and nekton collections was anticipated during 2014-2015, and as a result, additional water quality profiles were taken on the day of the nekton sampling at the surface and the bottom (Bonner et al. 2015). Beginning in 2016, water quality profiles and nekton collections occurred on the same day (Bonner et al. 2017).

Beam trawling with a (15’x5’) net was conducted at all primary sites (B01, B10, B22, B31 and B42) for a profiling of the pelagic and juvenile nekton. Shoreline nekton were collected at all primary sites using a modified 6.4 mm mesh Renfro beam trawl manufactured by Sea-Gear Corporation of Melbourne, Florida (Renfro 1962). Three replicate hauls were pulled parallel to shore for 15.2 m/haul on one bank per site- with the sampling bank being alternated during each sampling event and at each site (Figure 3). Additionally, Otter trawls (3.1 m wide, 38.2mm stretch mesh, 6.1 mm net fitted within cod end) were towed for approximately 5-minutes per replicate at each primary site using a 22’ Twin Vee Cat to sample bottom-dwelling nekton. A total of three replicate tows were made at each site for each sample date- except B42 during the current study. Trawls were performed facing upriver and aligned with the thalweg at an average speed of 2.5 knots and equipped with a 30-m tow line. In instances where snags interfered with the completion of a trawling replicate, catches were released, and the trawl was redeployed upstream of the snags. Multiple nets were brought during sampling events for quick deployment in the event a trawl got snagged and could not be freed in a timely manner. Otter trawls in the GOM were pulled parallel to the coastline using a 25’ Boston Whaler Guardian. Of the 369 replicate otter trawls performed in the Brazos estuary since 2014, only four were not completed- all of which occurred on October 17th, 2019- due to snags snaring all functional nets and preventing retrieval before sunset. These included the third replicate at B22, and all three replicates of B31 on October 17th, 2019.

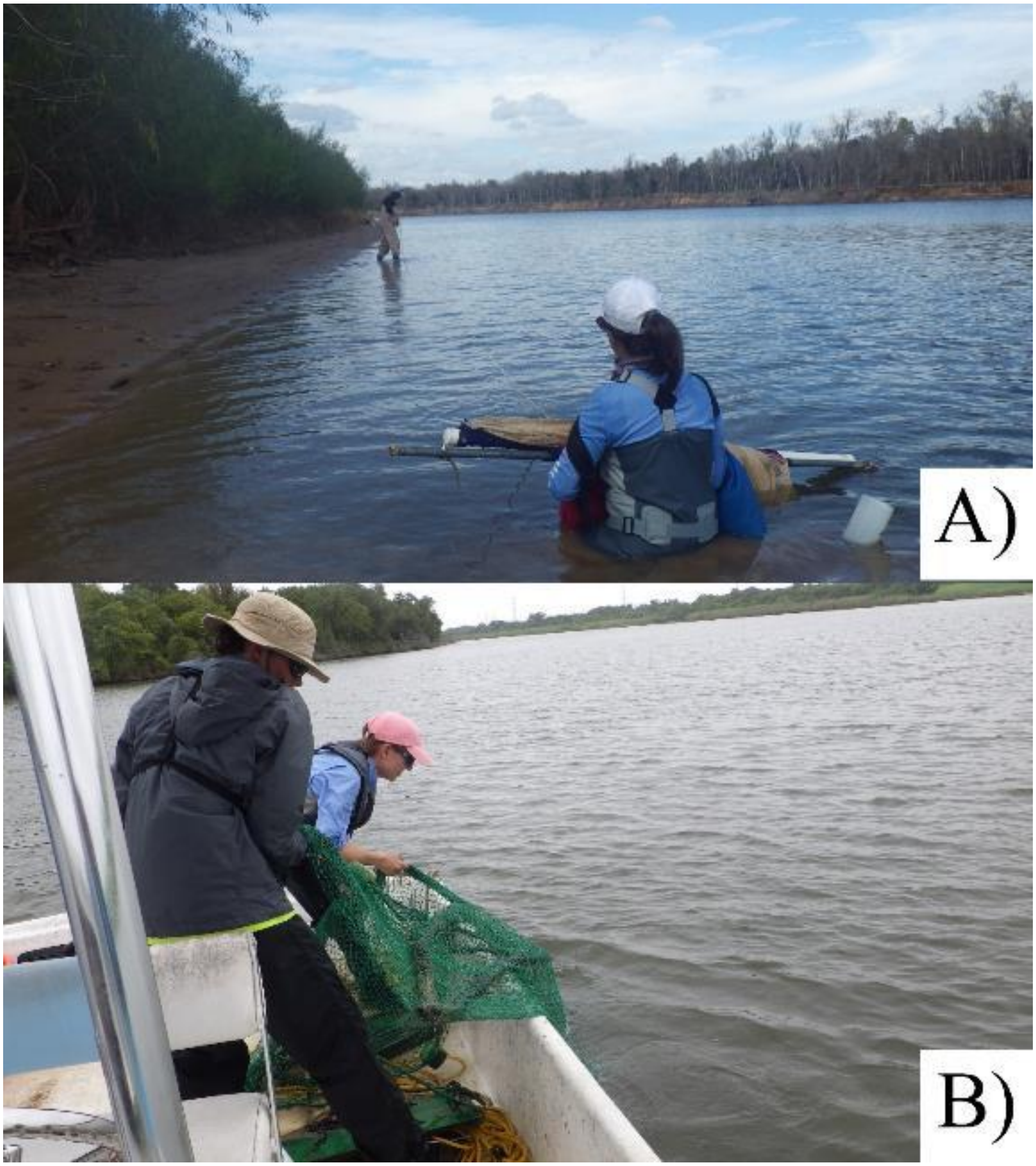


Figure 3. Nekton sampling gear used during the study. A) Beam trawl deployment on right bank at site B31. B) Otter trawl retrieval at site B10.

Each replicate for both sample methods was timed using a stopwatch and recorded in decimal minutes in order to calculate catch-per-unit-effort (CPUE). All nekton- finfish and invertebrates capable of independently swimming against water currents- collected during sampling events were identified to the lowest possible taxonomic level and counted. The first five individuals of each species captured in each replicate were measured using fish scales. For fish, the standard length (mm)- from the tip of the snout to the caudal peduncle- was taken. For crabs, the maximum width of the carapace was the standard measurement. For shrimp, the standard length would measure from the tip of the rostrum to the end of the telson. The only cephalopod captured during the study was the Atlantic Brief Squid (*Lolliguncula brevis*), which was measured from the tip of the mantle to the tip of the beak. During the otter trawls, photo vouchers were taken for each species captured. These photo vouchers included a scale for reference of size, the sample date, the sample site it was collected at, and the name of the species (Figure 61).

Any specimens that were not identified in the field were anesthetized with MS-222, euthanized and preserved in 10% formalin, and brought back to the EIH lab for subsequent analysis. All specimens were reported with scientific names and common names with the use of taxonomic keys. The common and scientific names for all species reported in this document reflect the most current nomenclature and taxonomic classification used by the American Fisheries Society (Angel et al. 2005; Page et al. 2013). Nekton taxa were categorized based on site collected, date collected, gear type and replicate sample number. Nekton collections were classified as the sum data of all three replicate hauls for each sample method at each site on the date they were collected.

Zooplankton trawls were conducted using a 1.5 m x 0.5 m, 100 µm mesh plankton net. Each replicate was towed for approximately three minutes, and samples were stored in 50-mL Nalgene bottles. Filtering of the samples had not been conducted in a timely manner as the previous years had been, so no new zooplankton catch data was available for analysis, and therefore excluded from the results.

Data Analysis

Hydrology

The daily average discharge from the USGS gage was the primary form of hydrological data used in the assessment of variation in river discharge and the relationships with biological and physiochemical variables. However, monthly average, and annual average discharge were also used to test the extensiveness of stream flow variation on different time scales. Graphs summarizing each discharge statistic during the sample period and throughout the active deployment of USGS gage #08116650- April 1st, 1967, to the present day- were plotted using the graphing software Sigmaplot 13.

The daily average discharge was also used to compute a mean and median daily average discharge value for the entire time the Rosharon gage has been active. The purpose of this was to create a criteria for extreme flow or flood stage conditions since TCEQ does not provide any official criteria for drought or overbank conditions (TCEQ 2014). Graphs were constructed using R and R Studio (v 4.0.3 and 1.4.1103 respectively) in order to calculate how many days each year the lower Brazos River exhibits extreme flow. In this case, the standard was the same for determining outliers using the empirical rule- taking twice the value of the standard deviation of the data and adding it to the mean of the data. These outliers were then plotted in order to determine how the frequency of extreme events has changed throughout time.

In order to test for significant differences in stream flow, each flow reading was categorized based on season, month, and year. The criteria for the seasons are based on TCEQ standards and include November to February for winter, March to June for spring, and July to October for summer (Table 2; Table 3). The nonparametric Kruskal-Wallis one-way analysis of variance (ANOVA) was executed in Minitab 19 in order to determine significant differences in median daily average discharge between sample years, months and seasons. The Kruskal-Wallis test was considered a more appropriate test than the parametric one-way ANOVA primarily because the measure of center is the median rather than the mean (Gobo et al. 2006). The lower Brazos River experiences periods of high flow throughout most of the spring and most of the winter quite regularly, and yet the average annual discharge is consistently reported below 10,000 cfs (NOAA 1990; USGS 2005; USGS 2008). The distribution of the data from the USGS gage on any time scale is heavily skewed to the left, therefore the median is more useful as the center of the data (Gobo et al. 2006). If the results of the Kruskal-Wallis test were statistically significant, then Dunn's multiple comparisons test was used to conduct pairwise comparisons between groups (Dinno 2015; Dunn 1964). In order to control the family-wise error rate, a Bonferroni-adjusted p-value was used for each pairwise comparison. This value was calculated by dividing the alpha (α) of the original Kruskal-Wallis test by the number of pairwise comparisons (Dinno 2015). However, setting the (α) to 0.05- as is the default in most statistical tests- would yield different significance levels for the medians of different grouping variables when using the Bonferroni-adjusted p-value to determine statistical significance. As a result, each time the Kruskal-Wallis and Dunn's multiple comparisons tests were run between different grouping variables, they would be given a family (α) that would yield identical Bonferroni-adjusted p-values of 0.006, which would yield 95.009% confidence intervals of the medians for all group categories.

Using Minitab 19, linear regression analysis was performed between the field discharge measured by the hydroboard-mounted ADCP and the USGS discharge data. The primary purpose of this test was to generate a predictive linear model and determine how accurate the USGS gage is at predicting discharge in the lower Brazos. Both the daily average discharge and the continuous discharge from the USGS gage were subjected to linear regression analysis with field discharge in order to determine the metric with a stronger correlation to field discharge. It was hypothesized that daily average discharge would be a more robust predictor of downstream flow- particularly during pulse events when measurements at Rosharon could take several hours to days to be detected in the estuary (Figure 59; Figure 60). The coefficient of determination (R^2) and standard deviation (S) were both used to judge the best predictive model of discharge in the lower Brazos.

Water Quality

Continuous

The continuous data utilized for analysis spanned the entire data collection histories of Bonner et al. (2015), Bonner et al. (2017), and the current study. The data acquired from the loggers at the continuous sites was imported into R and R Studio in order to use the data on the quarter-hourly scale to compute daily average values. Each daily average value was categorized by season in order to help visualize any existing seasonal trends. The daily average values of each variable would then be plotted against daily average discharge in order to determine the feasibility of using flow as a predictor for the variables measured- temperature, salinity, DO, and depth. The justification for using daily average values rather than the continuous measurements relates to the normal cycles of the day. All these variables are subject to diel cycles due to exposure by sunlight- temperature and DO- or tidal shifts- salinity and depth (Day et al. 2012). As a result, it would be difficult to associate any correlation between changes in discharge and changes in the water quality simply because they are expected to change throughout the course of a day. Daily mean values were expected to better reflect long-term seasonal changes as well as short-term changes due to changes in weather conditions and perhaps hydrology. Daily average values that did not utilize complete data from an entire day were still included, as the amount of suspect data removed would have left many days without a fully complete 24 hours' worth of data.

Once again, these variables were subjected to linear regression analysis using Minitab 19. Salinity and depth underwent nonlinear regression with daily average discharge due to being strongly correlated with flow but not conforming to a linear model. Salinity was subjected to a Log_{10}-transformation to determine if a linear regression model would yield a better fit than using non-transformed data for nonlinear regression. Temperature and DO did not exhibit any discernible correlation with flow, so generating a predictive model for each relied on choosing more strongly correlated predictors. The predictor variable for temperature was Julian day- the number of days since the beginning of the Julian year- while temperature was used as the predictor for DO. The (R^2) and (S) were used to judge the strength of the linear regression models while the lack-of-fit test and (S) were used to determine the predictive strength of the nonlinear regression models. The statistical software Past 4.0.3 was used in conjunction with Minitab in order to assist in choosing the best nonlinear model and provide parameter estimates in Minitab.

Profile

Water quality variables were summarized in Appendix E for surface and bottom measurements by mean ± 1 standard error (SE), maximum and minimum for each site, season, and flow tier. A two-way ANOVA was performed in Minitab 19 to test for significant differences in mean depth interpolated (surface, 25% depth, middle, 75% depth, and bottom) readings of temperature, salinity, DO, pH, turbidity, total depth, and Secchi disk transparency between sites and flow tiers. A two-way ANOVA is used to determine how the mean of a continuous variable varies by two independent grouping variables individually and in an interactive model. Although the ANOVA assumptions of samples being drawn from a normally distributed population and each population having a common variance were violated, the sample sizes for each site and flow tier were considered large enough to use this statistical test rather than the nonparametric alternative. This choice was also made in order to make a direct comparison to previous reports that performed the same test with smaller data sets and either provide evidence to refute or support those original conclusions (Bonner et al. 2017; Bonner et al. 2015). A significance level of ($\alpha = 0.05$) was used in order to test for an interaction effect between site and flow tier for each variable of interest. If no interaction effect was detected, but significant differences were detected between sites and/or flow tiers, then a post-hoc multiple comparison test was used to identify significant differences between sites and/or flow tiers. Tukey's HSD multiple comparison test was the post hoc test used for pairwise comparisons among sites and/or flow tiers when significant differences were detected. If an interaction effect was significant ($p \leq 0.05$), one-way ANOVAs and corresponding Tukey's HSD post-hoc tests were performed in R and R Studio in order to detect significant differences between sites during each flow tiers and significant differences between flow tiers at each site.

Multivariate analysis of water quality variables between seasons and flow tiers was performed in PRIMER 7 using the Principal Component Analysis (Clarke and Gorley 2015). Prior to performing PCA, all water quality data was normalized in order to ensure all variables had equal weighting. The variables used in the multivariate analysis included temperature, DO, salinity, and daily average discharge. The variables excluded from the multivariate analysis included pH, turbidity, and total depth. The decision to exclude pH stems from the fact that it uses a logarithmic scale, so even a normalization transformation was unlikely to give pH equal weighting during PCA. Turbidity was excluded because previous studies indicated that it exhibited strong correlations with most of the water quality variables (Miller 2014). One of the primary assumptions of PCA is that the variables being modeled are independent of one another and exhibit little or no correlation (Clarke and Gorley 2015). Due to both current and previous studies providing evidence that turbidity exhibits correlations with nearly all water variables, it was not used for characterizing water chemistry between seasons and flow tiers (Miller 2014). Total depth was also excluded because it is directly correlated with flow, and so including it in the multivariate analysis alongside daily average discharge was unnecessary. However, daily average discharge was substituted for total depth when performing PCA between the sample sites in the GOM. The results calculated were eigenvalues for each principal component (PC) generated, which would then be used to calculate what percent variation each principal component explained the variation between samples. Eigenvectors for each principal component would then show the coefficients in the linear combinations of variables composing the PCs. The sample data would then be plotted on a graph using the two PCs explaining the greatest amount of variation as the axes in order to visualize what grouping variables were driving the variation between samples.

Nekton

Total nekton abundance (N), species richness, catch per unit effort (CPUE), Shannon-Wiener Diversity, Shannon Evenness, and Margalef Richness were calculated for each nekton collection. The effort used in calculating CPUE was total decimal minutes rather than the total number of replicates. Even though each gear type used during sampling was used for exactly three replicates at each site on the date of sampling, the duration of each haul was not identical every time, and therefore may not be the most representative metric for effort. The values used for calculating Shannon-Wiener and

Shannon evenness were the actual abundances of each species captured in the collections rather than CPUE for each species (Swanson 2019).

Pearson correlation analysis was performed in R and R Studio in order to test for significance in correlation between surface water quality, bottom water quality, and all nekton community data for each gear type. If the correlation between any two variables was significant, it was graphed on a correlation plot with a color gradient scale based on the numeric value of the correlation coefficient (+/-). A complete summary of all correlation coefficients and the p-value of each pairwise comparison between variables is provided in Appendix J (Table 71; Table 72; Table 73; Table 74). The primary purpose of the correlation analysis was to determine whether surface or bottom water quality data would be appropriate in the use of any predictive models for nekton data. This was especially important for nekton collected by beam trawl since water quality measurements for each sampling event were taken at shore instead of the thalweg. In addition, since the water column being sampled by the beam trawl is very shallow, the entire water column can be sampled as opposed to the otter trawl which targets nekton dwelling near the bottom (Renfro 1962). This creates uncertainty in determining which part of the water column exhibits the strongest correlation with nekton communities.

The Similarity Percentages (SIMPER) test was performed in PRIMER 7 in order to calculate percent similarity between sites, seasons, and flow tiers based on species composition. The SIMPER test performs pairwise comparisons between all samples in order to determine the contribution of each species to the overall Bray-Curtis similarity within each grouping variable class, as well as the contribution of each species to the overall Bray-Curtis dissimilarity between each grouping variable class (Clarke et al. 2014). The results calculated by the SIMPER test detected species that contributed a minimum of 70% average similarity between collections at each site, season, and flow tier. It also listed species that contributed a minimum of 70% average dissimilarity between pairwise comparisons of sites, seasons, and flow tiers.

Nonmetric Multidimensional Scaling (nMDS) was implemented in PRIMER 7 to visualize patterns between nekton collections. The nMDS plot ranks each sample based on similarity to one another using a Bray-Curtis resemblance matrix in order to plot these multidimensional relationships in a two-dimensional space (Clarke 1993; Clarke and Gorley 2015). Prior to constructing the resemblance matrix and nMDS plot, all nekton abundances were transformed with the function $Log_{10}(1 + x)$. A stress test was also conducted simultaneously in order to validate the accuracy of the multivariate distances depicted. In this case, a stress level of (< 0.25) would be considered satisfactory in accepting the nMDS plots as trustworthy. A stress statistic value closer to zero indicated a higher likelihood that the rank similarities plotted were not due to chance (Clarke et al. 2014). Only collections using the otter trawl were plotted using nMDS because even with sum catch of all three replicates, the beam trawl still had several collections with zero catch. Zero catch collections plotted using nMDS inflate the dissimilarity in the resemblance matrix and make it more difficult to understand the relationships between collections with catch data. Only one otter trawl collection had to be excluded from the nMDs plots due to zero catch- B22 on September 27th, 2018- and another two were excluded because the collections were incomplete- B22 and B31 on October 17th, 2019.

The one-way Analysis of Similarities (ANOSIM) test was performed in tandem with nMDS in PRIMER 7 in order to test for significant differences in nekton communities between the groups of interest- site, season, and flow tier. The p-values of the ANOSIM test would then be used to determine if nekton collections were significantly different between groups. Another metric used to judge the relationship between groups would be the Spearman's rho (R) values. Rho values range from -1 to 1 in order to determine the strength of the similarity between two variables. A value closer to -1 or 1 indicates that the difference of mean Spearman's ranks between the groups is higher than the differences of mean ranks within the groups being compared. On the other hand, a value closer to zero is indicative of the mean ranks within groups and between groups being closer in value, and therefore exhibit fewer dissimilarities. The only collections that were excluded from the SIMPER, nMDS and ANOSIM tests were the incomplete otter trawl collections performed on 10/17/2019. Zero catch collections were considered complete collections and therefore included in the statistical analyses- except for the nMDS plots.

Cluster analysis was also conducted in PRIMER 7 by using a Bray-Curtis similarity resemblance matrix in order to create a dendrogram of collections based on similarity. A Similarity Profile (SIMPROF) test was also executed in order to overlay significant groupings between collections in the dendrogram. Cluster analysis was performed only on the Gulf sites because this test is not particularly useful in determining significant groups if the sample size is too large (Clarke et al. 2014).

The final portion of data analysis concerning the nekton was calculating significant differences between the calculated nekton community metrics- (*N*), species richness, CPUE, Shannon Diversity (*H'*), Shannon Evenness (*J'*), and Margalef Richness- for each collection method between sites, seasons, and flow tiers. The purpose of this was to determine which grouping variables best explained variation in nekton communities using a wide range of variables that are used to quantify diversity. Since the nekton data did not meet the assumptions for normality- due in part to zero catch collections- the Kruskal-Wallis test was selected for calculating significant differences. These tests were run using Minitab 19, and Dunn's multiple comparisons test was once again selected as the post-hoc test in the event the Kruskal-Wallis test detected a significant difference (Dunn 1964). The significance level (α) was adjusted according to the grouping variable being tested in order to ensure each post-hoc test used the same Bonferroni-adjusted p-value for determining significant differences in pairwise comparisons.

RESULTS:

Hydrology

Sampling History

The extensive field work conducted by EIH on the lower Brazos River has spanned from scouting locations in late 2011 to the sampling of the GOM in December 2019. Within that time frame, the estuary has experienced conditions ranging from considerable aridity to storm events like Hurricane Harvey (Figure 4). The variation in flow is considerable even within a single year, but patterns are still present within the data. The spring season has greater frequencies of maximum continuous and daily average discharge values for any given sampling year, with the winter months trailing directly behind. The only year of sampling that did not have maximum continuous or daily average discharge value in spring or winter was in August 2017 when Hurricane Harvey made landfall (Van Oldenborgh et al. 2017). It was this event that also produced the highest recorded continuous and daily average discharge values on August 29th, 2017-133,000 and 121,000 cfs respectively.

The months with the greatest frequency of maximum continuous and daily average discharge were June and November. Another common trend in the discharge was a high frequency of minimum discharge values occurring during the summer months. The month with the highest frequency of minimum continuous and daily average discharge values was August. The lowest daily average discharge value recorded during the sampling history was July 7th, 2011, at 94.40 cfs. However, this value was estimated by USGS due to a lack of continuous data throughout much of the year. The lowest accepted values were recorded on July 7th, 2013, at -125.00 cfs for continuous, and 119.00 for daily average discharge.

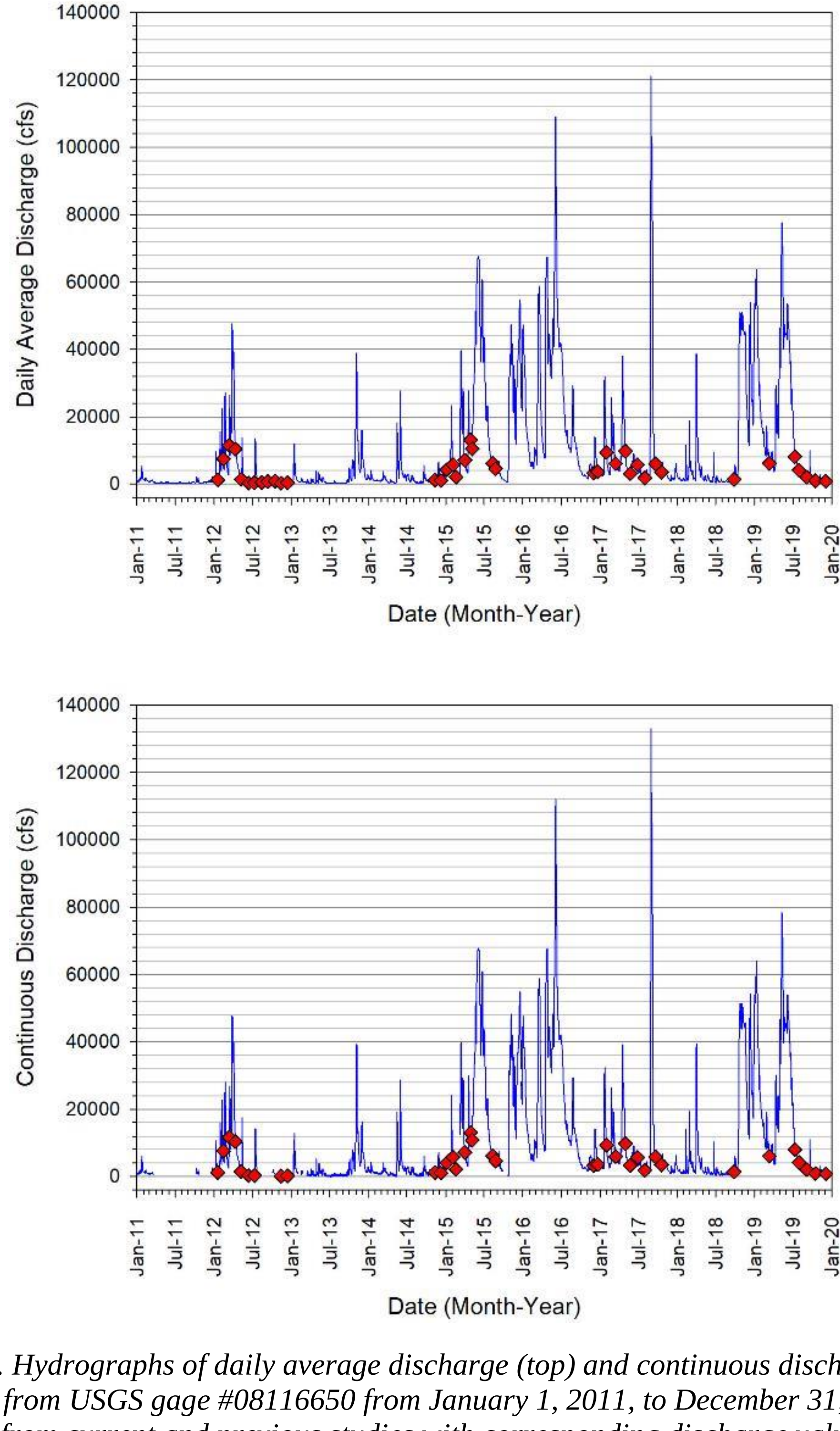
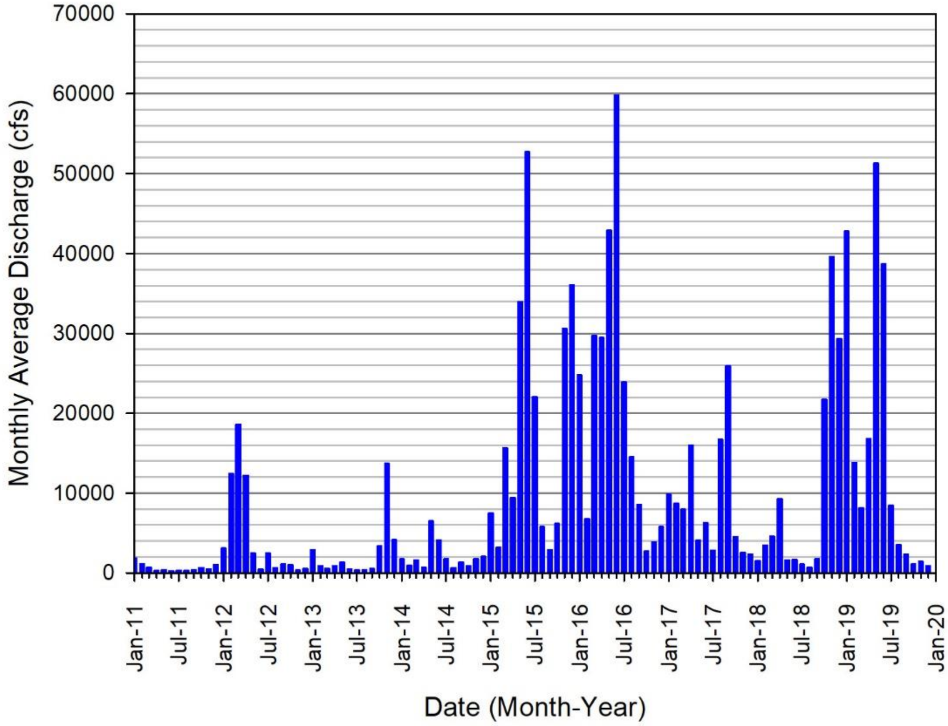


Figure 4. Hydrographs of daily average discharge (top) and continuous discharge (bottom) from USGS gage #08116650 from January 1, 2011, to December 31, 2019. Samples from current and previous studies with corresponding discharge values are denoted by (♦) (Bonner et al. 2017; Bonner et al. 2015; Miller 2014).

The months of May and June consistently ranked high in monthly average discharge for every year since 2011, with many instances of the maximum monthly average discharge being recorded during those months. During the Miller study in 2012, the highest monthly average discharge was recorded in March at 18,570 cfs while the lowest occurred in November at 333.4 cfs. The maximum and minimum monthly average discharge values to be recorded during the Bonner et al. 2015 study were 33,970 cfs in May 2015 and 1720 cfs in November 2014. The maximum monthly average discharge during 2016 was recorded in June at 59,820 cfs while the minimum was recorded in October at 2,693 cfs. During 2017, the month with the greatest monthly average discharge was September at 25,850 cfs. The month of December in 2017 had the lowest monthly average discharge at 2,342 cfs. The year 2018 did not see any significant increases in flow until the middle of October and reached its maximum monthly average discharge during November at 39.630 cfs. The minimum monthly average discharge during 2018 was recorded in August at 696.2 cfs. The highest monthly average discharge in 2019 occurred in May at 51,280 cfs while the minimum monthly average discharge was during the month of December at 884.1 cfs.

Since the activation of the USGS gage near Rosharon, TX, the average annual discharge has only been calculated above 15,000 cfs four times- two of which were recorded within the sampling history of the lower Brazos by EIH. These years include 1992 at 26,990 cfs, 2007 at 20,800 cfs, 2015 at 18,900 cfs, and 2016 at 21,080 cfs. The only year that had an annual average discharge below 1,000 cfs was during 2011 at 637.4 cfs. The years of 1967, and 1980 to 1984 are not shown with values due to the lack of complete data available for calculation.



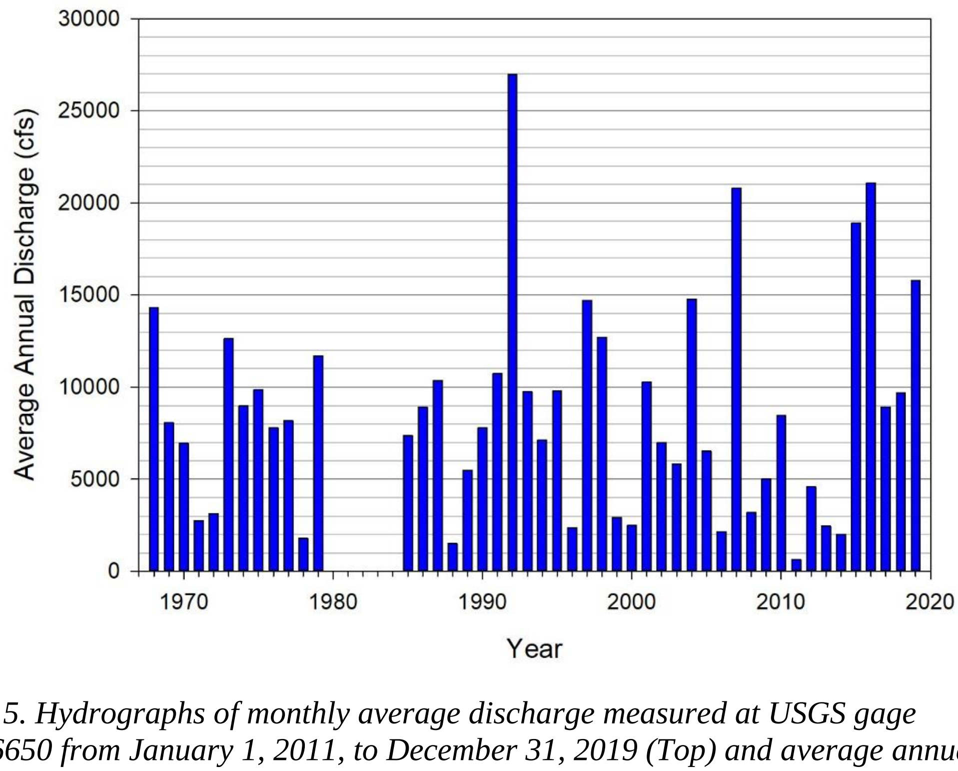


Figure 5. Hydrographs of monthly average discharge measured at USGS gage #08116650 from January 1, 2011, to December 31, 2019 (Top) and average annual discharge (cfs) of the calendar year from 1968 to 2019 using complete data (Bottom).

Extreme Event Analysis

Although the TCEQ standards provide useful criteria for defining flow tiers on short-term time scales, describing the "normal" range of river discharge on an annual scale can be very subjective. With daily average discharge data available since 1967, there is ample data to make informed conclusions about deviations from the normal trends of flow in the lower Brazos. A dot plot of all daily average discharge values recorded since April 1st, 1967, to December 31st, 2019, was constructed using R and R Studio in order to create a criterion for extreme flow events (Figure 6). The mean daily average discharge of 8,394.02 cfs was plotted against the median daily average discharge of 3,190 cfs in order to visualize the disparity in the spread of data. The mean and standard deviation (σ) of 12,737.93 cfs were used to calculate a standard for classifying extreme flow events. This standard was calculated by adding twice the value of the standard deviation to the mean daily average discharge, resulting in a value of 33,869.90 cfs.

Any daily average discharge value that was recorded above the outlier standard of 33,869.90 cfs was designated as extreme so that a histogram of the extreme flow could be generated (Figure 6). The purpose of this was to provide a visual representation of how frequently the lower Brazos experiences extreme flow, and if that trend has been increasing. The mean number of days in a year that experience over 33,869.90 cfs is 21.69 days while the median number of days is 13. Of the 53 years that had any daily average discharge data available- complete or otherwise- only 15 of those years were greater than the mean. Of those 15, six were within the last two decades- four of which took place during the EIH sampling history of the Brazos. There were also four years calculated to be outliers with more than 80.84 days of extreme discharge within the year: 1992, 2007, 2015, and 2016.

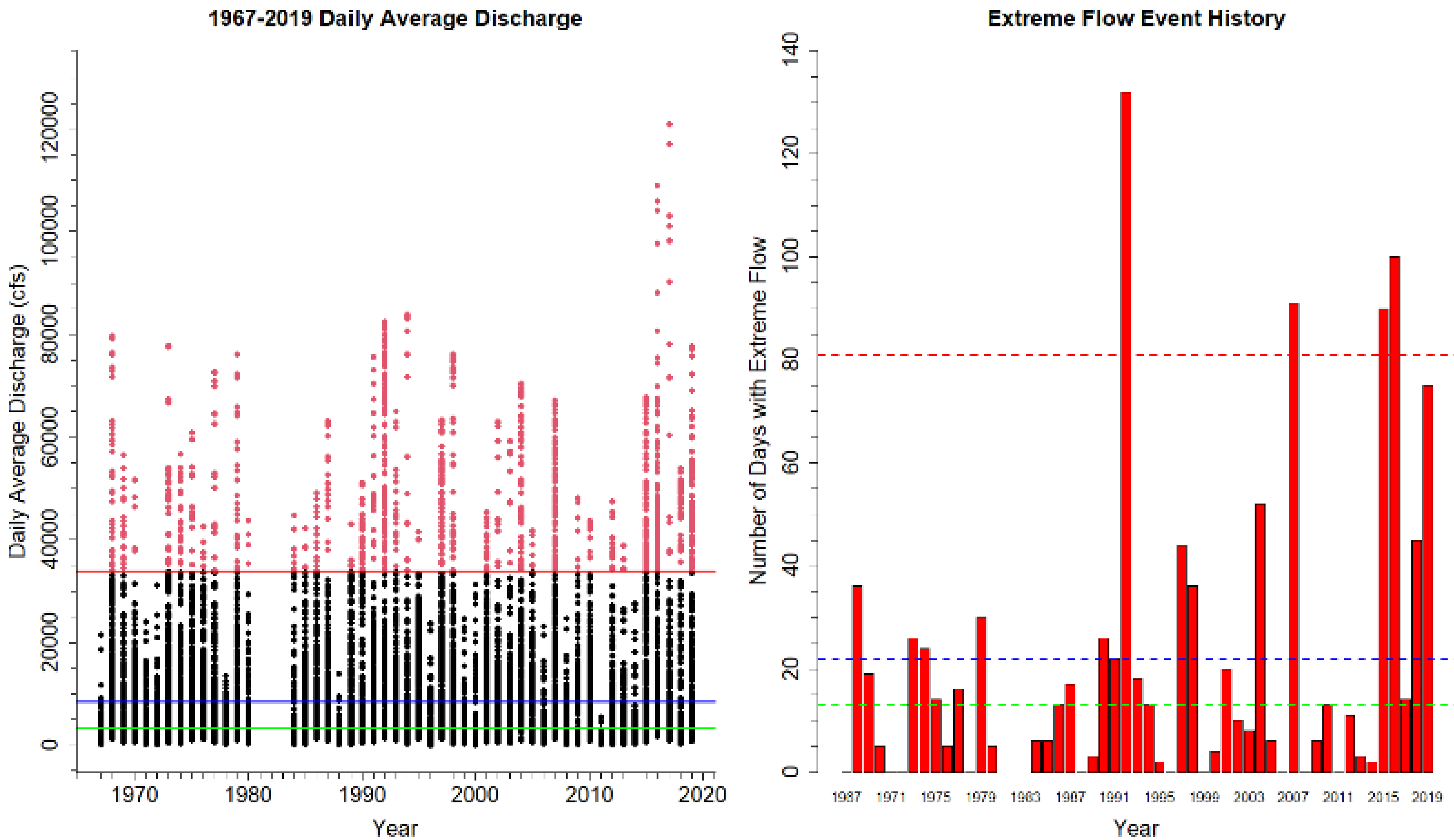


Figure 6. Dot plot of daily average discharge from USGS gage #08116650 from 1967 to 2019 (Left), and histogram of extreme flow events from the same time period (Right).   The green line represents the median, the blue line is the mean, and the red line is equal to the mean + 2σ.

Annual Variation

The nonparametric Kruskal-Wallis test was the primary form of analysis for determining significant differences in daily average discharge among different time scales. If significant differences between one or more of the medians was detected, Dunn's multiple comparisons test was performed post-hoc to determine which groups were significantly different. The family (α) for the Kruskal-Wallis test was chosen based on the number of comparisons between groups so that the resulting Bonferroni adjusted (α) for Dunn's multiple comparisons would always equal 0.006. This would yield 95.009% confidence intervals (CI) of the median daily average discharge.

Kruskal-Wallis tests were used to compare the variation between months throughout the entire sampling history of the USGS gage (1967-2019) and the sampling history conducted by EIH. Both scenarios revealed highly significant results ($p < 0.001$), and Dunn's multiple comparisons test was performed post-hoc (Figure 7). In both time periods, the month of August was the most significantly different from the other months and exhibited the least variation in daily average discharge. From 1967-2019, the month with the fewest number of statistically significant ($p \leq 0.006$) comparisons was January, while during 2011-2019 it was the month of June.

Kruskal-Wallis tests were also used to compare median daily average discharge between sampling years, and Dunn's multiple comparisons test revealed a stark divide between the two halves of the decade (Figure 8). Nearly all pairwise comparisons between the years 2011-2019 were significantly different ($p \leq 0.006$). The median daily average discharge of 2018 was significantly different from all other years. The year 2014 had the fewest significantly different comparisons at six and was not significantly different from 2012 or 2013.

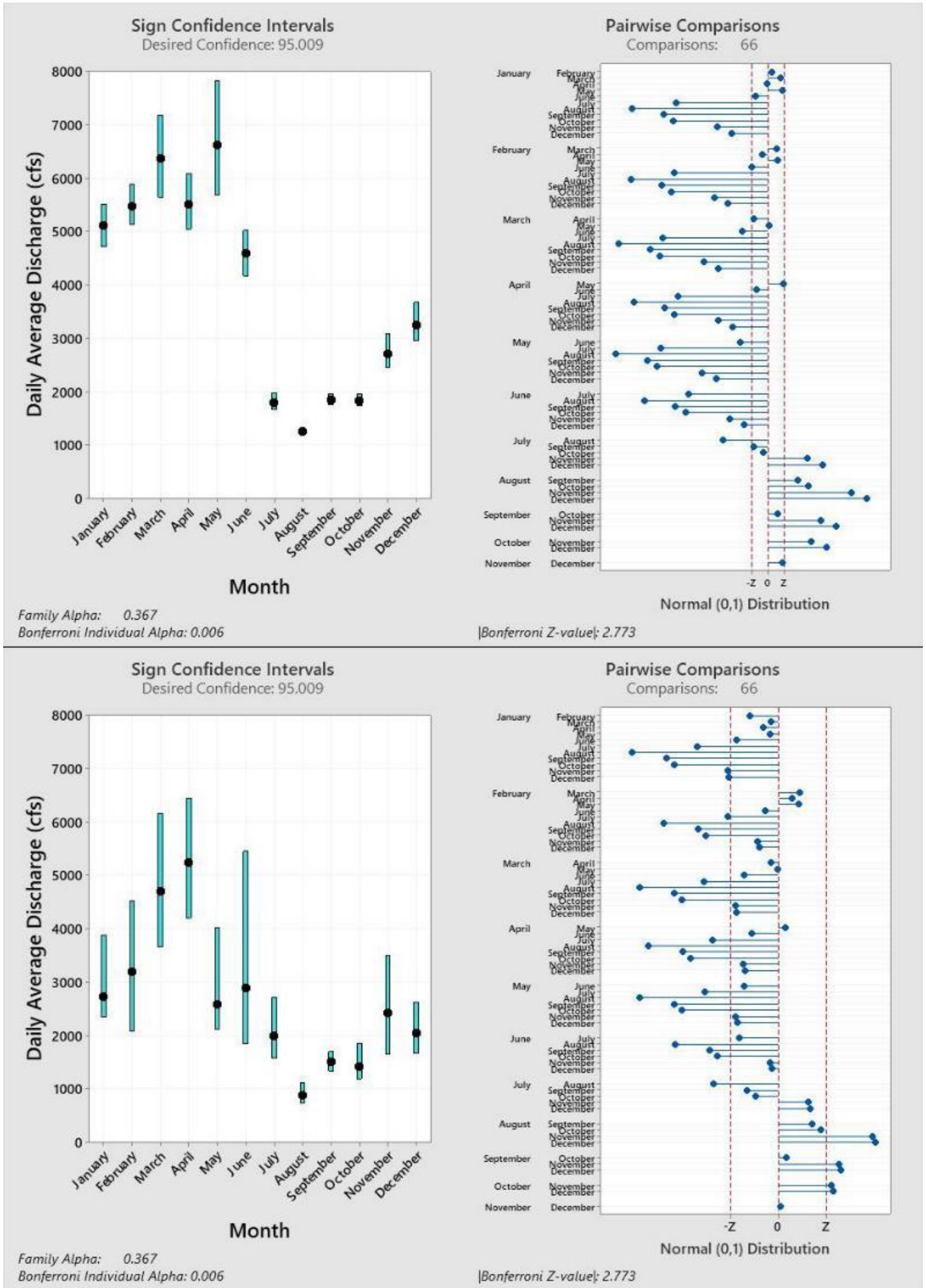


Figure 7. Dunn's multiple comparison test for significant differences in daily average discharge (cfs) between each month during the years 1967-2019 (Top) and 2011-2019 (Bottom). Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between months ($p \leq 0.006$).

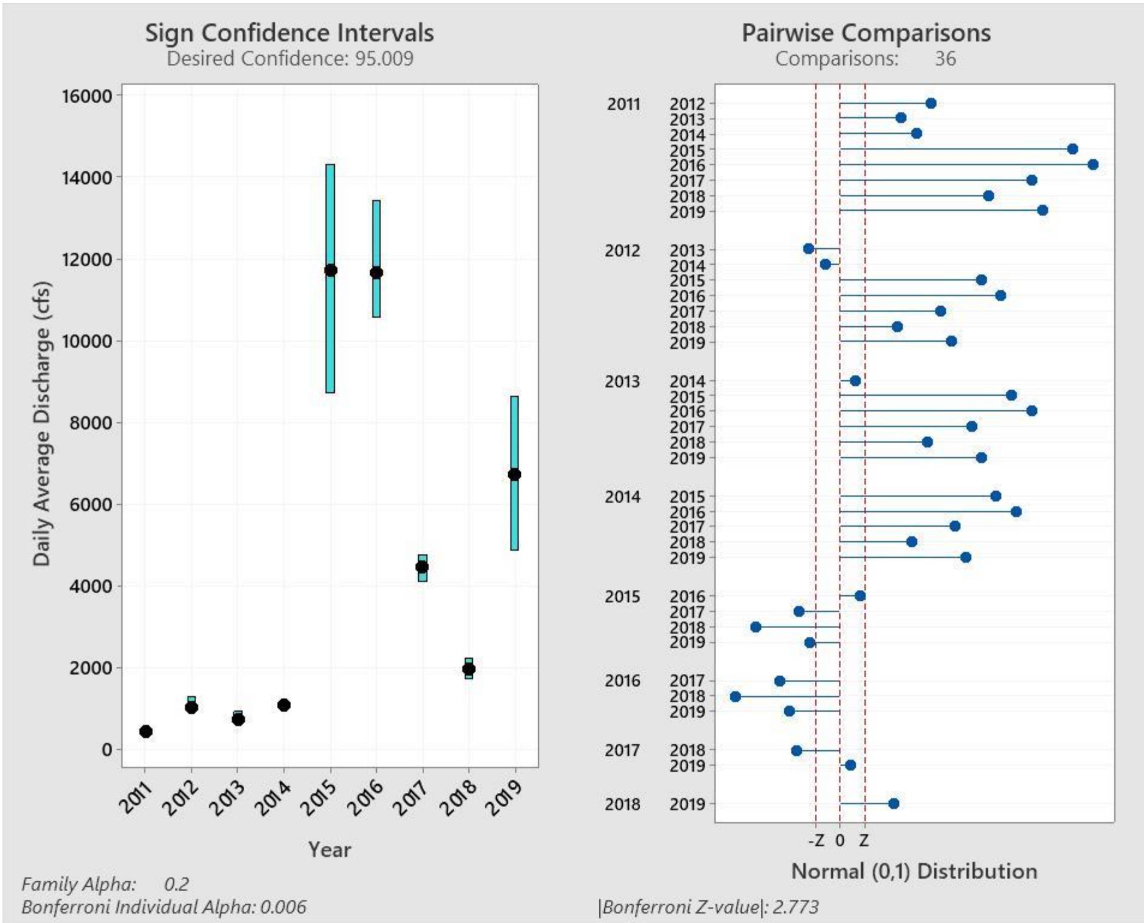


Figure 8. *Dunn's multiple comparison test for significant differences in daily average discharge (cfs) between each year from 2011-2019. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between years (p≤0.006).*

Seasonal Variation

An analysis of the seasons was conducted using the same procedure. Dunn's multiple comparisons test of daily average discharge for the seasons from 1967-2019 revealed that all three seasons are significantly different from one another ($p \leq 0.006$). However, in the case of 2011-2019, the spring and winter seasons were not significantly different from one another ($p > 0.006$) (Figure 9). In addition, each individual season was separately tested in order to determine the variation within each season during the sampling history. The summer season experienced the lowest degree of variation in daily average discharge between years; Dunn's multiple comparisons test calculated 30 significantly different ($p \leq 0.006$) pairwise comparisons out of 36 (Figure 10). In contrast, the winter season exhibited the greatest amount of variation in daily average discharge between sample years, as Dunn's multiple comparisons test calculated only 25 significantly different pairwise comparisons (Figure 11). This contradicted the results comparing each season, which suggested that the larger confidence interval of the spring season during 1967-2019 and 2011-2019 would mean that the spring season would exhibit more variation between sample years than the winter season. The spring season had a total of 29 significantly different pairings between years, and each individual year had at least six significantly different pairwise comparisons (Figure 12). The year 2018 had the least number of significantly different comparisons during the winter season, while 2017 had the least number of significantly different comparisons during the winter season (Figure 11). During the spring season, the years 2011, and 2017 were significantly different from all other years, while during the summer season, 2011, 2016, and 2018 were significantly different from all other years (Figure 10; Figure 12).

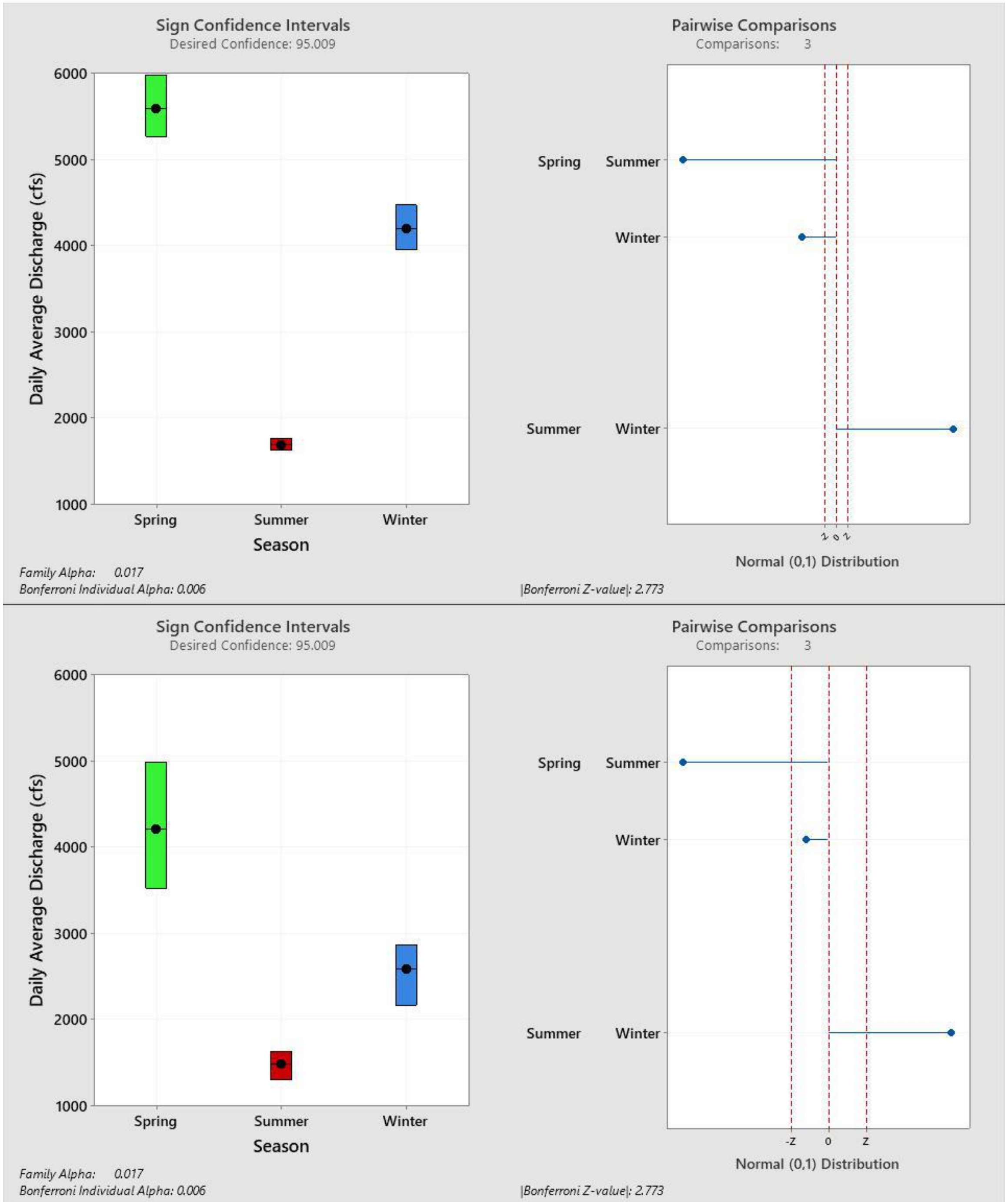


Figure 9. Dunn's multiple comparison test for significant differences in daily average discharge (cfs) between each season from 1967-2019 (Top) and 2011-2019 (Bottom). Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons ($p \leq 0.006$).

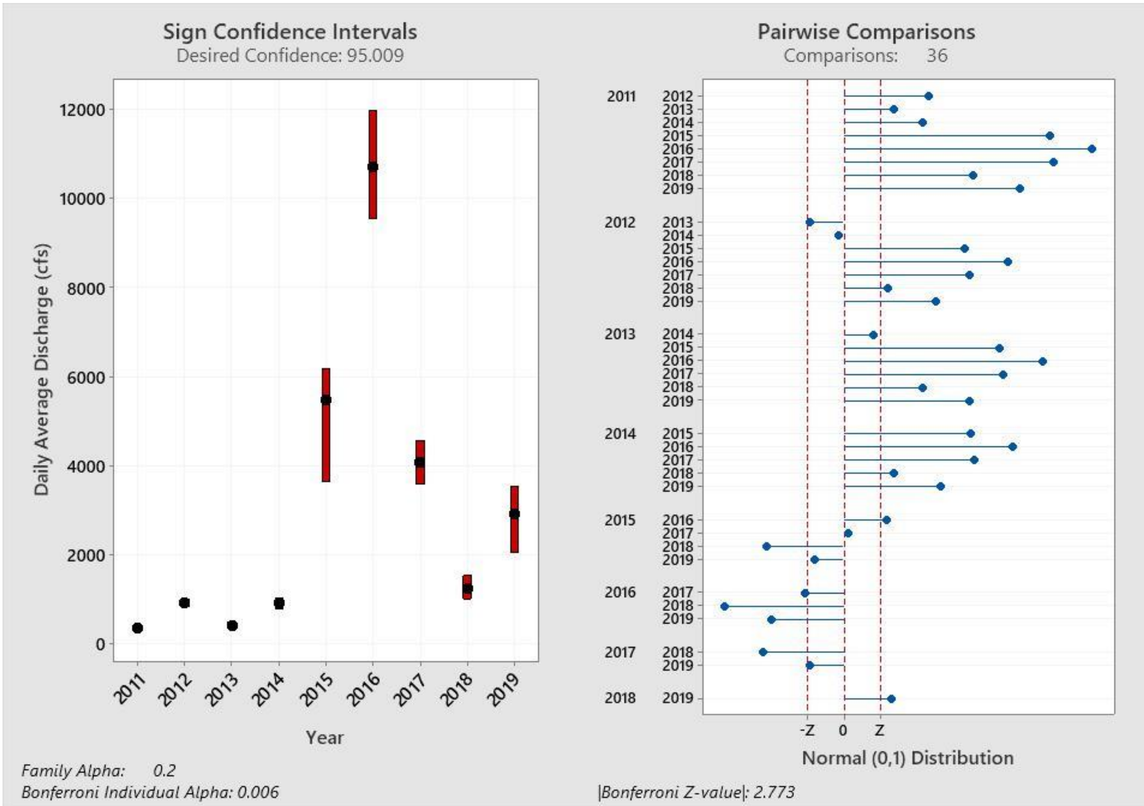


Figure 10. Dunn's multiple comparison test for significant differences in daily average discharge (cfs) between each year during the summer months. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between years ($p \leq 0.006$).

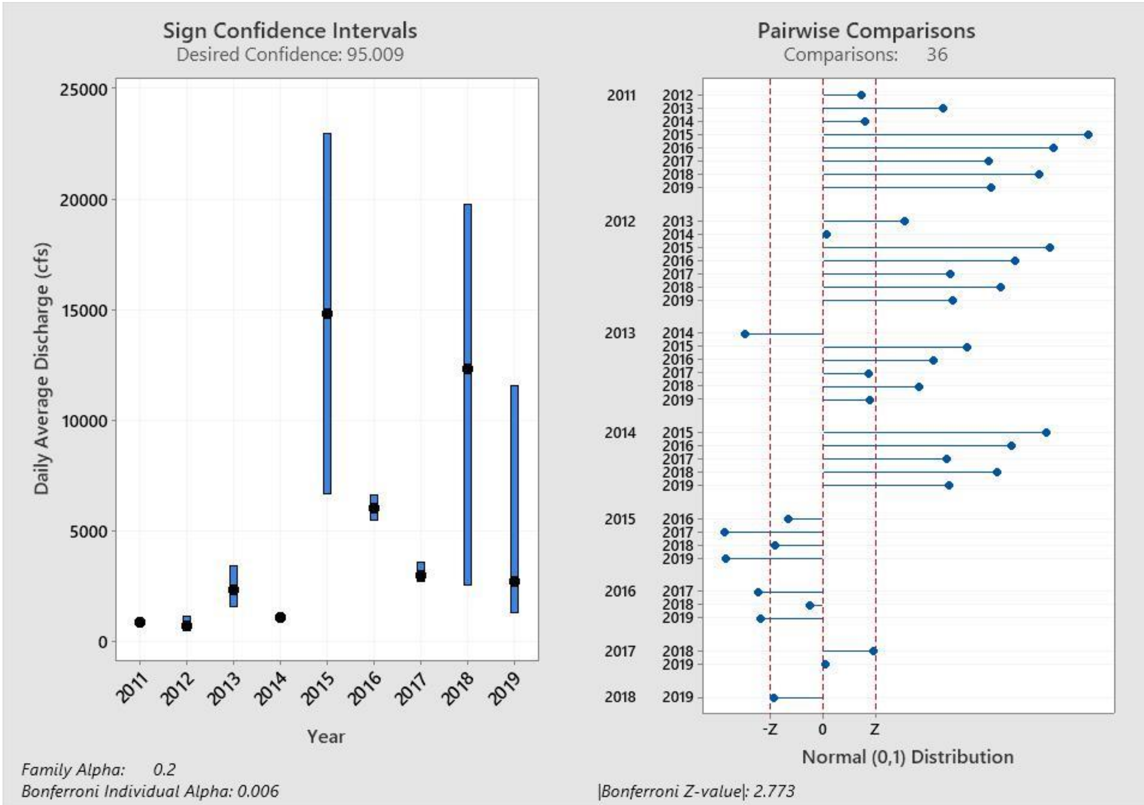


Figure 11. Dunn's multiple comparison test for significant differences in daily average discharge (cfs) between each year during the winter months. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between months ($p \leq 0.006$).

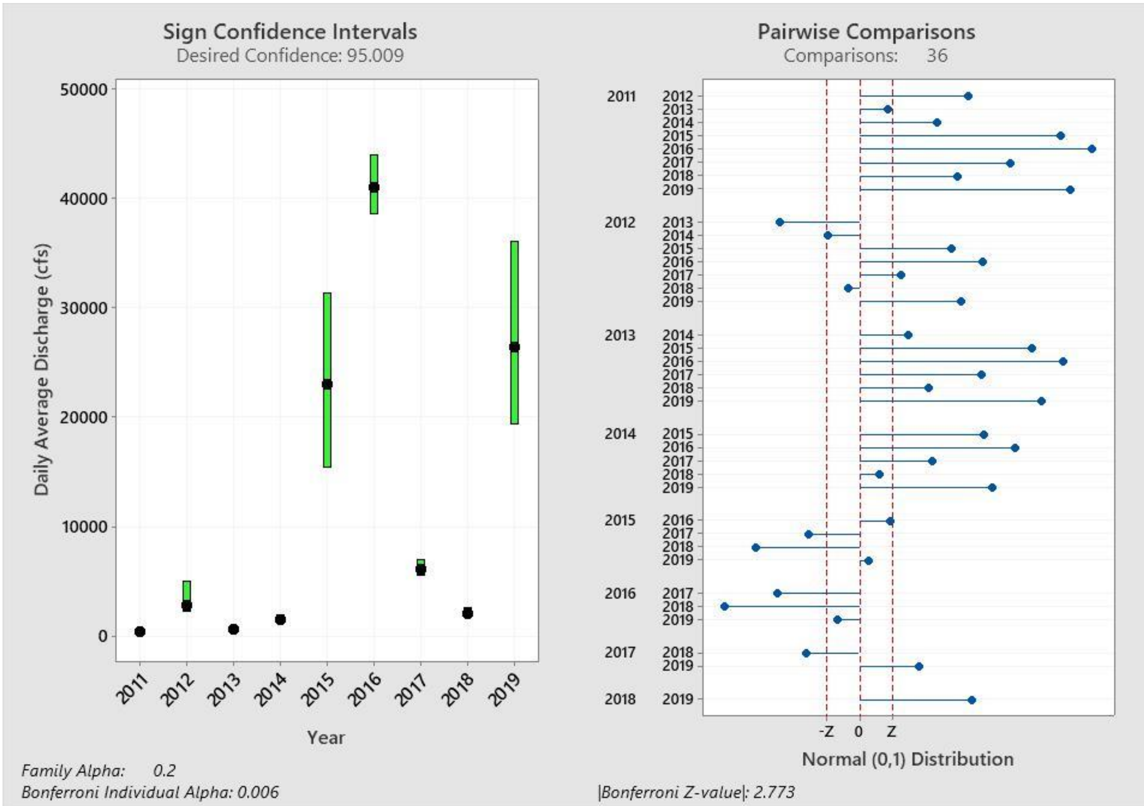


Figure 12. Dunn's multiple comparison test for significant differences in daily average discharge (cfs) between each year during the spring months. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between months ($p \leq 0.006$).

Linear Modeling of Downstream Discharge

Simple linear regression analysis was performed in order to determine the best form of USGS gage discharge data for predicting discharge measured during sample dates upstream of TCEQ segment 1201 at B42. The continuous discharge data utilized for the linear regression was the value measured at the time closest to when the Sontek River Surveyor recorded field discharge on the corresponding sample date. Daily average discharge values from the corresponding sample date were also plotted against field discharge and placed side by side with the continuous data. The analysis revealed that both fitted models could account for the variation seen in the field discharge (p ≤

0.05). The adjusted (R^2) for both models were exceptionally high, but the linear model using the continuous data had a slightly higher value of 0.8571 while the daily average discharge model had an (R^2) value of 0.8561 (Figure 13). The corresponding standard deviations (S) for each model were 1,222.13 and 1,226.12 respectively.

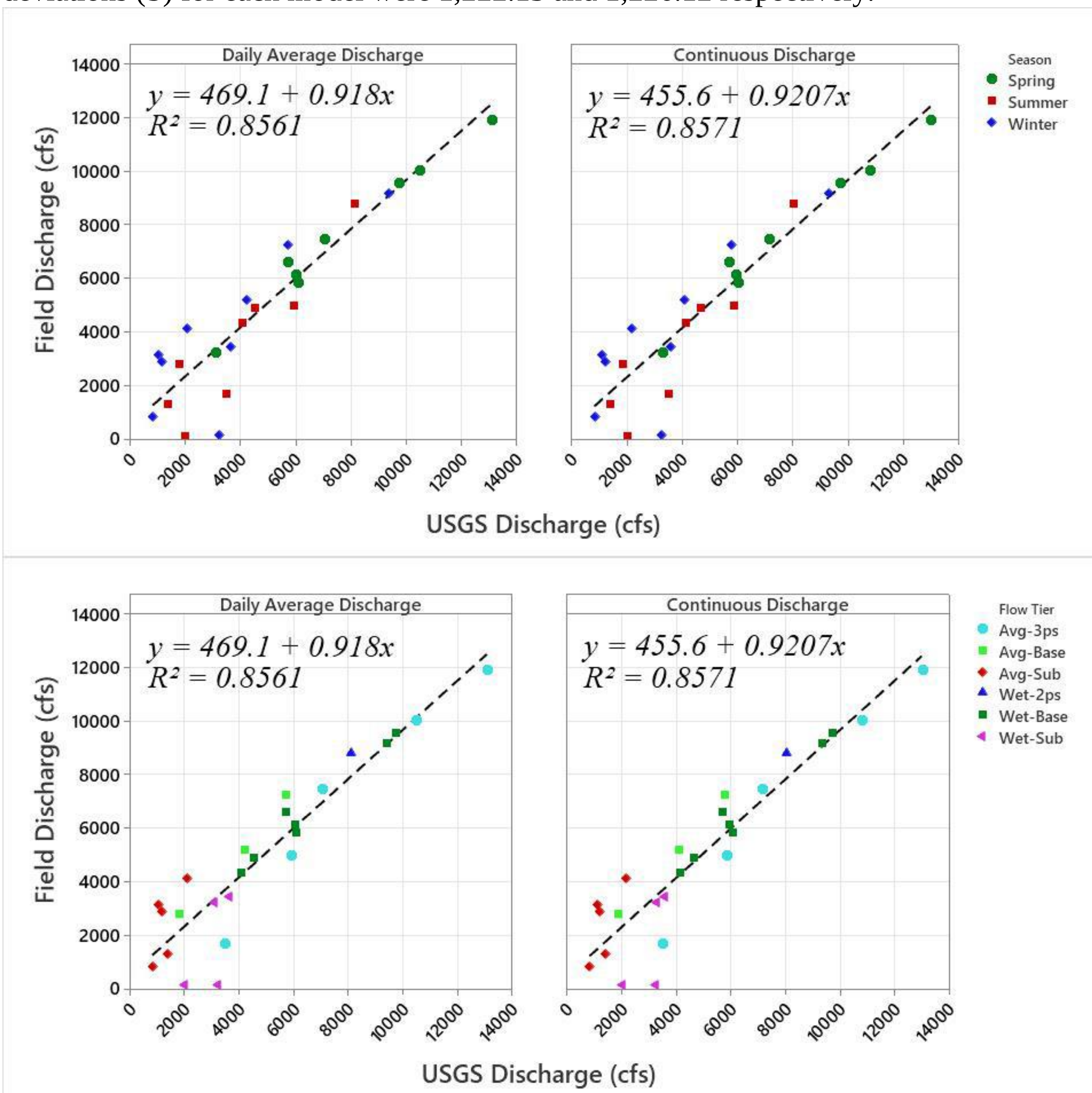


Figure 13. Linear regression models between field discharge and USGS discharge values with fitted line equations and adjusted (R^2) values.

Water Quality

Continuous Monitoring

Daily average discharge data was used as the primary predictor variable in various types of regression analysis for the data collected by the HOBO loggers and TROLL probes. As it was mentioned previously, the data was not utilized in its quarter-hourly time scale in which it was actively recording, but instead, daily average values were computed in R and R studio for pairing with daily average discharge data.

Temperature

When daily average temperature data was paired with daily average discharge data, there did not appear to be any distinguishable correlation between the two variables, and regression analysis supported that observation. However, when the temperature data was plotted against Julian day, it seemed to follow the pattern of a parabola (Figure 14). Regression analysis for a quadratic fit between Julian day and daily average temperature revealed high (R^2) values for each site (Figure 14). The corresponding standard deviations (S) for each site model were 2.73226 for the Upper site, 3.13674 for the Middle site, and 2.90323 for the Lower site. Given the apparent lack of variation in temperature between sites, a single quadratic model was also generated for the daily average temperature data of all the sites. With an (R^2) value of 0.807 and an (S) of 2.95729, the combined model does provide a good fit for the data ($p \leq 0.05$) while explaining a high amount of variation in the data and low variation between the predicted and actual values (Figure 15).

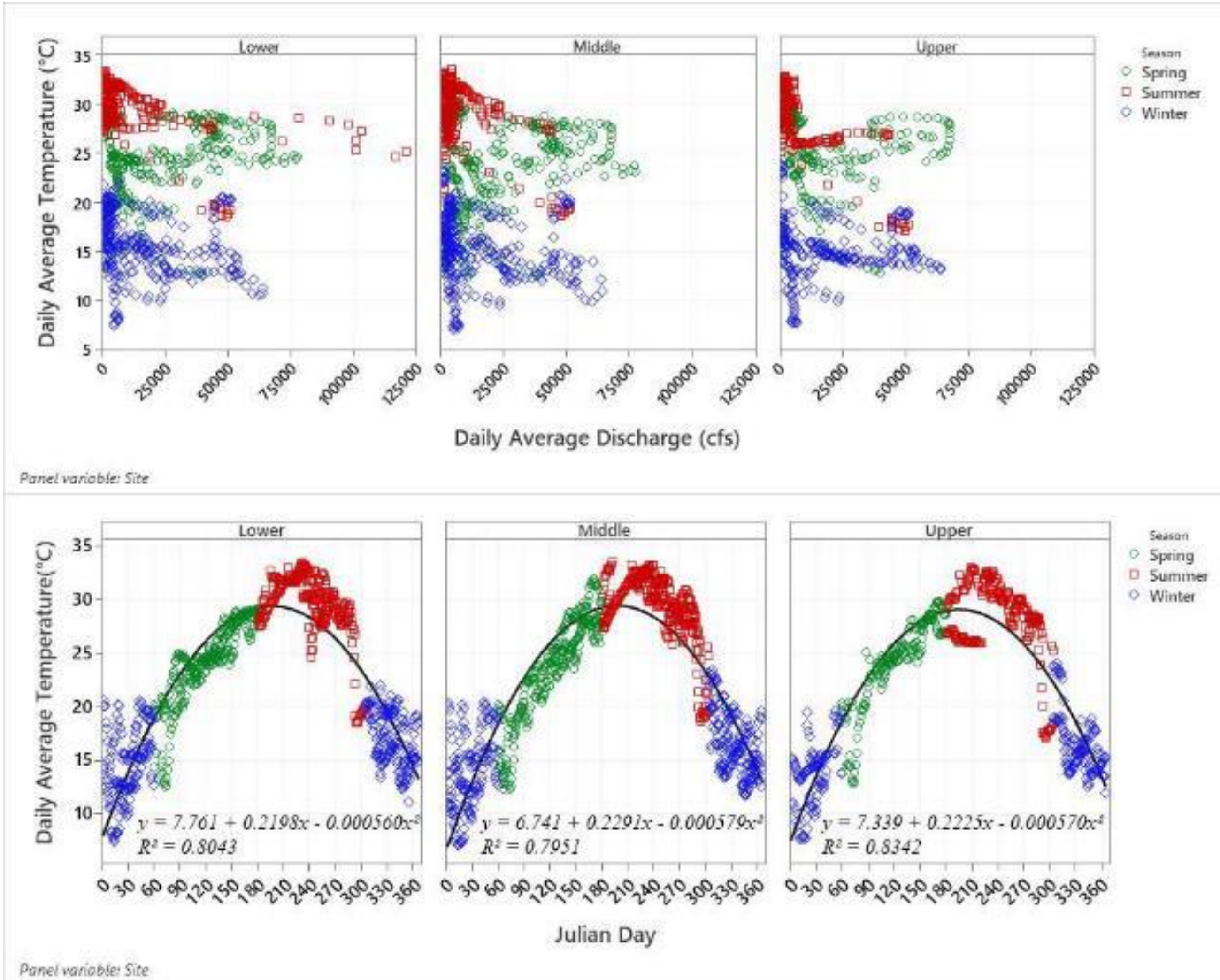


Figure 14. Scatterplots of daily average temperature and daily average discharge for each site (Top). Polynomial regression models for each site with corresponding (R^2) values between daily average discharge and Julian day (Bottom).

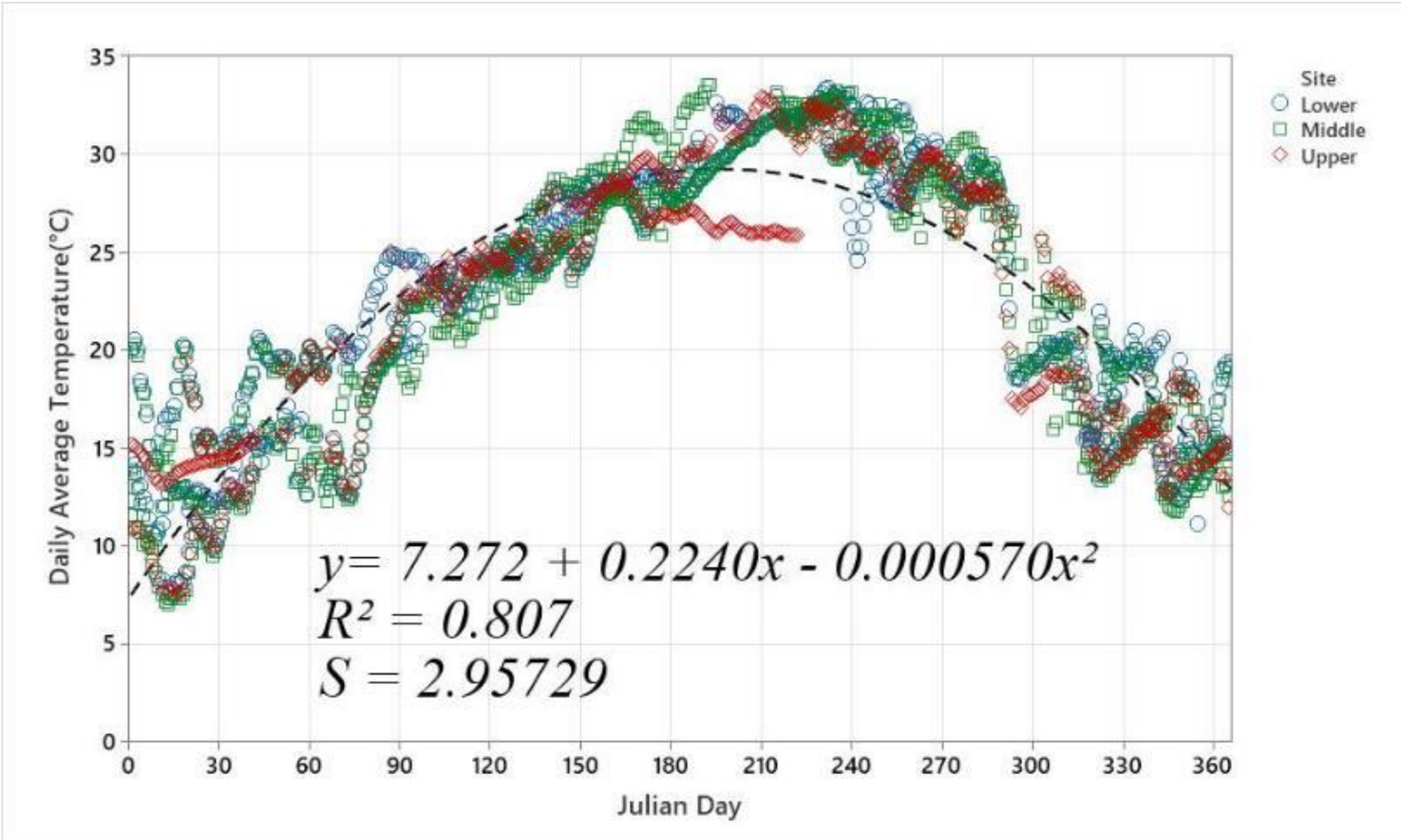


Figure 15. Polynomial regression model of daily average temperature and Julian day for the combined data of all continuous monitoring sites.

Salinity

Unlike water temperature, salinity had a much stronger relationship with river discharge. Two regression models between daily average salinity and daily average discharge were created: one linear, and one nonlinear. For the simple linear regression model, a Log_{10} transformation was applied to both the daily average salinity and daily average discharge data prior to performing regression analysis. Although the analysis indicated the models were adequate for explaining the variation in the data ($p \leq 0.05$), the (R^2) values significantly decreased as distance upstream increased (Figure 16). The standard deviations (S) increased the further upstream the site was located. A nonlinear regression analysis was also performed in order to formulate a model that would be more applicable to all sites and/or not require any data transformation. In this case an exponential decay function was used to fit the discharge data with the salinity data without applying a transformation (Figure 16). The nonlinear model appeared to be a better fit for the Upper site given the standard deviation of 0.960119. However, the standard deviations for the Middle and Lower sites were significantly higher. Even after accounting for the log transformation, only the Lower site did not have a lower standard deviation for the nonlinear model.

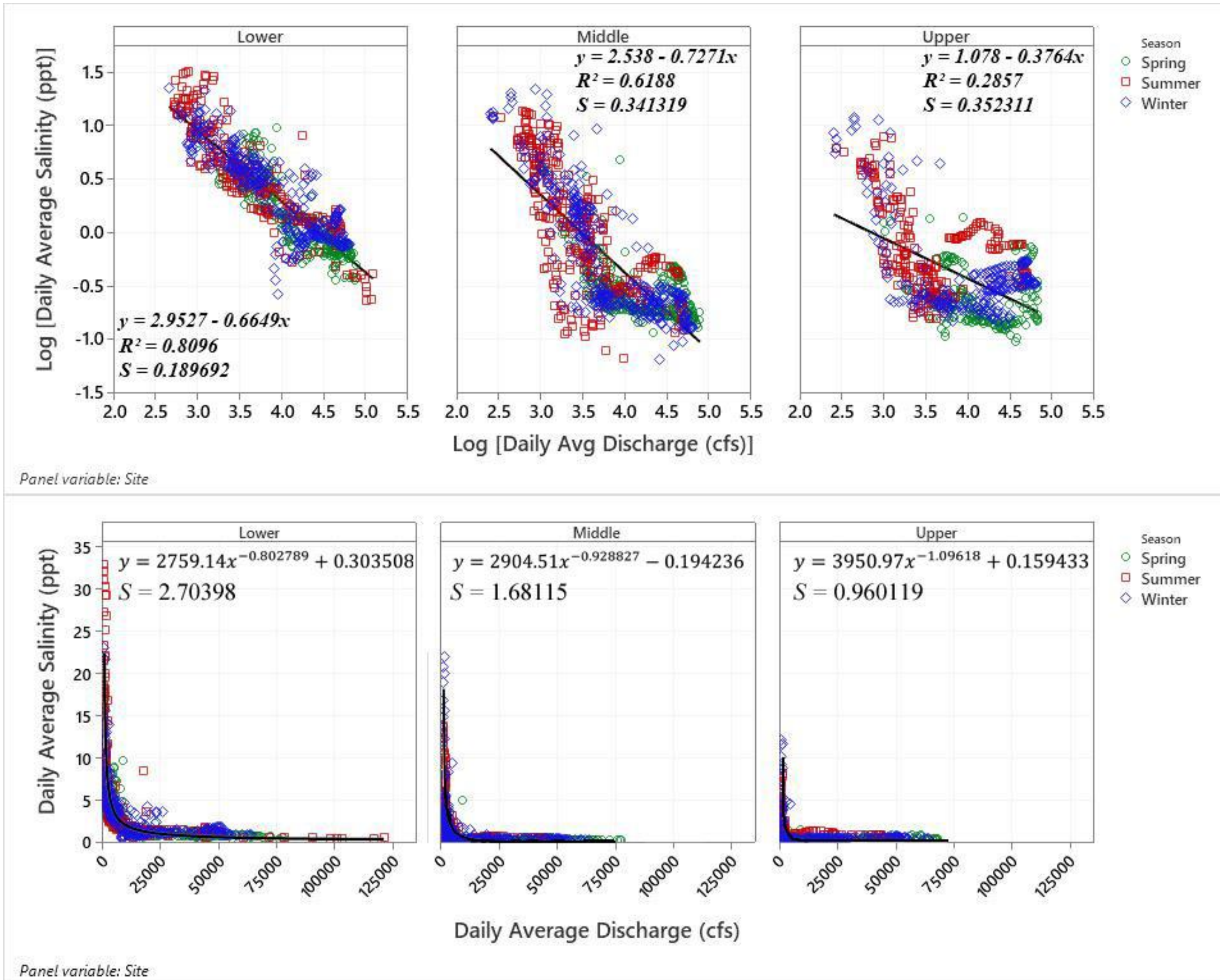


Figure 16. Simple linear regression model between the log transformed daily average salinity and daily average discharge data (Top). Nonlinear regression model between the daily average salinity and daily average discharge data (Bottom).

Relative Depth

As was the case with salinity, the barometric pressure-adjusted depth measured by the TROLLs had a very clear correlation with river discharge and was subjected to both linear and nonlinear regression analysis (Figure 17). Unlike the salinity data however, no transformation was performed prior to regression analysis as it was deemed unnecessary for a simple linear regression model. When regression analysis was performed using the simple linear model, only the Middle site exhibited a significantly high (R^2) value. Although the nonlinear regression analysis does not yield (R^2) values for the generated models, the standard deviations (S) were all lower for each site, signifying the sigmoidal fitted line exhibits lower variation between the predicted values and actual values than the simple linear models do- particularly for the Upper site.

Dissolved Oxygen

Dissolved oxygen (DO) was not significantly correlated with river discharge ($p > 0.05$), so temperature was chosen as the primary predictor variable (Table 4). However, even temperature could not explain more than 50% of the variation in DO at any site using the simple linear model (Figure 18). In order to generate a more powerful prediction model for daily average DO, multiple linear regression analysis was applied in order to determine if an interaction between temperature and discharge would explain a greater proportion of the variance in DO. The results of the multiple linear regression between discharge, temperature, and DO reveal that the addition of discharge to the model was a significant contribution ($p \leq 0.05$), and the (R^2) values increased while the (S) values dropped for each site model (Table 4).

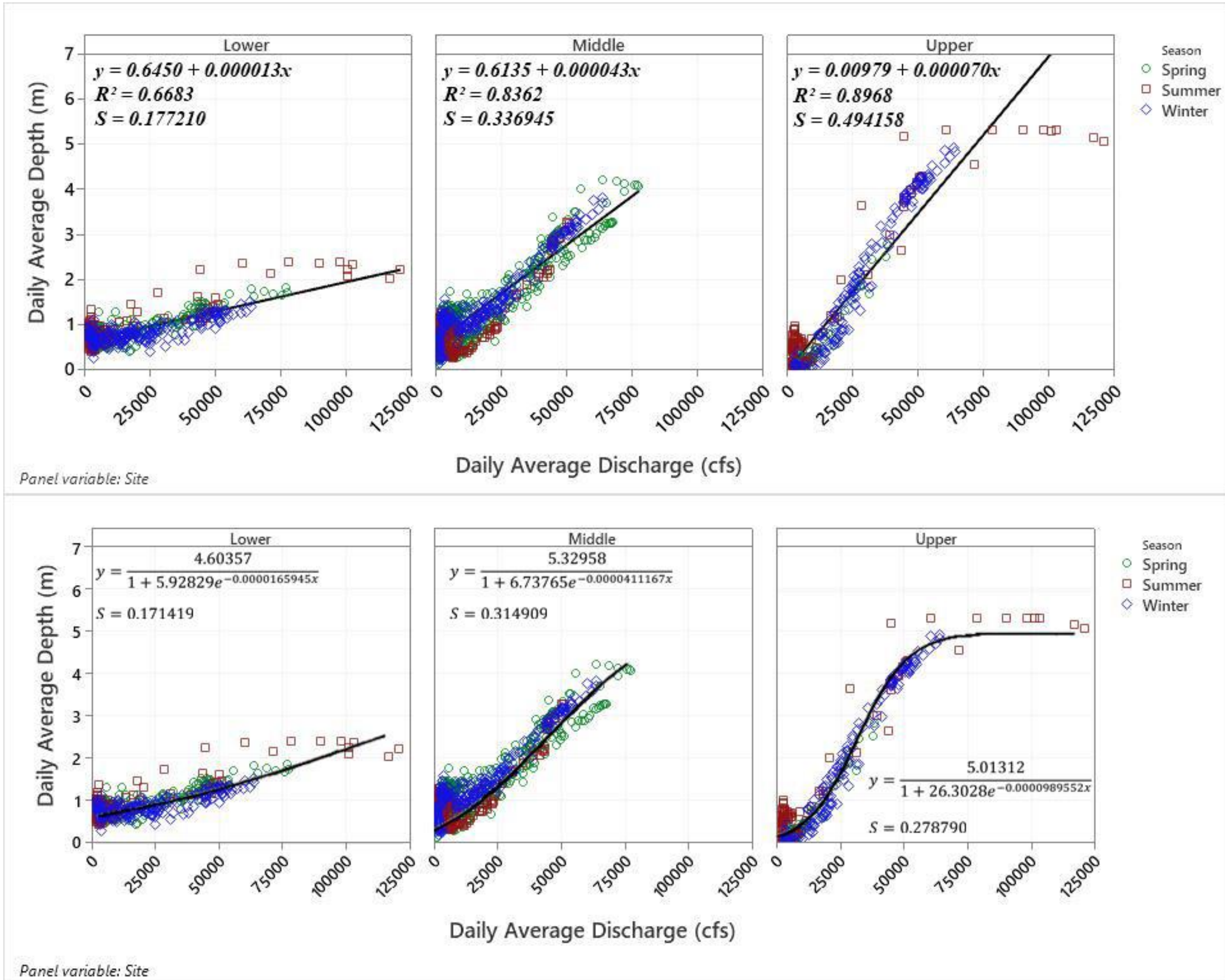


Figure 17. Simple linear regression model (Top) and nonlinear regression model between the daily average depth and daily average discharge data.

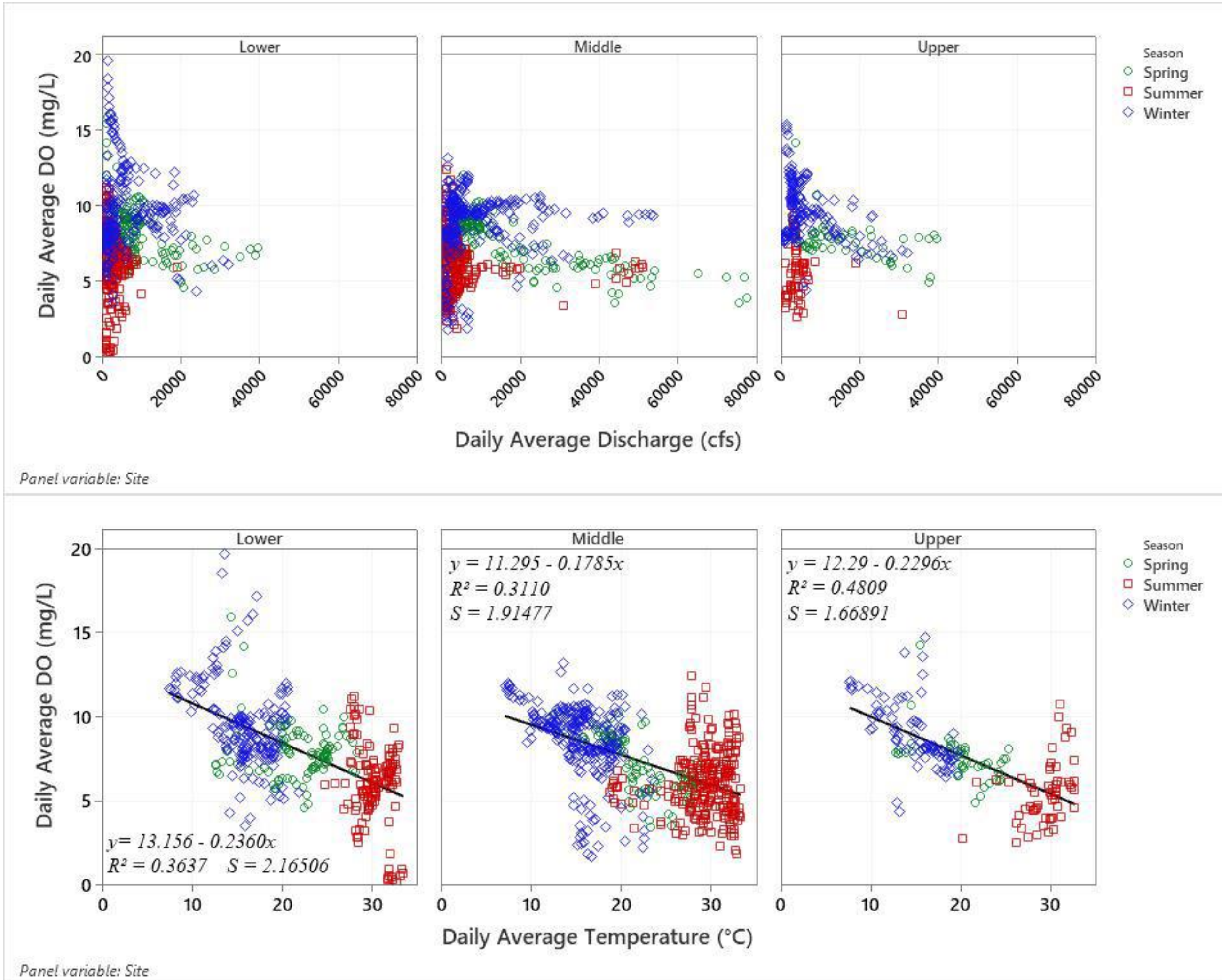


Figure 18. Scatterplots of daily average dissolved oxygen (DO) and daily average discharge for each site (Top). Linear regression models for each site between daily average discharge and daily average temperature (Bottom).

Table 4. Results of simple linear and multiple regression analysis for daily average dissolved oxygen (DO) data.

Variables Used	Site	Linear Regression Model	Adjusted R^2	S	p-value
Daily Average Discharge (Q)	Upper	y = 8.834 – 0.000065(Q)	0.0457	2.43311	0.455
	Middle	y = 7.488 – 0.000012(Q)	0.0032	2.27405	0.071
	Lower	y = 7.841 + 0.000014(Q)	0.0457	2.86299	< 0.001
Daily Average Temperature (T)	Upper	y = 12.29(T) – 0.2296	0.4809	1.66891	< 0.001
	Middle	y = 11.295(T) – 0.1785	0.3110	1.91477	< 0.001
	Lower	y = 13.156(T) – 0.236	0.3637	2.16506	< 0.001
Daily Average Discharge (Q) and Daily Average Temperature (T)	Upper	y = 13.497 – 0.2550(T) – 0.000069(Q)	0.5523	1.54988	< 0.001
	Middle	y = 11.770 – 0.1874(T) – 0.000029(Q)	0.3394	1.87486	< 0.001
	Lower	Y = 14.871 – 0.2815(T) – 0.000115(Q)	0.4328	2.04417	< 0.001

Profile Summary

The full summary statistics of each water quality variable measured during profile measurements are categorized by site and flow tier in Appendix D. Mean water temperature increased only slightly as distance from the mouth increased, although there were noticeable differences between flow tiers. Mean temperature at all depths was typically higher during average hydrological conditions. Dissolved oxygen (DO) readings were lowest at the bottom, likely due to reduced light levels for photosynthesis and increased turbidity. DO did not conform to a linear pattern among sites, as mean concentrations were highest in the upper reaches of the river, followed by B25 and the sites closest to the mouth while the central interior sites exhibited the lowest DO values. As for flow tiers, lowest DO concentrations occurred during Wet-2ps sampling events, followed closely by both subsistence flow tiers while the highest DO concentrations were detected during base flows. Salinity exhibited the greatest variation among sites and flow tiers with sites becoming increasingly more saline the further upstream they are. Average hydrological conditions yielded salinities higher than wet conditions, and as the flow tier decreased from pulse flows to subsistence, salinity increased. Thalweg depth also exhibited a similarly predictable variation; depth increased from subsistence to pulse flow tiers, and wet hydrologic conditions yielded greater maximum depths than the average hydrologic conditions. Sites that were closer to bends in the river- such as B15 and B22- tended to have greater depths, but the maximum depth at the thalweg still displayed a declining trend as distance to the river mouth decreased. Secchi disk transparency was highest during subsistence flow tiers and during average hydrological conditions, and decreased as conditions became more wet, flow tier increased, and/or distance from the river mouth increased. Given the direct correlation between Secchi disk transparency and turbidity, the trends in turbidity exhibited an inverse relationship with the trends seen in Secchi disk transparency. The mean pH remained relatively stable across the sites and flow tiers, although wet flow tiers tended to yield more alkaline conditions, with the lowest recorded pH readings during the Avg-Base flow tier.

Interactions between Site and Flow Tier

A series of two-way analysis of variance (ANOVA) tests were conducted on water quality variables measured using profile measurements at all sample depths in order to determine significant differences between the mean values of sites, flow tiers, and if the two groups exhibit an interaction effect. A significance level of ($\alpha = 0.05$) was used for the interaction and additive models for the two-way ANOVAs. If the null hypothesis of the interaction model was rejected ($p > 0.05$), then Tukey's pairwise comparisons would be performed post-hoc for the additive model- two independent one-way ANOVAs- to determine the main effect of site and flow tier on the water quality variable being tested. If the null hypothesis for the interaction model failed to be rejected ($p \leq 0.05$), site and flow tier would be broken down into levels so that subsequent

Tukey's pairwise comparisons could test for significant differences of means between all flow tiers or sites at only one site or flow tier level.

Variation in temperature did not exhibit an interaction effect between site and flow tier, and the initial results of the two-way ANOVA indicated there were also no significant differences in temperature between sites (Table 56). However, there were significant differences between flow tiers, and Tukey's pairwise comparisons revealed only two of the fourteen comparisons were not significantly different ($p > 0.05$) (Table 56; Figure 19). The results for dissolved oxygen (DO) also revealed no interaction effect, but there were significant differences between both sites and flow tiers (Table 57; Figure 20). The two-way ANOVA for turbidity revealed no interaction effect between sites and flow tiers, but as with DO, there were significant differences between sites and flow tiers. The Tukey's pairwise comparisons of sites seemed to show two distinct zones between sites- B01 to B10 and B15 to B42 (Table 58; Figure 21). The subsistence flows formed their own distinct group while the remaining flow tiers all collected into one large group, with Avg-3ps and Avg-Base being distinct from one another (Table 58). Thalweg depth did not exhibit an interaction effect between sites and flow tiers, but each group yielded significant differences (Table 59). The Tukey pairwise comparisons did not reveal any discernible spatial patterns, but wet flow tiers were significantly higher than average flow tiers, and a declining trend was observed from pulse to subsistence flows- except for Avg-Base which had the lowest mean depth (Figure 22). Secchi disk transparency also had no significant interaction effect between sites and flow tier but exhibited significant differences within site and flow tier. Unlike turbidity, Secchi disk transparency displayed an unbroken negative linear trend as sites became more distant from the mouth. Flow tier also followed a predictable trend of higher transparency during subsistence flows, and lowest transparency during wet flow tiers (Table 60; Figure 23).

Salinity and pH were the only water quality variables tested with two-way ANOVA that showed a significant interaction effect between site and flow tier ($p \leq 0.05$). Salinity followed a predictable decreasing trend in magnitude as distance from the mouth decreased, wet flow tiers having lower mean salinities, and increasing mean salinity from pulse to subsistence flows (Figure 24; Figure 25). The significant differences observed in pH had less apparent trends, although the ones worth noting are the more alkaline conditions during wet flow tiers, and the interior sites having lower mean values (Figure 26; Figure 27). Since both variables yielded significant p-values, the post-hoc Tukey's pairwise comparisons required the separation of data based on the different levels of one grouping variable in order to test for significant differences of means between all the levels of the opposing grouping variable (Table 61; Table 62; Table 63; Table 64; Table 65; Table 66).

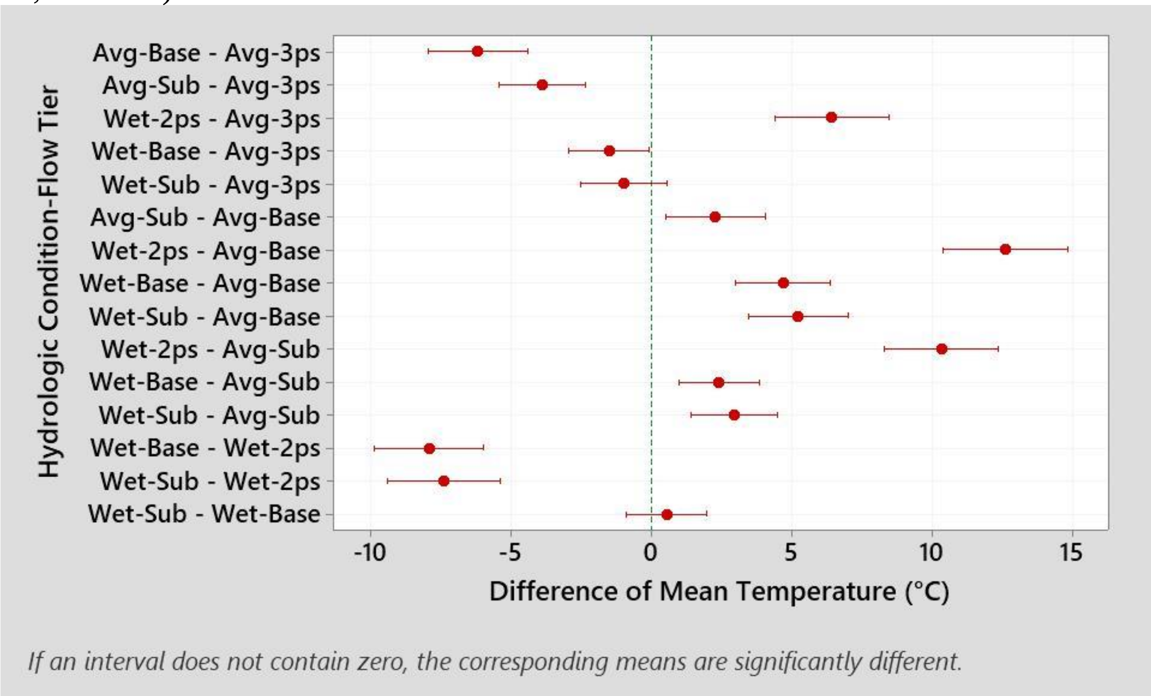


Figure 19. Confidence intervals (95%) plot of Tukey's simultaneous tests for differences in mean temperature (°C) between flow tiers.

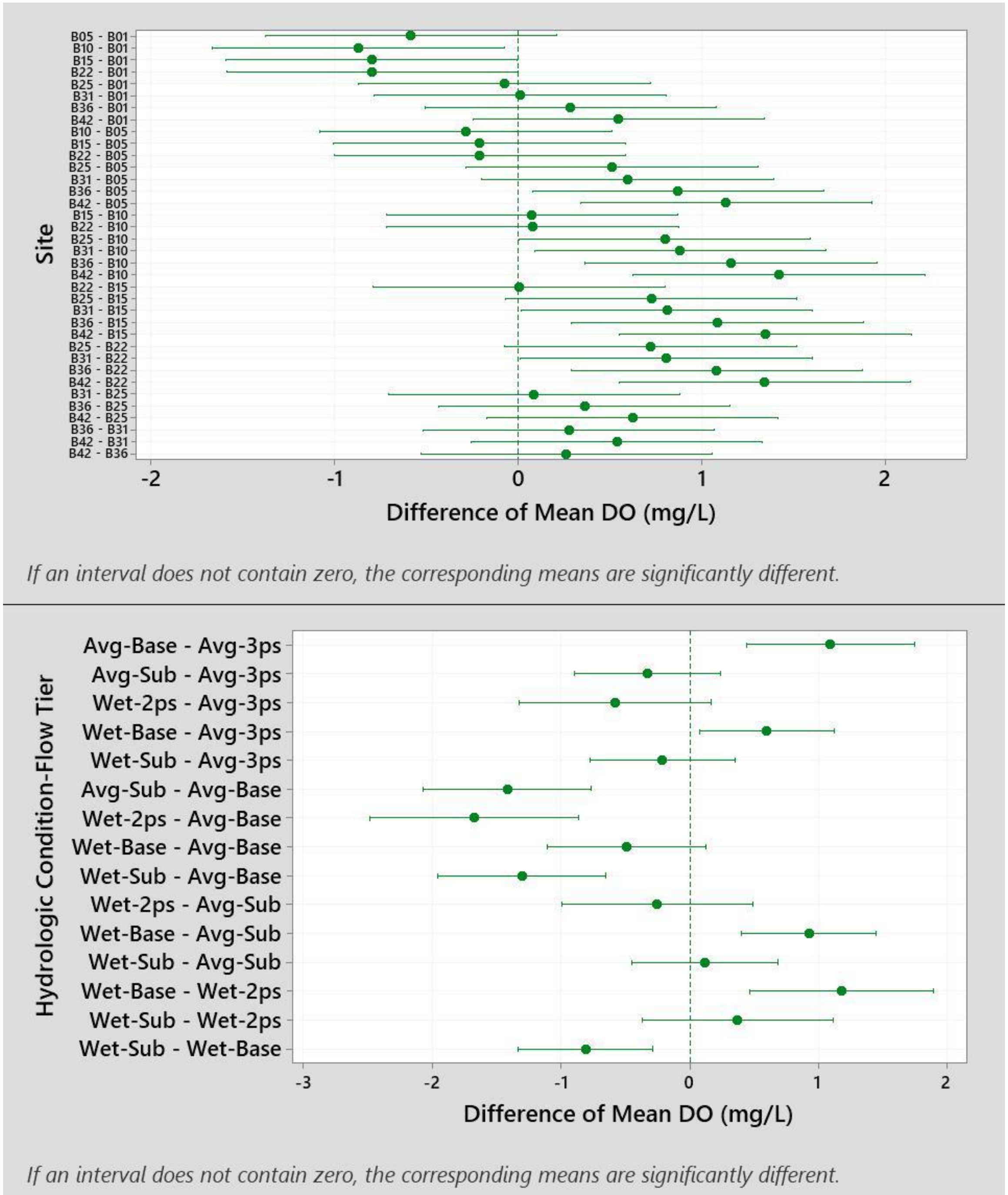


Figure 20. Confidence intervals (95%) plot of Tukey's simultaneous tests for differences in mean dissolved oxygen (mg/L) between sample sites (Top) and flow tiers (Bottom).

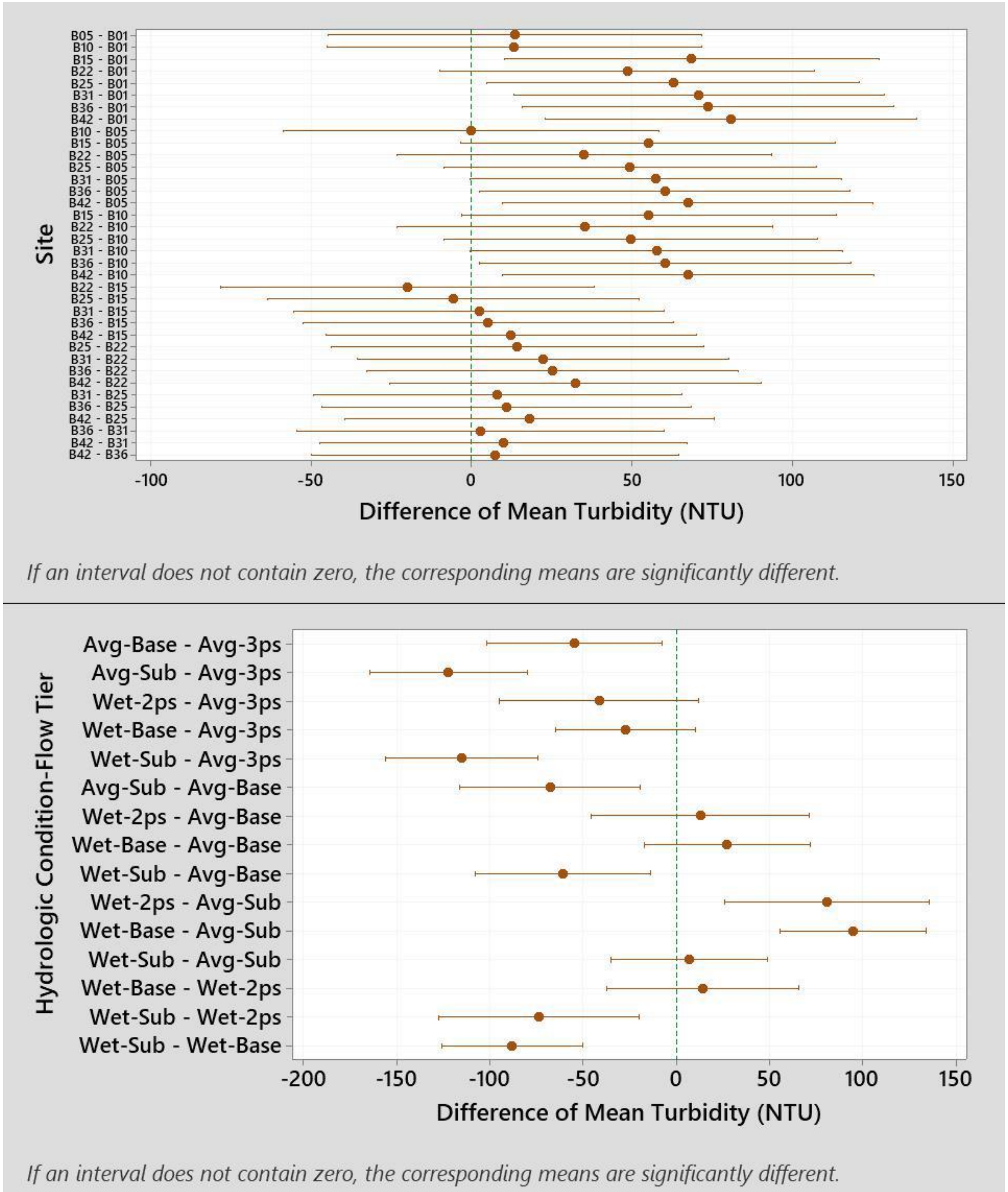


Figure 21. Confidence intervals (95%) plot of Tukey's simultaneous tests for differences in mean turbidity (NTU) between sample sites (Top) and flow tiers (Bottom).

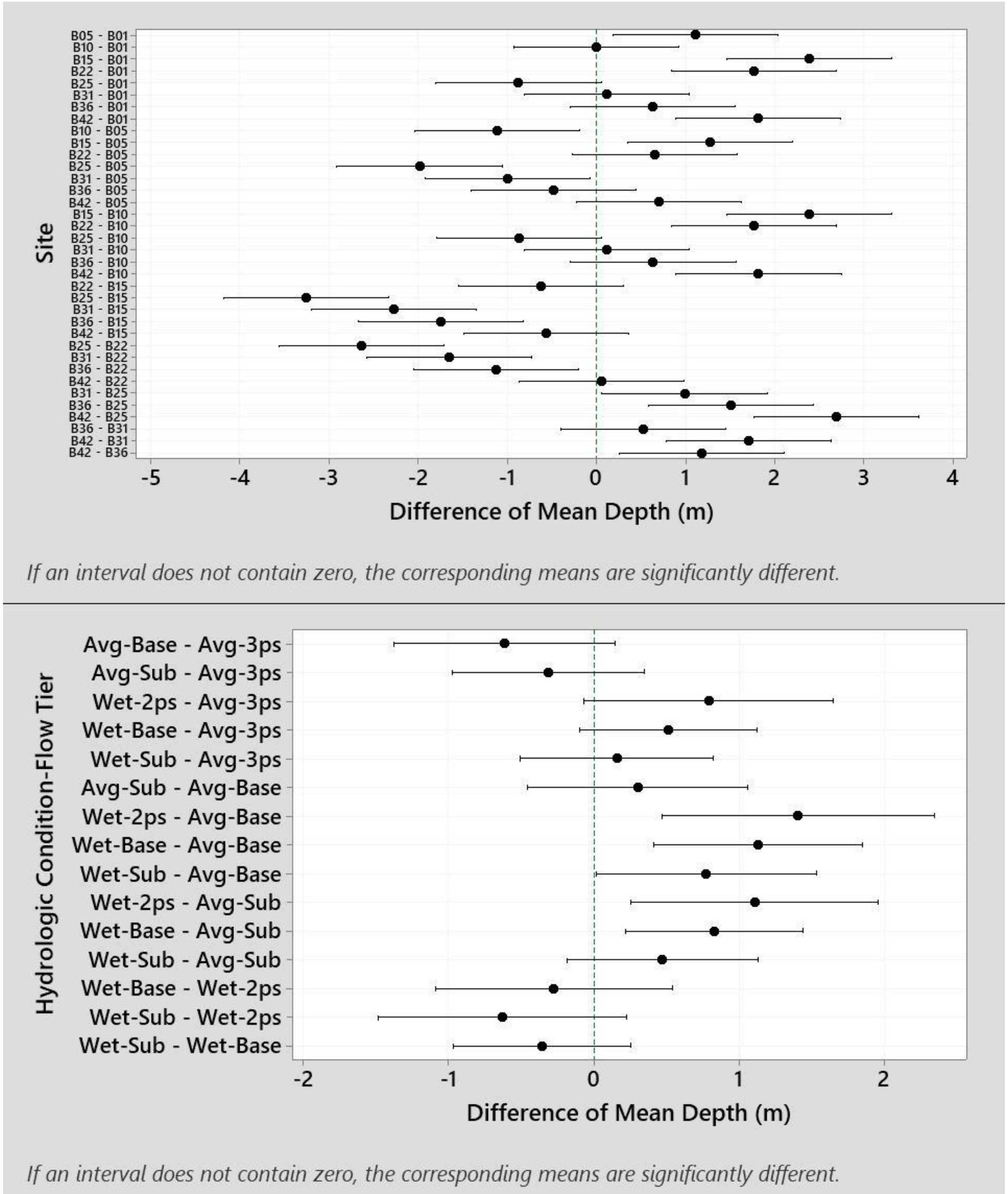


Figure 22. Confidence intervals (95%) plot of Tukey's simultaneous tests for differences in mean mid-channel total depth (m) between sites (Top) and flow tiers (Bottom).

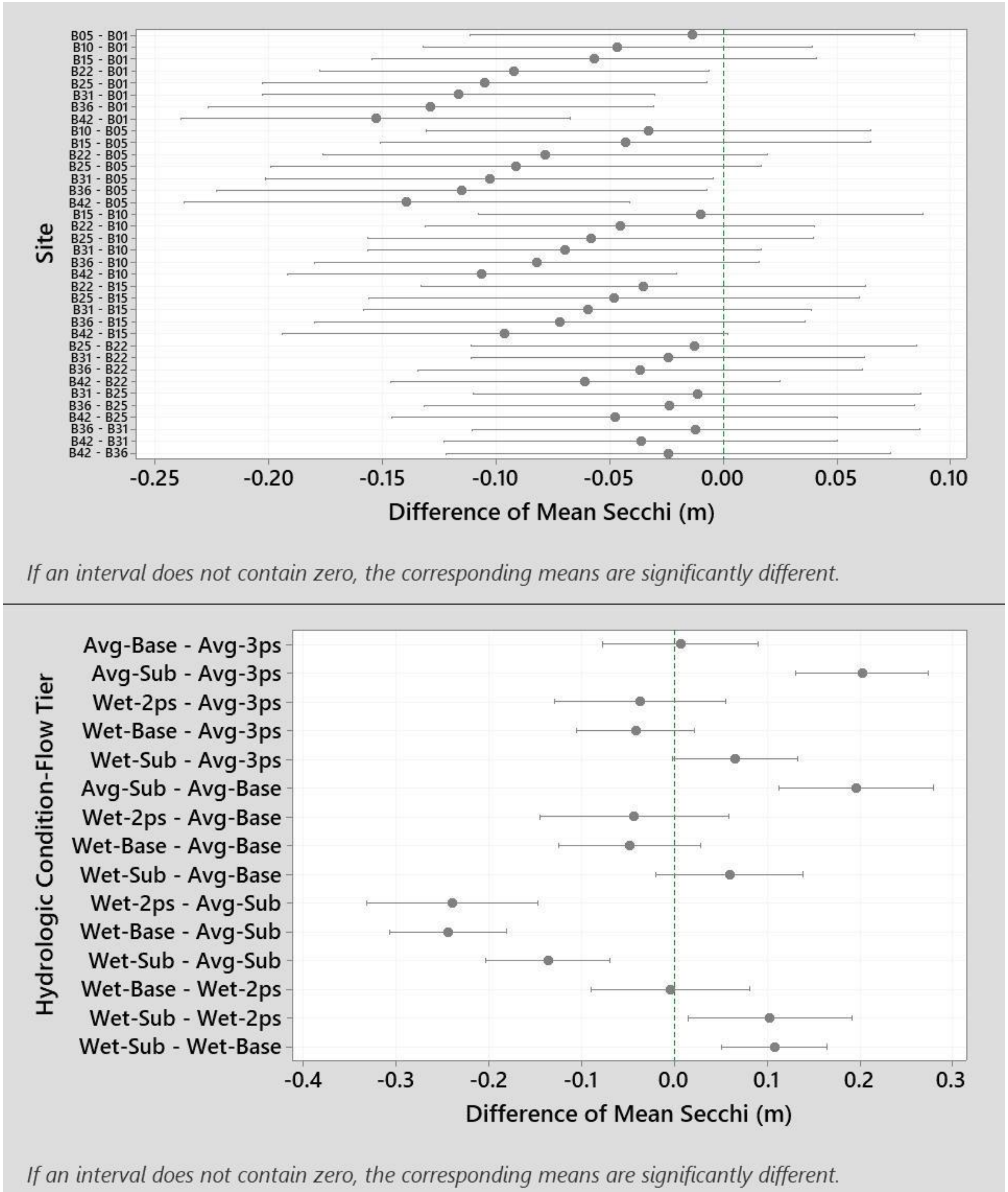


Figure 23. Confidence intervals (95%) plot of Tukey's simultaneous tests for differences in mean Secchi disk transparency (m) between sites (Top) and flow tiers (Bottom).

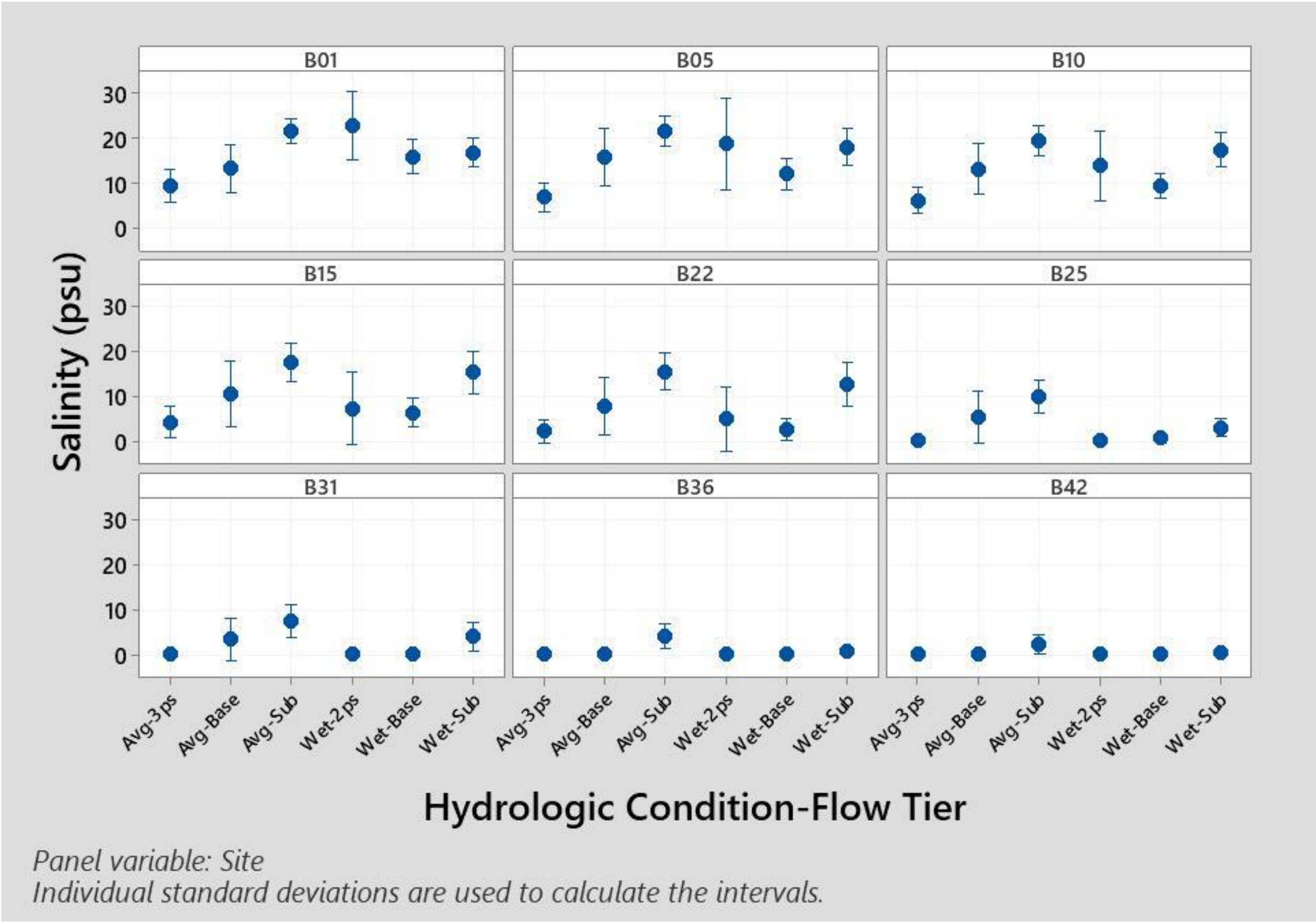


Figure 24. Confidence intervals (95%) plot of mean salinity (psu) for each flow tier between different sample sites. Results of two-way ANOVA Tukey pairwise comparisons listed in Table 63.

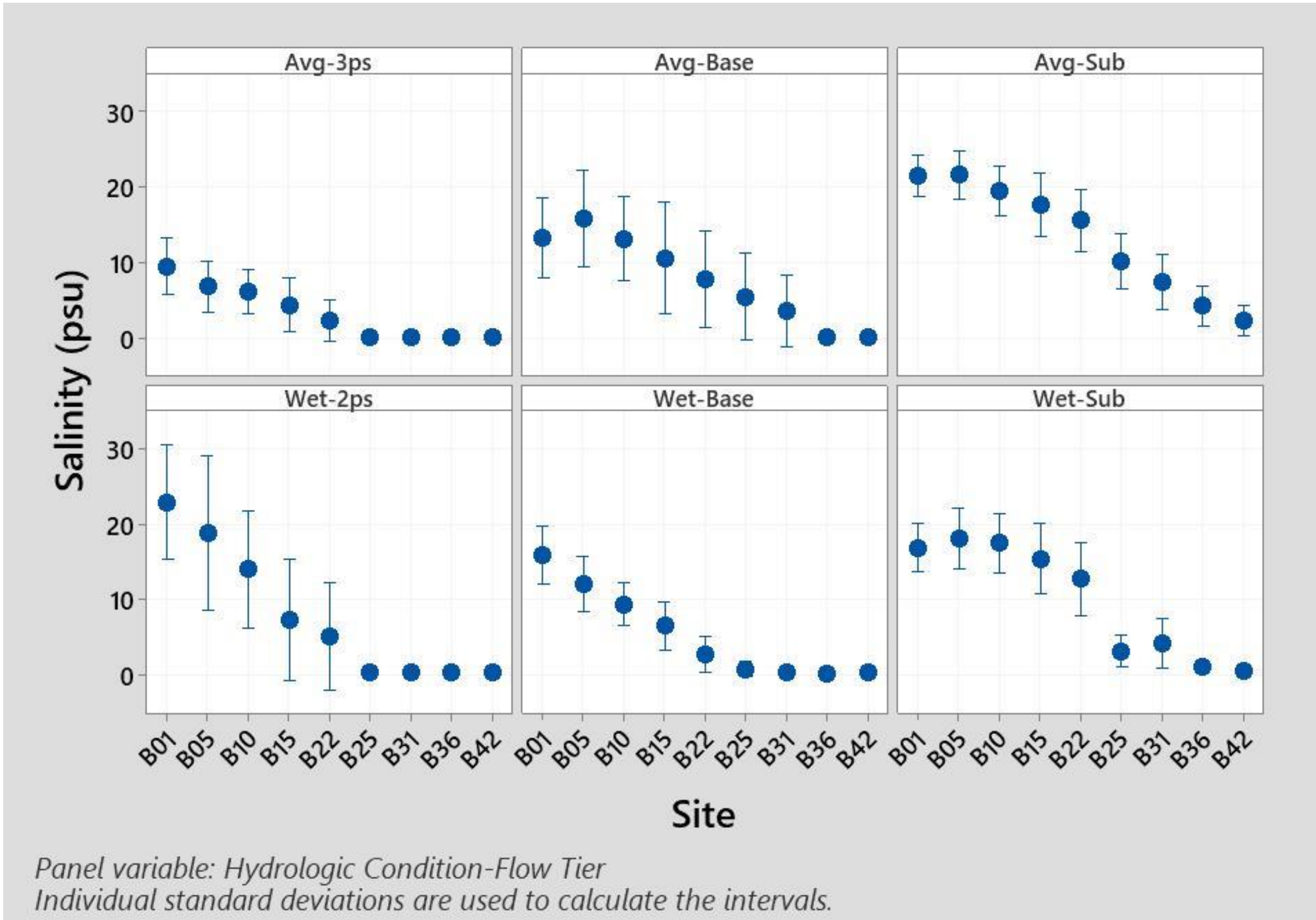


Figure 25. Confidence intervals (95%) plot of mean salinity (psu) for each sample site between different flow tiers. Results of two-way ANOVA Tukey pairwise comparisons listed in Table 64.

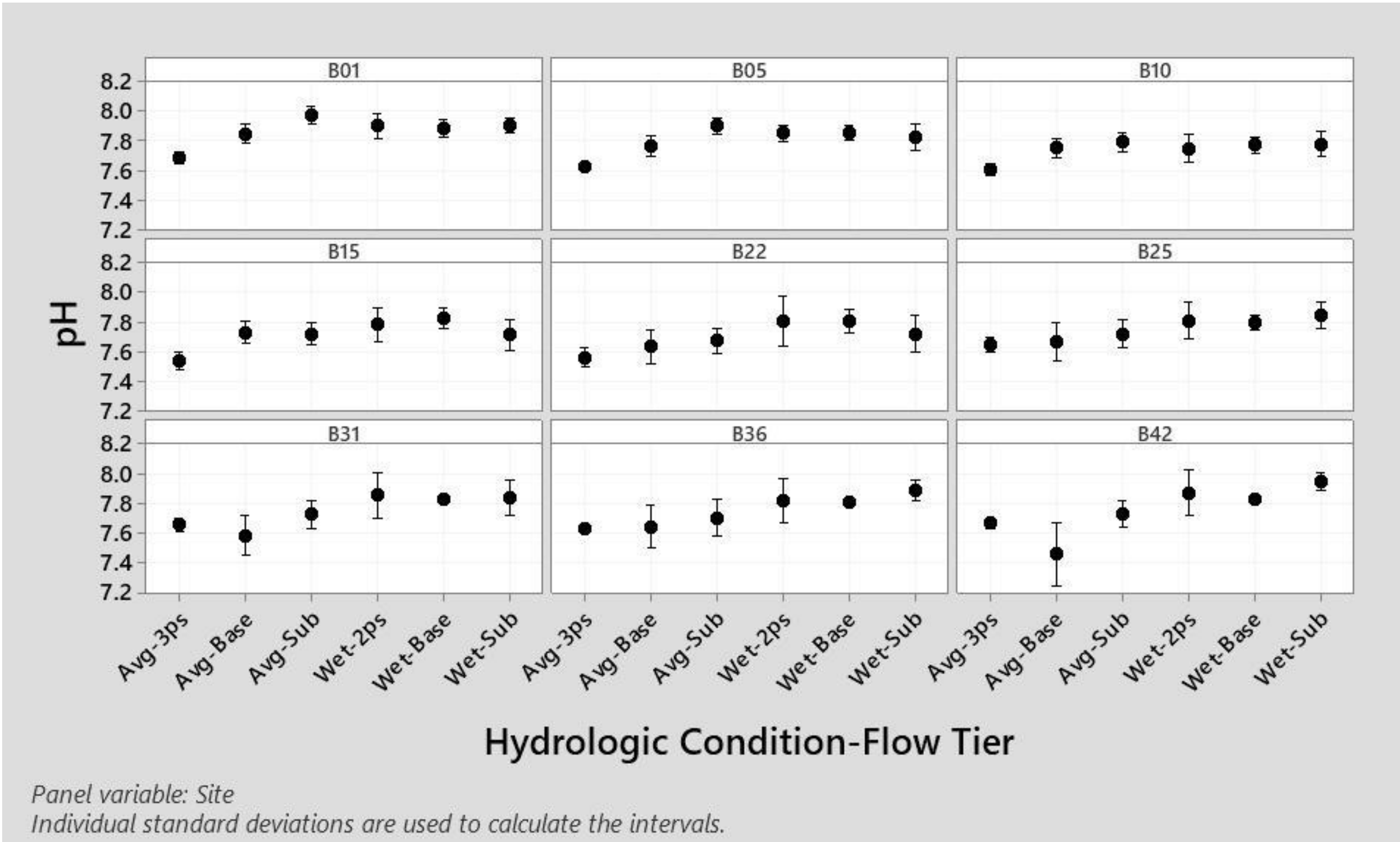


Figure 26. Confidence intervals (95%) plot of mean pH for each flow tier between sample sites. Results of two-way ANOVA Tukey pairwise comparisons listed in Table 65.

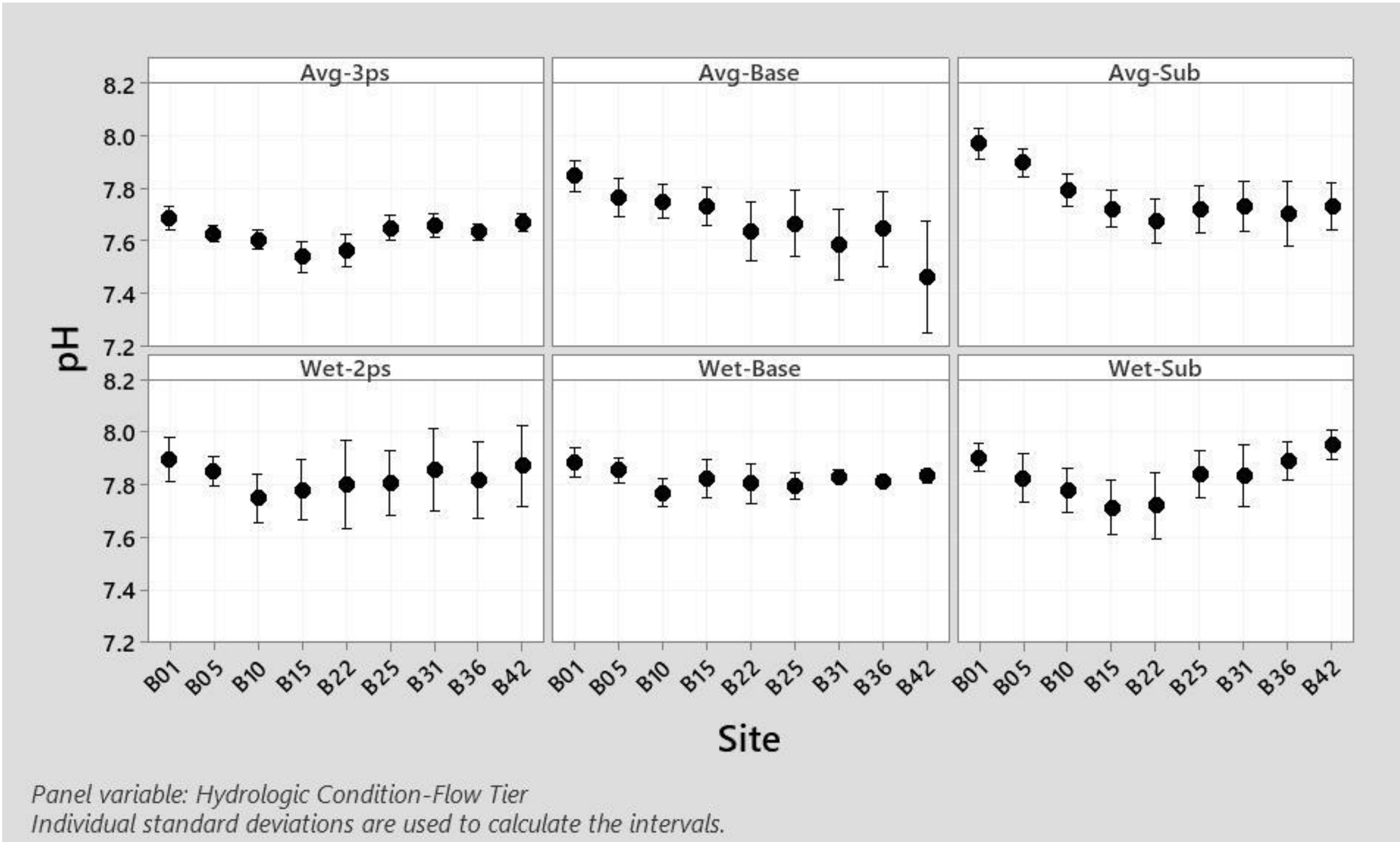


Figure 27. Confidence intervals (95%) plot of mean pH for each sample site between flow tiers. Results of two-way ANOVA Tukey pairwise comparisons listed in Table 66.

Principal Component Analysis

Principal Component Analysis (PCA) was run using PRIMER 7 in order to visualize patterns in water quality between seasons and flow tiers at both the surface and the bottom of the water column. For the bottom profile, principal component (PC) 1 accounted for 54.1% of the variation while PC2 accounted for 26.8%, equating to 81.4% total variation explained by PC1 and PC2. The coefficients of PC1 were a linear combination of -0.452 water temperature, -0.519 salinity, 0.613 dissolved oxygen (DO), and 0.387 daily average discharge. PC1 can be interpreted as an interaction effect between spatial differences and seasonal variation in water chemistry between the sample sites. The coefficients of PC2 were 0.641 water temperature, 0.361 salinity, -0.234 DO, and 0.635 daily average discharge. This could be interpreted as the combined effects of variation in season and increased flow tiers (Table 67; Figure 28).

The surface profile revealed less interaction between grouping variables when determining the source of variation in water quality. The coefficients of PC1 were a linear combination of 0.690 water temperature, 0.157 salinity, -0.706 DO, and -0.019 daily average discharge. PC1 in this case could be interpreted as primarily seasonal variation since temperature and DO are driving the variation. Conversely, daily average discharge and salinity dominated PC2 at 0.711 and -0.692 respectively while DO and temperature contributed very little at 0.069 and 0.106 respectively. This would indicate PC2 represents the impacts of increasing flow tiers, and the disparity in salinity between sample sites. PC1 explained 44.5% of the variation while PC2 explained 34.9%, making a cumulative total of 79.4% (Table 68; Figure 29). These results would also indicate that the perceived effects of seasonality, spatial differences and flow tier variation have more comparable effects at the surface than at the bottom. It also suggests that impact of river discharge on the variation in water quality is greater at the surface.

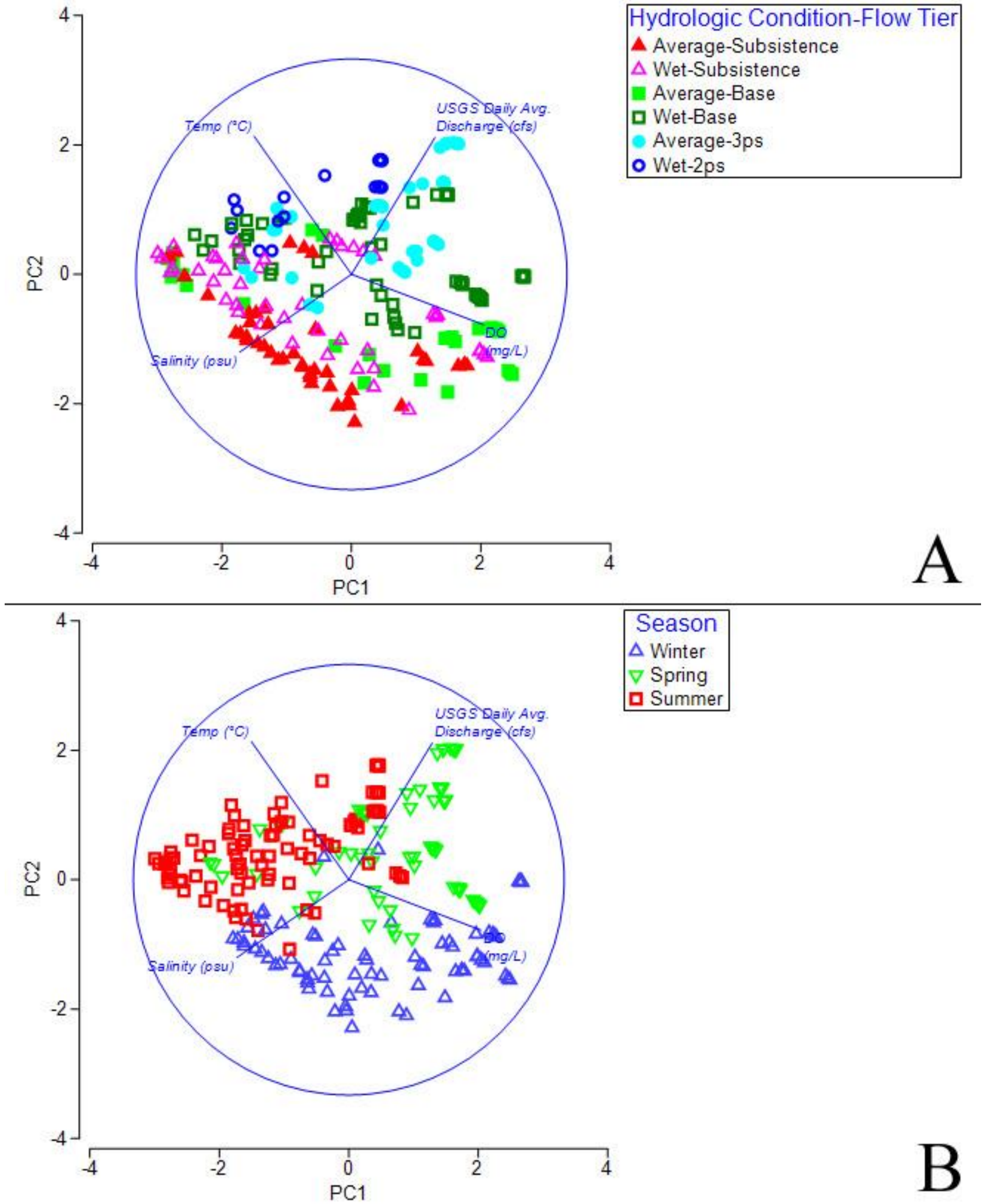


Figure 28. Principal component analysis (PCA) of normalized water quality profile samples taken at the bottom. Individual samples are grouped by flow tier (A) and season (B).

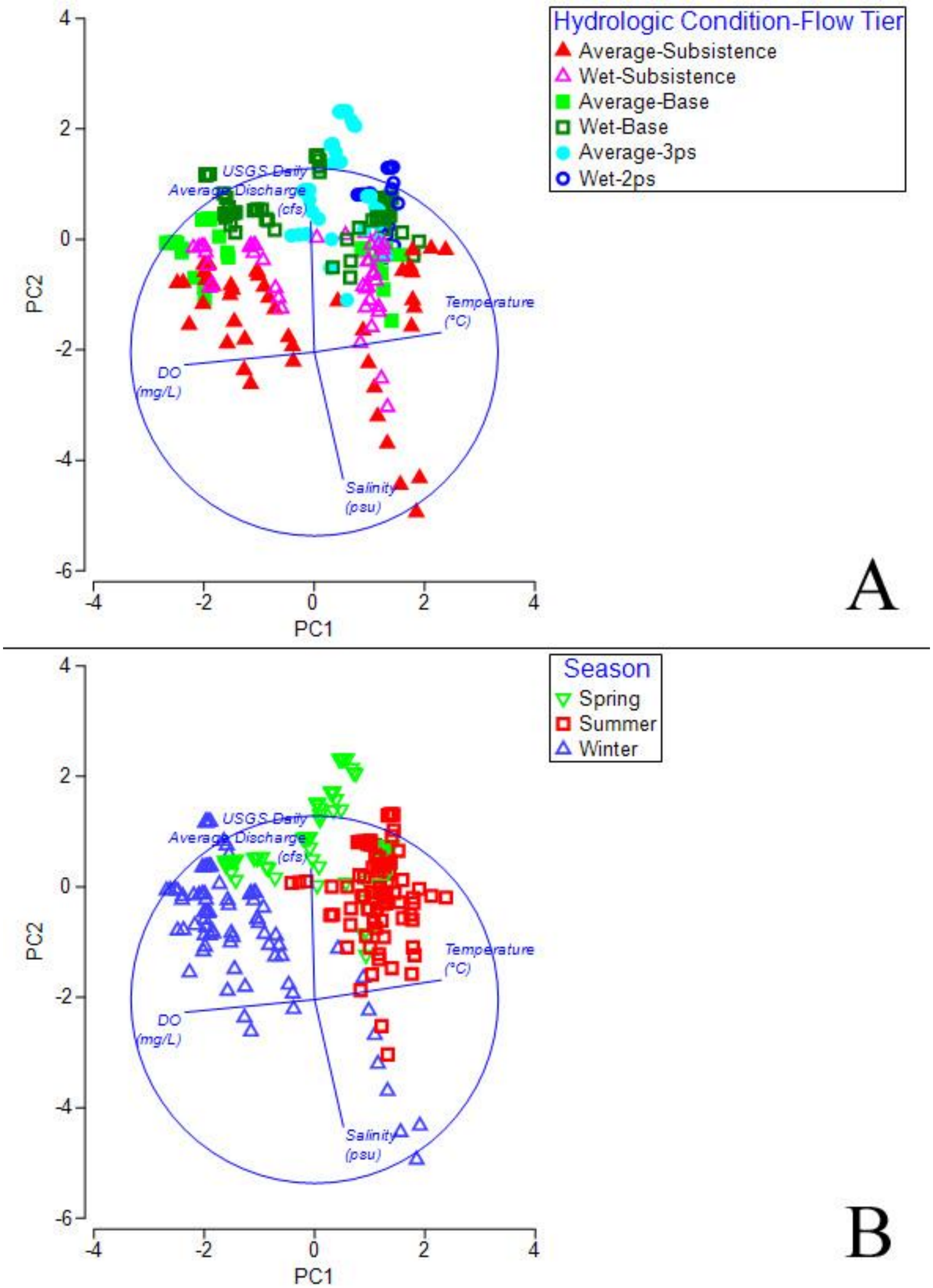


Figure 29. Principal component analysis (PCA) of normalized water quality profile samples taken at the surface. Individual samples are grouped by flow tier (A) and season (B).

The profile readings taken in the Gulf of Mexico (GOM) also revealed discernible patterns, although with fewer samples to use for the analysis, these results should be considered preliminary (Figure 30). For both surface and bottom profile readings, temperature and salinity were the dominant coefficients for PC1, while DO and total depth were the dominant coefficients in PC2. PC1 can be interpreted as the effects of seasonal variation, while PC2 can be interpreted as the spatial variation due to proximity to the river mouth. However, the percent variation explained by PC1 was 68.6% for the bottom profile while it was only 40.5% for the surface profile. PC2 saw less disparity between the two profiles; 30.2% variation explained in bottom water quality and 33.6% variation explained in surface water quality (Table 69; Table 70).

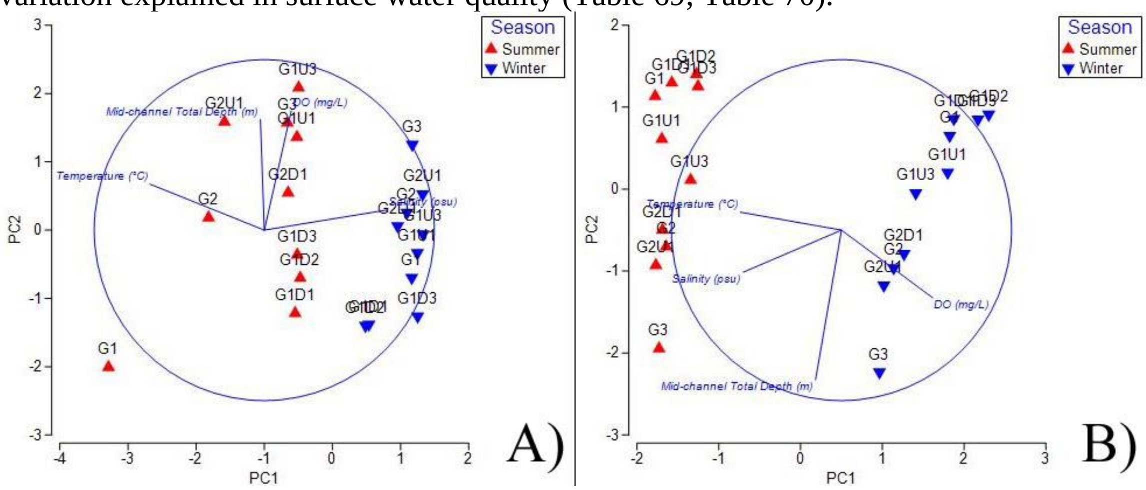


Figure 30. Principal component analysis (PCA) of normalized water quality profile samples taken from sample sites in the Gulf of Mexico (GOM) at the surface (A) and bottom (B).

Nekton Community

Community Metrics

Nekton replicates were compiled into collections so that only one value for each biological metric would be needed to represent the nekton community for the sample site and gear type for each sample date. This data would then later be used for testing relationships between biological data, water chemistry, and hydrology. A full summary table of the community metrics used in the subsequent analyses is found in Appendix G.

Total catch and catch per unit effort (CPUE) for each otter trawl collection could vary sporadically throughout the seasons and sites, but B10 and B01 would typically exhibit greater total catch and CPUE, with the maximum total catch and CPUE occurring on March 12th, 2019, at B10 with 2,827 individuals and 188.467 respectively (Table 34). A total of 123 otter trawl collections containing 37,909 individuals have been performed at the sample sites within the Brazos River since 2014, and only one yielded zero catch without being incomplete- B22 on September 27th, 2018 (Table 27; Table 34). Beam trawl collections totaled at 118 within the same time frame, but a total of 20 completed collections yielded zero catch and CPUE. Of those 20 collections, only the collection at B22 on December 20th, 2016, did not occur during the summer season. The maximum beam trawl yield occurred on January 7th, 2015, at B01 with a total catch of 1,368 individuals and a CPUE of 29.92126 (Table 33). The largest cumulative total catch values for the beam trawl were 4,285 individuals from 2014-2015 when grouped by study period, and 3,582 individuals at B01 when grouped by site. The lowest cumulative total catch values for the beam trawl method were 602 individuals for the current study, and 460 individuals at B31 (Table 25; Table 26). For the otter trawl collections, the largest cumulative catch occurred during the current study at 15,590 individuals when examining study periods and 14,523 individuals at B01 when comparing sites. The lowest cumulative catch yields occurred during 2014-2015 at 10,455 individuals and 506 individuals at B42 (Table 27; Table 28).

The taxa collected throughout the years has also been subject to large variations in number of taxa collected and species compositions. The lowest cumulative number of species collected for a given study was during the Emmitte (1983) study at 37 while the highest cumulative number of species collected was during the Miller (2014) study at 63. The most taxa collected cumulatively during the time frame of the data used for analysis was 61 from 2014-2015 while the lowest was 49 for the current study (Table 31). The greatest number of taxa tallied for any single collection was using the otter trawl at a total of 15. This occurred once during the winter on December 1st, 2016, and once during the summer on September 5th, 2019 (Table 34). Since the Johnson (1977) study, a total of 124 nekton taxa have had their presence in the Brazos estuary confirmed using the sampling gear and methods outlined in this study, with a total of 16 species being collected during every major study since then. However, four species of fish and one invertebrate were documented in the estuary only as recently as the current study using identical sampling methods. Red Shiner (*Cyprinella lutrensis*), Blacktail Shiner (*Cyprinella venusta*), and Ghost Shiner (*Notropis buchanani*) were confirmed with the beam trawl, while the Thinstripe Hermit Crab (*Clibanarius vittatus*) and Crested Cusk Eel (*Ophidion josephi*) were confirmed using the otter trawl. All the listed species were collected during the month of July apart from the Thinstripe Hermit Crab which was collected on March 12th, 2019 (Table 30).

Shannon-Wiener Diversity (*H´*), Shannon Evenness (*J´*), and Margalef Richness were all used as indices to measure diversity and homogeneity of species in the Brazos River. Shannon-Wiener diversity between sampling methods typically exhibited inverse relationships with each other regarding season and site, but patterns among flow tiers were less distinguishable. The maximum calculated (*H´*) values for both sample methods were recorded on the same date- December 11th, 2014, during an Avg-Sub flow tier- at B10 with a value of 2.098 for the otter trawl, and B31 with a value of 1.698 for the beam trawl. The maximum Margalef Richness Index calculated for the otter trawl was 2.97 and occurred on the same date and site as the maximum calculated (*H´*). The maximum

Margalef Richness index for beam trawl catch data of 2.485 occurred at a different sample site and date: May 24th, 2017, at B42 during a Wet-Sub flow tier (Table 33; Table 34). Shannon evenness (J') is measured on a scale of zero to one in order to determine how similar the abundances of each species collected are in each sample. The (J') for the beam trawl data ranged from zero to one at all sites, seasons and flow tiers except for B01 where the maximum evenness calculated was 0.968 and the Wet-Sub flow tier which was the only flow tier that reached the minimum value of zero. Evenness for otter trawl catch data ranged from zero to one during all seasons, but not for all flow tiers and sites. Only during the Avg-3ps and Wet-Base flow tiers was the range for evenness all-encompassing, but the Avg-Base flow tier did reach the maximum value of one. Evenness only reached its minimum value for the otter trawl samples at B22, B31 and B42. Of those three sites, only B31 did not reach the maximum value. Site B01 attained both the maximum and minimum Shannon evenness (Table 33; Table 34).

Correlation Analysis

After the nekton samples were mathematically classified using the various community metrics outlined above, the next step was to pair the nekton data with the concurrent water quality and hydrological data and calculate statistically significant linear correlations ($p \leq 0.05$) between the data. Pearson correlation analysis was performed in R in order to calculate correlations between all available data and plot them in a correlation matrix (Figure 31; Figure 32). Water quality data was separated by data taken from the bottom profile and the surface profile in order to quantify if existing correlations between biological and physiochemical data are more prominent in different regions of the water column.

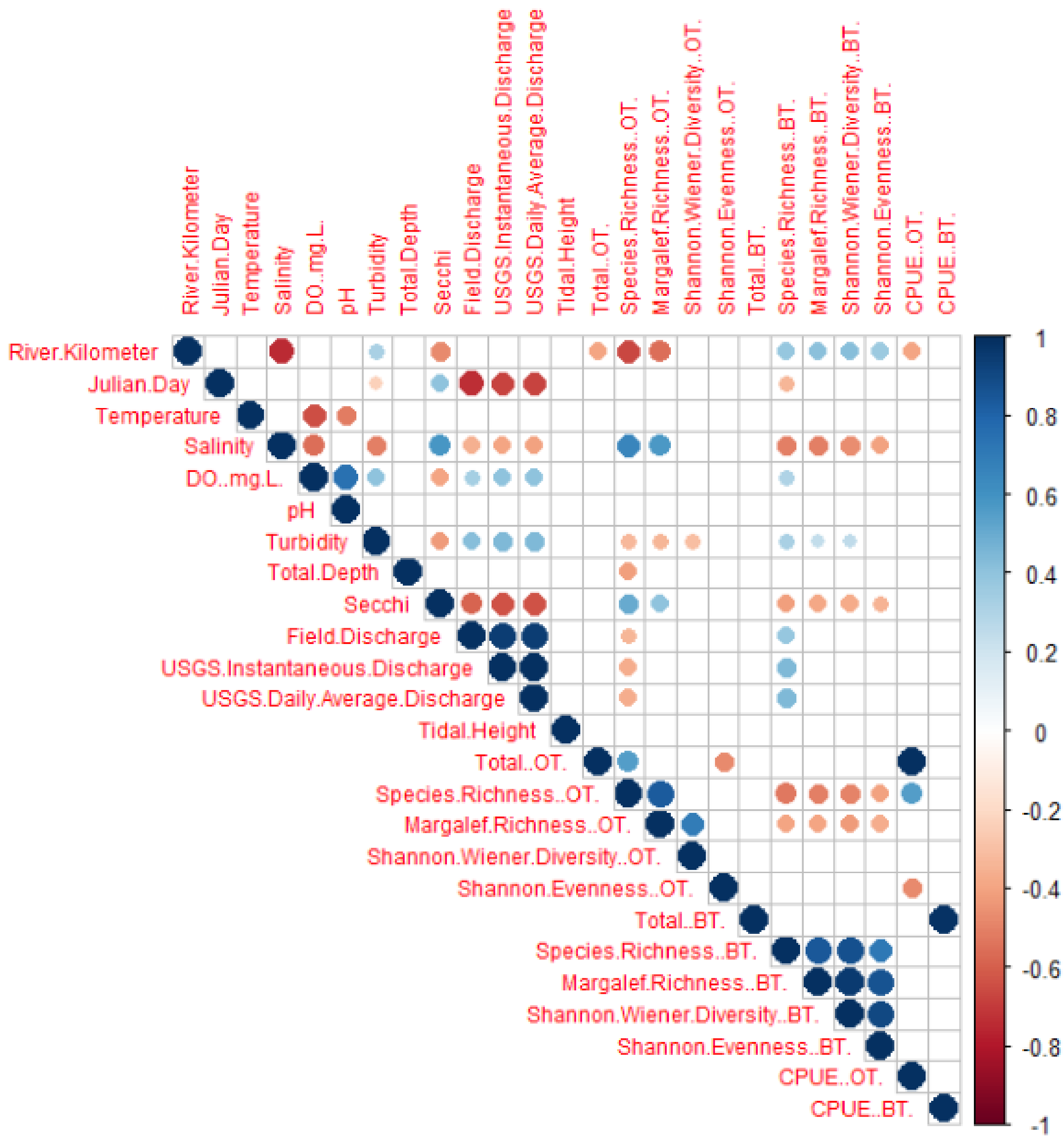


Figure 31. Pearson correlation matrix between hydrology and nekton community metrics with bottom profile water quality. Red circles represent negative correlations while positive correlations are colored blue. Strength of correlation is indicated by circle size and color saturation. Any blank square indicates an insignificant (p > 0.05) correlation between the two corresponding variables. (OT = otter trawl, BT = beam trawl).

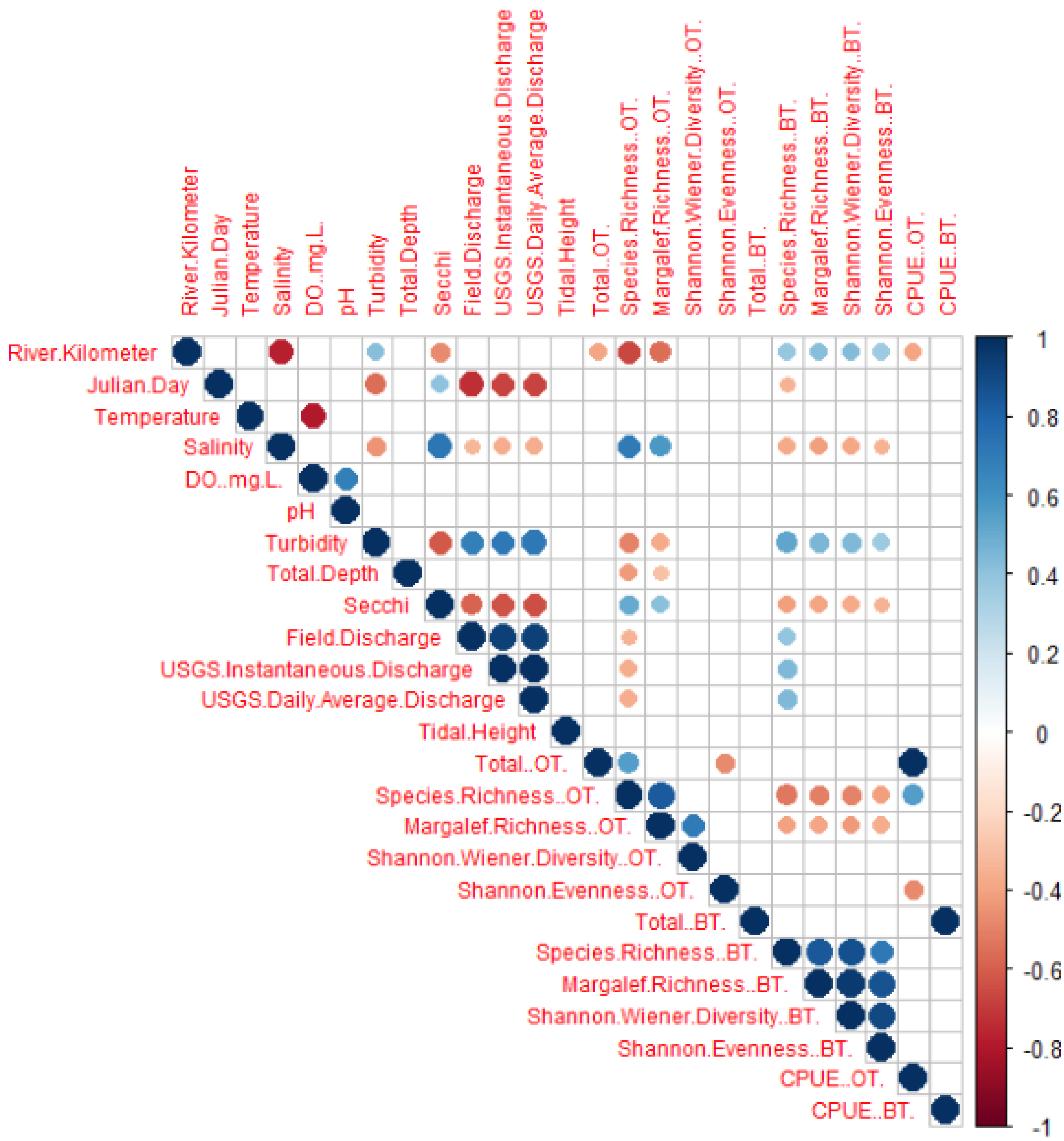


Figure 32. Pearson correlation matrix between hydrology and nekton community metrics with surface profile water quality. Red circles represent negative correlations while positive correlations are colored blue. Strength of correlation is indicated by circle size and color saturation. Any blank square indicates an insignificant (p > 0.05) correlation between the two corresponding variables. (OT = otter trawl, BT = beam trawl).

Variables that exhibited significant correlations with the at least one nekton community metric included river kilometer (distance from the mouth), Julian day, salinity (psu), DO (mg/L), turbidity (NTU), total depth (m), Secchi disk transparency (m) and river discharge (cfs). Otter trawl data negatively correlated with river kilometer included total catch, species richness, Margalef Richness and CPUE, with species richness exhibiting the strongest correlation of all the listed variables at both the bottom (r = -0.666) and the surface (r = -0.668). Beam trawl data was positively correlated with river kilometer, but total catch and CPUE did not exhibit significant correlations. The Shannon-Wiener diversity index exhibited the strongest correlation with river kilometer at the bottom (r = 0.426) and the surface (r = 0.430). Beam trawl species richness was negatively correlated with Julian day at the bottom (r = -0.338) and surface (r = -0.344) but exhibited a significant positive correlation with DO only at the bottom (r = 0.307). Salinity was most strongly correlated with biological data among all water quality and hydrological variables tested. Species richness and Margalef Richness for otter trawl catch exhibited significant positive correlations with salinity at the bottom (r = 0.656, and r = 0.573) and surface (r = 0.708, and r= 0.578). The beam trawl catch data demonstrated an inverse relationship with salinity; species richness, Margalef Richness, Shannon-Wiener Diversity, and Shannon evenness exhibited significant correlations with salinity at both the bottom and surface. Of the listed community metrics, species richness exhibited the strongest correlation with bottom salinity (r = -0.506) while Margalef Richness was most strongly correlated with surface salinity (r = -0.414).

Turbidity, Secchi disk transparency and river discharge all exhibited significant correlations with each other and the nekton community data for the otter trawl and beam trawl. Species richness, Margalef Richness, and Shannon-Wiener Diversity for otter trawl collections were significantly correlated with turbidity at the bottom (r = -0.327, r = -0.333, and r = -0.308). At the surface, only species richness and Margalef Richness were significantly correlated with turbidity at (r = -0.491) and (r = -0.374) respectively.

Species richness for beam trawl data exhibited the strongest positive correlation with turbidity at the bottom (r = 0.326) and surface (r = 0.529). Species Richness, Margalef Richness, and Shannon-Wiener Diversity were all significantly correlated with bottom and surface turbidity, while Shannon evenness was significantly correlated with only surface turbidity. The correlations observed between turbidity and nekton data were almost perfectly inverse that of the correlations observed with Secchi disk transparency. All the variables correlated to turbidity were correlated to Secchi disk transparency at the surface, with the species richness once again exhibiting the strongest correlation of all for the otter trawl (r = 0.508) and beam trawl (r = -0.416). Between all the nekton community metrics, only species richness was significantly correlated with river discharge. Species richness for otter trawl collections was negatively correlated with all discharge metrics while beam trawl species richness was positively correlated. Of the three flow measurements- field, instantaneous, and daily average- used to test for correlations, daily average discharge from the USGS gage near Rosharon yielded the strongest correlations for otter trawl (r = -0.370) and beam trawl data (r = 0.445). Total depth was the final water quality variable significantly correlated with nekton community data, but only with otter trawl species richness (r = -0.422) (Table 71; Table 72; Table 73; Table 74).

Community Similarity

The SIMPER test was used in PRIMER 7 in order to calculate similarity between nekton communities between sites, seasons, and flow tiers for each sampling method. Site B01 exhibited the highest average similarity among the otter trawl collections within the river at 45.36%. The dominant species included Atlantic Croaker (*Micropogonias undulatus*), Star Drum (*Stellifer lanceolatus*), White Shrimp (*Litopenaeus setiferus*), and Blue Crab (*Callinectes sapidus*) (Table 75). The average percent similarity between beam trawl collections at B01 was 11.25%, with only two primary contributors: Atlantic Croaker and Gulf Menhaden (*Brevoortia patronus*) (Table 76). The site with the greatest average similarity between beam trawl collections was B42 at 19.57%, but for otter trawl collections the average percent similarity of B42 collections was nearly double at 35.08%. The species contributing to the average similarity included Ohio River Shrimp (*Macrobrachium ohione*) for both gear types, Blue Catfish (*Ictalurus furcatus*) for the otter trawl, and Daggerblade Grass Shrimp (*Palaemonetes pugio*) for the beam trawl (Table 75; Table 76). The similarity in nekton communities for otter trawl collections were fairly streamlined in how the species compositions changed. B01 and B10 had the same species contributing to average percent similarity with the only exception being the fourth species; Blue Crab contributed to B01, but for B10 it was Bay Anchovy (*Anchoa mitchilli*). The transition to B22 saw a decrease in the number of contributor species to three, with Blue Catfish contributing the most (39.99%), followed closely by Atlantic Croaker and White Shrimp. Finally, the transition to primarily freshwater species was cemented at B31 as the contributing species dropped to two and were identical for B31 and B42 (Table 75).

For the beam trawl communities, the changes in contributor species were more sporadic, as evidenced by the low percent similarities between collections. From B01 to B10, White Shrimp was included in the cumulative percent similarity, but was then replaced as the primary invertebrate with Blue Crab and Daggerblade Grass Shrimp. B31 did not include Atlantic Croaker in contribution to average similarity, and B31 exhibited the lowest average percent similarity between collections at 8.58%. B42 did not have any fish species contributing to average similarity between beam trawl collections (Table 76).

Season was the second grouping variable among nekton collections subjected to SIMPER analysis. However, collections from B42 were excluded for the SIMPER analysis between seasons since this site was not sampled during the current study, and therefore represents incomplete spatial data for each season. Otter trawl collections for each season included Atlantic Croaker and Blue Catfish as major contributors to sample similarity. Additional contributor species during the spring season included Blue Crab and Ohio River Shrimp. During the winter season, White Shrimp and Bay Anchovy preceded Blue Catfish in contributing the greatest percent similarity between collections. For the summer season there were a total of five species contributing to average percent similarity: White Shrimp, Atlantic Croaker, Star Drum, Sand Seatrout (*Cynoscion arenarius*), and Blue Catfish. The summer season exhibited the greatest average percent similarity between otter trawl collections at 32.06%, while the seasons of spring and winter exhibited the greatest average percent dissimilarity to each other (79.12%) (Table 77).

Conversely, the beam trawl collections during the summer season exhibited the lowest percent similarity (1.56%) while the winter season presented the greatest average percent similarity (20.63%). Despite these disparities in similarity between collections, it was the pairing of spring and summer that had the greatest average dissimilarity (97.05%). The species comprising the greatest cumulative percent similarity for the winter season included Atlantic Croaker, White Shrimp, and Darter Goby (*Ctenogobius boleosoma*). During the spring season, the contributor species consisted of Gulf Menhaden, Daggerblade Grass Shrimp, Bay Anchovy and Atlantic Croaker. Bay Anchovy was the greatest contributor species during the summer season, followed by Blue Crab, Darter Goby, and the Skimmer Dragonfly nymph (*Libellulidae spp.*) (Table 78).

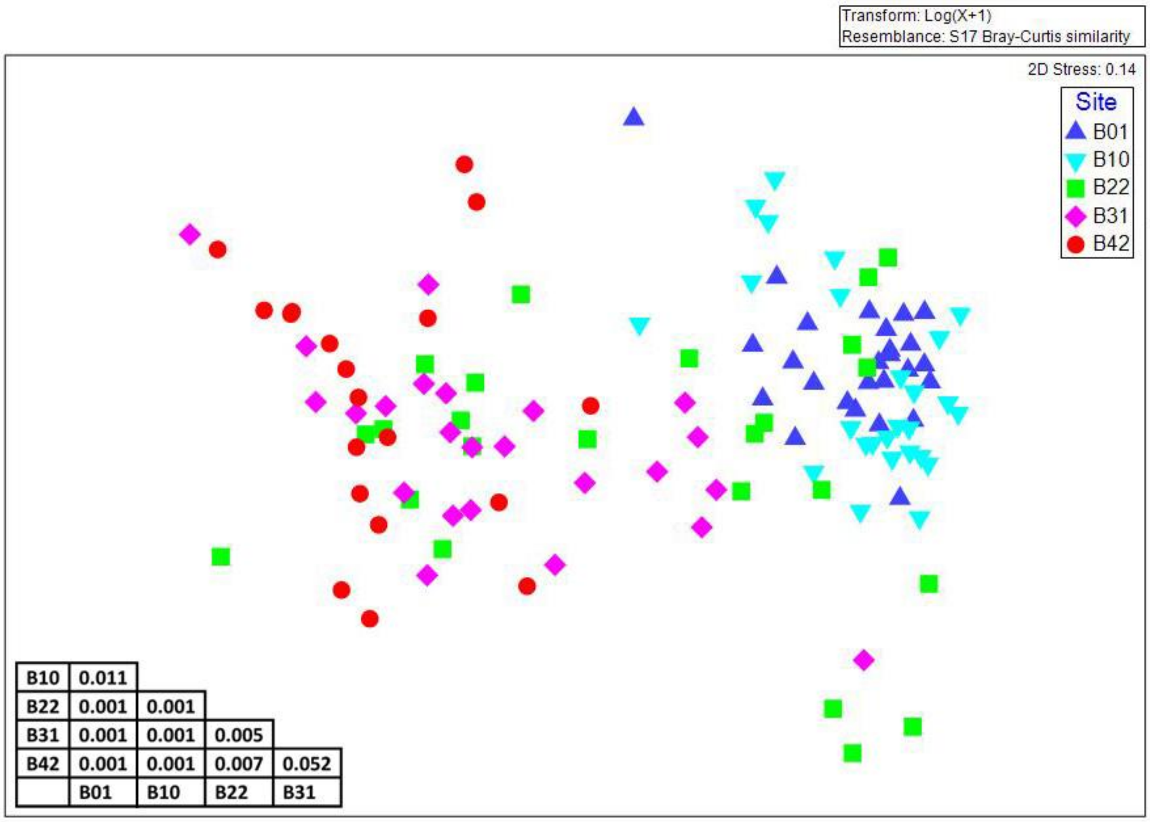
Each of the six flow tier classifications that the river experienced since 2014 were also subjected to SIMPER analysis to discern if any patterns in community similarity could be observed when grouped by flow tier. Like the seasonal analysis, B42 collections were excluded from SIMPER analysis between flow tiers so as not to give equal weighting to site collections that lack representatives from the current study. Atlantic Croaker was calculated to be a major contributor to percent similarity between otter trawl collections of all flow tier categories. Avg-Sub and Wet-Sub each shared three species contributing to average percent similarity: Atlantic Croaker, White Shrimp, and Bay Anchovy: However, the final contributor species for Avg-Sub conditions was Spot (*Leiostomus xanthurus*), while for Wet-Sub it was Star Drum and Sand Seatrout. The percent similarity between collections for the Avg-Sub flow tier was also the highest among all the flow tiers at 33.42%. The base flows also shared most of the species contributing to average percent similarity: Atlantic Croaker, Blue Catfish, and Blue Crab. For Avg-Base the species list also included White Shrimp, while for Wet-Base there were two additional species contributing to sample similarity: Star Drum and Ohio River Shrimp. During the pulse flows, the three fish species comprising the sample similarities included Atlantic Croaker, Star Drum, and Blue Catfish, but Avg-3ps also included Ohio River Shrimp while the Wet-2ps flow tier include White Shrimp (Table 79).

The nekton communities sampled with the beam trawl exhibited far greater average percent dissimilarity between flow tiers and average similarity between collections within a single flow tier than what was calculated for the otter trawl data. Collections during Avg-Sub and Wet-Sub flow tiers were composed of similar contributing species, though Wet-Sub exhibited the lowest average similarity percentage (5.24%) while Avg-Sub was the second highest (16.36%). Primary contributors for both flow tiers included White Shrimp and Atlantic Croaker, though Avg-Sub also included Blue Crab. Avg-Base and Avg-3ps exhibited the lowest average percent dissimilarity from one another at 84.45%. The species contributing to the percent similarity between collections included Atlantic Croaker, Darter Goby, and Gulf Menhaden for both flow tiers, with the addition of Daggerblade Grass Shrimp for Avg-3ps. The communities sampled under Wet-Base conditions were most similar to the pulse flows, with Striped Mullet (*Mugil cephalus*), Daggerblade Grass Shrimp, Gulf Menhaden, and Bay Anchovy comprising the greatest cumulative percent similarity between collections (Table 80).

Multivariate Analysis

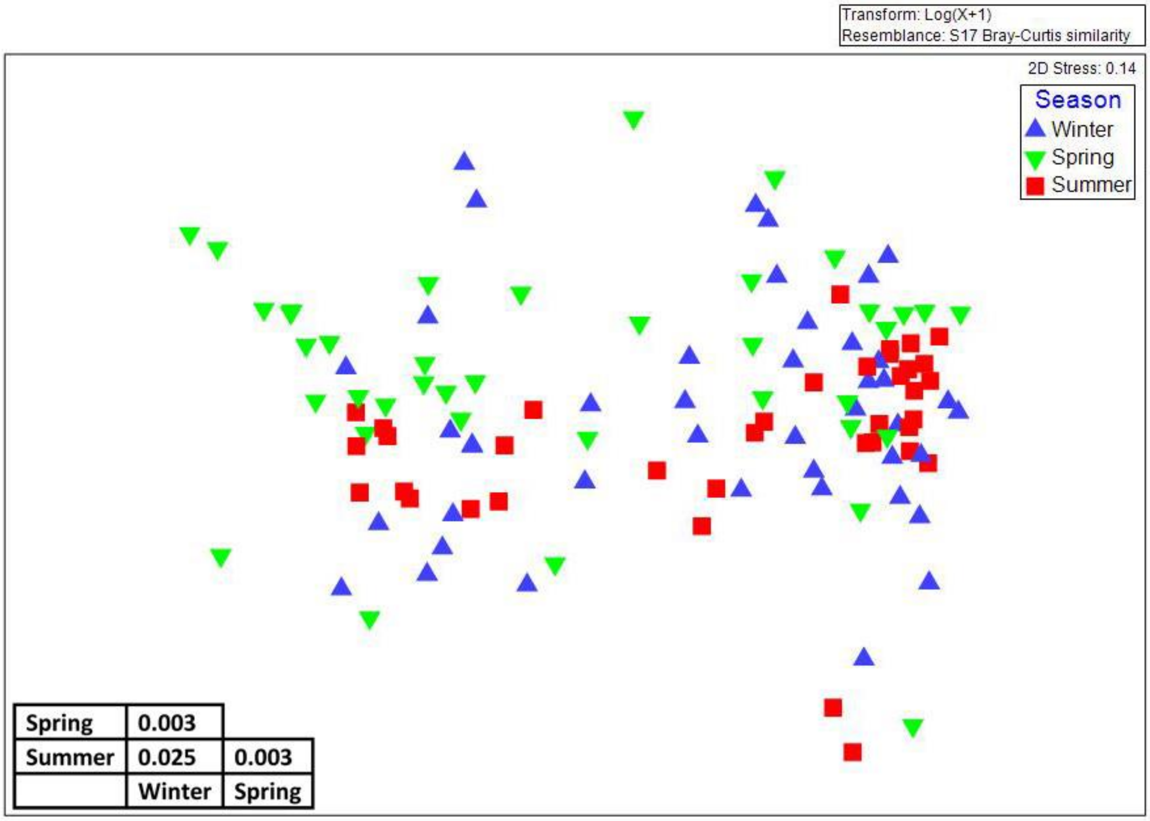
In order to better examine and portray the similarities between nekton abundances from otter trawl collections, Nonmetric Multidimensional Scaling (nMDS) analysis was conducted in order to plot each collection in two-dimensional space and observe relationship trends between collections based on site, season, and flow tier. Three collections were excluded from the analysis due to zero catch and/or failure to complete all three replicates within the collection: B22 on September 27th, 2018, B22 on October 17th, 2019, and B31 on October 17th, 2019 (Table 34). An Analysis of Similarities (ANOSIM) test was also performed to provide statistical transparency of observed patterns and determine if similarity between groups was greater than or equal to similarity within groups (Clarke and Gorley 2015).

When categorizing total catch from otter trawl collections by site, there was a visible a gradient between the downstream sites, and the upstream sites, with B22 acting as a median. However, the results of the ANOSIM test revealed the only sites with collections having greater similarity to each other than within their own site were B31 and B42 ($p > 0.05$) (Figure 33). Every other pairwise comparison between site collections was significantly different, but the rho (R) values of each comparison revealed that average dissimilarity between collections decreased as distance (km) between sites decreased (Table 81). Collections between seasons were all significantly different from one another, with the collections between spring and summer exhibiting the greatest (R) value of 0.114, and therefore the greatest dissimilarity (Table 82). The patterns of dissimilarity were more difficult to discern by the nMDS plot alone, but the results of the ANOSIM revealed the significant differences (Figure 34). The Avg-Sub flow tier was significantly different from Avg-Base, Avg-3ps and Wet-Base (Figure 35). The Wet-Sub flow tier was also significantly different from Avg-3ps and Wet-Base ($p \leq 0.05$), and the (R) value was highest between Wet-Sub and Wet-Base (0.035) (Table 83).



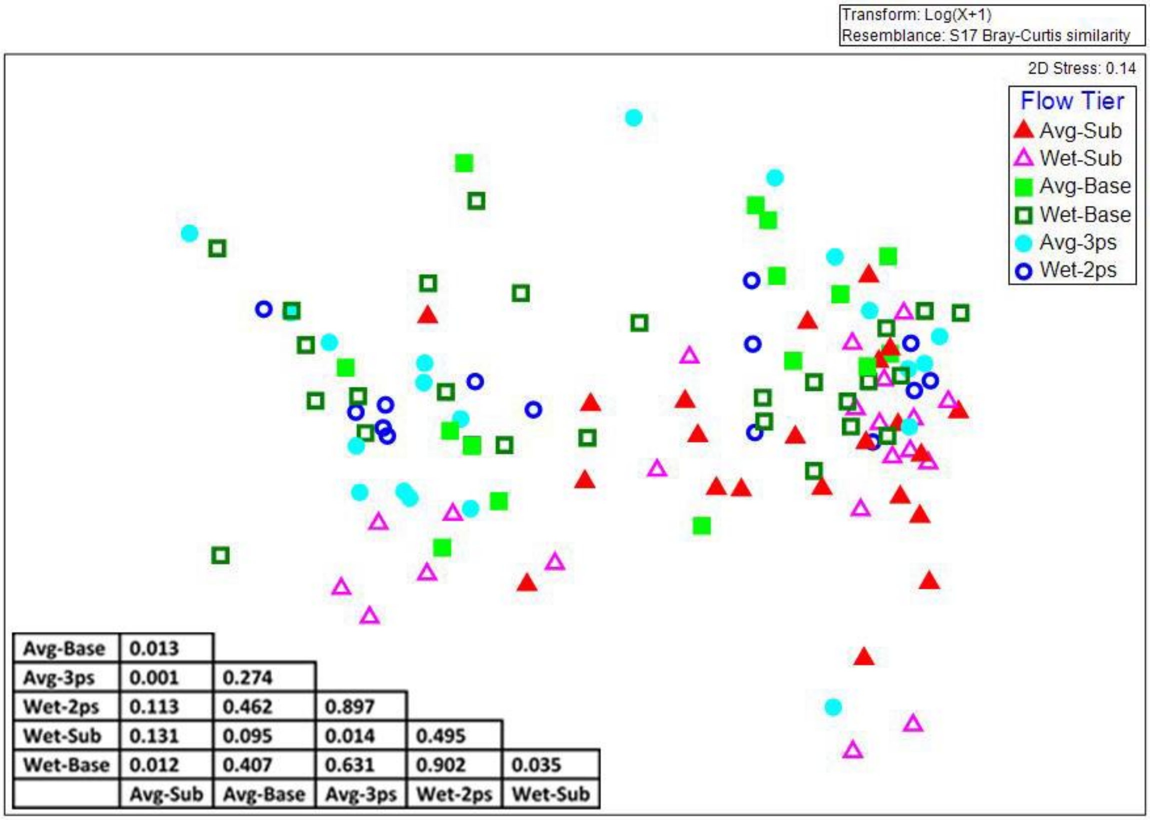
B10	0.011			
B22	0.001	0.001		
B31	0.001	0.001	0.005	
B42	0.001	0.001	0.007	0.052
	B01	B10	B22	B31

Figure 33. Non-metric MDS ordination plot of ranked similarity of nekton community total catch between 120 otter trawl collections by site. The p-value results from the Analysis of Similarities (ANOSIM) test are listed in the table in the lower left corner.



Spring	0.003	
Summer	0.025	0.003
	Winter	Spring

Figure 34. Non-metric MDS ordination plot of ranked similarity of nekton community total catch between 120 otter trawl collections by season. The p-value results from the Analysis of Similarities (ANOSIM) test are listed in the table in the lower left corner.



Avg-Base	0.013				
Avg-3ps	0.001	0.274			
Wet-2ps	0.113	0.462	0.897		
Wet-Sub	0.131	0.095	0.014	0.495	
Wet-Base	0.012	0.407	0.631	0.902	0.035
	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub

Figure 35. Non-metric MDS ordination plot of ranked similarity of nekton community total catch between 120 otter trawl collections by flow tier. The p-value results from the Analysis of Similarities (ANOSIM) test are listed in the table in the lower left corner.

The ANOSIM results for the beam trawl collections revealed similar patterns to what was observed for the otter trawl collections. B01 collections were significantly different and dissimilar from collections at all other sites except B10 ($R = -0.02$, $p = 0.814$). Collections from B10 were calculated to be distinct only from B42 ($R = 0.16$, $p = 0.003$). In addition to being significantly different from B01, beam trawl collections at B22 were significantly different from B42 collections ($R = 0.156$, $p = 0.003$). Collections from B42 proved to be significantly different from all sites except B31 (Table 84). When significant differences between seasons were analyzed for beam trawl collections, all seasons were determined to be significantly different from one another, but unlike the otter trawl collections, winter and summer exhibited the greatest average dissimilarity (R = 0.321) (Table 85). The results of the ANOSIM test comparing beam trawl collections between flow tiers showed that Avg-Sub conditions were significantly different from all other flow tiers, with the greatest average dissimilarity between Wet-2ps conditions (R = 0.378). Other pairwise comparisons that proved to be significantly different included Avg-3ps and Wet-Sub, as well as the comparison between Avg-Base and Wet-2ps (Table 86).

The final form of multivariate analysis was Cluster analysis in PRIMER 7 in order to determine significant groupings between otter trawl collections from the GOM. The first significant cluster to be identified was a combination of the G1 and G1U1 collections from the summer with a percent similarity of 77.18%. The next cluster to be identified was that of G1 and G2 during the winter with a percent similarity of 76.61%. This cluster was then subsequently grouped with the collection from G1U1 during winter to form yet another cluster with an average similarity of 71.37%. The final cluster composed of individual collections included G2 and G1D1 with an average similarity of 46.59% (Table 87).

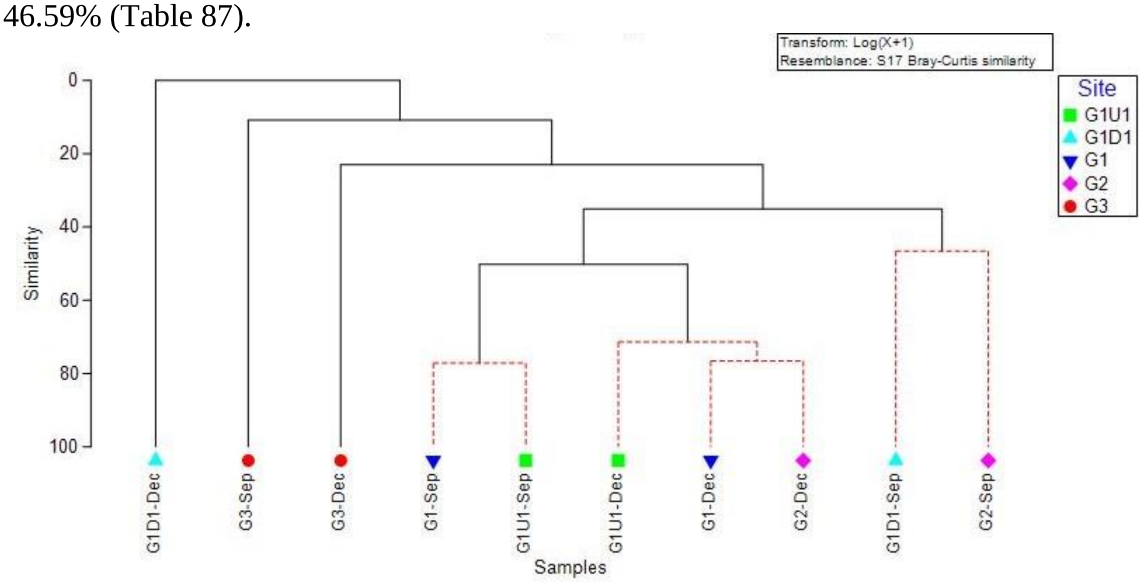


Figure 36. Dendrogram of GOM otter trawl collections describing percent similarity between nekton abundances at different sites using cluster analysis.

Variation in Nekton Diversity

The final stage of data analysis for the nekton collections was the usage of the nonparametric Kruskal-Wallis test and Dunn's multiple comparisons in order to determine how the different measures of nekton community diversity vary spatially, seasonally, and by flow tier. Collections from all sample sites were used in order to quantify significant differences between the medians of the various community metrics when grouped by site. However, because B42 was not sampled during the current study, community metrics from this site were excluded when examining variation between seasons and flow tier in order to ensure equal distribution of data between these groups. In addition, the family (α) for the Kruskal-Wallis test was adjusted according to what grouping variable was being tested so that the Bonferroni-adjusted (α) for each individual comparison would always be identical and yield 95.009% confidence intervals of the medians.

Total catch did not exhibit any significant differences among beam trawl collections when comparing sites ($p > 0.0556$) or flow tiers ($p > 0.0834$) (Table 88; Table 90). However, there were significant differences detected between the seasons; summer was significantly different from both winter and spring ($p \leq 0.0167$) (Figure 37). When total catch between otter trawl collections was subjected to the same analysis, no significant differences between seasons were detected ($p > 0.0167$) (Table 92). When examining spatial variation of total catch, B42 was determined to be significantly different from all other sites, and there was also a significant difference between B01 and B22 (Figure 38). Median total catch between flow tiers did exhibit significant differences; total catch during Avg-3ps conditions was significantly different from that of Wet-Sub and Avg-Sub (Figure 39).

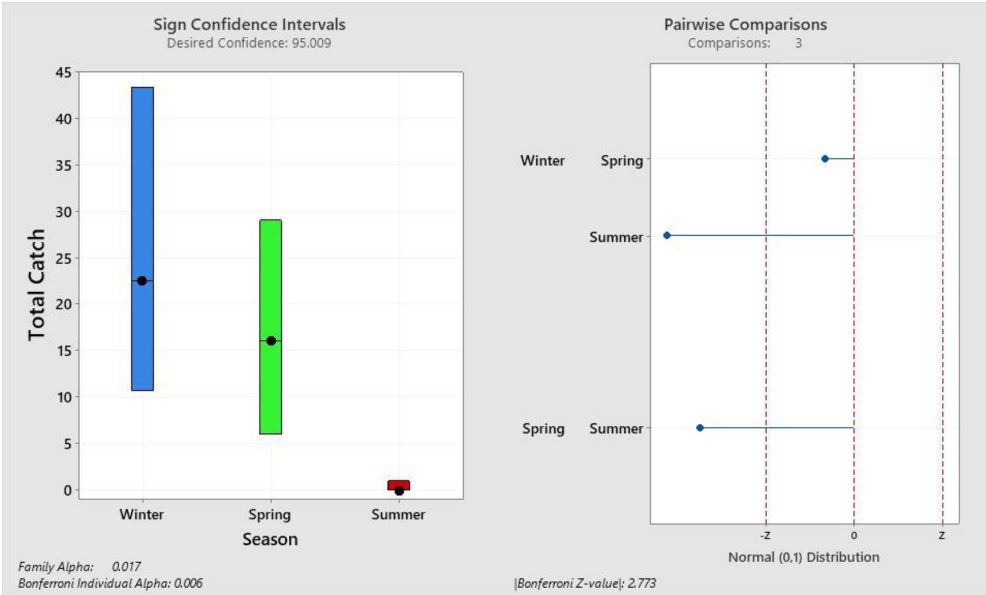


Figure 37. Dunn's multiple comparison test for significant differences in beam trawl total catch between seasons. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons ($p \leq 0.006$).

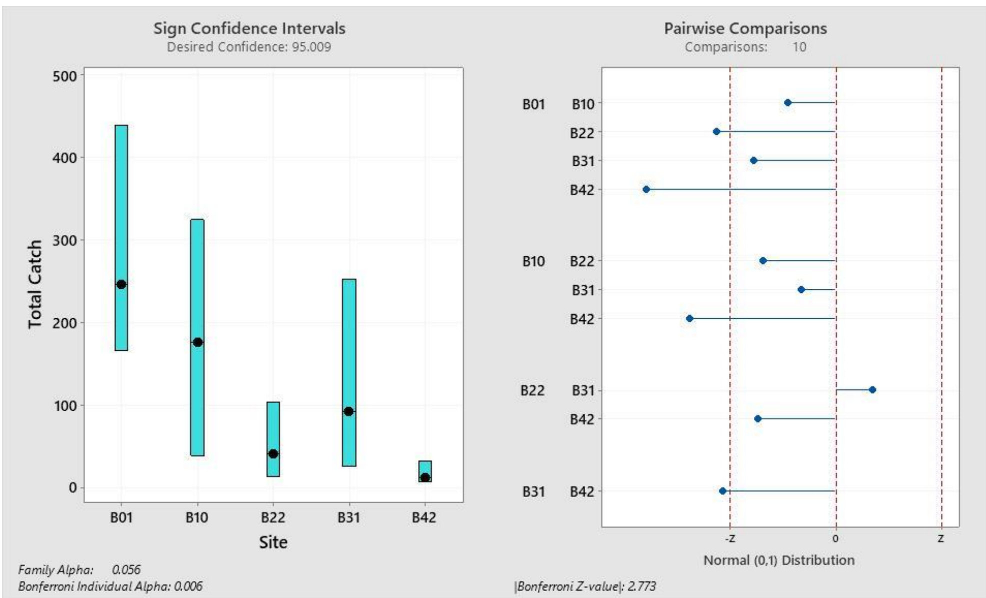


Figure 38. Dunn's multiple comparison test for significant differences in otter trawl total catch between sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites ($p \leq 0.006$).

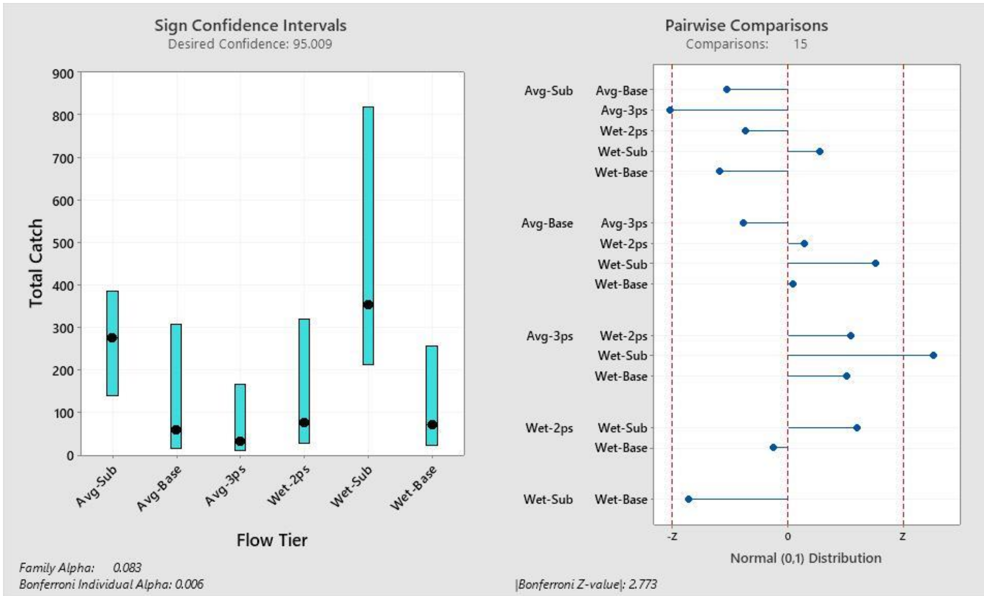


Figure 39. Dunn's multiple comparison test for significant differences in otter trawl total catch between flow tiers. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between flow tiers ($p \leq 0.006$).

Median species richness was significantly different between season ($p \leq 0.0167$) and flow tiers ($p \leq 0.0834$) for beam trawl collections. Between flow tiers however, the only pairing determined to be significantly different was Avg-3ps and Wet-Sub ($p = 0.0017$) (Table 96; Figure 67). Species richness during the summer was significantly lower than during the winter ($p < 0.001$) or spring ($p < 0.001$) (Figure 40). Species richness for otter trawl collections did not exhibit significant differences in medians between seasons, but significant differences between sites ($p < 0.001$) and flow tiers ($p = 0.001$) were detected (Table 97; Table 98; Table 99). Site B01 exhibited significant differences in median species richness between all sites except B10 ($p = 0.312$). B10 had identical statistical comparisons between sites as B01 (Figure 41). Significantly different pairings between flow tiers for otter trawl collections included Wet-Base to Avg-Sub, Avg-Sub to Avg-3ps, and Avg-3ps to Wet-Sub (Figure 42).

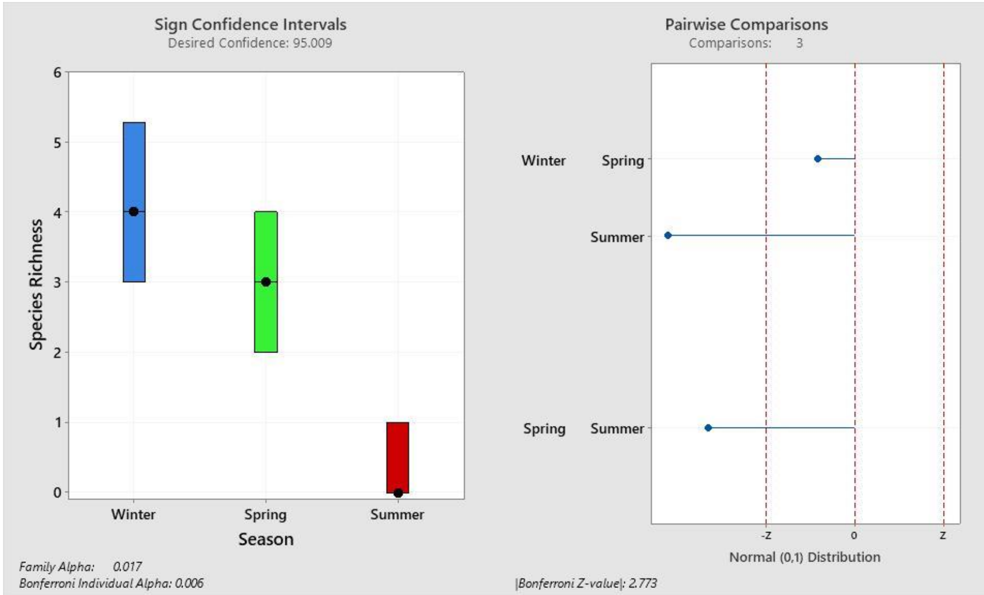


Figure 40. Dunn's multiple comparison test for significant differences in beam trawl species richness between seasons. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons (p≤0.006).

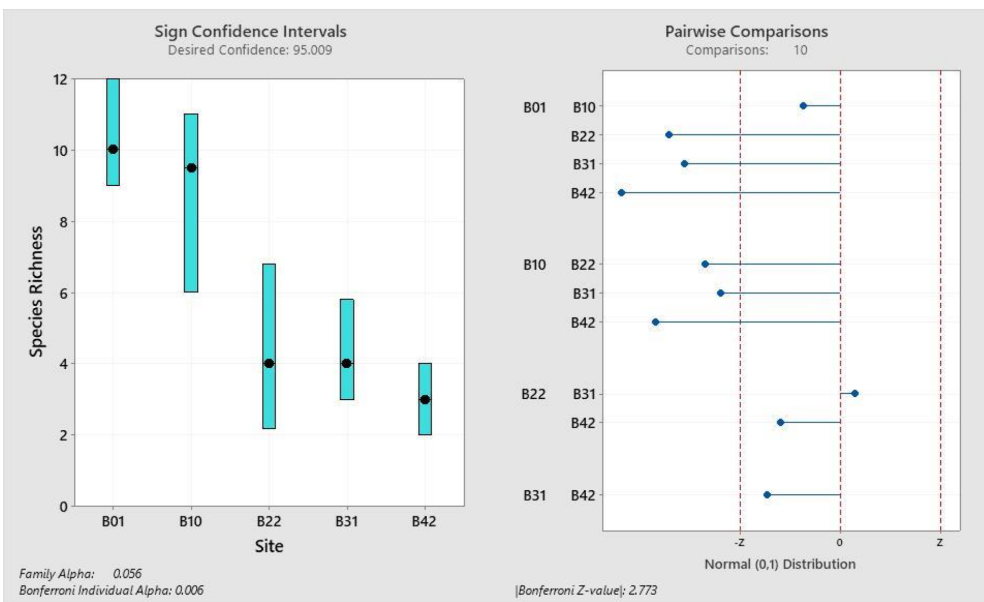


Figure 41. Dunn's multiple comparison test for significant differences in otter trawl species richness between sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites (p≤0.006).

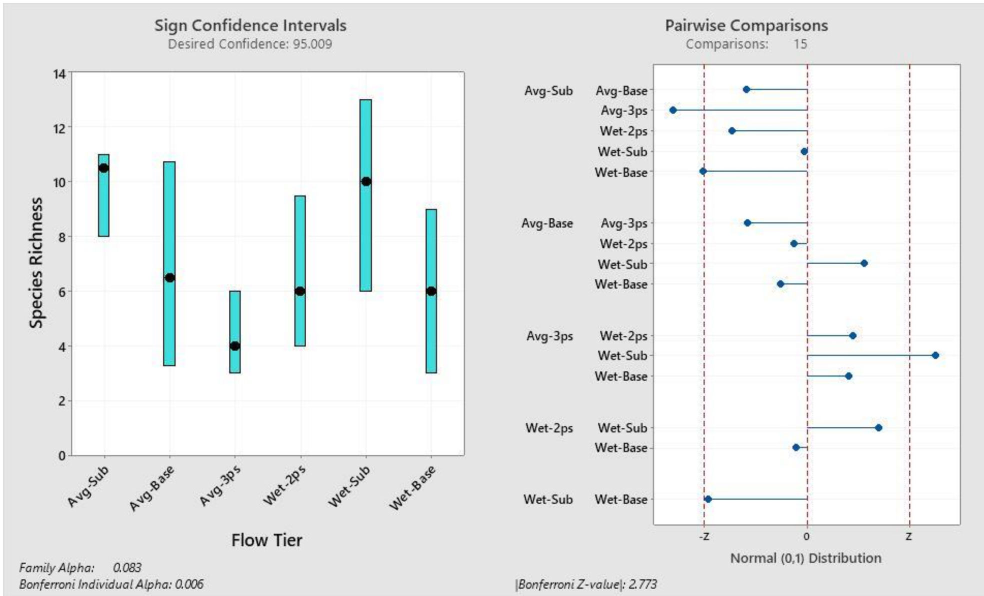


Figure 42. Dunn's multiple comparison test for significant differences in otter trawl species richness between flow tiers. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between flow tiers ($p \leq 0.006$).

Among the two sampling methods, Shannon-Wiener diversity indices exhibited very few significant differences between grouping variables. Both gear types were subject to significant differences between sites, although the only statistically significant comparison for the beam trawl collections was that of B01 and B42 ($p < 0.001$) (Table 100; Figure 68). Among the otter trawl collections, only B10 was significantly different from more than one site- B22, B31, and B42 (Figure 43). The median Shannon-Wiener diversity index for the summer season of beam trawl collections was significantly different from both the winter and spring season (Figure 44). No significant differences between seasons were detected for the otter trawl collections ($p > 0.017$), and no significant differences were detected between flow tiers for either sampling method ($p > 0.0834$) (Table 102; Table 105).

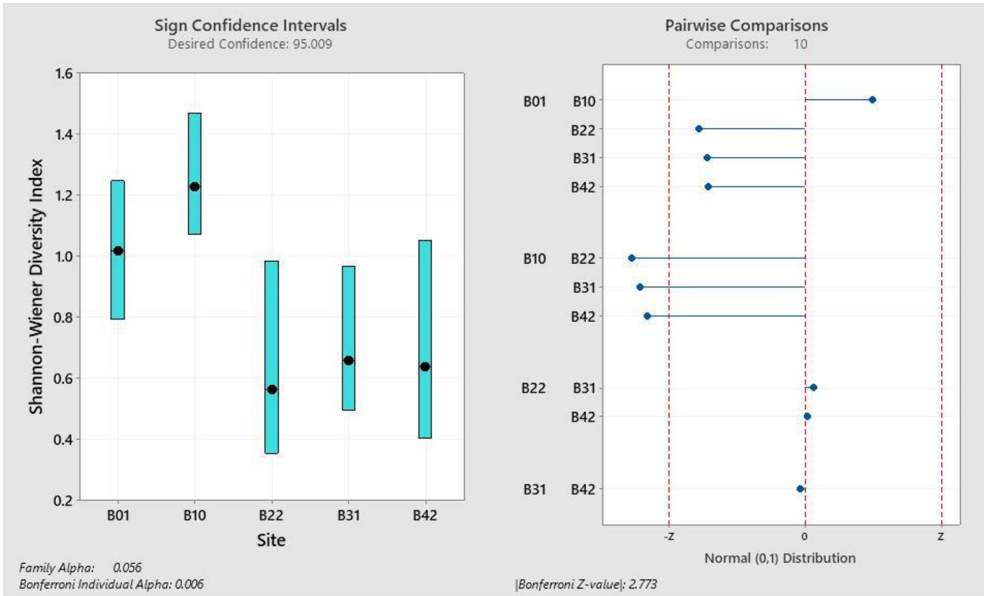


Figure 43. Dunn's multiple comparison test for significant differences in otter trawl Shannon-Wiener indices between sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites (p≤0.006).

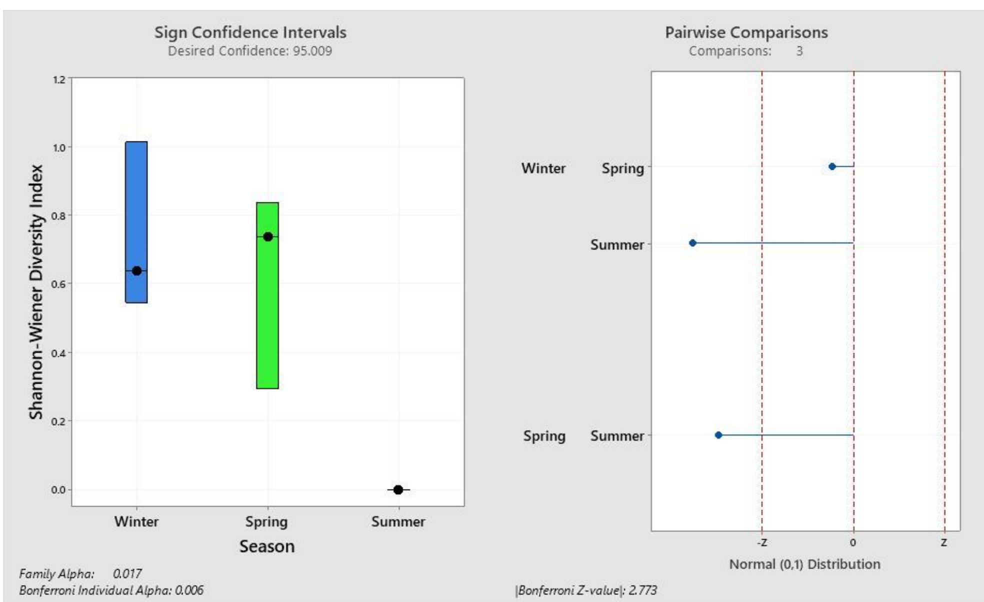


Figure 44. Dunn's multiple comparison test for significant differences in beam trawl Shannon-Wiener indices between seasons. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons (p≤0.006).

Shannon evenness was the only nekton community metric which did not yield any significant differences in otter trawl collections when grouped by site, season, or flow tier (Table 109;Table 110; Table 111). Shannon evenness between beam trawl collections at B01 and B42 was significantly different (p = 0.0006), though this was the only statistically significant comparison among the ten possible (Table 109; Figure 69). Grouping by season also generated significant differences between beam trawl collections. Like previous tests between seasons of beam trawl data, the spring and winter season were not significantly different from each other, but both were significantly different from the summer season (Figure 45). Grouping Shannon evenness by flow tier did not yield a significant result (p = 0.793) for the Kruskal-Wallis test (Table 111).

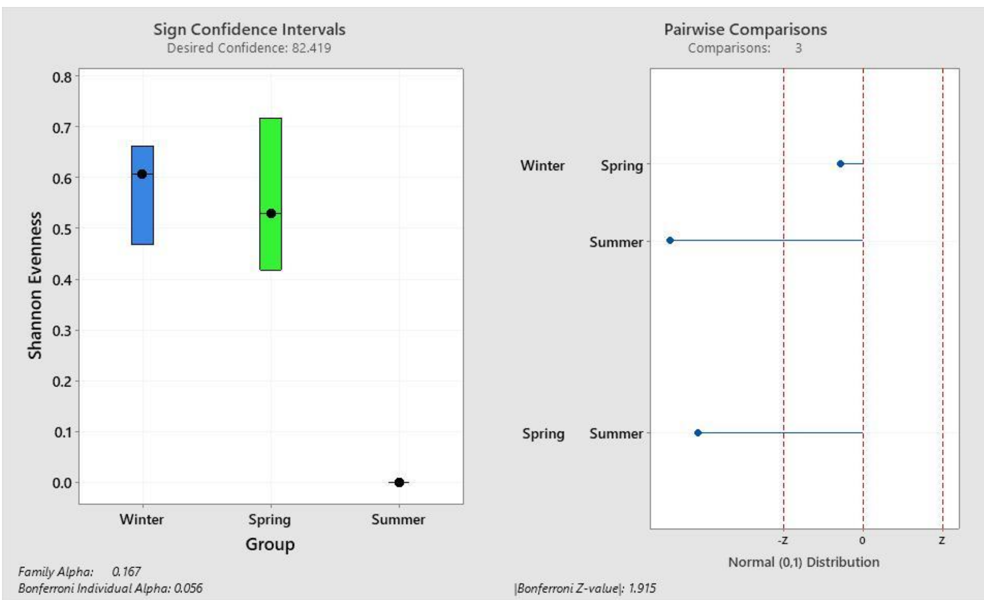


Figure 45. Dunn's multiple comparison test for significant differences in beam trawl Shannon-Wiener evenness between seasons. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons (p<u><</u>0.006).

The Kruskal-Wallis tests performed on the Margalef Richness indices of beam trawl and otter trawl collections revealed significant differences between sites for both sampling methods. However, the beam trawl collections contained only one significantly different pairing of sites in the form of B01 and B42 (Table 112; Figure 70). The Margalef Richness indices from the otter trawl collections demonstrated a far greater degree of significant grouping between sites. The Dunn's multiple comparison test calculated that B01 and B10 were significantly different from all sample sites but were not significantly different from one another (Figure 46). Margalef richness was also determined to be significantly different between flow tiers. However, only one pairing of flow tiers proved to be significantly different- Avg-3ps and Avg-Sub- while all others were not ($p > 0.006$) (Figure 71). Margalef richness indices from the beam trawl collections were significantly different when examining season ($p < 0.001$), with the summer season once again having a significantly lower median Margalef richness than both the winter ($p < 0.001$) and spring ($p = 0.001$) (Figure 47).

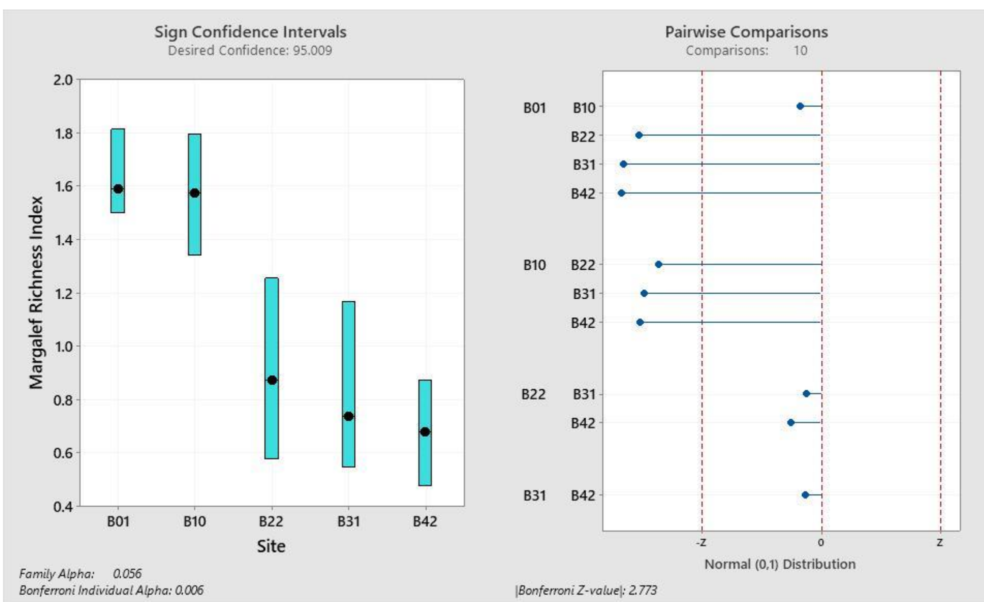


Figure 46. Dunn's multiple comparison test for significant differences in otter trawl Margalef richness indices between sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites ($p \leq 0.006$).

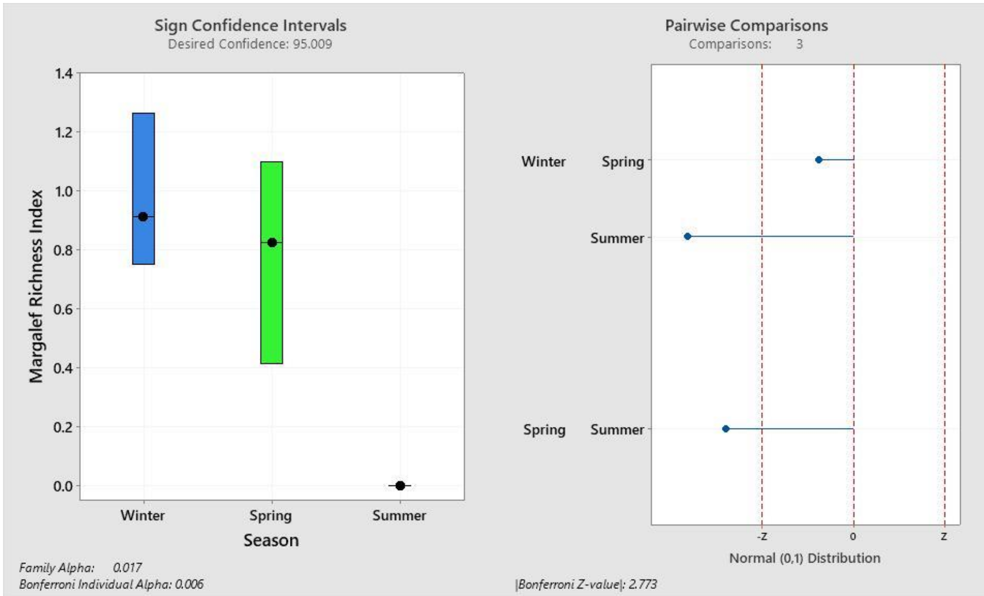


Figure 47. Dunn's multiple comparison test for significant differences in beam trawl Margalef richness indices between seasons. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons (p≤0.006).

The final community metric subjected to the Kruskal-Wallis test and post-hoc Dunn's multiple comparison test was catch per unit effort (CPUE). The only grouping variable that generated significant differences between CPUE among beam trawl collections was season ($p < 0.001$). Once again, the summer season CPUE was significantly lower than that of the winter and spring collections (Figure 48). Otter trawl collections subjected to the Kruskal-Wallis test indicated that significant differences in CPUE existed between sites ($p < 0.001$) and flow tiers ($p = 0.007$), but not season ($p = 0.02$) (Table 122). CPUE at site B42 was significantly lower than all other sample sites except for B22 ($p = 0.048$). B22 CPUE was also calculated to be significantly different from CPUE at B01 ($p = 0.002$) (Figure 49). Only two significantly different pairings between flow tiers were detected; Avg-3ps was calculated to be significantly different from both the Avg-Sub ($p = 0.003$) and Wet-Sub flow tier ($p = 0.001$) (Figure 50).

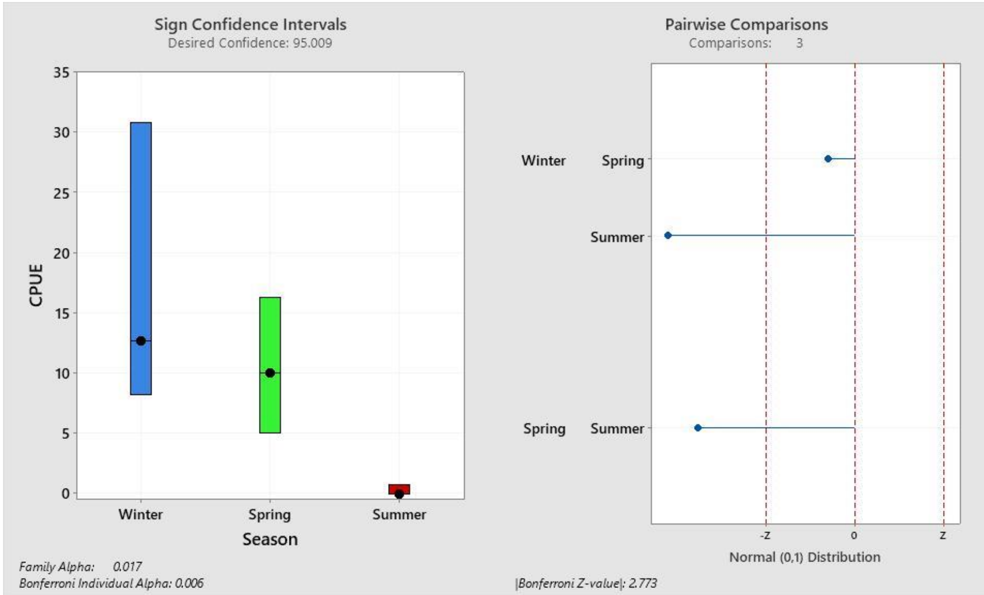


Figure 48. Dunn's multiple comparison test for significant differences in beam trawl CPUE between seasons. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between seasons (p<u><</u>0.006).

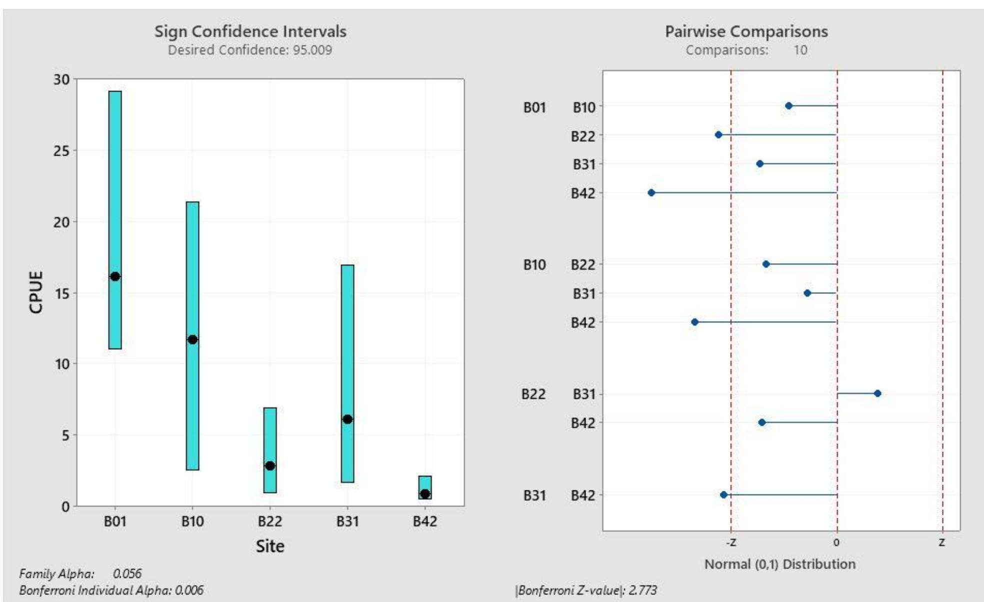


Figure 49. Dunn's multiple comparison test for significant differences in otter trawl CPUE between sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites (p<u><</u>0.006).

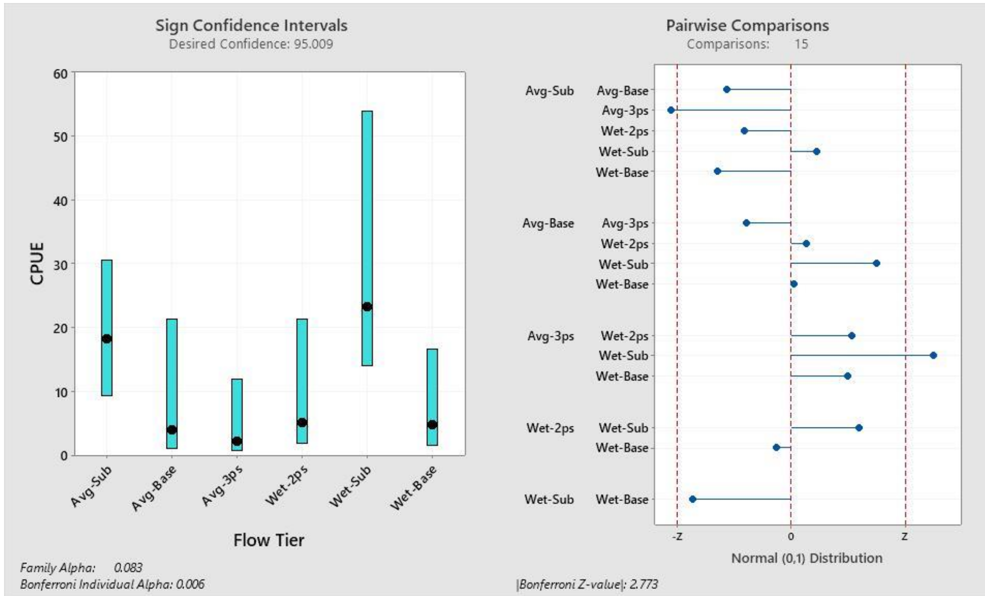


Figure 50. Dunn's multiple comparison test for significant differences in otter trawl CPUE between flow tiers. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between flow tiers (p≤0.006).

DISCUSSION:

Hydrology

Every study conducted on the ecology of the Brazos River since 2012 has sought to quantify how freshwater inflow affects water chemistry and biological communities. The reactions of the various biotic and abiotic factors of interest in the estuary to freshwater inflow have been extensively analyzed throughout the years, and the consensus is that the lower Brazos River is a highly dynamic and diverse ecosystem prone to temporal and spatial shifts in water quality and nekton communities. However, these conclusions stem mostly from the indirect effects freshwater inflow has on the river ecology- such as reducing salt wedge intrusion, and thereby limiting disbursement of marine species into the estuary- rather than how flow itself is a direct contributor to the variability of the ecosystem (Bonner et al. 2017; Greenwood et al. 2007). In addition to continuing the analysis of the influences of freshwater inflow on biological communities and water chemistry in the Brazos estuary, this study also sought to describe the normal range of variation in hydrology and classify the sampling history in the Brazos estuary based on observed trends and differences in river discharge.

Long-Term Temporal Variation

The Brazos River has a low annual average discharge despite being one of the largest watersheds in Texas and the southern United States (Kimmel 2011; NOAA 1990). A total of 53 years has passed from the time the USGS gage #08116650 was deployed and the completion of research for this study. Five of those years did not have complete data to compute average annual discharge, but the remaining for analysis was sufficient to visualize and understand the typical temporal patterns in hydrology of the lower Brazos. There were 26 years from 1967 to 2019 that exceeded the reported mean average annual discharge of 7,400 cfs (NOAA 1990). The maximum number of consecutive years to exceed this average discharge value was five, and occurred from 1973 to 1977, and 2015 to 2019.

The absence of an official standard for flood conditions and the dynamic nature of freshwater inflow in the lower Brazos makes it difficult to determine when flow could be categorized as abnormally high. Since currently accepted flow tier standards were based on daily average discharge, this was determined to be an appropriate metric of data for assessing extreme conditions as well (TCEQ 2014). The empirical rule was used to determine the cutoff for daily average discharge conditions that could be considered normal. With the outlier standard for daily average discharge equating to 33,869.90 cfs, a total of 1,068 days has been confirmed to having a daily average discharge value greater than the extreme flow standard. The histogram of extreme events was more revealing as it showed the average number of days in a year that experience these flow conditions is only 21.69 days. Only 15 out of the 51 years that have at least partial data to compare to these standards exceeded the mean number of days with extreme flow. Six of those 15 years occurred since 2004, and four of those years occurred within the sampling history of the study (Figure 6).

Although the year 2017 did not meet this classification, the landfall of Hurricane Harvey made significant contribution to the days with extreme flow for that year. Hurricane Harvey also produced one of the wettest months of August on record in the lower Brazos watershed- a huge deviation from the norm since August typically yields the lowest discharge values (Figure 5; Figure 7). Prior to the commencement of the Miller study, Texas endured one of the worst recorded droughts in the state's history (Miller 2014; Nielsen-Gammon 2012). The initial effects of the drought began in October 2010, and persisted up until mid-2012 (Nielsen-Gammon 2012). However, the effects of the drought on the Brazos River could still be observed as late as mid-2013

(Figure 4). This drought event is also the reason why the year 2011 was the only year with not a single daily average discharge value above the mean daily average discharge of 8,394.02 cfs. This year also had the lowest number of days over the median daily average discharge of 3,190 cfs- only five days during that year were equal to or greater than this value (Figure 6). The analysis of extreme flow throughout the years, as well as the extreme weather events that have occurred and no doubt influenced much of the data collected during this study all provide evidence that there are significant shifts in climate occurring throughout the Brazos watershed and are affecting the normal variations in freshwater inflow throughout the year (Nielsen-Gammon 2012; Van Oldenborgh et al. 2017). If the trend of extreme flow continues, it seems likely that variation in water quality associated with different flow tiers will become more significant and have greater impacts on all areas of the water column. In addition, the species compositions of benthic nekton communities for different flow tiers are also likely to become more dissimilar to each other as greater frequency of high discharge events limits the movement of marine and estuarine species due to decreased salinity regimes.

Seasonal Variation

Further proof of short-term hydrological shifts was provided from the seasonal analysis of daily average discharge. Dunn’s multiple comparison test calculated the median daily average discharge during the spring and winter seasons from 1967-2019 to be significantly higher than 2011-2019. In addition, while all three seasons were determined to be significantly different from each other within the recording history of the USGS gage, the daily average discharge of the spring and winter seasons were not significantly different from one another during 2011-2019. A trend that was consistent throughout the seasons was greater daily average discharge during the spring season, with winter taking second place, and summer typically having the lowest daily average discharge values (Figure 9). These trends were within expectations of the regional climate patterns in the northern Gulf of Mexico (Wagner and Austin 1999)

Annual Variation

When each month was statistically compared using the Kruskal-Wallis tests and proceeding Dunn's multiple comparison tests in the different time periods, further disparity was revealed. The confidence intervals of the median daily average discharge were far larger during 2011-2019 than 1967-2019, and as a result the number of significantly different comparisons between months was larger. Dunn's multiple comparison test between median daily average discharge of each month of the year revealed 49 significantly different comparisons during 1967-2019, compared to 32 out of a possible 66 during 2011-2019. The larger confidence intervals could merely be the result of a smaller dataset, but the results of the analysis between each year contradict this (Figure 7). A larger confidence interval of the median daily average discharge is indicative of higher variability within the year. This is further supported by confidence intervals in the early half of the sampling history suffering from the 2011 drought being much smaller than those in the latter half which were significantly wetter years. This pattern seemed to persist when daily average discharge values of each year were compared by season. The summer season had the most significantly different comparisons from 2011 to 2019, even though this season experiences consistent and decreased river discharge (Figure 10). On the other hand, the winter season had the fewest significantly different comparisons at only 25 out of 36 possible (Figure 11). What can be inferred from these results is that variability in river discharge is increasing as time passes, and the greatest frequency of this variation is likely to originate during the summer season- which constitutes the entirety of the hurricane season in the Gulf of

Mexico. In addition, although many patterns between months and seasons remain relatively consistent, there is still a large margin for change.

Linear Modeling of Downstream Discharge

The results of the linear models predicting field discharge directly above TCEQ segment 1201 from continuous and daily average discharge values from the USGS gage were not within expectations. None of the reports prior to this study attempted to quantify the linear relationship between discharge measured in the lowest portion of the nontidal Brazos River, and the discharge values measured at the same time over 100 kilometers upstream (Bonner et al. 2017; Bonner et al. 2015). The results of the game camera experiment seemed to indicate that the water being measured at the gage could take anywhere from 6 to 24 hours to reach the areas of the river in sight of the cameras (Table 59; Table 60). As a result, it was hypothesized that daily average discharge would be a more robust predictor for discharge within TCEQ segment 1201. However, the results of the linear regression analysis indicated that despite the gap in time it takes for freshwater at Rosharon, TX to reach the Brazos estuary, continuous discharge is just as effective at predicting discharge downstream as daily average discharge is. In fact, the analysis clearly showed that continuous discharge model to be slightly more accurate with an (R^2) value of 0.8571 compared to the daily average discharge model which was 0.8561 (Figure 13).

These models are somewhat biased because the sample days during which the field discharge values were collected were all during days where the continuous discharge did not exceed 20,000 cfs for several days. This was done on purpose for two reasons: the first being safety; flows exceeding 20,000 cfs would make upstream travel more difficult due to stream velocity and a higher risk of floating debris. Monitoring the continuous discharge at the USGS gage was the simplest way to ensure sampling occurred when flow was not too high, and it was relatively stable. The second reason sampling occurred during flows of less than 20,000 cfs was to ensure that the data for each part of the protocol could be collected. If the flow was too high, the water quality measurements would be less accurate since the river would carry the sonde further downstream rather than let it remain relatively static in mid-water. In addition, river discharges above 20,000 cfs would have made otter trawl collections nearly impossible due to the amount of drag the trawl creates when towed upstream. Finally, measurement of field discharge above TCEQ segment 1201 would have been more challenging in high flow conditions since the ACDP mounted on the hydroboard needs to be towed several times perpendicular to the flow roughly on a transect.

The results of the game camera analysis could indicate the lack of samples taken during significantly higher flow may weaken the predictive power of the linear models, but there is a degree of hypocrisy in making this conclusion. The time estimate of water from Rosharon reaching the estuary is reliant on photo series taken during deluge events. For changes in water levels at the Middle and Lower sites to be discernible from the photos, the freshwater inflow would need to exceed the changes in water level caused by the shifting tides. These changes in water height would need to occur relatively quickly- within a maximum span of a few days- and in great magnitudes- greater than 5,000 cfs. Such rapid and dramatic changes are quite rare; there were approximately eleven events from August 3rd, 2018, to December 9th, 2019, that spanned anywhere from one to three days when changes in water height were significant enough to notice in the photos, and cross reference continuous discharge and gage height values with the TROLL data from the continuous sites. Events such as these could certainly decrease the reliability of using USGS data to predict downstream discharge, but since they are so uncommon, it is unlikely that measurements taken during the occurrence of such events could sufficiently impact the correlation between USGS discharge and discharge measured downstream.

Water Quality

Many of the analyses performed on the water quality data represent a continuation and expansion of data processing and investigation into the effects of freshwater inflow on the physiochemical environment of the Brazos estuary. Previous reports acknowledged data gaps and limited scope of sampling in each year of study and recommended further sampling to corroborate preliminary conclusions and provide new opportunities for further research.

Continuous Monitoring

Although the continuous monitoring of water quality using HOBOs and TROLLs has been ongoing since 2014, no attempts have yet been made to utilize the data for time series analysis or regression analysis with river discharge (Bonner et al. 2017; Bonner et al. 2015; Swanson 2019). The results in this paper represent the first time the data collected using these types of monitoring gear in the lower Brazos River has faced any form of statistical scrutiny rather than simple observations of trends. The continuous data collected every 15 minutes from the monitoring gear would undergo quality control so that any data suspected to be recorded during problematic conditions- such as not being submerged or buried in sediment- could be excluded from the analysis. This continuous data would then be used to compute daily average values to compare to daily average discharge. The reason that the variables would only undergo analysis after being converted to daily mean values relates to the normal diel patterns of each variable. Temperature and Dissolved Oxygen (DO) are naturally going to be higher during the middle of the day and lower at night, while salinity and water depth are correlated with tidal shifts (Day et al. 2012; Mitsch et al. 2015; Mitsch and Gosselink 2015).

For any predictive models between river discharge and continuous monitoring data to be reliable, any discharge values would need to reflect the same time scale and location as the data recorded downstream. The results of the game camera time lapse experiment and linear modeling of field discharge are supportive of the hypothesis that continuous discharge data could not only be used for predicting downstream field discharge taken at the same time, but also for any other variables that exhibit a strong correlation with freshwater inflow (Figure 13; Figure 59; Figure 60). However, because many of these variables are sensitive to not only time of day but are also correlated with other metrics of water quality, daily average discharge was determined to be a more robust predictor since pairing it with daily averages of water quality variables would account for the subtle changes and diel patterns throughout the entire day (Mitsch and Gosselink 2015). The results of the Pearson correlation analysis supported this hypothesis, as the correlation coefficients between daily average discharge and the water quality profile data that was also recorded on the HOBOs and TROLLs- temperature, salinity, depth, and DO- all had slightly higher correlation coefficients than what was calculated between those same variables and continuous discharge from the USGS gage (Figure 31; Figure 32). Each mean was calculated from each continuous measurement taken every fifteen minutes, making a maximum of 96 continuous measurements to calculate the daily mean. However, since the monitoring gear was subject to interference from the environment, every single continuous measurement could not be retained for calculation, which meant that many daily mean values calculated were the result of incomplete data. However, plotting the continuous data against the daily average values and corresponding discharge values revealed that these discrepancies had little impact on the time-series data, and with far fewer values to process, made the analysis more manageable (Figure 63; Figure 64; Figure 65; Figure 66).

Plotting daily average temperature against daily average discharge revealed no obvious relationship between the two variables, and the Pearson correlation analysis confirmed this (Figure 14; Figure 31; Figure 32). It was hypothesized that some form of correlation should exist between the two variables since it has been proven that season has a significant impact on both (Greenwood et al. 2007; Wagner and Austin 1999). Miller (2014) showed that throughout the course of a year, water temperatures followed the pattern of a parabola at all sample sites, and these patterns could also be observed in the long-term monitoring of temperature via HOBO (Figure 63). This observed relationship made it plausible a quadratic regression fit could be used between Julian day and daily average temperature in order to create a predictive model for water temperature in the estuary. The resulting models all exhibited strong (R^2) values, and the overlaying of seasons for each data point provided further evidence of the relationship between time of year and water temperature (Figure 14). Miller (2014) also used the Kruskal-Wallis test and Dunn's multiple comparison test post-hoc in order to show that river kilometer-distance from the mouth- had no significant effect on differences in water temperature. These conclusions were the justification for the creation of a quadratic model between Julian day and water temperature using data from all continuous sites (Figure 15). The theory was that if no significant differences between water temperature exist between sites, then a single model could be just as useful for predicting water temperature as a series of model for each site would be. The results of the two-way ANOVA for temperature supported the results of the nonparametric tests conducted by Miller (2014) and therefore gives statistical evidence that creating linear models for predicting water temperature for each site is unnecessary (Table 56). However, since daily average temperatures often represented an incomplete series of continuous measurements, the usage of any model presented in this study for the purpose of predicting river temperature should be treated with caution.

Freshwater inflow has a more significant effect on water salinity between sites due to increased river discharge limiting the migration distance of the salt wedge upstream and increasing vertical mixing of more saline water at the bottom with oligohaline water near the surface (Greenwood 2007; Guenther and MacDonald 2012; Stevens et al. 2013). The inverse relationship between salinity and freshwater inflow was expected to be seen at all sites prior to the construction of the linear models between daily average discharge and daily average salinity (Figure 64). Though the raw data did not appear to be a good candidate for linear regression analysis, the application of a $\log_{10}$ transformation circumvented this issue (Figure 16). However, what became apparent through the log transformed models was the varying degrees of magnitude that freshwater inflow affected daily average salinity, which could also be seen from the non-transformed scatterplots and hydrographs (Figure 16; Figure 64).

The (R^2) values decreased substantially as distance from the river mouth increased, which is likely since the relationship between salinity and flow is not perfectly linear (Figure 16). The Lower site could experience shifts in salinity as great as 25 ppt within the span of a few days, whereas within the same time, the Middle site may only drop as much as 2 ppt, and the Upper site may not exceed 1 ppt for several weeks prior or after (Figure 64). The effects of freshwater inflow on salinity are far greater when the salinity is higher, and salinity will be significantly lower when the site is further upstream and beyond the reach of the tidal influence (Mitsch and Gosselink 2015). As a result, the use of a linear regression model for predicting salinity downstream- even for sites closer to the mouth- is likely not very accurate. The use of the exponential decay function in nonlinear regression analysis proved to be much more accommodating for the Middle and

Upper sites, and the disparity between the standard deviations for each model was significantly reduced (Figure 16).

A similar pattern was observed when performing linear regression analysis on relative depth recorded from the paired Level and Baro TROLLs. Although the daily average depth and daily average discharge were significantly correlated to one another, and the linear model yielded high (R^2) values for each site, these linear models should not be relied upon due to the nature of river depth. Every river has a carrying capacity for volume of water it can accommodate, and when this capacity is exceeded, it results in flooding (Day et al. 2012). This means that there is a finite amount of water that can be in the river without the water spilling over the banks, and once flood stage is reached, the maximum depth of the river cannot go any higher. Different sections of the river experience flooding at different times because while some areas of the river may be shallower, they can be significantly wider with greater bank slopes. This phenomenon was observed during October 2018, when tremendous precipitation in the upper Brazos watershed led to flooding within TCEQ segment 1201. The Middle and Upper sites both experienced overbank conditions and burial due to increased sediment loading that prevented gear retrieval until February of the following year. However, within that same time, the Lower site experienced far less sediment loading on the banks, and no recorded instances where the freshwater inflow rose above the banks (Figure 58). The profile of the river topography near the Lower site is much wider than it is further upstream, which means larger volumes of water can be contained within this area of the river without substantially increasing the water levels. This could be observed in the scatterplots between daily average depth and daily average discharge at the Lower site and even at the Middle site, but this was clearly not the case at the Upper site (Figure 17). For this reason, a sigmoidal growth curve was used in nonlinear regression analysis in order to address these hydrological facts. Even though the time series plots at the Middle and Lower sites do not follow the sigmoidal curve as well as the Upper site, this model should still be used for using daily average discharge to predict daily average depth because patterns observed at the Upper site are just as likely to occur downstream (Figure 58; Figure 65).

The linear regression analysis of Dissolved Oxygen proved to be more complicated as the initial modeling between daily average discharge and daily average DO did not reveal any linear correlation between the two (Figure 18). However, the time-series graph of the DO data with a hydrograph of the river discharge seemed to contradict these results (Figure 66). In addition, the results of the Pearson correlation matrix for bottom water quality clearly indicated there was a significant correlation between discharge and DO (Figure 31). The variable to exhibit the strongest significant correlation with DO was temperature, so this was the predictor variable chosen for simple linear regression analysis (Figure 18). Although the regression models proved to be a good fit, multiple linear regression analysis was also performed to determine if the addition of daily average discharge could increase the (R^2) value, decrease the standard deviation, or both. This decision ultimately proved to yield more significant results, as the multiple linear regression model had both higher (R^2) values and lower standard deviations of the residuals (Table 4). These results are consistent with how DO levels change within the river. As water temperatures increase, the solubility of oxygen decreases, and therefore decreases DO levels in the water, which is why hypoxic conditions are so common during the summer season (Day et al. 2012; Justus et al. 2014). However, increased freshwater inflow can disrupt this negative trend by increasing vertical mixing and distributing more oxygenated water near the surface to the bottom of the water column, as well as bringing cooler water to the surface to increase DO retention

(Bonner et al. 2017; Day et al. 2012). These results indicate that a predictive model for DO in the lower Brazos would be more accurate with the implementation of both water temperature and discharge data, rather than a single variable (Table 4). Multiple linear regression analysis for DO had been conducted from measurements taken from the profile, discharge values, and river kilometer, but the resulting model did not explain as much of the variation in DO as the current model (Bonner et al. 2017).

Water Quality Profile

A topic of interest that has been thoroughly tested since the advent of the BBASC recommendation reports is the spatial variation of water quality within the Brazos River, and if the effects of freshwater inflow are independent of the spatial differences between sample sites. The use of the two-way ANOVA has been used previously to test for interaction effects between river kilometer and flow tiers both by using combined profile measurements from each site, as well as examining individual measurements from the water column (Bonner et al. 2017; Bonner et al. 2015; Miller 2014). Bonner et al. (2015) only used profile measurements from the surface, middle and bottom, because these were the only measurements taken by Miller (2014) for comparison. Both reports to the Texas Water Development Board (TWDB) only utilized the two-way ANOVA for salinity and DO data (Bonner et al. 2017; Bonner et al. 2015). In addition, both reports suffered from having smaller sample sizes of water quality data, and the results of the normality test for the current study suggest that the analyses run in previous years were in greater violation for the assumptions of the ANOVA. The current study utilized all five profile depth measurements for the two-way ANOVA in order to increase the sample size and provide a more extensive range of values to represent the physiochemical environment at each site and during each flow tier. In addition, every water quality variable that was measured with the sonde- except for specific conductivity and DO %- were tested for differences in means between sites, flow tiers, and an interaction between the two groups.

The results of the two-way ANOVA for water temperature revealed no significant differences between sample sites (Table 56). The same conclusion was drawn by Miller (2014) through the usage of the Kruskal-Wallis test. The null hypothesis for no significant differences between temperature means of flow tiers was rejected, but Tukey's pairwise comparisons did not generate significant groupings of flow tiers with detectable patterns (Table 56). The groupings that were generated were primarily between flow tiers that had samples taken during at least two seasons, and with a similar number of samples taken for each season (Table 2). The flow tiers that formed individual significant groupings were primarily those with samples only representing a single season such as Wet-2ps. These types of groupings also influenced what flow tiers yielded the highest mean temperatures. The Wet-2ps flow tier had the highest recorded mean temperature among all the flow tiers at 31.45 °C, but this is likely a result of only two samples being taken during this flow tier, both of which occurred during the summer (Table 56). This is suggestive that the adopted flow tiers by TCEQ are effective in distinguishing differences in water quality while accounting for season, but only if the samples collected for these flow tiers includes representatives from each season (TCEQ 2014).

The results of the two-way ANOVA for DO reveal that both spatial differences and differences in flow tiers could explain the variation in mean DO independently, but not in an interactive model. The highest mean DO was recorded at B42 with a value of 7.307 mg/L and remained relatively high throughout the upper river and at B01. The lowest mean DO values were typically recorded at the middle sites- B10 to B22- with the lowest recorded mean DO at 5.89 mg/L from B10 (Table 57). These results corroborate the findings made by Bonner et al. (2017), and it was suggested that this was related to the stability of the salt wedge. The greatest variations in salinity typically occurred within the middle sites since they are both far enough from the GOM to be impacted by freshwater inflow, yet far enough upstream to experience great upticks in salinity during increased tidal heights (Bonner et al. 2017). Bottom DO and bottom salinity have a significant negative correlation with each other, so the presence of a stable salinity gradient at most of the sample depths was likely to result in the low DO readings in this region of the river (Figure 31). The significant groupings between flow tiers showed that the base flows were distinct from all other flow tiers (Table 57). These groupings could be the result of the base flow tiers possessing the highest mean daily average discharge values for their corresponding sample dates (Table 2). There is ample evidence from the current study to demonstrate the positive correlation between DO and freshwater inflow, so these results provide clarity to the significant differences observed (Table 4; Figure 31).

The results of the two-way ANOVA for Turbidity and Secchi disk transparency were almost entirely within expectations. Secchi disk transparency followed an unbroken trend of decreasing visibility from B01 to B42 (Table 60). For turbidity the trend of decreasing mean was not perfectly linear, as B15 ranked above B25 and B05 ranked above B10 for higher mean turbidity readings (Table 58). This broken pattern of turbidity is not fully understood, as both the listed sample sites are not near bends in the river, and therefore should not be subjected to increased stream velocity stirring up sediment from the bottom and the banks (Figure 1). The patterns in flow tier were also easy to interpret and expect; subsistence flows yielded greater Secchi disk transparency and decreased turbidity. The greatest mean Secchi reading was 0.267 meters at B01, and 0.358 meters for the Avg-Sub flow tier, with the corresponding mean turbidity values at

33.685 NTU and 19.542 NTU respectively (Table 58; Table 60). Secchi disk clarity was also higher during average hydrological conditions than wet, and base flows were clearer than pulse flows- except for Wet-Base. As river discharge increases, the amount of sediment being transported downstream will increase, and therefore reduces visibility in the water column. Pulse conditions yielded higher mean turbidity values, and wet conditions were also more likely to increase turbidity. The greatest mean turbidity values were calculated to be 141.473 NTU for Avg-3ps, and 114.465 NTU for B42 (Table 58).

Despite both variables exhibiting strong correlations between river kilometer and river discharge, neither exhibited a significant interaction effect when tested with the two-way ANOVA (Table 58; Table 60). One explanation for this could be that although variation between each group exists, these variations are not significantly high enough to yield a detectable interaction effect between the two. Another problem that is directly linked to turbidity is that the sonde measurements could vary sporadically- especially on the bottom- and stabilization of readings sometimes yielded questionable measurements. Although these technical difficulties did not constitute most of the turbidity measurements, they were not uncommon, and likely a major source of data error.

Thalweg depth also did not exhibit a significant interaction effect between site and flow tier despite the significant differences detected within each group. Miller (2014) concluded that maximum depth increases as distance from the mouth increases, but these observations were made from only four sites as opposed to the current nine. The groupings generated from Tukey's pairwise comparisons did not reveal any obvious spatial patterns; the greatest average thalweg depth was recorded at B15 with a mean total depth of 8.08 meters and followed closely by B42 at 7.51 meters. The lowest mean depth was recorded at B25 at a depth of 4.824 meters. In direct contrast to the site groupings, groupings for the flow tiers followed an almost unbroken pattern. The maximum mean thalweg depth was 7.169 meters and was calculated for the Wet-2ps flow tier. As flow tier went from pulse, to base, and to subsistence, mean depth decreased. Flow tiers classified under wet hydrological conditions also had greater recorded depths than those classified as average. The lowest average thalweg depth was calculated for the Avg-Base flow tier at 5.766 meters (Table 59).

The two-way ANOVA for salinity was the first case of an interaction effect between site and flow tier being detected for any water quality variable (Table 61). These results were consistent with the analyses performed in 2015 and 2017 despite both reports having smaller sample sizes and using fewer profile measurements during the ANOVA (Bonner et al. 2017; Bonner et al. 2015). The overall trends were identical as well; sites that were further upstream exhibited lower salinity readings at all profile depths, and flow tiers associated with increased daily average discharge yielded lower mean salinities (Table 7; Table 8; Figure 24; Figure 25; Figure 31; Figure 32). The highest salinities reported always occurred between B01 and B10, with the maximum mean salinity recorded at 16.280 psu for B01 (Table 7; Figure 24). The maximum mean salinity among flow tiers was 13.378 psu for the Avg-Sub flow tier (Table 8). Since an interaction effect was detected, a series of reduced, one-way ANOVA tests and Tukey's pairwise comparisons were performed in order to assess site differences within each flow tier, and flow tier differences within each site. The differences between flow tiers at each site were difficult to interpret, but some patterns could be extracted. Mean salinity for the Avg-Sub flow tier was significantly different from mean salinity for the Avg-3ps flow tier at all sites. The Wet-Base mean salinity was significantly different from the Avg-Sub mean salinity at all sites except B01. In addition, the only instance where the Avg-Sub flow tier was significantly different from the Avg-Base flow tier was at B36 and B42 (Table 63). The spatial differences between flow tiers were far more apparent and consistent with results from previous studies. B01, B05, and B10 were all significantly different from both B36 and B42 for each flow tier category. These same three sites were also significantly different from every site upstream of B22 except during the Avg-Base flow tier. The Wet-Base flow tier exhibited the greatest variance among all flow tiers with a total of 22 significantly different pairwise comparisons out of a possible 36, while the Avg-Base exhibited the lowest degree of variance with only seven significantly different comparisons (Table 64). The low variance was unexpected since mean salinity during the summer is significantly higher than during the spring or winter (Miller 2014).

The second variable to have an interaction effect detected between site and flow tier was pH- which had never been subjected to this type of analysis in previous years. Miller (2014) did not find any significant differences between mean at the different sites using the Kruskal-Wallis test, so these initial results are cause enough for surprise. The highest mean pH among flow tiers was Wet-2ps with a value of 7.824 while among sites it was B01 at 7.86. There were no recorded cases throughout the entire sampling history where recorded pH fell out of the acceptable range of 6.5-9.0 (TCEQ 2012). Average flow tier conditions exhibited a transition to more neutral pH from pulse to subsistence flow tiers, while the inverse was true during wet conditions. The lowest mean pH values were recorded for the Avg-3ps flow tier at 7.63, while the lowest between sites was at B22 with a value of 7.70 (Table 7; Table 8). The distribution of mean pH between sites followed a similar pattern to what was observed for DO concentrations- higher values in the upper river and near the mouth, while the lowest values were typically recorded at B10 to B22 (Table 7). It's also interesting to note that the Pearson correlation analysis calculated a significant correlation between pH and DO (Figure 31; Figure 32). The reason for this trend could be related to the stability of the salt wedge intrusion in this region of the river, just as it was the case for DO (Bonner et al. 2017). However, the logarithmic scale on which pH is recorded is significantly different than the scales of other water quality variables, and any observed relationships ought to be carefully classified. Even the results of the two-way ANOVA should be taken with caution since all studies that utilized this test violated at least one assumption of running the ANOVA. The site with the fewest significant differences in mean pH between flow tiers was B22, while the site with the greatest variation was B42 (Table 65). The Wet-2ps and Wet-Base flow tiers did not exhibit any significant differences in pH between sites, and the Avg-Sub flow tier had the greatest variation between sites of any flow tier (Table 66).

Principal component analysis (PCA) was conducted by Miller (2014) and concluded that 49.1% of sample variation in bottom water quality could be explained by temporal variation while 28.8% of the variation could be explained by spatial differences, based on the coefficients for each water quality variable used in PCA- temperature, salinity, DO, daily average discharge, and total depth. In the current study, total depth was excluded from the PCA since the ANOVA results did not reveal any obvious trends in river kilometer, and because total depth was highly correlated with discharge (Figure 17). In addition to using bottom water quality from 2014 onwards for PCA, the surface water quality was also subjected to PCA. The purpose of this was to reach a conclusion as to what variables drive the variation between samples taken from all areas of the water column that are sampled for nekton. The greatest contributors to the eigenvector of PC1 for bottom profile were DO (0.613) and salinity (-0.519). Both variables are significantly different between sites and directly related to the depth and location of the salt wedge in the estuary, but the prominence of the DO coefficient is also suggestive that seasonal effects are a part of PC1 (Figure 20; Figure 24; Figure 25; Table 67). This could be seen in the PCA plot where a rough horizontal gradient could be seen between seasons. For PC2, the highest coefficients were temperature (0.641) and daily average discharge

(0.635), and PC2 accounted for 34.9% of the variation between samples (Table 67). PC2 is also likely a combination of grouping variations since the contribution of temperature would be directly linked to seasonal changes, whereas the contribution of discharge would be more indicative of shifting flow regimes.

PC1 and PC2 for the current PCA model accounted for a cumulative total of 81.4% of the variation whereas the Miller (2014) model accounted for 77.9% of the variation (Table 67). This is suggestive that using only the four variables chosen in the current PCA is sufficient for explaining sample variation. Spatial differences explained a greater proportion of variation in water quality from the samples taken since 2014, whereas during 2012, it was season (Miller 2014). Since there were only four sample sites utilized by EIH prior to 2014, it's possible that a smaller sample size and a smaller range of sample sites undermined the importance of spatial differences in the estuary in the Miller (2014) study. This would have been especially true with DO, since a great degree of variation in oxygen levels occurs within the middle sites, but with most of them absent in 2012, the extent of the variation in DO due to spatial differences would have been significantly reduced, and likely give more weight to its role in contributing to seasonal differences (Figure 20).

The patterns observed in the PCA of the surface profile data were more consistent with the results and conclusions outlined by Miller (2014). The DO coefficient was the largest contributor to the eigenvector for PC1 and was inversely related to temperature- all clear signs of the relationship between temperature and DO during seasonal changes. There was also a very clear horizontal gradient between samples when grouped by season, which provides further prove that the likely source of 44.5% of the variation between samples is season (Figure 29; Table 68). The interpretation of PC2 was equally easy to interpret; with the highest eigenvector coefficient of 0.673 belonging to daily average discharge, and the second designated for salinity at 0.662, it was clear that the 34.9% of sample variation explained by PC2 was due to variation of freshwater inflow (Table 68). When samples were grouped by flow tier, the vertical gradient of subsistence to pulse flows became apparent (Figure 29). The results of both PCA plots indicate that season plays a role in the variation of water quality at any depth. The variation explained by flow tier is more prevalent at the surface likely since the direct effects of discharge- velocity, sediment loading, etc.- are more significant at the surface than the bottom (Day et al. 2012). The variation explained by spatial differences is likely more important for bottom profile due to the interaction between discharge and the halocline (Bonner et al. 2017). Most salinity readings at the surface did not exceed 10 psu even at B01 during the summer, so any spatial relationships derived from variation in salinity are likely to be reduced in comparison to the bottom profile (Table 7; Table 8).

Nekton Community

Correlation Analysis

The purpose of the correlation analysis was to generate a matrix of significant correlations that could quickly detail all significant relationships between hydrology, water quality and nekton community variables. The water quality measurements were separated based on surface and bottom profile in order to determine whether water quality at the surface or bottom would yield significant differences between correlation coefficients. This was of particular importance when correlating water quality with beam trawl community data since the profile measurements are taken at the thalweg for each site while the beam trawls are conducted on the bank. Although the beam trawl is meant for sampling larval nekton in shallow water, each beam trawl collection is in fact sampling the entire water column in its path (Renfro 1962). Prior to this study, most analyses between nekton communities collected with the beam trawl were reliant on data collected from the bottom profile (Miller 2014; Swanson 2019). The water quality variable with the greatest correlation between otter trawl and beam trawl nekton community data is salinity (Figure 31; Figure 32).

The results of both the bottom and surface Pearson correlation analysis indicated that the bottom salinity yielded higher correlation coefficients between all beam trawl data that was determined to be significantly correlated ($p \leq 0.05$) with salinity (Table 71; Table 73). These results are unusual because the maximum salinity at the bottom near the bank would never approach salinity levels at the thalweg- particularly at sites closer to the mouth. In addition, all otter trawl data that was significantly correlated with salinity had higher correlation coefficients with surface salinity than the bottom (Table 72; Table 74). Though the differences in these correlation coefficients are not very large (< 0.15), it is nonetheless confusing as to why this was observed; benthic nekton should theoretically have a higher correlation with water quality at the same depth they were sampled.

One theory that could explain this phenomenon could be the vertical migration of the salt wedge in the river. During periods of increased flow, the halocline in the estuary is forced further downstream, and the freshwater rises over the denser layer of saline water, forcing it closer to the bottom. However, when freshwater inflow decreases, this pattern is reversed, and the salt wedge travels further upstream and closer to the surface (Bonner et al. 2017; Day et al. 2012). If surface salinity is higher, then it stands to reason that salinity at all regions of the water column will be higher than average, and therefore would give nekton that are less tolerant to low-salinity conditions a larger roof over their heads. With greater freedom to roam throughout the water column and more conducive conditions for estuarine nekton, this could explain the increased positive correlation with species richness and Margalef Richness for otter trawl collections (Figure 32). Data from beam trawl collections was inversely correlated with salinity, so any relationship with salinity from the thalweg would likely come from the maximum salinity value- which almost always occurs at the bottom. The salinity taken from the bottom is representative of how high the salinity can reach at any point in the river, and if nekton communities targeted with the beam trawl are negatively correlated with this, any values indicating increased diversity would decrease as maximum salinity increases.

Community Similarity

The results of the SIMPER analysis indicated the communities sampled with the otter trawl are more similar between collections for any grouping- season, site, and flow tier- than beam trawl collections. There was never an instance when the percent similarity of beam trawl collections of a single group was higher than the percent similarity of between otter trawl collections between the same group. This could be a result of a very high number of collections with no catch reported; SIMPER analysis cannot compute a value of percent similarity when no community data is available. This would also explain the low percent similarity between beam trawl collections during the summer- there were 15 zero catch collections for beam trawl since 2014, and only one was not recorded during the summer season (Table 33). Otter trawl collections were most similar when grouped by site, with the average similarity of collections between all sites at approximately 33.97%, and collections most similar at B01 with an average similarity of 45.36% (Table 75). The relationship between sample site and community similarity could clearly be seen when plotted using nMDS, with a clear dividing line between the upper and lower sites, and B22 crossing the median between the sites most frequently (Figure 33). This also illustrates the low average percent similarity of B22 collections at only 19.94% (Table 75). The average percent similarity between otter trawl collections when grouped by season was the lowest among the groups tested at

26.97%, with collections most similar during the summer season at 32.06% (Table 77). Average percent dissimilarity in pairwise comparisons between seasons was also substantially higher than comparisons between sites and flow tiers. Beam trawl collections exhibited the opposite trend of having higher average percent similarity between seasons, and lowest average percent similarity between sites (Table 76; Table 78). These preliminary results suggested that seasonal variation is more important for shoreline nekton communities while spatial variation plays a bigger role in influencing nekton communities near the bottom of the thalweg.

The results of the ANOSIM tests supported these initial conclusions for both otter trawl and beam trawl collections. The null hypothesis for an ANOSIM test assumes that the similarity between two groups is greater than or equal to the similarity within each group. For seasonal otter trawl collections, the null hypothesis for each comparison is rejected, and greater similarity between nekton collections grouped by season is not concluded (Table 82). The null hypothesis for seasonal comparisons between beam trawl collections is also rejected, which implies that greater percent similarity of collections occurs within season rather than between seasons (Table 85). Many of the ANOSIM tests between flow tiers were not significant ($p > 0.05$) for otter trawl collections, which suggests that with greater similarity between groups than within, that flow tier is not as influential on community composition as season or site location (Table 83). This can be observed and corroborated through the nMDS plot, where there are very few observable patterns in collections grouped by flow tier (Figure 35). The average dissimilarity between flow tiers for beam trawl collections was lower than those of the otter trawl collections, which is likely why a greater frequency of the ANOSIM results were significant ($p \leq 0.05$) (Table 86). As for site comparisons, only the otter trawl collections between B31 and B42 were determined to be more similar between one another than within their own classification (p = 0.052) (Table 81). Although the results of the SIMPER analysis revealed that percent similarity of site collections were comparatively high, average percent dissimilarity between sites was substantially higher (Table 75). Conversely, the average percent similarity within beam trawl collections never exceeded 20%, while average percent dissimilarity between sites always exceeded 90%- except between B31 and B42 (Table 84). The ANOSIM results of beam trawl collections grouped by site support this since similarity between B01 and all sites upstream of B10 did not exceed similarity within the sites (p = 0.815). The same was true of comparisons between B42 and all sites downstream of B31 (p = 0.099).

The cluster analysis from the collection taken in the GOM formed groupings primarily based on spatial variation. The collections with greater total catch and greater species richness were typically from G1 and G1U1, and this was likely related to the transport of nutrients from upstream, as well as the vertical mixing promoted by freshwater discharge (Day et al. 2012). The inclusion of G2 in the second highest similarity grouping is indicative that the positive hydrological effects from the river reach as far as two kilometers offshore. Although G1D1 is as close to the river mouth as G1U1, its position further down the coast is likely why collections were not as lucrative and less similar to collections from G1 and G1U1 (Table 87). This is likely related to sediment transport; the Brazos River discharges more sediment into the GOM than any other watershed in the state of Texas (Rodriguez et al. 2000). Otter trawl collections from the river sites exhibited a significant negative correlation with turbidity, so it stands to reason that the same correlation would be observed in the GOM. As sediments from the watershed pour into the GOM, they are carried southwest down the coastline by gulf currents, thereby altering bottom topography and decreasing oxygen levels due to restricting access to sunlight for photosynthesis by phytoplankton communities (Day et al. 2012).

Variation in Nekton Diversity

The results of these tests were further corroborated when the usage of the Kruskal-Wallis and Dunn's multiple comparison test compared calculated community metrics between sites, seasons, and flow tiers. Every community metric for otter trawl collections- total catch, species richness, Shannon-Wiener diversity, Shannon evenness, Margalef Richness, and CPUE- exhibited no significant differences between seasons, which were supported by the results of the SIMPER analysis and ANOSIM tests (Table 92; Table 98; Table 104; Table 110; Table 116; Table 122). However, it's important to note that the lack of significant differences could also be related to how the Kruskal-Wallis test was performed. The family (α) of each test was dependent on the grouping variable used since the objective was to test for significant differences between the medians based on their 95.009% confidence intervals. For the test between seasons, the family (α) was 0.0167 so that the Bonferroni adjusted p-value for post-hoc comparisons would be 0.006. There were cases where the adjustment of the family (α) may have prevented the detection of significant differences- this could have been proved true for comparisons of total catch, species richness, and CPUE (Table 92; Table 98; Table 122). Nevertheless, these results are supported by both the SIMPER analysis and ANOSIM tests, so the decision to adjust the family (α) according to group may still be justifiable.

All community metrics for otter trawl collections- except Shannon evenness- proved to be significantly different ($p \leq 0.033$) between sites, which further supports the idea that spatial variation is the most important factor for consideration in mid-channel benthic nekton communities (Table 91; Table 97; Table 103; Table 115; Table 121). Only Margalef Richness and Shannon evenness did not show significant differences between flow tiers for otter trawl collections. This would appear to contrast with the results of the ANOSIM test, but the number of significantly different pairwise comparisons only ranged from one to three out of a possible 15 (Table 110; Table 116). One comparison that always proved to be statistically significant was between Avg-3ps and Avg-Sub. Previous studies within the Brazos River have proven that river discharge has significant impacts on the movement and diversity of nekton species, though most of these studies were conducted in the upper Brazos watershed (Zeug and Winemiller 2008). Proximity to the estuary likely affects the direct impacts of freshwater inflow on nekton communities and is more likely to be linked to indirect impacts due to the relationship of salinity with nekton communities and discharge. Larger sample sizes and greater seasonal representation for flow tiers would be required to definitively conclude if significant differences in community metrics between flow tiers exist or not.

For the beam trawl collections, the results of the nonparametric tests of the various community metrics appeared to be directly inverse of what was observed with otter trawl collections. Every metric tested proved to be significantly different between seasons, with summer always having the lowest median value and being significantly different from winter and spring (Table 89; Table 95; Table 101; Table 107; Table 113; Table 119). Shannon-Weiner diversity, Shannon evenness, and Margalef richness exhibited significant differences between different sites for beam trawl collections, though in each case, the only significantly different comparison was B01 and B42 (Table 100; Table 106; Table 112; Figure 68; Figure 69; Figure 70). This could be a result of having uneven sample sizes since B42 was not sampled during the current study. However, given the huge disparity of salinity between those two sites and the negative correlation exhibited between beam trawl community metrics and salinity, this significant difference detected is likely still valid. In addition, beam trawl community metrics exhibited no significant differences between flow tiers except for the test on species richness. However, there was only one significant comparison in this case- Avg-3ps and Wet-Sub- and the results of this comparison could likely be explained by the fact that none of the samples taken during the Avg-3ps occurred during the winter season as was the case with Wet-Sub. This likely resulted in an imbalance between median species richness that ultimately led to the conclusion drawn from the significant p-value (Table 96; Figure 67). However, it is also worth noting that none of the flow tiers had equal representation among the different seasons (Table 2). If imbalance of seasonal representation could explain significant differences detected between flow tiers for beam trawl community metrics, then the results should have yielded more significant comparisons between flow tiers. This would have been especially true for flow tiers with larger sample sizes for the summer season like Wet-2ps; the summer season proved to be significantly different from the winter and spring season for every community metric tested among the beam trawl communities (Table 2; Figure 37; Figure 40; Figure 44; Figure 45; Figure 47; Figure 48). Since there were so few statistically significant comparisons between flow tiers despite the unequal sample sizes of seasons, this suggests that the adopted flow tier standards by TCEQ are useful for assessing nekton community health.

The significant differences observed between season are no doubt linked to the life cycle of many marine fish species native to the GOM. Fish such as Gulf Menhaden and Atlantic Croaker spawn during late summer in oligotrophic waters offshore in order to avoid offspring predation (Pattillo et al. 1997). After hatching at the end of summer to early winter, the larval fish journey back towards shore to seek shelter and food in estuaries, salt marshes and wetlands (Soto et al. 1998). The season with the peak recruitment of the previously mentioned fish species occurs during the winter, and this was quite apparent when the catch data for each species was classified by season (Miller 2014; Pattillo et al. 1997; Soto et al. 1998; Swanson 2019).

Conclusions and Recommendations

The estuary of the Brazos River has continued to prove to be a highly dynamic and variable ecosystem within the upper Texas coast. The analysis of daily average discharge has revealed the normal patterns of variation in hydrology that are needed in order to meet nutrient requirements, and how the last decade of sampling within the river has diverged from the normal patterns of variation (Engle et al. 2007; Orlando et al. 1993). The extreme flow event analysis is indicative that the frequency of extreme events like drought and flooding is becoming higher than it was in previous decades, and these events are not limited to any single month, season, or year. The Kruskal-Wallis test proved useful in confirming that median freshwater inflow is typically higher in the first half of the year from late winter to late spring, while the latter half of the year experiences lower daily average discharge likely due to decreased precipitation until the advent of winter. However, when comparing variation within seasons during the sampling history, it was clear that hydrological input for the Brazos River has not been consistent in recent years. As variation in river discharge on annual and seasonal scales becomes more disruptive and erratic as time progresses, the need for greater oversight of water management and flow monitoring will likely become greater. Continued monitoring of river discharge both within the estuary and from the USGS gage are recommended in order to confirm the plausibility of increased extremity of high and low flow events.

The linear model of daily average discharge with field discharge using a hydroboard-mounted ADCP also proved that despite the distance upstream from the mouth, the usage of automated data from USGS gage #08116650 is very useful and accurate for predicting flow directly above TCEQ segment 1201. However, since there is a shortage of field discharge readings above 15,000 cfs, it would be advisable to attempt more field measurements during greater discharge events in order to determine if such events negatively impact the strength of the correlation- particularly during high magnitude pulse events (Figure 60).

The use of daily average discharge data from the USGS gage also proved useful in predicting daily average salinity, temperature, DO and depth at the continuous sites. Alternative methods for deploying the HOBOs should be investigated more thoroughly in order to minimize data removal due to burial by sediment. The results of the linear modeling of field discharge with daily average discharge and continuous discharge also suggests that the use of continuous flow data could be used for predicting continuous data from the HOBOs and TROLLs as was initially contrary to what was hypothesized. Another suggestion for future use of this data could be systematic classification of the variables for each measurement taken. Classification could include flow tier, as well as determining if observed conditions are indicative of unfavorable environmental quality such as hypoxia. This data sorting could then be used to determine how frequent such events are, and if they are gradually becoming more frequent and/or severe.

This high degree of variation in flow can prove troublesome for the ecology in the estuary- where all the freshwater inflow ends up. The results of the two-way ANOVAs indicated that variation in flow tier yields significant differences for every water quality variable that was measured in the field. This also proved to be the case in spatial variation between sites- with the only exception being temperature. The most significant result from the parametric tests was the conclusion that spatial variation and flow tier exhibit an interactive effect for variation in mean pH and salinity. This interaction effect has been detected in previous studies despite using a more limited sample size of data

(Bonner et al. 2017; Bonner et al. 2015). This interaction effect is important for consideration when performing any ecological study in the Brazos estuary due to the high number of significant correlations that salinity exhibits with nekton community metrics and other environmental variables (Figure 31; Figure 32). The behavior of the halocline in the estuary its relationship with freshwater inflow is the backbone of the estuarine ecosystem, and at least merits continuous monitoring through the usage of HOBOs. However, because it has been established that the variation in salinity is dependent on both distance from the river mouth and the flow tier, the current protocol of performing depth-interpolated profiles at several areas of TCEQ segment 1201 is necessary in order to properly monitor these changes.

The nekton community analyses indicated that flow tier does account for some of the variation observed in diversity, though these observations are few and likely limited by the small and uneven sample sizes for each flow tier. Spatial variation was shown to have the greatest impact on nekton occupying the deeper sections of the river- likely related to utilization of the estuary for food sources, salinity levels, and marine predator avoidance. Spatial variation is indirectly linked to river discharge because it involves the variation in salinity as distance from the mouth changes- which discharge has a direct correlation with (Figure 31; Figure 32). Seasonal variation accounted for the trends observed in the juvenile and larval nekton communities occupying the shallow waters adjacent to the banks. This is reflective of the life cycle of many marine fishes in the Gulf of Mexico; reaching adulthood in estuaries, spawning offshore during late summer, and the juvenile fish swimming upriver during winter and spring in order to mature in an environment with greater habitat diversity and nutrient supply. Season may control the input of larval and juvenile nekton species, but the results of the Pearson correlation analysis prove that salinity is still critical in the ecology of these communities (Figure 31;

Figure 32). One sample method suggested in the original proposal for the current study was to use seine nets to sample tidal creeks connected to the lower Brazos near B01. It is highly advisable to attempt this method in future research of the Brazos estuary as the costs of performing seine collections in a smaller region would likely be lower than the extensive and widespread sampling conducted since 2012. In addition, this form of sampling could also be useful in determining the movement of larval fish during high flow events. Since the tidal creeks are somewhat separated from the main current of the Brazos River, it seems likely that in periods of extreme flow juvenile and larval fish would seek shelter from the deluges of increased discharge even during peak recruitment periods. The relative isolation from the main current would also make sampling of nekton communities much safer and increase the threshold of river discharge that still allows technicians to perform nekton sampling.

The otter trawl collections performed in the GOM demonstrate that nekton communities are subject to spatial variation, just as they are in the river. Sites closer to the river mouth and upstream of the mouth had greater total catch and species richness (Table 29; Table 34). In order to conclude whether freshwater discharge can affect the distributions of nekton species, further sampling in required. If an additional site could be sampled from both downstream and upstream from the mouth, this could also increase the understanding of the effect sediment loading and river discharge has on nearshore communities. Continued sampling in the GOM would also be useful in determining the correlation between increased river discharge and periods of hypoxia in the nearshore waters. Biological sampling in both the river and nearshore GOM waters still merits continuation simply because the usage of identical methods spanning over four decades has proven that certain nekton species remain to be scientifically documented within the Brazos estuary (Table 29; Table 34).

One final topic for future study was the high abundance of the cymothoid ectoparasite *Cymothoa excisa* (Figure 62). These parasitic isopods are found throughout the Gulf of Mexico and the eastern coast of South America and are often known as "tongue-eating lice". The reason for this alias is their mode of parasitism; free-swimming adults invade the buccal cavity of a fish, and cause the tongue to atrophy due to prolonged feeding from the blood vessels at the base (Cook 2012). This parasite is known from a variety of host species captured in tropical waters representing at least six different families, including the most common species in the Brazos estuary and the entire Texas coast- the Atlantic Croaker (Joca et al. 2015). The distribution of this parasite and the range of hosts that it will infect is still poorly understood, and research of this parasite in Texas is extremely limited (Cook 2012). Although many studies have used Atlantic Croaker as a species of interest in the research of this parasite, the primary host in the Brazos River was the Star Drum. Beginning on July 31st, 2019, data on the presence of this parasite was added to the protocol in order to document the frequency of parasitism and the host species. The presence of this parasite was only detected at B01 and B10, with far greater abundances of both the parasite and evidence of parasitism occurring at B01. The three host species documented included Star Drum, Atlantic Croaker, and Silver Perch (*Bairdiella chrysoura*). Among the 24 replicate trawls performed at B01 and B10 from July 31st, 2019 and December 5th, 2019, 305 individuals were determined to have severed tongues, and 40 of these individuals still had at least one parasite present on the gill filaments or in the buccal cavity. This was an interesting development in the current study that unfortunately could not be given proper investigation due to the great importance and necessity of completing sampling for the Brazos River using outlined protocols. However, the scarcity of research on this organism was confirmed by early July 2019, and it was determined that if any data could be reported regarding this species, it could serve as the basis for any future research targeting the ecology of this intriguing marine parasite.

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Zeug, S., and K. Winemiller. 2008. Relationships between hydrology, spatial heterogeneity, and fish recruitment dynamics in a temperate floodplain river. River Research Applications 24(1):90-102.

APPENDIX A:

SUPPLEMENTARY PHOTOS

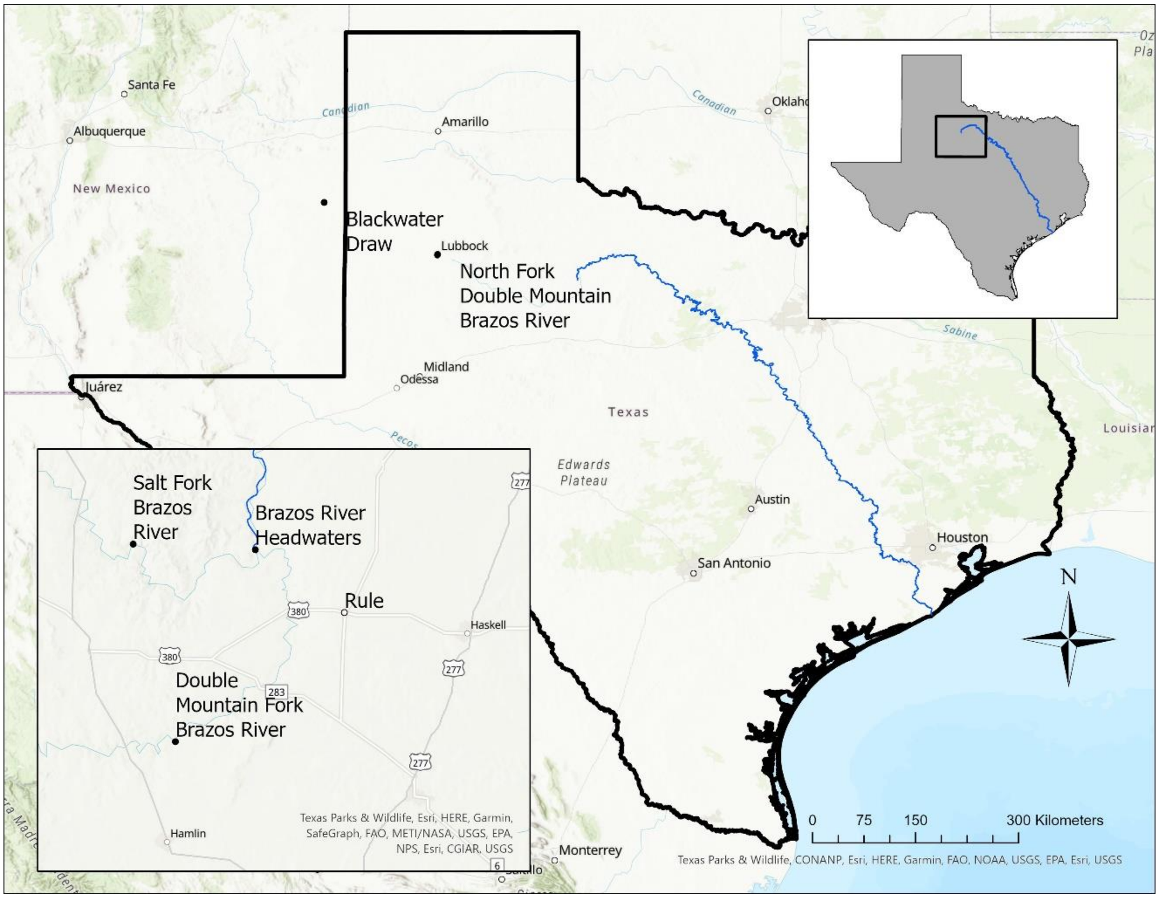


Figure 51. Map of Texas showing the route of the Brazos River from its headwaters near Rule, TX to the Gulf of Mexico near Freeport, TX. Although the Blackwater Draw and North Fork Double Mountain Brazos River flow directly into the headwaters, their flow is not continuous year-round, and therefore neither are officially recognized as headwaters.

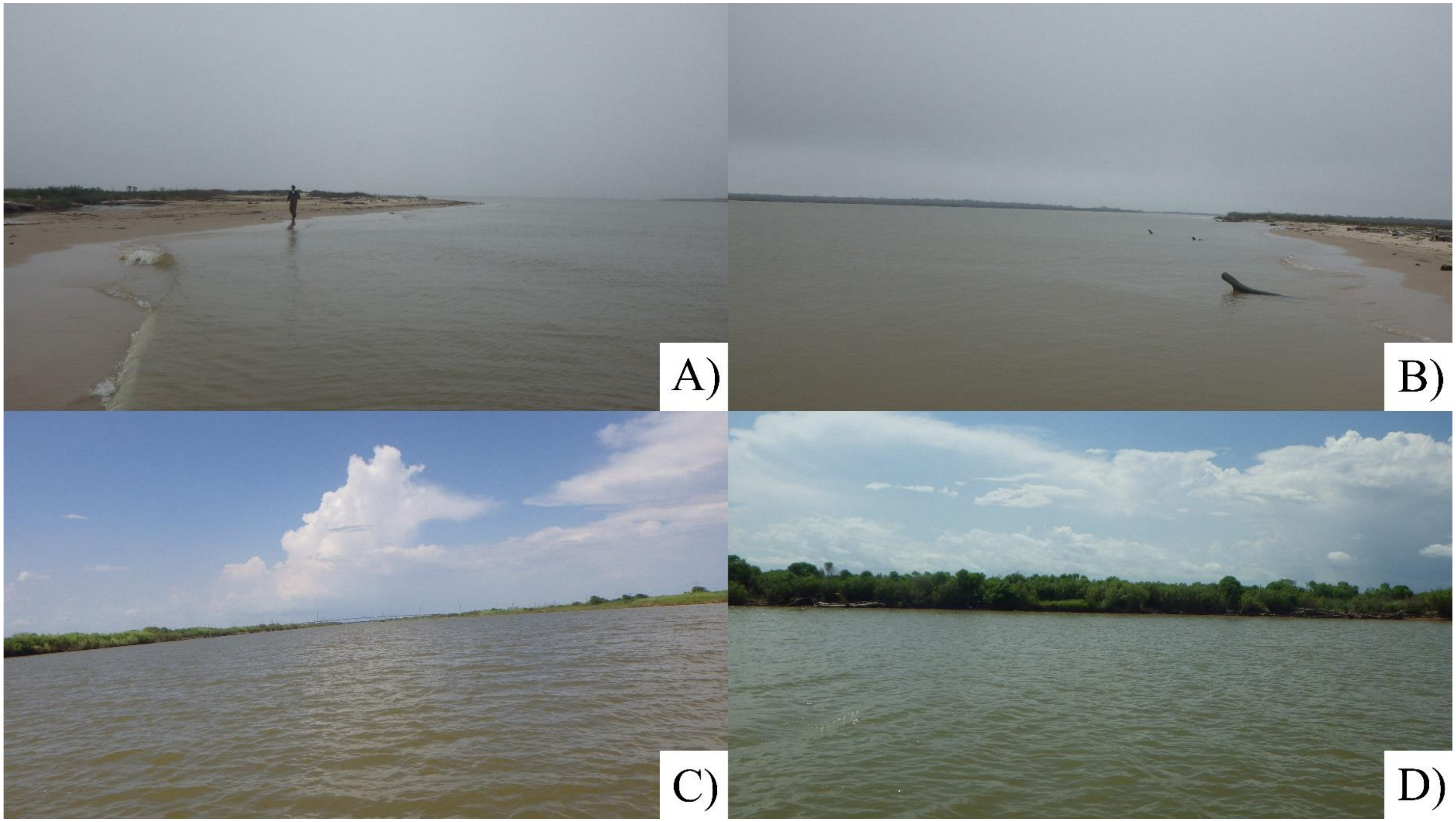


Figure 52. Site Collage of B01 and B05. A) Downstream view at B01 from left bank. B) Upstream view at B01 from left bank. C) Upstream view at B05. D) Right bank at B05.

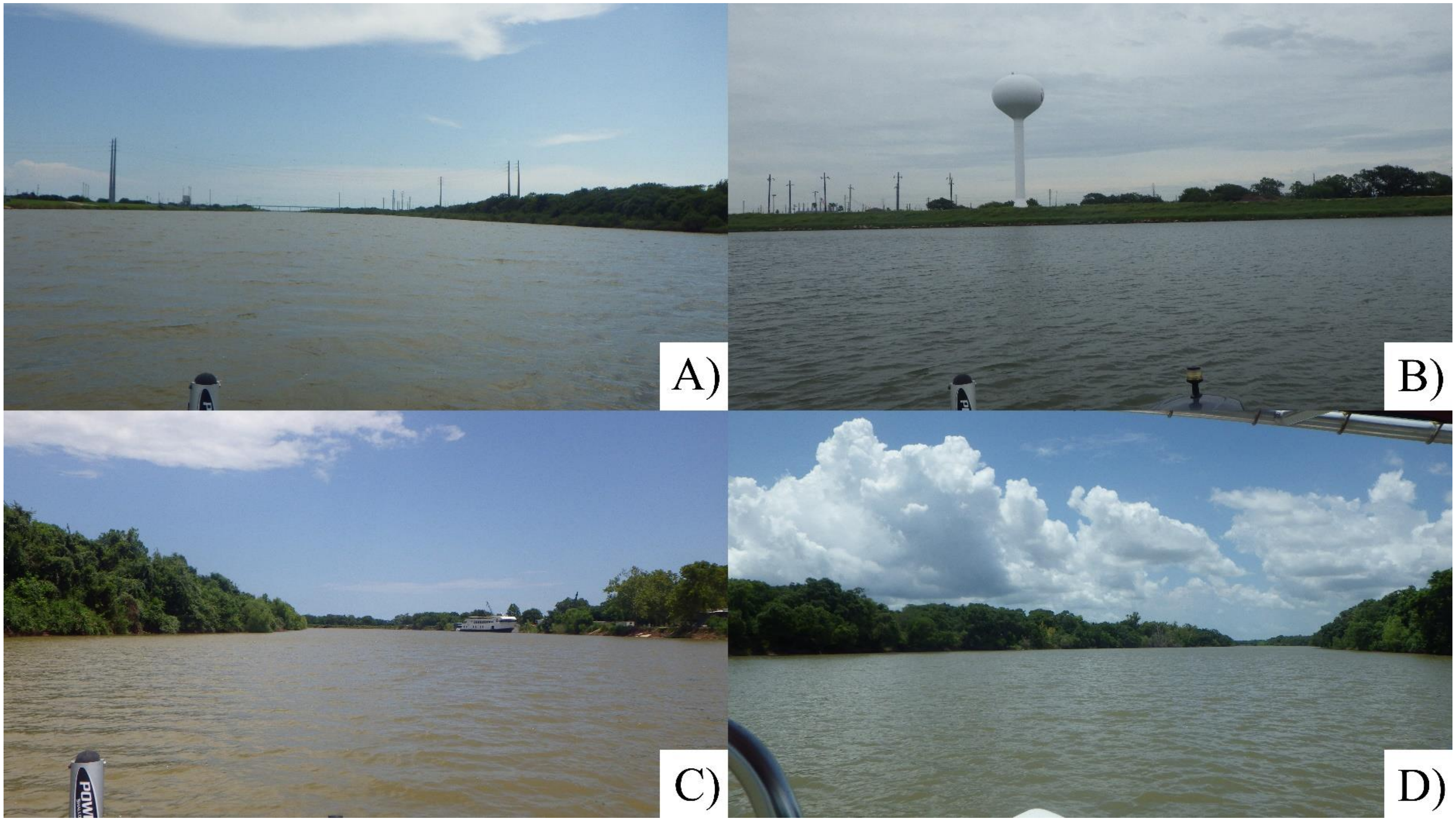


Figure 53. Site collage of B10 and B15. A) Downstream view at B10. B) Left bank at B10. C) Downstream view at B15. D) Upstream view at B15.

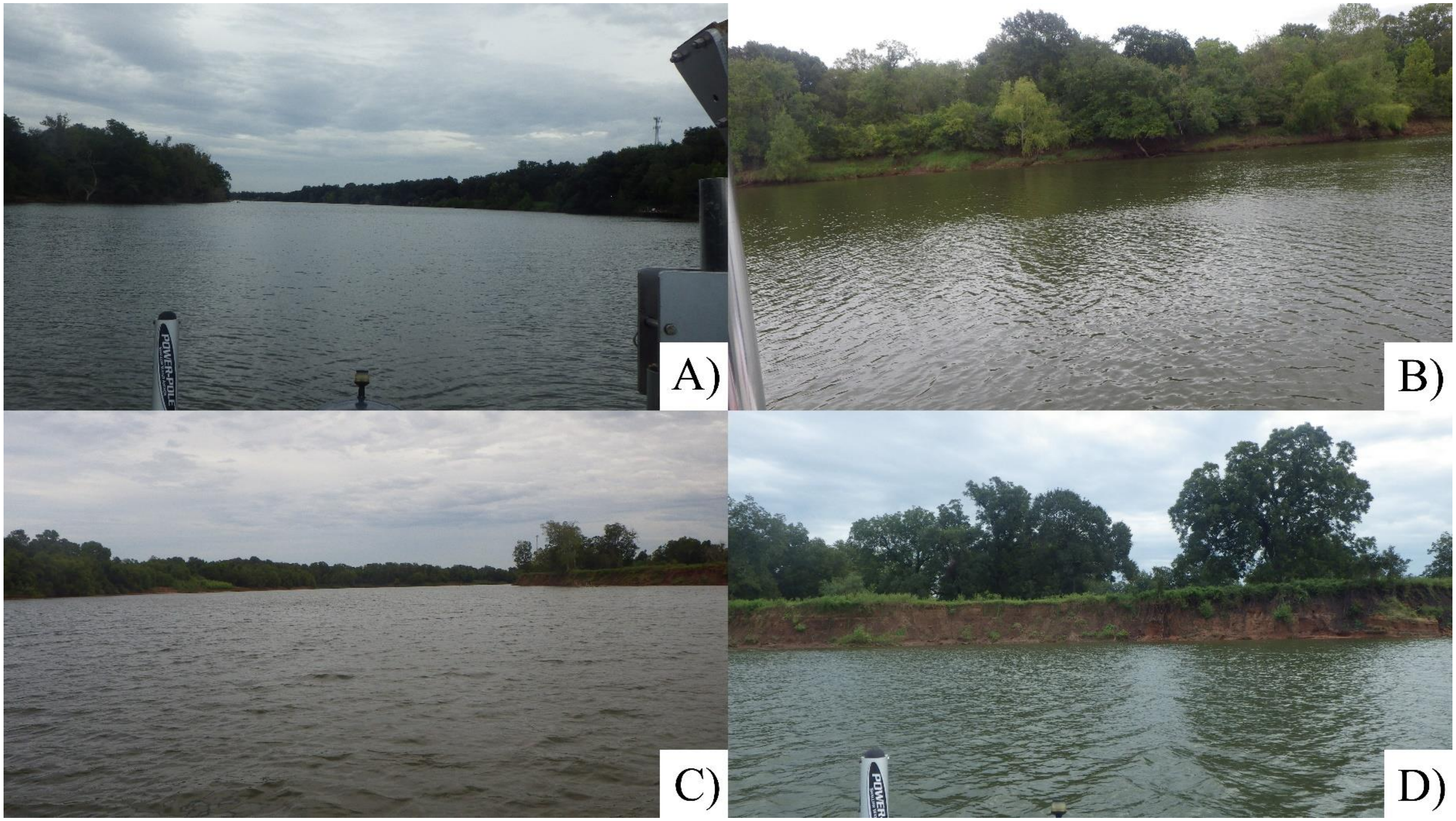


Figure 54. Site collage of B22 and B25. A) Downstream view at B22. B) Right bank at B22. C) Downstream view at B25. D) Right bank at B25.

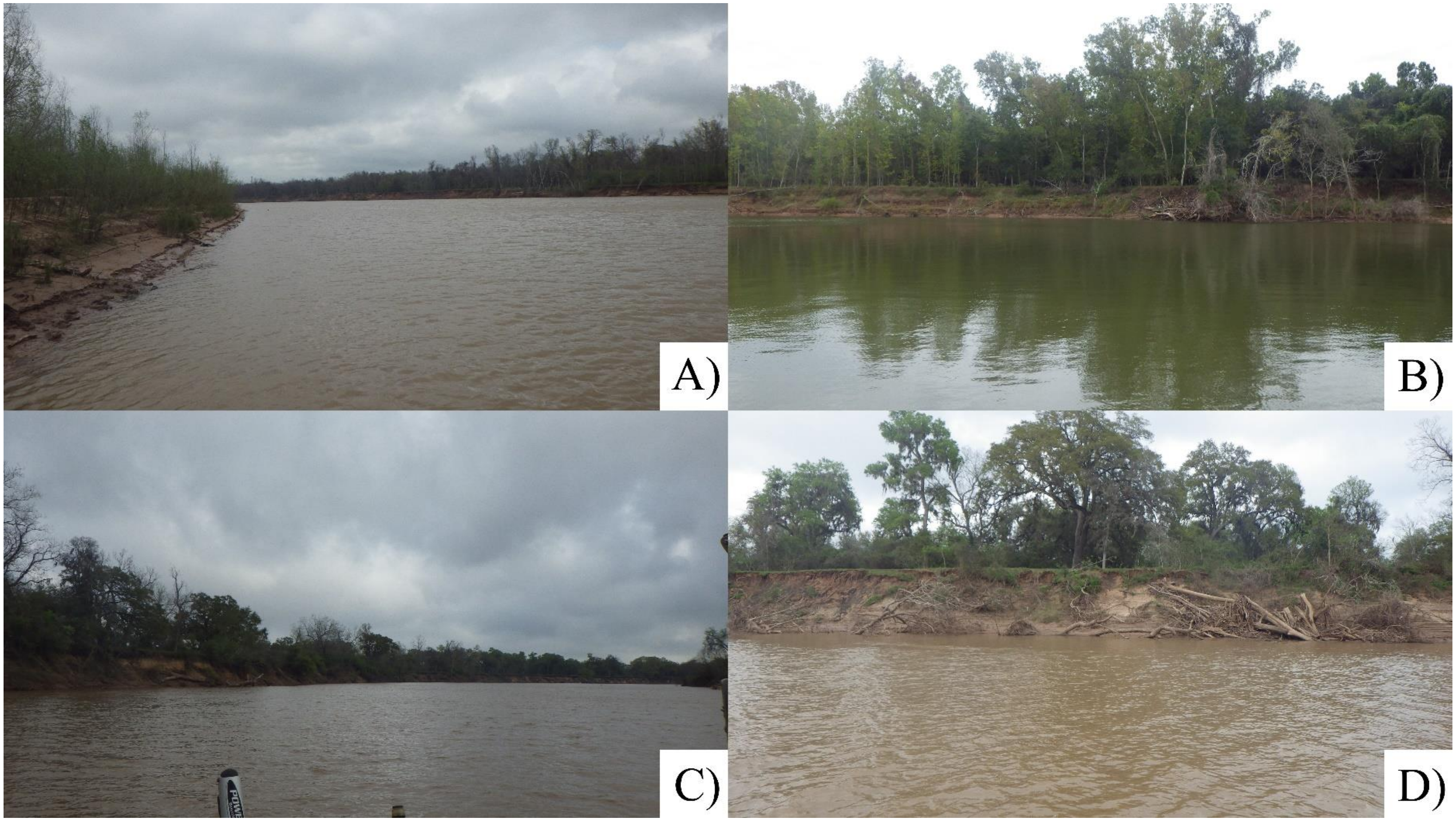


Figure 55. Site Collage of B31 and B36. A) Upstream view at B31 from right bank. B) Left bank at B31. C) Downstream view at B36. D) Left bank at B36.

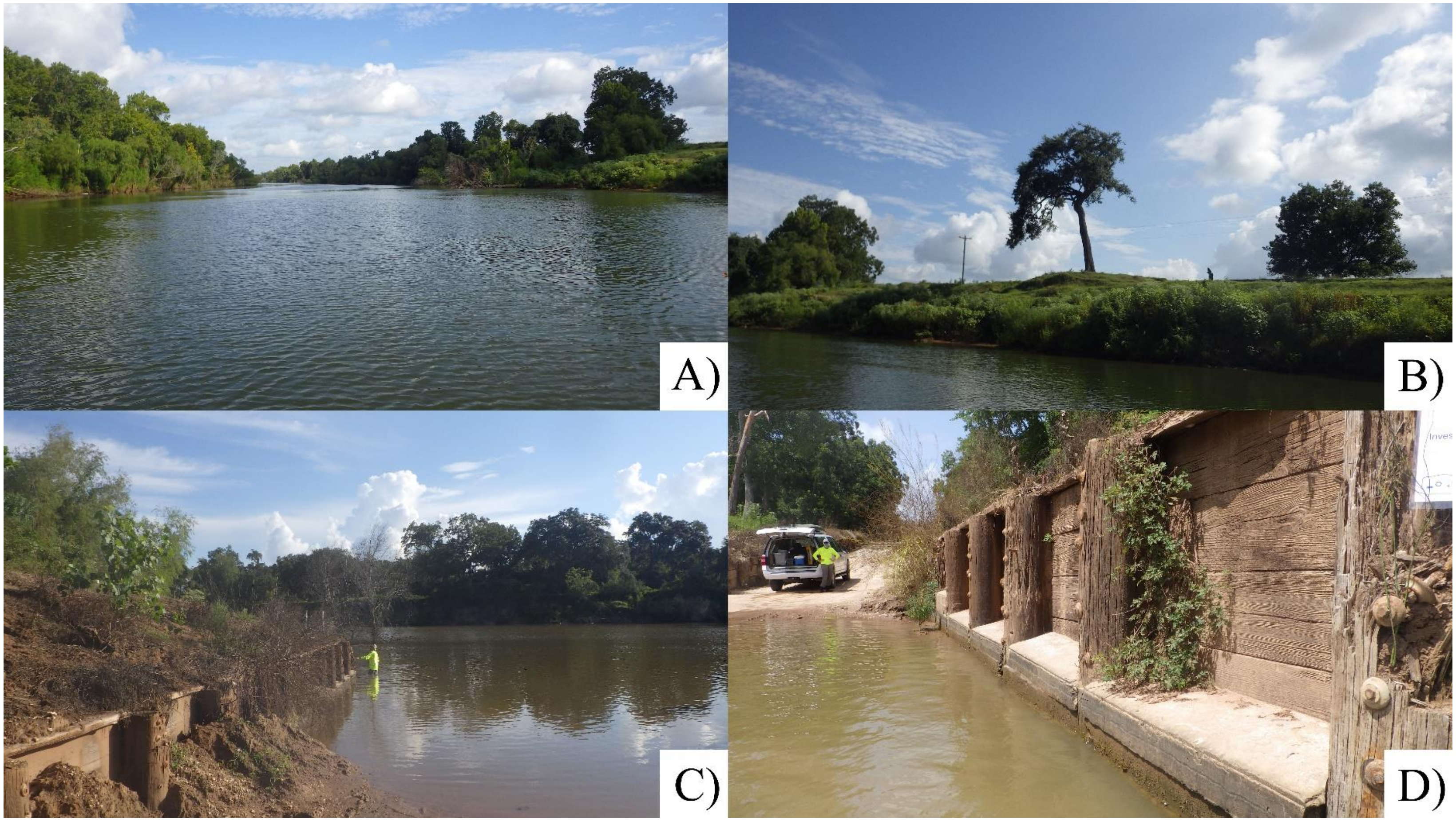


Figure 56. Site Collage of B42 and Upper site. A) Upstream view at B42. B) Left bank at B42. C) Taking side-by-side sonde readings at Upper site. D) View of boat ramp at Upper site from river.

Figure 57. Lower and Middle Site Collage. A) View of boat ramp at Middle site. Taking side-by-side readings at B) Middle site and D) Lower site. View of boat ramp at Lower site.

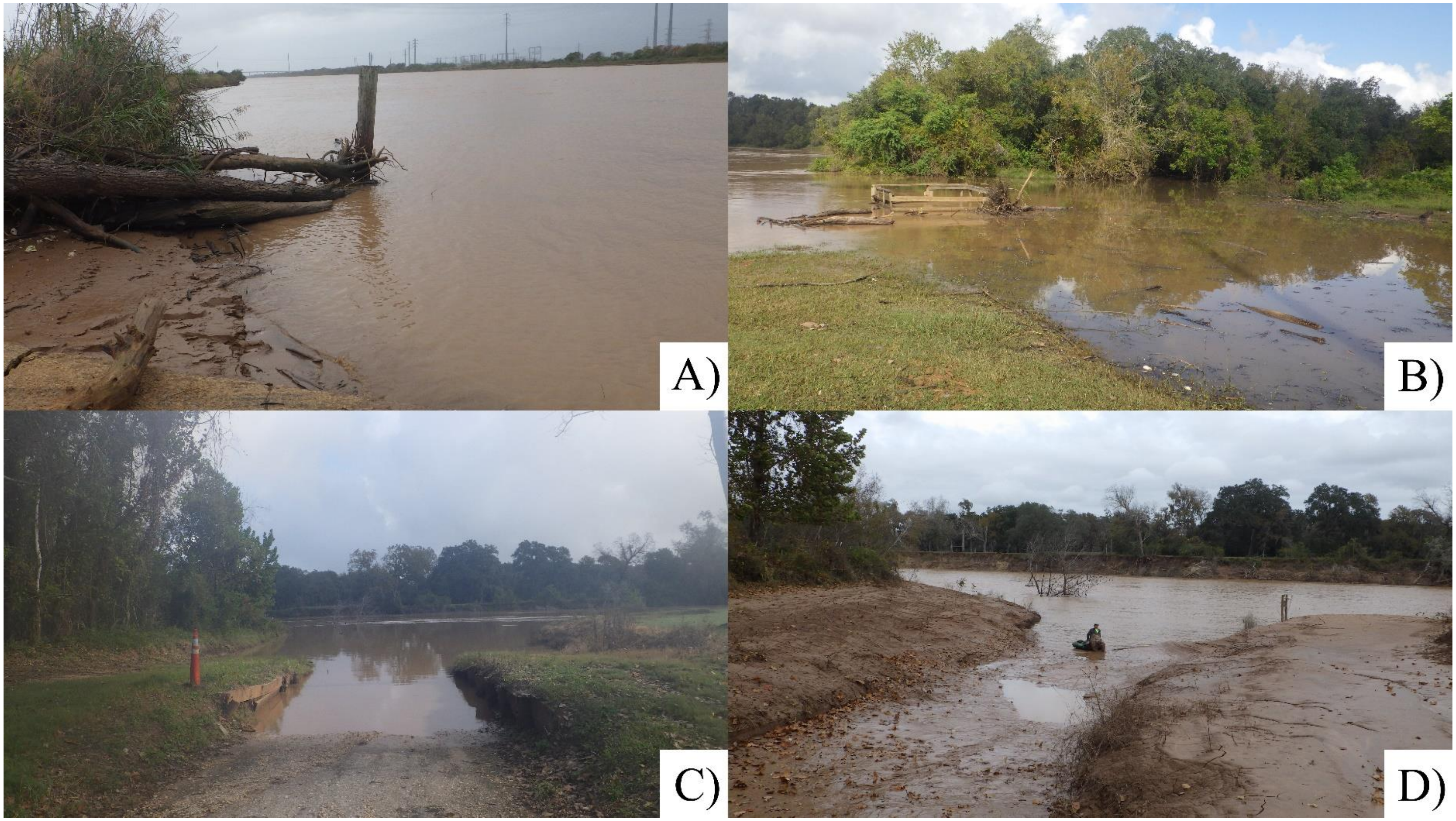


Figure 58. Site collage of continuous sites at flood stage between October 2018 and February 2019. A) Lower site on 11/29/2018. B) View of submerged boat ramp at Middle site on 11/06/2018. C) View of submerged boat ramp at Upper site on 11/06/2018. View of buried boat ramp at Upper site on 11/29/2018 after water levels had dropped.

Figure 59. Time lapse photos from Lower (Bottom) and Middle (Top) game cameras between 10/14/18 to 10/16/18. Timestamps at the bottom of the photos are one hour behind actual time. Discharge values in the top left show what was recorded at USGS gage #08116650 at the time the photo was taken.

Figure 60. Time lapse photos from Lower (Bottom) and Middle (Top) game cameras between 10/18/18 to 10/23/18. Timestamps at the bottom of the photos are one hour behind actual time. Discharge values in the top left show what was recorded at USGS gage #08116650 at the time the photo was taken.

Figure 61. Example photo vouchers of common nekton species found in the Brazos estuary.

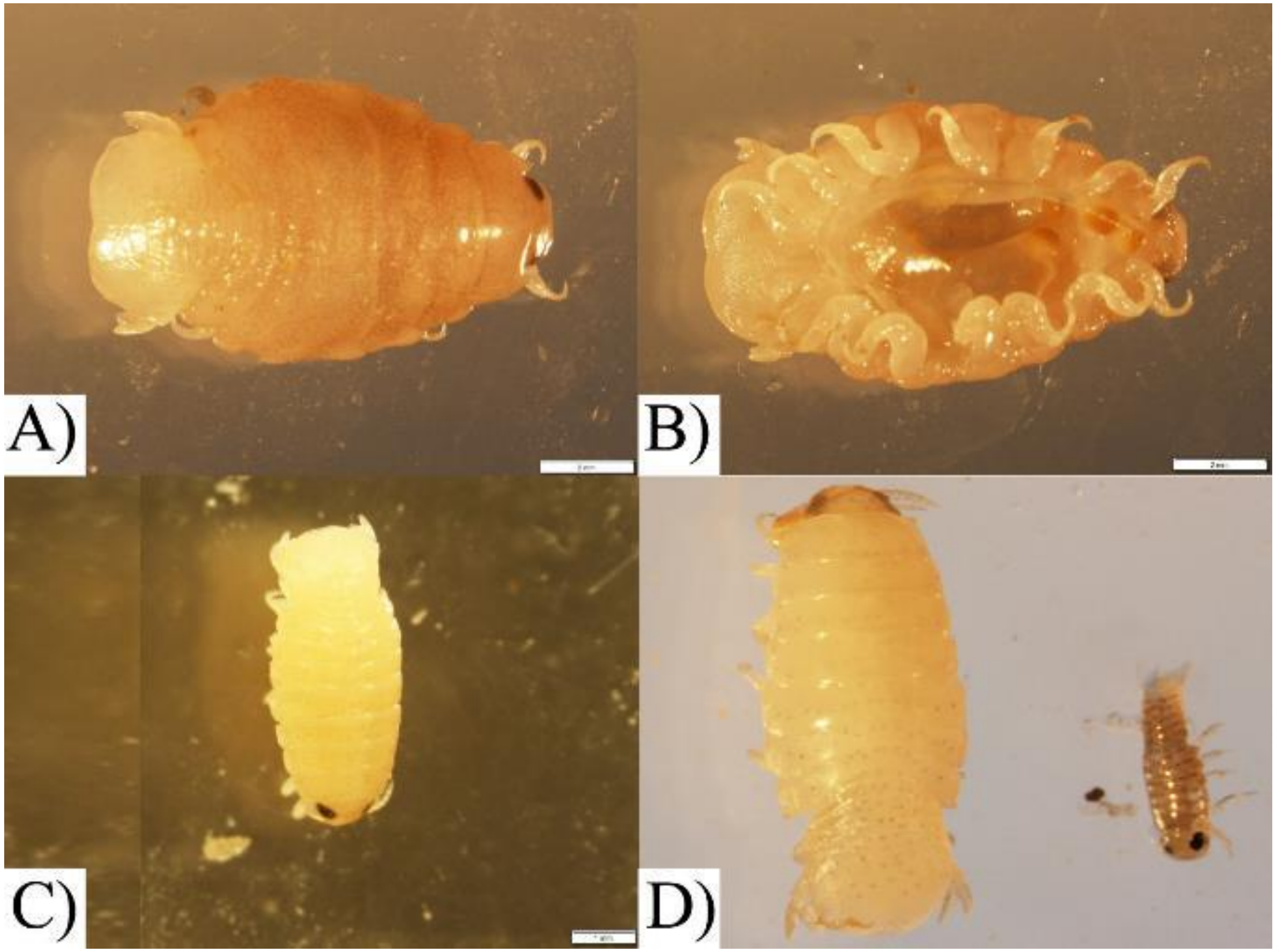


Figure 62. Microscopic imagery of Cymothoa excisa- a common ectoparasitic isopod extracted from the oral and gill cavities of Star Drum during the current study. Mature female dorsal view (A) and ventral view (B). (C) Mature male dorsal view. (D) Dorsal view of an intermediate female (left) and juvenile (right).

APPENDIX B:

SITE LOCATIONS

Table 5. Sampling sites including approximate distance from mouth (RKM; + upstream; - downstream into Gulf of Mexico), GPS coordinates and site type- refer to Table 1 for site type definitions.

Site	RKM	Latitude	Longitude	Site Type
G03	-3	28.8457	-95.3709	Primary
G02U1	-3	28.86508	-95.3582	Secondary
G02D1	-3	28.85212	-95.3866	Secondary
G02	-2	28.85813	95.37266	Primary
G01U3	-4	28.89297	-95.3338	Secondary
G01D3	-4	28.85201	-95.4169	Secondary
G01U1	-2	28.8751	-95.3616	Tertiary
G01D2	-3	28.84946	-95.4002	Secondary
G01D1	-2	28.8628	-95.388	Tertiary
G01	-1	28.86862	-95.3758	Primary
B01	1	28.88368	-95.38227	Primary
B05	5	28.92592	-95.38534	Secondary
Lower[a]	10	28.96457	-95.37428	Continuous
B10	10	28.96682	-95.37464	Primary
B15	15	28.98117	-95.41979	Secondary
B22	22	29.00908	-95.45314	Primary
Middle[b]	25	29.03151	-95.47712	Continuous
B25	25	29.02987	-95.48269	Secondary
B31	31	29.03473	-95.50422	Primary
Upper[a]	36	29.04816	-95.53421	Continuous
B36	36	29.04785	-95.53343	Secondary
B42	42	29.07288	-95.57167	Secondary[c]

[a] First utilized in Bonner et al. 2017; listed coordinates reflect current study as they were different in previous sampling years.
[b] First utilized in Bonner et al. 2015; listed coordinates reflect current study as they were different in previous sampling years.
[c] B42 was a primary site prior to current study but was downgraded to a secondary site due to previous studies showing low abundances of estuarine nekton. Grab samples were still collected at B42 in addition to vertical water quality profile readings.

APPENDIX C:

DATA SOURCES

Table 6. Automated data sources for hydrology and meteorology utilized for current and previous studies.

Data Acquired	Agency	Station ID	Source and Comments
Local weather forecast, daily precipitation	Weather Underground	KTXLAKEJ79	Lake Jackson, TX Weather Conditions | Weather Underground (wunderground.com)
Water Level and Tidal Height	National Oceanic and Atmospheric Administration (NOAA)	8772447 Tide Gage at Freeport, TX	Station Home Page - NOAA Tides & Currents *This station was taken offline at 18:45 on May 24, 2020. Station 8772471 was used for tide data in the event station 8772447 was unavailable.*
Annual, Monthly, Daily, and quarter-hourly discharge	United States Geological Survey (USGS)	08116650 Brazos River near Rosharon, TX	USGS Current Conditions for USGS 08116650 Brazos Rv nr Rosharon, TX
Monthly Palmer Hydrological Drought Index (PHDI)	Texas Water Development Board (TWDB)	N/A	Water Data For Texas

APPENDIX D:

CONTINUOUS MONITORING GRAPHS

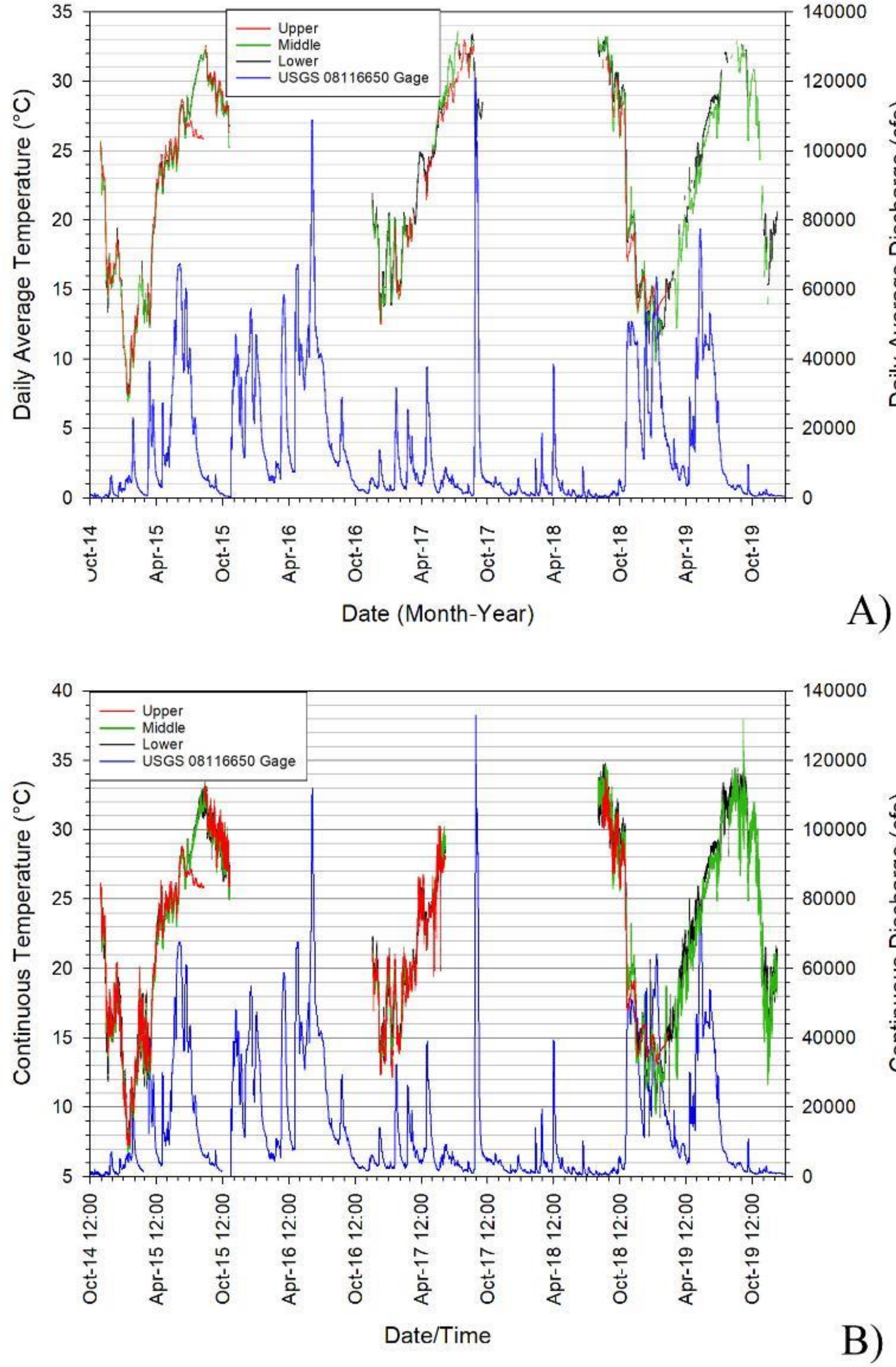


Figure 63. Time series graphs of temperature data and discharge data. A) Daily average data. B) Continuous data.

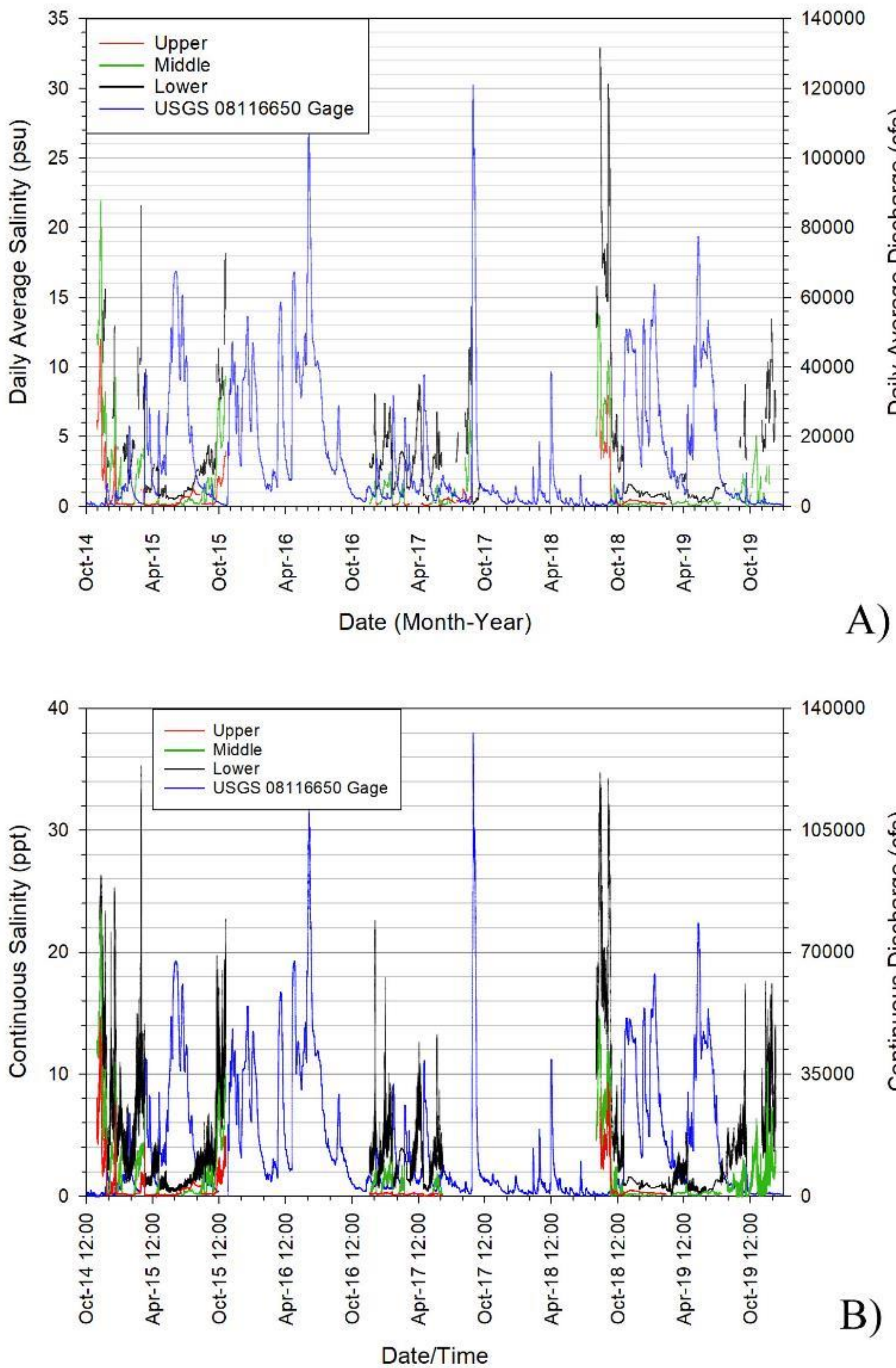


Figure 64. Time series graphs of salinity data and discharge data. A) Daily average data. B) Continuous data.

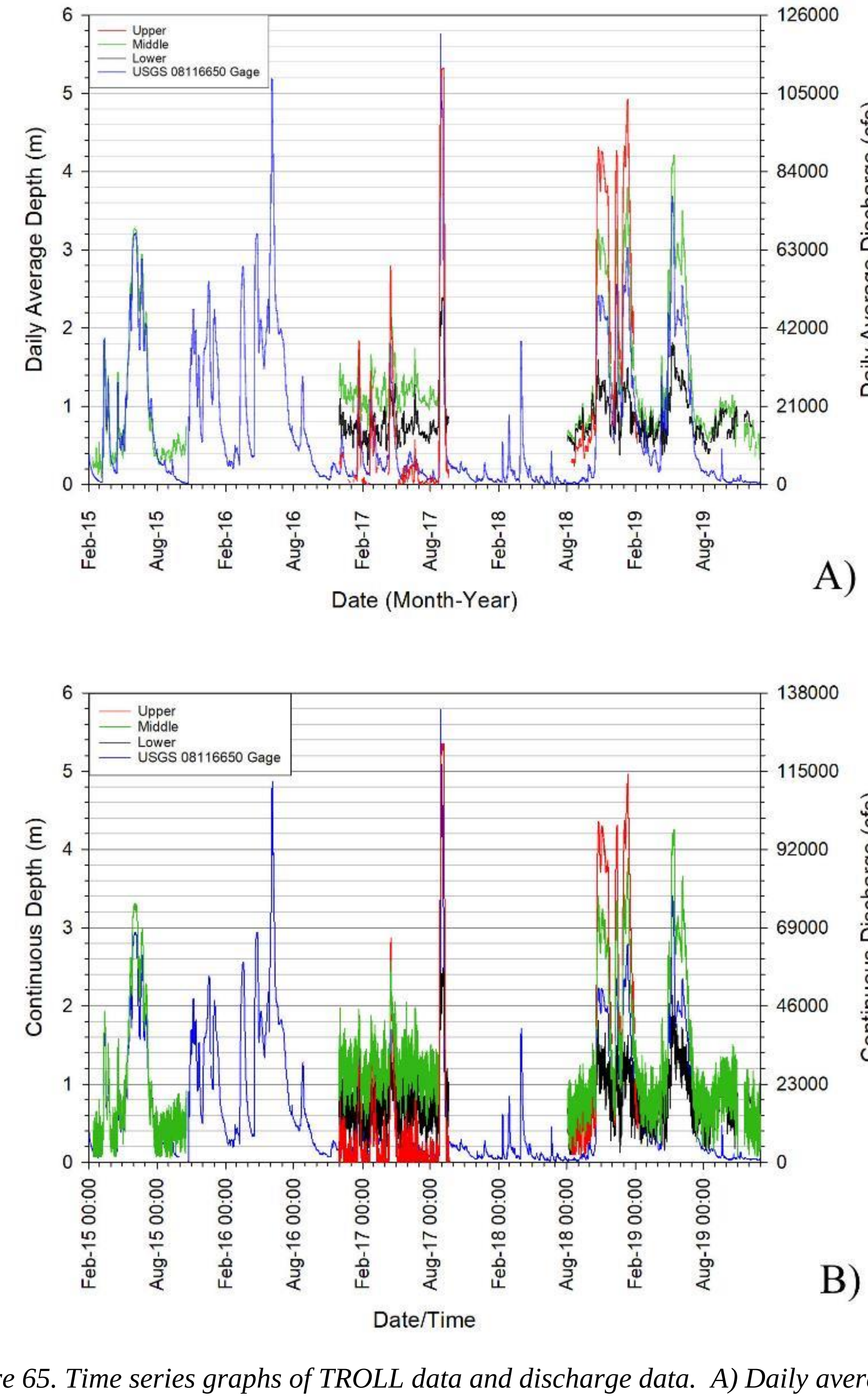
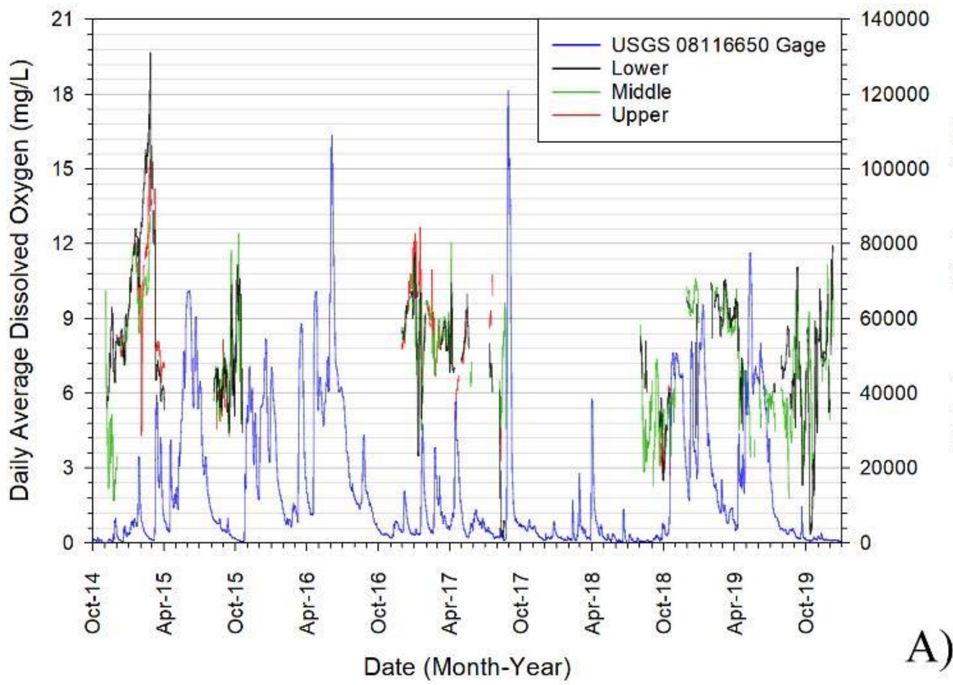


Figure 65. Time series graphs of TROLL data and discharge data. A) Daily average data. B) Continuous data.



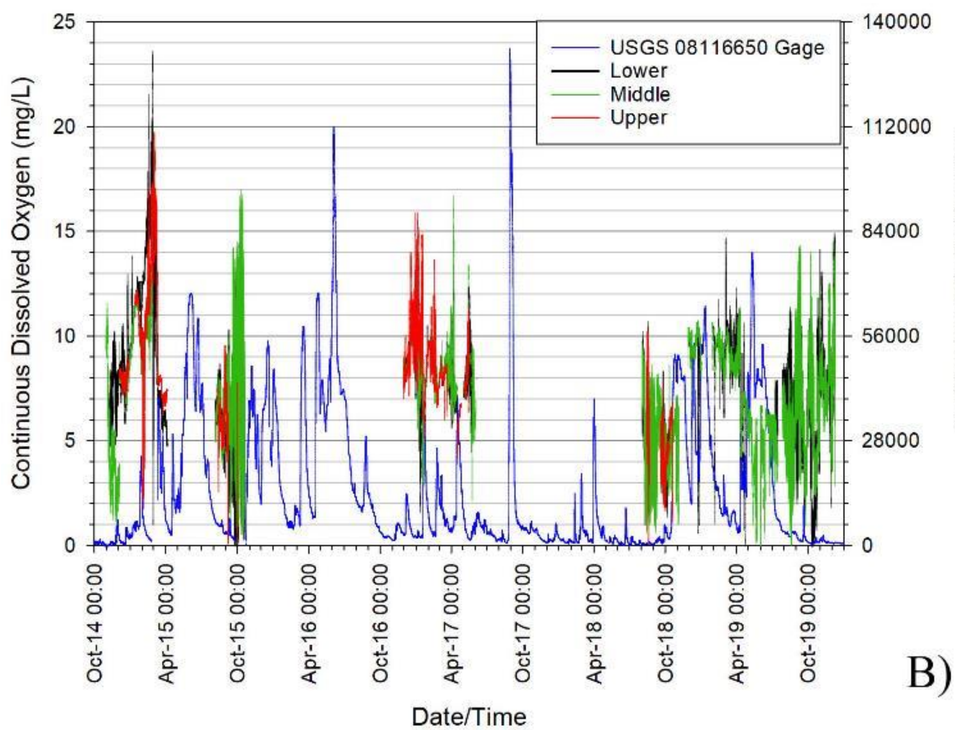


Figure 66. Time series graphs of dissolved oxygen data and discharge data. A) Daily average data. B) Continuous data.

APPENDIX E:

SUMMARY STATISTICS FOR WATER QUALITY PROFILE

Table 7. Summary statistics of water quality for each site at the surface, bottom, and combined depth profiles.

		Surface		Bottom		All	
Variable	**Site**	**Mean**	**SE Mean**	**Mean**	**SE Mean**	**Mean**	**SE Mean**
Temperature (°C)	B01	23.26	1.21	22.82	1.21	23.032	0.537
	B05	23.59	1.21	23.33	1.20	23.507	0.536
	B10	23.56	1.24	23.92	1.17	23.805	0.536
	B15	23.46	1.28	24.66	1.23	24.058	0.558
	B22	23.47	1.28	24.58	1.19	23.888	0.551
	B25	23.40	1.27	23.81	1.22	23.488	0.555
	B31	23.45	1.29	23.62	1.27	23.479	0.562
	B36	23.34	1.29	23.39	1.29	23.321	0.566
	B42	23.32	1.31	23.35	1.30	23.285	0.572
Salinity (psu)	B01	6.87	1.03	23.80	1.45	16.280	0.865
	B05	5.346	0.916	22.92	1.88	14.910	0.946
	B10	4.214	0.875	20.20	1.56	12.923	0.839
	B15	2.169	0.755	18.76	2.12	10.351	0.975
	B22	1.685	0.642	14.75	2.41	7.653	0.909
	B25	1.257	0.534	7.11	1.91	3.371	0.581
	B31	0.873	0.422	5.19	1.81	2.693	0.552
	B36	0.603	0.285	1.749	0.879	1.142	0.278
	B42	0.439	0.157	1.090	0.667	0.709	0.199
DO (mg/L)	B01	7.424	0.280	6.459	0.347	6.797	0.138
	B05	7.484	0.282	5.116	0.416	6.216	0.169
	B10	7.465	0.321	4.348	0.420	5.929	0.191
	B15	7.527	0.307	4.760	0.459	6.002	0.201
	B22	7.487	0.298	4.687	0.541	6.006	0.224
	B25	7.386	0.308	5.818	0.544	6.726	0.192
	B31	7.503	0.316	6.169	0.575	6.810	0.205
	B36	7.625	0.338	6.711	0.461	7.085	0.176
	B42	7.788	0.327	7.074	0.393	7.346	0.160
pH	B01	7.8552	0.0296	7.8978	0.0338	7.8656	0.0140
	B05	7.8548	0.0288	7.7863	0.0380	7.8048	0.0144
	B10	7.8696	0.0327	7.6511	0.0261	7.7411	0.0140
	B15	7.8633	0.0339	7.6004	0.0379	7.7180	0.0180
	B22	7.8496	0.0374	7.5615	0.0438	7.7012	0.0204
	B25	7.8081	0.0366	7.6663	0.0444	7.7499	0.0166
	B31	7.8230	0.0383	7.6922	0.0462	7.7559	0.0184

Variable	Site	Surface		Bottom		All	
		Mean	SE Mean	Mean	SE Mean	Mean	SE Mean
	B36	7.8130	0.0426	7.7185	0.0398	7.7557	0.0177
	B42	7.8130	0.0477	7.7407	0.0446	7.7678	0.0200
Turbidity (NTU)	B01	29.30	7.08	56.96	9.04	35.70	3.52
	B05	35.48	8.25	119.2	52.8	49.5	11.4
	B10	49.9	12.7	62.4	19.4	49.73	6.47
	B15	61.7	14.2	247	167	104.5	34.2
	B22	70.9	15.4	105.4	28.0	84.52	9.28
	B25	86.6	17.6	104.4	21.6	97.33	8.61
	B31	92.7	17.1	128.5	29.4	104.41	9.47
	B36	100.8	17.7	113.7	18.8	107.26	8.15
	B42	97.4	16.1	137.1	21.6	114.41	8.27
Total Depth (m)	B01	5.733	0.269	5.733	0.269	5.733	0.118
	B05	6.815	0.195	6.815	0.195	6.8152	0.0858
	B10	5.702	0.261	5.702	0.261	5.702	0.115
	B15	8.086	0.229	8.086	0.229	8.086	0.101
	B22	7.466	0.194	7.466	0.194	7.4659	0.0854
	B25	4.830	0.268	4.830	0.268	4.830	0.118
	B31	5.816	0.213	5.816	0.213	5.8155	0.0939
	B36	6.336	0.224	6.336	0.224	6.3357	0.0985
	B42	7.5174	0.0903	7.5174	0.0903	7.5174	0.0398
Secchi (m)	B01	0.2720	0.0260	0.2720	0.0260	0.2720	0.0114
	B05	0.2481	0.0295	0.2481	0.0295	0.2481	0.0129
	B10	0.2253	0.0287	0.2253	0.0287	0.2253	0.0126
	B15	0.2049	0.0359	0.2049	0.0359	0.2049	0.0157
	B22	0.1799	0.0290	0.1799	0.0290	0.1799	0.0128
	B25	0.1567	0.0291	0.1567	0.0291	0.1567	0.0127
	B31	0.1568	0.0293	0.1568	0.0293	0.1568	0.0129
	B36	0.1331	0.0210	0.1331	0.0210	0.13306	0.00915
	B42	0.1190	0.0164	0.1190	0.0164	0.11904	0.00723

Table 8. Summary statistics of water quality for each flow tier at the surface, bottom, and combined depth profiles.

Variable	Flow Tier	Surface		Bottom		All	
		Mean	SE Mean	Mean	SE Mean	Mean	SE Mean
Temperature (°C)	Avg-3ps	25.002	0.334	25.095	0.375	25.043	0.157
	Avg-Base	18.86	1.87	19.17	1.75	18.861	0.802
	Avg-Sub	20.770	0.742	21.488	0.800	21.138	0.348
	Wet-2ps	31.868	0.120	31.317	0.269	31.521	0.0905
	Wet-Base	23.578	0.778	23.570	0.769	23.533	0.343
	Wet-Sub	23.660	0.932	24.467	0.923	24.066	0.412
Salinity (psu)	Avg-3ps	1.032	0.218	5.87	1.36	3.411	0.450
	Avg-Base	1.961	0.445	13.99	2.51	7.830	0.926
	Avg-Sub	6.30	1.05	19.05	1.59	13.378	0.711
	Wet-2ps	1.531	0.449	13.89	3.46	7.69	1.24
	Wet-Base	1.231	0.203	10.04	1.48	5.367	0.500
	Wet-Sub	3.232	0.534	16.42	1.78	9.942	0.714
DO (mg/L)	Avg-3ps	6.700	0.106	6.122	0.201	6.4159	0.0739
	Avg-Base	8.618	0.248	6.451	0.616	7.505	0.226
	Avg-Sub	7.793	0.343	5.032	0.398	6.086	0.179
	Wet-2ps	6.632	0.139	5.189	0.373	5.822	0.136
	Wet-Base	7.632	0.185	6.181	0.319	7.010	0.109
	Wet-Sub	7.614	0.211	4.931	0.451	6.202	0.169
pH	Avg-3ps	7.6620	0.0148	7.6164	0.0215	7.6269	0.00786
	Avg-Base	7.7704	0.0521	7.5870	0.0418	7.6763	0.0204
	Avg-Sub	7.8767	0.0323	7.7071	0.0347	7.7713	0.0146
	Wet-2ps	7.8789	0.0413	7.7678	0.0433	7.8249	0.0185
	Wet-Base	7.8706	0.0124	7.7798	0.0253	7.8238	0.00855
	Wet-Sub	7.9584	0.0204	7.7142	0.0418	7.8288	0.0153
Turbidity (NTU)	Avg-3ps	122.2	16.0	178.9	25.7	141.69	8.75
	Avg-Base	81.6	11.2	122.3	43.3	87.32	9.90
	Avg-Sub	21.33	4.83	28.33	5.91	21.82	2.33
	Wet-2ps	74.3	17.6	124.5	29.1	99.9	10.7
	Wet-Base	88.36	9.55	191.0	69.1	114.5	14.6
	Wet-Sub	24.40	2.62	36.27	5.47	26.68	1.68
Mid-channel Total Depth (m)	Avg-3ps	6.377	0.250	6.377	0.250	6.377	0.111
	Avg-Base	5.766	0.225	5.766	0.225	5.7660	0.0990
	Avg-Sub	6.066	0.248	6.066	0.248	6.066	0.110
	Wet-2ps	7.224	0.256	7.224	0.256	7.224	0.112
	Wet-Base	6.893	0.162	6.893	0.162	6.8933	0.0718
	Wet-Sub	6.537	0.236	6.537	0.236	6.537	0.105

Variable	Flow Tier	Surface		Bottom		All	
		Mean	SE Mean	Mean	SE Mean	Mean	SE Mean
Secchi (m)	Avg-3ps	0.1562	0.0141	0.1562	0.0141	0.15616	0.00621
	Avg-Base	0.1611	0.0254	0.1611	0.0254	0.1611	0.0111
	Avg-Sub	0.3572	0.0322	0.3572	0.0322	0.3572	0.0142
	Wet-2ps	0.1179	0.0178	0.1179	0.0178	0.11793	0.00773
	Wet-Base	0.11403	0.00863	0.11403	0.00863	0.11403	0.00383
	Wet-Sub	0.2217	0.0172	0.2217	0.0172	0.22173	0.00762

Table 9. Summary statistics of water profile for site B01.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.18	1.24	6.43	11.87	24.53	31.80
	75.00%	22.88	1.22	6.32	11.16	24.49	30.84
	Bottom	22.82	1.21	6.30	11.13	24.46	30.86
	Middle	23.03	1.22	6.32	11.64	24.46	30.73
	Surface	23.26	1.21	6.29	12.38	24.03	31.59
Salinity (psu)	25.00%	11.03	1.38	7.20	1.80	8.72	27.59
	75.00%	22.40	1.57	8.16	1.80	24.19	34.87
	Bottom	23.80	1.45	7.55	1.79	25.02	34.01
	Middle	17.30	1.90	9.86	1.81	19.11	35.51
	Surface	6.87	1.03	5.34	1.82	6.13	27.60
DO (mg/L)	25.00%	6.783	0.317	1.646	2.960	6.580	9.580
	75.00%	6.674	0.290	1.508	3.790	6.530	9.170
	Bottom	6.459	0.347	1.801	1.560	6.630	9.090
	Middle	6.644	0.291	1.513	4.080	6.410	9.230
	Surface	7.424	0.280	1.454	5.280	7.130	10.400
pH	25.00%	7.8119	0.0290	0.1507	7.5200	7.8100	8.1200
	75.00%	7.9111	0.0329	0.1711	7.5800	7.9000	8.2400
	Bottom	7.8978	0.0338	0.1759	7.5700	7.9000	8.2400
	Middle	7.8522	0.0298	0.1549	7.5800	7.8200	8.1700
	Surface	7.8552	0.0296	0.1536	7.5900	7.8400	8.2100
Turbidity (NTU)	25.00%	31.39	7.58	38.64	1.00	16.05	165.20
	75.00%	31.00	6.99	35.63	1.80	21.35	169.80
	Bottom	56.96	9.04	46.10	-5.20	49.75	177.20
	Middle	29.86	7.62	38.87	0.60	16.10	164.80
	Surface	29.30	7.08	36.11	0.20	15.45	146.90
Total Depth (m)	Bottom	5.733	0.269	1.397	3.755	5.575	8.967
Secchi (m)	Surface	0.2720	0.0260	0.1349	0.0640	0.2740	0.6140

Table 10. Summary statistics of water profile for site B05.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.59	1.26	6.52	11.53	24.56	31.90
	75.00%	23.37	1.22	6.33	12.67	24.42	31.52
	Bottom	23.33	1.20	6.22	12.85	24.43	31.98
	Middle	23.66	1.20	6.24	12.14	24.40	31.69
	Surface	23.59	1.21	6.29	12.76	24.72	32.05
Salinity (psu)	25.00%	8.35	1.43	7.44	1.41	6.34	27.31
	75.00%	21.47	1.85	9.62	1.66	24.09	34.53
	Bottom	22.92	1.88	9.75	1.88	25.12	34.65
	Middle	16.46	1.96	10.17	1.51	19.70	33.11
	Surface	5.346	0.916	4.760	1.370	4.180	24.550
DO (mg/L)	25.00%	6.674	0.342	1.778	3.180	6.620	9.410
	75.00%	5.799	0.364	1.894	2.310	5.890	8.660
	Bottom	5.116	0.416	2.159	0.860	5.430	8.140
	Middle	6.005	0.328	1.703	2.760	5.900	8.890
	Surface	7.484	0.282	1.465	5.030	7.270	10.090
pH	25.00%	7.7830	0.0232	0.1205	7.5700	7.8000	8.0700
	75.00%	7.8326	0.0362	0.1883	7.3100	7.8300	8.1600
	Bottom	7.7863	0.0380	0.1972	7.2100	7.7800	8.1000
	Middle	7.7674	0.0322	0.1676	7.4200	7.8000	8.1000
	Surface	7.8548	0.0288	0.1498	7.5800	7.8300	8.1800
Turbidity (NTU)	25.00%	35.40	8.79	44.80	-0.90	17.05	166.20
	75.00%	27.34	9.24	47.14	0.10	11.00	187.20
	Bottom	119.2	52.8	269.0	-1.7	25.8	1196.5
	Middle	30.12	8.46	43.15	0.10	11.65	159.80
	Surface	35.48	8.25	42.07	-1.00	18.45	167.20
Total Depth (m)	Bottom	6.815	0.195	1.013	4.168	6.938	8.095
Secchi (m)	Surface	0.2481	0.0295	0.1218	0.0740	0.2490	0.5800

Table 11. Summary statistics of water profile for site B10.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.65	1.27	6.58	11.52	24.27	32.50
	75.00%	23.98	1.18	6.12	12.72	24.38	31.91
	Bottom	23.92	1.17	6.06	12.78	24.34	31.78
	Middle	23.92	1.23	6.40	12.47	24.33	33.16
	Surface	23.56	1.24	6.45	11.52	24.33	32.22
Salinity (psu)	25.00%	7.11	1.35	6.99	0.72	4.78	24.27
	75.00%	18.32	1.66	8.65	2.81	22.48	31.33
	Bottom	20.20	1.56	8.09	3.74	23.75	32.01
	Middle	14.77	1.70	8.82	1.27	15.92	30.45
	Surface	4.214	0.875	4.549	0.700	3.170	24.100
DO (mg/L)	25.00%	6.834	0.347	1.801	2.080	6.550	9.610
	75.00%	5.170	0.390	2.024	1.100	5.740	8.530
	Bottom	4.348	0.420	2.184	0.790	3.680	8.210
	Middle	5.829	0.381	1.980	1.240	6.000	8.850
	Surface	7.465	0.321	1.670	5.240	7.120	11.870
pH	25.00%	7.7956	0.0259	0.1346	7.5600	7.7700	8.0500
	75.00%	7.6852	0.0256	0.1332	7.3800	7.6900	7.9500
	Bottom	7.6511	0.0261	0.1357	7.3100	7.6700	7.9400
	Middle	7.7041	0.0267	0.1387	7.4200	7.7300	7.9800
	Surface	7.8696	0.0327	0.1697	7.5800	7.8600	8.2900
Turbidity (NTU)	25.00%	51.1	13.3	67.9	0.7	27.9	281.6
	75.00%	44.7	14.6	74.4	1.6	16.4	299.0
	Bottom	62.4	19.4	97.2	-4.8	31.2	434.2
	Middle	41.0	12.3	62.7	-0.6	13.9	233.9
	Surface	49.9	12.7	65.0	0.8	26.0	287.3
Total Depth (m)	Bottom	5.702	0.261	1.355	3.037	5.607	8.291
Secchi (m)	Surface	0.2253	0.0287	0.1491	0.0420	0.1800	0.6380

Table 12. Summary statistics of water profile for site B15.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.39	1.28	6.63	10.72	23.96	32.31
	75.00%	24.66	1.24	6.43	13.11	23.90	33.51
	Bottom	24.66	1.23	6.39	13.48	23.90	33.45
	Middle	24.11	1.29	6.71	10.70	23.90	33.37
	Surface	23.46	1.28	6.64	10.98	24.21	32.53
Salinity (psu)	25.00%	3.31	1.03	5.34	0.14	1.13	20.10
	75.00%	17.07	2.17	11.26	0.14	22.42	32.34
	Bottom	18.76	2.12	10.99	0.14	23.42	32.98
	Middle	10.45	2.18	11.33	0.14	4.79	30.51
	Surface	2.169	0.755	3.926	0.140	0.950	20.070
DO (mg/L)	25.00%	6.745	0.367	1.906	2.700	6.520	9.740
	75.00%	5.030	0.457	2.377	0.360	4.830	9.280
	Bottom	4.760	0.459	2.385	0.430	4.650	9.280
	Middle	5.950	0.431	2.242	0.750	5.950	9.520
	Surface	7.527	0.307	1.596	5.370	7.200	11.050
pH	25.00%	7.7863	0.0322	0.1674	7.5200	7.7800	8.0800
	75.00%	7.6304	0.0370	0.1922	7.2100	7.6700	8.0100
	Bottom	7.6004	0.0379	0.1971	7.1900	7.6500	8.0400
	Middle	7.7096	0.0388	0.2015	7.2100	7.7200	8.0600
	Surface	7.8633	0.0339	0.1760	7.5300	7.8500	8.2200
Turbidity (NTU)	25.00%	70.3	16.1	81.9	-3.0	40.6	324.7
	75.00%	71.4	23.9	122.0	-1.6	7.1	430.8
	Bottom	247	167	850	1	17	4362
	Middle	72.5	20.0	101.8	-1.8	26.6	371.8
	Surface	61.7	14.2	72.2	1.0	37.7	311.2
Total Depth (m)	Bottom	8.086	0.229	1.188	5.500	8.430	9.936
Secchi (m)	Surface	0.2049	0.0359	0.1480	0.0300	0.1500	0.6390

Table 13. Summary statistics of water profile for site B22.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.27	1.27	6.61	10.50	23.94	32.00
	75.00%	24.45	1.19	6.21	13.15	23.88	33.12
	Bottom	24.58	1.19	6.16	13.14	24.20	33.09
	Middle	23.68	1.29	6.70	10.52	23.88	32.98
	Surface	23.47	1.28	6.66	10.81	24.08	32.69
Salinity (psu)	25.00%	1.813	0.655	3.402	0.140	0.390	17.220
	75.00%	13.92	2.27	11.82	0.14	21.75	30.76
	Bottom	14.75	2.41	12.50	0.14	22.35	30.83
	Middle	6.10	1.81	9.39	0.14	0.59	29.40
	Surface	1.685	0.642	3.338	0.140	0.360	17.100
DO (mg/L)	25.00%	7.095	0.311	1.616	4.070	6.540	9.660
	75.00%	4.641	0.551	2.861	0.300	5.340	9.330
	Bottom	4.687	0.541	2.811	0.320	5.220	9.340
	Middle	6.120	0.490	2.548	0.270	5.930	9.390
	Surface	7.487	0.298	1.548	5.040	7.240	10.040
pH	25.00%	7.8115	0.0342	0.1776	7.5300	7.8000	8.1300
	75.00%	7.5604	0.0441	0.2289	7.1200	7.5700	7.9900
	Bottom	7.5615	0.0438	0.2274	7.1100	7.5700	8.0100
	Middle	7.7230	0.0378	0.1962	7.3900	7.7100	8.1400
	Surface	7.8496	0.0374	0.1946	7.5300	7.8500	8.1900
Turbidity (NTU)	25.00%	79.8	16.7	85.1	3.5	52.3	348.6
	75.00%	83.5	23.6	120.2	-3.9	18.1	439.5
	Bottom	105.4	28.0	142.7	-7.4	29.0	487.5
	Middle	83.0	18.6	94.7	-4.0	49.0	354.0
	Surface	70.9	15.4	78.3	-9.0	43.2	321.1
Total Depth (m)	Bottom	7.466	0.194	1.008	4.402	7.570	8.988
Secchi (m)	Surface	0.1799	0.0290	0.1504	0.0340	0.1420	0.7300

Table 14. Summary statistics of water profile for site B25.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.31	1.27	6.61	10.49	23.94	32.04
	75.00%	23.55	1.27	6.58	10.50	23.92	32.00
	Bottom	23.81	1.22	6.35	13.14	23.91	32.10
	Middle	23.38	1.26	6.54	10.45	23.93	31.94
	Surface	23.40	1.27	6.62	10.72	23.99	32.20
Salinity (psu)	25.00%	1.380	0.547	2.842	0.140	0.370	14.220
	75.00%	4.79	1.60	8.34	0.14	0.37	26.80
	Bottom	7.11	1.91	9.92	0.14	0.37	28.63
	Middle	2.316	0.953	4.955	0.140	0.370	22.050
	Surface	1.257	0.534	2.773	0.140	0.330	14.030
DO (mg/L)	25.00%	7.210	0.311	1.614	4.400	6.590	9.840
	75.00%	6.337	0.505	2.624	0.430	6.240	9.640
	Bottom	5.818	0.544	2.826	0.390	6.070	9.490
	Middle	6.876	0.383	1.991	1.840	6.550	9.750
	Surface	7.386	0.308	1.600	5.090	6.620	10.000
pH	25.00%	7.7937	0.0330	0.1717	7.5500	7.7600	8.1300
	75.00%	7.7185	0.0351	0.1825	7.3300	7.6900	8.0800
	Bottom	7.6663	0.0444	0.2307	7.2000	7.6500	8.0200
	Middle	7.7630	0.0311	0.1617	7.5100	7.7200	8.1000
	Surface	7.8081	0.0366	0.1899	7.5500	7.7600	8.1600
Turbidity (NTU)	25.00%	94.9	18.9	96.2	5.7	56.3	370.8
	75.00%	100.3	20.0	103.8	-1.4	58.4	402.8
	Bottom	104.4	21.6	112.1	-6.7	61.4	439.7
	Middle	100.0	19.1	99.3	0.5	60.0	394.0
	Surface	86.6	17.6	90.0	-6.7	53.4	356.8
Total Depth (m)	Bottom	4.830	0.268	1.394	3.042	4.402	7.558
Secchi (m)	Surface	0.1567	0.0291	0.1199	0.0200	0.1200	0.4610

Table 15. Summary statistics of water profile for site B31.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.35	1.28	6.63	10.48	24.02	32.38
	75.00%	23.59	1.27	6.62	10.45	24.14	32.37
	Bottom	23.62	1.27	6.60	10.45	24.35	32.36
	Middle	23.40	1.27	6.59	10.45	24.00	32.39
	Surface	23.45	1.29	6.69	10.47	24.14	32.70
Salinity (psu)	25.00%	0.901	0.438	2.278	0.140	0.290	11.850
	75.00%	4.80	1.67	8.70	0.14	0.31	24.42
	Bottom	5.19	1.81	9.38	0.14	0.31	25.08
	Middle	1.699	0.841	4.369	0.140	0.290	19.950
	Surface	0.873	0.422	2.191	0.140	0.290	11.390
DO (mg/L)	25.00%	7.302	0.319	1.659	3.520	7.240	9.890
	75.00%	6.200	0.572	2.975	0.160	6.430	9.890
	Bottom	6.169	0.575	2.988	0.220	6.430	9.920
	Middle	6.876	0.408	2.120	0.860	6.530	9.880
	Surface	7.503	0.316	1.641	3.530	7.310	9.890
pH	25.00%	7.8037	0.0351	0.1825	7.5200	7.8000	8.1000
	75.00%	7.6900	0.0456	0.2368	7.1800	7.6700	8.0700
	Bottom	7.6922	0.0462	0.2399	7.2000	7.6800	8.0700
	Middle	7.7707	0.0348	0.1807	7.4000	7.7900	8.0800
	Surface	7.8230	0.0383	0.1991	7.5200	7.8000	8.1500
Turbidity (NTU)	25.00%	100.0	18.8	97.9	7.6	54.4	367.4
	75.00%	98.8	20.0	104.1	-1.1	53.1	368.7
	Bottom	128.5	29.4	152.6	1.0	69.5	694.8
	Middle	102.1	19.2	99.9	-0.7	53.9	369.6
	Surface	92.7	17.1	89.0	7.3	51.5	339.0
Total Depth (m)	Bottom	5.816	0.213	1.108	3.423	5.752	8.175
Secchi (m)	Surface	0.1568	0.0293	0.1492	0.0320	0.1200	0.7100

Table 16. Summary statistics of water profile for site B36.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.24	1.28	6.66	10.12	24.00	32.28
	75.00%	23.34	1.28	6.66	10.11	24.40	32.27
	Bottom	23.39	1.29	6.68	10.12	24.40	32.27
	Middle	23.30	1.28	6.65	10.11	24.15	32.28
	Surface	23.34	1.29	6.72	10.13	24.08	32.80
Salinity (psu)	25.00%	0.619	0.301	1.565	0.140	0.260	8.310
	75.00%	1.504	0.767	3.986	0.140	0.260	17.830
	Bottom	1.749	0.879	4.567	0.140	0.280	20.130
	Middle	1.237	0.644	3.345	0.140	0.260	15.120
	Surface	0.603	0.285	1.482	0.140	0.260	7.870
DO (mg/L)	25.00%	7.364	0.320	1.663	3.950	7.240	10.000
	75.00%	6.805	0.429	2.231	1.230	6.570	9.980
	Bottom	6.711	0.461	2.398	0.950	6.570	9.980
	Middle	6.918	0.402	2.088	1.490	6.580	10.000
	Surface	7.625	0.338	1.757	4.040	7.320	11.720
pH	25.00%	7.7789	0.0373	0.1937	7.4400	7.7700	8.1300
	75.00%	7.7270	0.0393	0.2040	7.3700	7.7300	8.0800
	Bottom	7.7185	0.0398	0.2070	7.3600	7.7400	8.0700
	Middle	7.7411	0.0388	0.2015	7.4000	7.7400	8.1200
	Surface	7.8130	0.0426	0.2212	7.4400	7.8000	8.2700
Turbidity (NTU)	25.00%	105.2	18.3	95.0	11.6	64.9	348.8
	75.00%	109.3	18.9	98.3	2.1	73.5	366.9
	Bottom	113.7	18.8	97.7	6.0	78.6	359.6
	Middle	107.2	18.7	97.0	2.5	70.1	357.1
	Surface	100.8	17.7	92.0	10.9	54.1	335.3
Total Depth (m)	Bottom	6.336	0.224	1.162	4.856	6.109	10.235
Secchi (m)	Surface	0.1331	0.0210	0.0864	0.0360	0.1180	0.3730

Table 17. Summary statistics of water profile for site B42.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.22	1.29	6.72	9.99	24.16	32.40
	75.00%	23.30	1.29	6.72	9.97	24.36	32.30
	Bottom	23.35	1.30	6.75	9.97	24.35	32.30
	Middle	23.23	1.29	6.71	9.99	24.13	32.30
	Surface	23.32	1.31	6.81	10.02	24.26	33.60
Salinity (psu)	25.00%	0.447	0.163	0.848	0.140	0.280	4.660
	75.00%	0.967	0.644	3.344	0.140	0.280	17.650
	Bottom	1.090	0.667	3.466	0.140	0.280	17.930
	Middle	0.599	0.313	1.626	0.140	0.280	8.720
	Surface	0.439	0.157	0.816	0.140	0.280	4.490
DO (mg/L)	25.00%	7.521	0.317	1.646	4.550	7.330	10.130
	75.00%	6.980	0.426	2.214	1.180	7.140	10.080
	Bottom	7.074	0.393	2.040	1.780	7.170	10.050
	Middle	7.366	0.321	1.670	4.390	7.320	10.100
	Surface	7.788	0.327	1.700	4.730	7.560	11.900
pH	25.00%	7.7796	0.0440	0.2284	7.1000	7.8100	8.1000
	75.00%	7.7459	0.0453	0.2351	7.0300	7.8000	8.0800
	Bottom	7.7407	0.0446	0.2315	7.0900	7.8000	8.0800
	Middle	7.7596	0.0441	0.2290	7.0500	7.8000	8.0900
	Surface	7.8130	0.0477	0.2476	7.1500	7.8400	8.2500
Turbidity (NTU)	25.00%	106.7	17.5	90.9	14.6	67.2	346.3
	75.00%	117.5	19.1	99.1	0.0	96.2	363.3
	Bottom	137.1	21.6	112.1	3.9	89.8	406.3
	Middle	113.3	18.3	95.2	13.3	91.4	351.1
	Surface	97.4	16.1	83.4	14.3	60.2	312.2
Total Depth (m)	Bottom	7.5174	0.0903	0.4692	6.6130	7.5540	8.3390
Secchi (m)	Surface	0.1190	0.0164	0.0853	0.0280	0.1100	0.4300

Table 18. Summary statistics of water profile for Average-Subsistence flow tier.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	20.767	0.783	5.250	13.780	18.860	31.080
	75.00%	21.434	0.797	5.348	13.300	20.180	32.040
	Bottom	21.488	0.800	5.366	13.330	20.740	32.070
	Middle	21.230	0.795	5.331	13.250	20.040	31.950
	Surface	20.770	0.742	4.976	15.200	19.160	29.520
Salinity (psu)	25.00%	8.71	1.27	8.53	0.17	4.66	27.59
	75.00%	18.24	1.53	10.30	0.17	22.48	29.09
	Bottom	19.05	1.59	10.65	0.17	23.93	31.09
	Middle	14.58	1.52	10.22	0.17	18.59	27.61
	Surface	6.30	1.05	7.07	0.17	3.06	27.60
DO (mg/L)	25.00%	6.784	0.327	2.195	2.080	6.870	10.130
	75.00%	5.167	0.398	2.670	0.300	5.340	9.730
	Bottom	5.032	0.398	2.672	0.320	5.310	9.810
	Middle	5.655	0.388	2.602	0.270	5.880	9.750
	Surface	7.793	0.343	2.299	3.530	7.810	11.900
pH	25.00%	7.8096	0.0250	0.1680	7.4400	7.7900	8.1300
	75.00%	7.7200	0.0351	0.2357	7.3300	7.7000	8.2200
	Bottom	7.7071	0.0347	0.2329	7.3300	7.6700	8.2200
	Middle	7.7433	0.0290	0.1944	7.3900	7.7600	8.1500
	Surface	7.8767	0.0323	0.2167	7.4400	7.8400	8.2900
Turbidity (NTU)	25.00%	21.48	4.69	29.30	-3.00	11.10	116.90
	75.00%	16.93	5.07	32.05	-3.90	4.95	141.60
	Bottom	28.33	5.91	37.37	-3.10	15.25	154.40
	Middle	20.99	5.56	35.15	-4.00	7.85	141.60
	Surface	21.33	4.83	30.16	-9.00	10.90	119.30
Total Depth (m)	Bottom	6.066	0.248	1.666	3.080	6.029	10.235
Secchi (m)	Surface	0.3572	0.0322	0.1849	0.0580	0.2990	0.7300

Table 19. Summary statistics of water profile for Average-Base flow tier.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	18.70	1.87	9.72	9.99	13.15	32.50
	75.00%	18.95	1.79	9.29	9.97	13.57	32.80
	Bottom	19.17	1.75	9.08	9.97	13.70	32.70
	Middle	18.63	1.83	9.53	9.99	13.15	32.60
	Surface	18.86	1.87	9.70	10.02	13.19	33.60
Salinity (psu)	25.00%	3.93	1.23	6.41	0.14	1.03	27.31
	75.00%	12.28	2.43	12.64	0.14	8.35	32.34
	Bottom	13.99	2.51	13.03	0.14	11.07	32.98
	Middle	7.00	2.00	10.41	0.14	1.68	31.43
	Surface	1.961	0.445	2.313	0.140	0.940	8.290
DO (mg/L)	25.00%	7.939	0.430	2.236	2.700	9.070	10.110
	75.00%	6.838	0.614	3.193	0.160	8.390	10.080
	Bottom	6.451	0.616	3.202	0.220	8.010	10.050
	Middle	7.676	0.449	2.332	3.250	8.890	10.100
	Surface	8.618	0.248	1.290	6.060	9.090	10.130
pH	25.00%	7.7048	0.0429	0.2229	7.1000	7.7200	8.1000
	75.00%	7.6230	0.0439	0.2283	7.0300	7.6600	7.9800
	Bottom	7.5870	0.0418	0.2173	7.0900	7.5500	7.9800
	Middle	7.6963	0.0411	0.2133	7.0500	7.7200	7.9900
	Surface	7.7704	0.0521	0.2709	7.1500	7.7600	8.1300
Turbidity (NTU)	25.00%	82.4	11.6	60.4	6.9	65.6	186.5
	75.00%	70.6	13.4	69.4	5.1	39.1	199.6
	Bottom	122.3	43.3	225.0	6.5	69.5	1196.5
	Middle	79.7	12.2	63.3	6.9	63.2	189.0
	Surface	81.6	11.2	58.0	10.9	69.8	181.9
Total Depth (m)	Bottom	5.766	0.225	1.168	3.535	5.971	7.560
Secchi (m)	Surface	0.1611	0.0254	0.1106	0.0400	0.1190	0.4320

Table 20. Summary statistics of water profile for Average-3ps flow tier.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	24.953	0.334	2.237	21.700	24.530	29.090
	75.00%	25.130	0.375	2.513	21.660	24.420	29.640
	Bottom	25.095	0.375	2.515	21.530	24.430	29.510
	Middle	25.034	0.352	2.363	21.700	24.400	29.020
	Surface	25.002	0.334	2.243	21.700	24.500	29.110
Salinity (psu)	25.00%	1.486	0.461	3.092	0.140	0.220	18.640
	75.00%	5.20	1.28	8.61	0.14	0.22	24.93
	Bottom	5.87	1.36	9.09	0.14	0.22	25.37
	Middle	3.466	0.989	6.635	0.140	0.220	23.270
	Surface	1.032	0.218	1.466	0.140	0.220	7.600
DO (mg/L)	25.00%	6.718	0.112	0.753	5.270	6.550	8.630
	75.00%	6.118	0.215	1.441	1.580	6.370	8.340
	Bottom	6.122	0.201	1.348	2.410	6.360	8.060
	Middle	6.421	0.144	0.966	3.510	6.420	8.450
	Surface	6.700	0.106	0.714	5.240	6.570	8.750
pH	25.00%	7.6400	0.0129	0.0862	7.5200	7.6300	7.9100
	75.00%	7.6098	0.0203	0.1361	7.1200	7.6200	8.0000
	Bottom	7.6164	0.0215	0.1443	7.1700	7.6200	8.0100
	Middle	7.6062	0.0161	0.1083	7.2100	7.6000	7.8300
	Surface	7.6620	0.0148	0.0995	7.5300	7.6300	7.9200
Turbidity (NTU)	25.00%	130.8	16.8	112.8	8.4	129.4	370.8
	75.00%	143.3	19.8	132.7	2.5	127.1	439.5
	Bottom	178.9	25.7	172.6	-7.4	157.8	694.8
	Middle	133.2	17.6	118.3	5.3	129.0	394.0
	Surface	122.2	16.0	107.5	-6.7	121.5	356.8
Total Depth (m)	Bottom	6.377	0.250	1.677	3.037	6.464	9.936
Secchi (m)	Surface	0.1562	0.0141	0.0795	0.0280	0.1490	0.3500

Table 21. Summary statistics of water profile for Wet-Subsistence flow tier.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.682	0.931	6.243	13.280	26.460	31.770
	75.00%	24.382	0.924	6.197	11.830	26.950	33.160
	Bottom	24.467	0.923	6.191	12.130	27.050	33.090
	Middle	24.140	0.932	6.255	13.120	26.590	33.370
	Surface	23.660	0.932	6.252	13.090	26.290	31.700
Salinity (psu)	25.00%	4.424	0.824	5.528	0.340	1.880	22.290
	75.00%	15.09	1.74	11.67	0.34	20.86	31.40
	Bottom	16.42	1.78	11.97	0.34	22.54	33.87
	Middle	10.54	1.59	10.68	0.34	6.12	30.46
	Surface	3.232	0.534	3.580	0.340	1.750	16.030
DO (mg/L)	25.00%	7.041	0.260	1.745	4.300	6.230	9.840
	75.00%	5.299	0.420	2.817	0.280	5.710	9.800
	Bottom	4.931	0.451	3.022	0.300	5.640	9.790
	Middle	6.124	0.341	2.285	0.510	5.860	9.820
	Surface	7.614	0.211	1.416	5.750	7.110	9.890
pH	25.00%	7.8989	0.0220	0.1478	7.6100	7.8900	8.1300
	75.00%	7.7516	0.0393	0.2639	7.1300	7.7700	8.0800
	Bottom	7.7142	0.0418	0.2805	7.1100	7.7500	8.0900
	Middle	7.8209	0.0286	0.1920	7.4200	7.8300	8.1000
	Surface	7.9584	0.0204	0.1372	7.6500	7.9600	8.1900
Turbidity (NTU)	25.00%	25.94	2.74	18.37	-0.90	25.00	66.40
	75.00%	23.18	3.75	25.15	-1.70	10.80	96.20
	Bottom	36.27	5.47	36.25	0.30	21.00	177.20
	Middle	23.80	3.38	22.70	-1.70	15.60	96.50
	Surface	24.40	2.62	17.55	0.10	23.20	60.20
Total Depth (m)	Bottom	6.537	0.236	1.586	3.042	6.330	9.477
Secchi (m)	Surface	0.2217	0.0172	0.1153	0.1020	0.1830	0.6120

Table 22. Summary statistics of water profile for Wet-Base flow tier.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	23.453	0.775	6.148	14.120	24.000	30.800
	75.00%	23.587	0.767	6.089	14.110	24.000	31.880
	Bottom	23.570	0.769	6.107	14.120	23.990	31.960
	Middle	23.476	0.772	6.130	14.110	24.000	31.200
	Surface	23.578	0.778	6.176	14.170	24.080	31.800
Salinity (psu)	25.00%	1.975	0.445	3.529	0.140	0.370	19.320
	75.00%	8.69	1.35	10.73	0.14	0.37	34.87
	Bottom	10.04	1.48	11.71	0.22	0.41	34.01
	Middle	4.90	1.05	8.30	0.14	0.37	34.44
	Surface	1.231	0.203	1.611	0.140	0.370	6.530
DO (mg/L)	25.00%	7.357	0.195	1.545	4.800	7.250	9.520
	75.00%	6.765	0.251	1.995	0.860	7.000	9.500
	Bottom	6.181	0.319	2.529	0.450	6.460	9.490
	Middle	7.118	0.213	1.693	3.830	7.220	9.510
	Surface	7.632	0.185	1.465	5.030	7.390	9.520
pH	25.00%	7.8421	0.0138	0.1096	7.6300	7.8300	8.1200
	75.00%	7.8038	0.0227	0.1803	7.1900	7.8100	8.2400
	Bottom	7.7798	0.0253	0.2012	7.1500	7.8100	8.2400
	Middle	7.8225	0.0164	0.1302	7.4700	7.8200	8.1700
	Surface	7.8706	0.0124	0.0985	7.6500	7.8600	8.1100
Turbidity (NTU)	25.00%	96.6	10.4	82.5	8.7	68.3	281.5
	75.00%	97.7	12.1	96.0	6.4	63.3	296.3
	Bottom	191.0	69.1	548.7	-4.8	78.6	4361.6
	Middle	99.0	11.3	89.8	5.0	68.0	288.1
	Surface	88.36	9.55	75.79	10.30	63.10	268.90
Total Depth (m)	Bottom	6.893	0.162	1.283	3.889	6.947	9.542
Secchi (m)	Surface	0.11403	0.00863	0.06629	0.02000	0.10200	0.37600

Table 23. Summary statistics of water profile for Wet-2ps flow tier.

Variable	Depth of Readings	Mean	SE Mean	StDev	Minimum	Median	Maximum
Temperature (°C)	25.00%	31.659	0.120	0.509	30.700	31.570	32.380
	75.00%	31.337	0.263	1.116	29.040	31.390	33.510
	Bottom	31.317	0.269	1.139	29.010	31.400	33.450
	Middle	31.425	0.176	0.747	29.870	31.400	32.390
	Surface	31.868	0.120	0.510	31.050	31.760	32.690
Salinity (psu)	25.00%	3.08	1.28	5.41	0.28	0.32	20.28
	75.00%	12.68	3.43	14.54	0.28	0.36	34.63
	Bottom	13.89	3.46	14.68	0.28	6.64	34.65
	Middle	7.27	2.76	11.72	0.28	0.33	35.51
	Surface	1.531	0.449	1.906	0.280	0.320	6.010
DO (mg/L)	25.00%	6.278	0.147	0.623	5.350	6.070	7.460
	75.00%	5.061	0.393	1.667	1.180	5.570	7.400
	Bottom	5.189	0.373	1.581	2.220	5.535	7.370
	Middle	5.948	0.202	0.858	4.450	5.930	7.460
	Surface	6.632	0.139	0.591	6.030	6.375	7.720
pH	25.00%	7.8406	0.0383	0.1625	7.6200	7.8200	8.1000
	75.00%	7.8006	0.0412	0.1749	7.5600	7.7450	8.0700
	Bottom	7.7678	0.0433	0.1836	7.5500	7.6800	8.0700
	Middle	7.8367	0.0425	0.1804	7.6000	7.8300	8.1400
	Surface	7.8789	0.0413	0.1751	7.6200	7.8850	8.1600
Turbidity (NTU)	25.00%	91.9	21.9	92.9	13.1	53.6	273.7
	75.00%	109.7	26.6	112.9	11.8	57.3	324.8
	Bottom	124.5	29.1	123.5	17.3	66.3	398.5
	Middle	99.3	24.2	102.6	9.2	54.8	301.1
	Surface	74.3	17.6	74.7	14.7	47.3	266.6
Total Depth (m)	Bottom	7.224	0.256	1.087	4.402	7.543	8.984
Secchi (m)	Surface	0.1179	0.0178	0.0666	0.0500	0.1005	0.2900

APPENDIX F:

SURFACE WATER GRAB LABORATORY RESULTS

Table 24. Laboratory results for surface water grab samples.

Date	Site	Nitrate+Nitrite-N (mg/L)	TKN (mg/L)	Total P (mg/L)	TSS (mg/L)	Chlorophyll-a (ppb)
11/11/2014	B42	0.500	2.50	0.192	12	
	B31	0.560	1.3	0.210	9.4	
	B22	0.430	1.2	0.250	9.6	
	B10	0.320	1.5	0.060	11	
	B01	1.60	0.70	0.780	36	
12/09/2014	B42	1.040	1.70	0.310	114	
	B31	1.30	0.70	0.370	97	
	B22	1.370	0.90	0.470	38.5	
	B10	1.330	0.2	0.480	19	
	B01	1.330	< 0.2	0.154	14.8	
01/06/2015	B42	1.100	1.3	0.440	118	
	B31	1.260	1.34	0.190	121	
	B22	0.970	0.73	0.300	122	
	B10	1.250	1.00	0.260	55	
	B01	1.260	0.60	0.250	38.5	
02/04/2015	B42	0.640	1.20	0.320	166	
	B31	0.670	1.30	0.390	204	
	B22	0.710	1.30	0.420	152	
	B10	0.740	1.20	0.480	150	
	B01	0.820	0.60	0.128	73	
02/18/2015	B42	1.010	2.50	0.170	43.5	
	B31	0.930	2.60	0.180	39.3	
	B22	0.950	1.90	0.200	32.3	
	B10	1.240	0.60	0.270	40.2	
	B01	0.620	0.50	0.130	33.7	
04/01/2015	B42	1.460	2.00	0.670	192	
	B31	1.580	2.20	1.410	182	
	B22	1.700	1.80	1.900	154	
	B10	1.680	2.00	0.430	120	
	B01	1.570	1.20	0.460	65.3	
04/29/2015	B42	1.240	2.60	0.330	184	
	B31	1.340	1.10	0.510	24.5	
	B22	1.350	2.30	1.190	200	
	B10	1.320	1.80	0.530	37.9	
	B01	1.490	1.30	0.740	203	
05/06/2015	B42	0.870	0.60	0.470	395	
	B31	0.930	3.70	0.120	454	
	B22	1.960	2.10	0.640	343	
	B10	0.780	2.70	0.440	207	
	B01	0.840	1.00	0.220	140	
08/12/2015	B42	0.260	1.10	0.130	17	
	B31	0.380	0.50	0.090	18	
	B22	0.400	0.60	0.090	17.8	
	B10	0.440	0.30	0.060	11.2	
	B01	0.470	2.00	0.270	20.8	
08/25/2015	B42	0.260	2.00	0.220	66.5	
	B31	0.370	1.70	0.030	49.5	

Date	Site	Nitrate+Nitrite-N (mg/L)	TKN (mg/L)	Total P (mg/L)	TSS (mg/L)	Chlorophyll-a (ppb)
	B22	0.350	1.30	0.140	61.5	
	B10	0.330	1.40	0.160	45.3	
	B01	0.450	1.30	0.150	30.7	
12/1/2016	B42	1.38	1.1	0.41	63	22.3
	B31	1.18	1.3	0.27	67	24.8
	B22	1.38	1.2	0.37	49	20.9
	B10	0.85	0.8	0.38	28.4	9.6
	B01	0.23	1.2	0.31	18.4	9.1
12/20/2016	B42	0.82	2.8	0.25	85	11.1
	B31	0.82	1.7	0.38	69	12.7
	B22	0.73	2.9	0.32	62.8	10.6
	B10	1.61	1.2	0.76	55.2	5.5
	B01	0.64	1.5	0.21	44	5.3
01/31/2017	B42	0.85	0.6	0.54	366	< 3
	B31	0.89	0.6	0.98	392	< 3
	B22	0.99	0.5	1.15	332	< 3
	B10	0.91	0.3	0.34	226	3.1
	B01	0.96	1.3	0.29	83.5	< 3
03/15/2017	B42	0.87	1.8	0.2	123	11.5
	B31	0.89	0.6	0.25	125	11.7
	B22	0.83	1	0.22	74	11.8
	B10	0.89	0.6	0.23	66	10.8
	B01	0.87	0.9	0.21	53	11.5
5/1/2017	B01	0.58	0.6	0.188	37.6	4.1
	B10	0.56	0.8	0.314	38.9	3.8
	B22	0.57	0.8	0.31	72.6	< 3
	B31	0.61	1.8	0.566	86.1	< 3
	B42	0.61	1	0.724	256	4.3
5/24/2017	B01	< 0.02	0.6	0.33	24.5	< 3
	B10	0.05	0.4	0.34	28	10.1
	B22	< 0.02	1	0.51	35	7
	B31	0.09	0.7	0.96	51	9.6
	B42	0.19	1	0.69	52.7	31.7
6/27/2017	B42	0.41	0.7	0.35	159	4.8
	B31	0.38	1.5	0.27	128	< 3
	B22	0.57	1.7	0.22	80.4	< 3
	B10	0.64	1.9	0.13	28.5	< 3
	B01	0.47	0.6	0.29	21.8	3.6
7/31/2017	B42	< 0.02	0.9	0.33	43.7	28.4
	B31	0.3	< 0.2	0.32	29.3	11.8
	B22	0.3	0.3	0.22	23.7	7
	B10	0.3	0.6	0.11	17.2	12
	B01	0.3	0.2	0.09	13.6	10.8
9/20/2017	B42	0.19	1.7	0.14	84	16
	B31	0.99	1.6	0.1	54	17.3
	B22	0.03	1.5	0.9	37.5	15.6
	B10	0.14	1.1	0.12	29	21.1
	B01	0.19	1.2	0.09	28	11.5
10/18/2017	B01	0.66	0.5	0.3	15.7	14.7
	B10	0.63	0.7	0.31	18	20.9
	B22	0.49	0.8	0.28	24.5	32.2
	B31	0.38	0.9	0.44	33	26.7
	B42	0.34	0.8	0.43	31.5	42.8
9/19/2018	G3	0.18	0.2	1.05	25.5	3.4

Date	Site	Nitrate+Nitrite-N (mg/L)	TKN (mg/L)	Total P (mg/L)	TSS (mg/L)	Chlorophyll-a (ppb)
	G2	< 0.02	0.5	1.68	25	5.8
	G1	0.22	1	6.93	34	< 3
09/27/2018	B42	0.21	0.8	1.33	22.6	12
	B31	0.61	1	2.3	15.5	6.2
	B22	0.18	0.9	1.2	13.9	< 3
	B10	0.2	0.7	2.95	11.8	4.6
	B01	0.22	0.9	1.55	13.1	3.4
03/12/2019	B01	0.98	< 1	0.23	29.6	4.1
	B10	0.82	< 1	0.3	40.8	7.2
	B22	0.77	< 1	0.13	54.00	6.7
	B31	0.7	1.3	0.25	90.5	8.4
	B42	0.72	1	0.2	103	5
07/11/2019	B42	0.48	0.9	0.52	245	9
	B31	0.56	1	0.21	99.3	10.2
	B22	0.73	0.8	0.33	78	3.5
	B10	0.46	0.4	0.14	56.8	NA
	B01	0.53	< 0.2	0.13	29.6	3.4
07/31/2019	B42	0.06	1.2	1.53	25.2	29.1
	B31	0.04	1.6	0.17	33.2	29.6
	B22	0.03	< 1	0.39	33.6	NA
	B10	0.03	2.1	0.4	55.6	25.2
	B01	0.06	< 1	0.18	54	16.6
09/05/2019	B01	0.2	1.1	0.129	23.5	19.5
	B10	0.25	1	0.131	18	19.7
	B22	0.31	1	0.117	19.5	19.2
	B31	0.18	1.7	0.117	31	22.8
	B42	0.05	1.3	0.118	42	26.9
10/17/2019	B10	< 0.02	< 1	0.106	16	19.5
	B01	0.07	< 1	0.142	29.2	13.5
	B22	0.1	1	0.101	16.8	17.3
	B31	0.06	1	0.0824	17.6	30.5
	B42	< 0.02	1.2	< 0.06	36	29.6
12/04/2019	G3	< 0.02	0.3	< 0.06	12.6	10.8
	G2	< 0.02	0.5	< 0.06	12.6	5.3
	G1	< 0.02	0.4	< 0.06	14	8.9
12/05/2019	B01	0.15	0.9	0.0777	24.8	4.1
	B10	0.02	1	0.0775	22.4	4.3
	B22	< 0.02	1	< 0.06	20	4.1
	B31	0.05	1	< 0.06	16.4	8.4
	B42	0.12	1.3	0.0964	38.1	5

APPENDIX G:

NEKTON COLLECTION SUMMARY STATISTICS

Table 25. Beam trawl catch data for each sample period since 2014.

Family	Scientific Name	Common Name	Sampling Period 2014-2015	Sampling Period 2016-2017	Sampling Period 2018-2019	Total Catch
Penaeidae	*Farfantepenaeus aztecus*	Brown Shrimp	42	4	1	**47**
	Farfantepenaeus duorarum	Pink Shrimp	2			**2**
	Litopenaeus setiferus	White Shrimp	279	58	20	**357**
	Rimapenaeus similis	Roughback Shrimp	1			**1**
Sergestidae	*Acetes americanus*	Sergestid Shrimp	17			**17**
Palaemonidae	*Macrobrachium carcinus*	Bigclaw River Shrimp	1			**1**
	Macrobrachium ohione	Ohio River Shrimp	92	130	64	**286**
	Macrobrachium rosenbergii	River Prawn		1		**1**
	Palaemonetes pugio	Daggerblade Grass Shrimp	64	92	15	**171**
	Palaemonetes vulgaris	Marsh Grass Shrimp	25			**25**
	Macrobrachium spp.	Macrobrachium spp.	1			**1**
	Palaemonetes spp.	Palaemonetes spp.	6			**6**
Hippolytidae	*Tozeuma carolinense*	Arrow Shrimp	1			**1**
Portunidae	*Callinectes sapidus*	Blue Crab	52	14	11	**77**
	Callinectes similis	Lesser Blue Crab	10			**10**
Panopeidae	*Rithropanopeus harrisii*	Estuarine mud crab	1			**1**
Libellulidae	*Libellulidae spp.*	Skimmer Dragonfly		6	7	**13**
Albulidae	*Albula vulpes*	Bonefish	1			**1**
Engraulidae	*Anchoa mitchilli*	Bay Anchovy	19	40	2	**61**
Clupeidae	*Brevoortia patronus*	Gulf Menhaden	669	48	425	**1142**
	Dorosoma cepedianum	Gizzard Shad			2	**2**
	Alosine spp.	Alosine spp.		5		**5**
Cyprinidae	*Cyprinella lutrensis*	Red Shiner			1	**1**
	Cyprinella venusta	Blacktail Shiner			1	**1**
	Lythrurus fumeus	Ribbon Shiner		19		**19**
	Macrhybopsis hyostoma	Shoal Chub		6	1	**7**
	Notropis buchanani	Ghost Shiner			2	**2**
	Pimephales vigilax	Bullhead Minnow	51	1	2	**54**
	Cyprinidae spp.	Cyprinidae		1		**1**
Catostomidae	*Erimyzon sucetta*	Lake Chubsucker	2			**2**
Loricariidae	*Pterygoplichthys spp.*	Armored Catfish		1		**1**
Ariidae	*Ariopsis felis*	Hardhead Catfish			1	**1**
Ictaluridae	*Ictalurus furcatus*	Blue Catfish	9	6	13	**28**
	Ictalurus punctatus	Channel Catfish	5	1		**6**

Family	Scientific Name	Common Name	Sampling Period			Total Catch
			2014-2015	2016-2017	2018-2019	
Mugilidae	*Mugil cephalus*	Striped Mullet	126	86	19	**231**
Atherinopsidae	*Menidia beryllina*	Inland Silverside		3		**3**
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	1	8		**9**
Centrarchidae	*Lepomis cyanellus*	Green Sunfish	1			**1**
	Lepomis macrochirus	Bluegill	2			**2**
	Lepomis spp.	Lepomis spp.		1		**1**
Carangidae	*Caranx hippos*	Crevalle Jack		1		**1**
Gerreidae	*Eucinostomus argenteus*	Spotfin Mojarra		1		**1**
	Eucinostomus melanopterus	Flagfin Mojarra	6		1	**7**
Sparidae	*Lagodon rhomboides*	Pinfish	4			**4**
Sciaenidae	*Larimus fasciatus*	Banded Drum	1			**1**
	Leiostomus xanthurus	Spot	4			**4**
	Micropogonias undulatus	Atlantic Croaker	2680	184	13	**2877**
Gobiidae	*Ctenogobius shufeldti*	Freshwater Goby	2			**2**
	Ctenogobius boleosoma	Darter Goby	88	4		**92**
	Gobiosoma bosc	Naked Goby	1	6		**7**
	Gobiidae spp.	Gobiidae spp.	2			**2**
Paralichthyidae	*Citharichthys spilopterus*	Bay Whiff	10	5		**15**
	Paralichthyidae spp.	Paralichthyidae		2		**2**
Cynoglossidae	*Symphurus plagiusa*	Blackcheek Tonguefish	7			**7**
Unconfirmed	*Unconfirmed*	Unconfirmed			1	**1**
Grand Total			**4285**	**734**	**602**	**5621**

Table 26. Beam trawl catch data for each sample site since 2014.

Family	Scientific Name	Common Name	Sampling Period					Total
			B01	B10	B22	B31	B42	
Penaeidae	*Farfantepenaeus aztecus*	Brown Shrimp	8	35	4			**47**
	Farfantepenaeus duorarum	Pink Shrimp	1	1				**2**
	Litopenaeus setiferus	White Shrimp	54	200	91	8	4	**357**
	Rimapenaeus similis	Roughback Shrimp	1					**1**
Sergestidae	*Acetes americanus*	Sergestid Shrimp	17					**17**
Palaemonidae	*Macrobrachium carcinus*	Bigclaw River Shrimp		1				**1**
	Macrobrachium ohione	Ohio River Shrimp	1	1	8	92	184	**286**
	Macrobrachium rosenbergii	River Prawn					1	**1**
	Palaemonetes pugio	Daggerblade Grass Shrimp	17	34	34	24	62	**171**
	Palaemonetes vulgaris	Marsh Grass Shrimp	6	9	3	7		**25**
	Macrobrachium spp.	Macrobrachium spp.	1					**1**
	Palaemonetes spp.	Palaemonetes spp.	5			1		**6**
Hippolytidae	*Tozeuma carolinense*	Arrow Shrimp	1					**1**
Portunidae	*Callinectes sapidus*	Blue Crab	2	7	33	23	12	**77**
	Callinectes similis	Lesser Blue Crab	3	3	2		2	**10**
Panopeidae	*Rithropanopeus harrisii*	Estuarine Mud Crab			1			**1**
Libellulidae	*Libellulidae spp.*	Skimmer Dragonfly		1	4	5	3	**13**
Albulidae	*Albula vulpes*	Bonefish	1					**1**
Engraulidae	*Anchoa mitchilli*	Bay Anchovy	17	5	9	15	15	**61**
Clupeidae	*Brevoortia patronus*	Gulf Menhaden	296	560	72	140	74	**1142**
	Dorosoma cepedianum	Gizzard Shad			1	1		**2**
	Alosine spp.	Alosine spp.		5				**5**
Cyprinidae	*Cyprinella lutrensis*	Red Shiner			1			**1**
	Cyprinella venusta	Blacktail Shiner			1			**1**
	Lythrurus fumeus	Ribbon Shiner				1	18	**19**
	Macrhybopsis hyostoma	Shoal Chub				2	5	**7**

Family	Scientific Name	Common Name	Sampling Period					Total
			B01	B10	B22	B31	B42	
	Notropis buchanani	Ghost Shiner				2		**2**
	Pimephales vigilax	Bullhead Minnow			5	43	6	**54**
	Cyprinidae spp.	Cyprinidae spp.		1				**1**
Catostomidae	*Erimyzon sucetta*	Lake Chubsucker	1			1		**2**
Loricariidae	*Pterygoplichthys spp.*	Armored Catfish					1	**1**
Ariidae	*Ariopsis felis*	Hardhead Catfish		1				**1**
Ictaluridae	*Ictalurus furcatus*	Blue Catfish			10	12	6	**28**
	Ictalurus punctatus	Channel Catfish			1		5	**6**
Mugilidae	*Mugil cephalus*	Striped Mullet		9	190	31	1	**231**
Atherinopsidae	*Menidia beryllina*	Inland Silverside		1	1	1		**3**
Poeciliidae	*Gambusia affinis*	Western Mosquitofish					9	**9**
Centrarchidae	*Lepomis cyanellus*	Green Sunfish					1	**1**
	Lepomis macrochirus	Bluegill				1	1	**2**
	Lepomis spp.	Lepomis spp.					1	**1**
Carangidae	*Caranx hippos*	Crevalle Jack		1				**1**
Gerreidae	*Eucinostomus argenteus*	Spotfin Mojarra		1				**1**
	Eucinostomus melanopterus	Flagfin Mojarra			2	3	2	**7**
Sparidae	*Lagodon rhomboides*	Pinfish	4					**4**
Sciaenidae	*Larimus fasciatus*	Banded Drum	1					**1**
	Leiostomus xanthurus	Spot	3	1				**4**
	Micropogonias undulatus	Atlantic Croaker	2120	303	118	14	322	**2877**
Gobiidae	*Ctenogobius shufeldti*	Freshwater Goby			1	1		**2**
	Ctenogobius boleosoma	Darter Goby	9	14	28	29	12	**92**
	Gobiosoma bosc	Naked Goby		5		2		**7**
	Gobiidae spp.	Gobiidae spp.					2	**2**
Paralichthyidae	*Citharichthys spilopterus*	Bay Whiff	6	1	4		4	**15**
	Paralichthyidae spp.	Paralichthyidae spp.	2					**2**
Cynoglossidae	*Symphurus plagiusa*	Blackcheek Tonguefish	5	1	1			**7**
Unconfirmed	*Unconfirmed*	Unconfirmed				1		**1**
Grand Total			**2582**	**1201**	**625**	**460**	**753**	**5621**

Table 27. Otter trawl catch data for each sample period since 2014.

Family	Scientific Name	Common Name	Sampling Year 2014-2015	Sampling Year 2016-2017	Sampling Year 2018-2019	Total Catch
Loliginidae	*Lolliguncula brevis*	Atlantic Brief Squid	3	2		**5**
Mysidae	*Taphromysis louisianae*	Mysid Shrimp			4	**4**
Penaeidae	*Farfantepenaeus aztecus*	Brown Shrimp	3	1009	25	**1037**
	Farfantepenaeus duorarum	Pink Shrimp	2	1		**3**
	Litopenaeus setiferus	White Shrimp	146	310	1370	**1826**
	Rimapenaeus similis	Roughback Shrimp	1			**1**
Sergestidae	*Acetes americanus*	Sergestid Shrimp	105			**105**
Palaemonidae	*Macrobrachium ohione*	Ohio River Shrimp	157	211	72	**440**
	Macrobrachium rosenbergii	River Prawn		253		**253**
	Palaemonetes pugio	Daggerblade Grass Shrimp	14	18		**32**
	Palaemonetes vulgaris	Marsh Grass Shrimp	2	1		**3**
	Macrobrachium spp.	Macrobrachium spp.		229		**229**
Hippolytidae	*Tozeuma carolinense*	Arrow Shrimp	1			**1**
Diogenidae	*Clibanarius vittatus*	Thinstripe Hermit Crab			1	**1**
Epialtidae	*Libinia emarginata*	Common Spider Crab		1		**1**
	Libinia spp.	Spider Crab		1	1	**2**
Portunidae	*Callinectes sapidus*	Blue Crab	60	395	55	**510**
Menippidae	*Menippe adina*	Gulf Stone Crab			1	**1**
Panopeidae	*Rithropanopeus harrisii*	Estuarine Mud Crab	1			**1**
Dasyatidae	*Dasyatis americana*	Southern Stingray		1		**1**
Lepisosteidae	*Atractosteus spatula*	Alligator Gar			2	**2**
Engraulidae	*Anchoa mitchilli*	Bay Anchovy	1207	647	2086	**3940**
Clupeidae	*Brevoortia patronus*	Gulf Menhaden	31	56	50	**137**
	Dorosoma cepedianum	Gizzard Shad	6	12	24	**42**
	Dorosoma petenense	Threadfin Shad	1	11	23	**35**
Cyprinidae	*Macrhybopsis hyostoma*	Shoal Chub		1		**1**
Cyprinidae	*Cyprinidae*	Cyprinidae		4		**4**
Catostomidae	*Ictiobus bubalus*	Smallmouth Buffalo	1			**1**
Ariidae	*Ariopsis felis*	Hardhead Catfish	61	112	121	**294**
	Bagre marinus	Gafftopsail Catfish	29	53	215	**297**

Family	Scientific Name	Common Name	Sampling Year			Total Catch
			2014-2015	2016-2017	2018-2019	
Ictaluridae	*Ameirus melas*	Black Bullhead	1			**1**
	Ictalurus furcatus	Blue Catfish	956	1142	1601	**3699**
	Ictalurus punctatus	Channel Catfish	66	7	2	**75**
	Pylodictis olivaris	Flathead Catfish		1		**1**
Ophidiidae	*Ophidion josephi*	Crested Cusk Eel			1	**1**
Mugilidae	*Mugil cephalus*	Striped Mullet	5	6	6	**17**
Triglidae	*Prionotus tribulus*	Bighead Searobin	2			**2**
Centrarchidae	*Lepomis gulosus*	Warmouth	1			**1**
Carangidae	*Caranx hippos*	Crevalle Jack		1	1	**2**
	Chloroscombrus chrysurus	Atlantic Bumper	2	1		**3**
	Selene vomer	Lookdown	1			**1**
Lutjanidae	*Lutjanus griseus*	Mangrove Snapper	7			**7**
Gerreidae	*Eucinostomus argenteus*	Spotfin Mojarra		3	2	**5**
	Eucinostomus melanopterus	Flagfin Mojarra	123			**123**
	Gerres cinereus	Yellowfin Mojarra	8			**8**
Sparidae	*Archosargus probatocephalus*	Sheepshead	6	10		**16**
	Lagodon rhomboides	Pinfish			2	**2**
Polynemidae	*Polydactylus octonemus*	Atlantic Threadfin		1		**1**
Sciaenidae	*Aplodinotus grunniens*	Freshwater Drum		1	1	**2**
	Bairdiella chrysoura	Silver Perch	35	71	76	**182**
	Cynoscion arenarius	Sand Seatrout	90	241	387	**718**
	Cynoscion nebulosus	Spotted Seatrout	2		7	**9**
	Larimus fasciatus	Banded Drum	5		2	**7**
	Leiostomus xanthurus	Spot	18	7	137	**162**
	Menticirrhus americanus	Southern Kingfish			1	**1**
	Micropogonias undulatus	Atlantic Croaker	6830	4883	5262	**16975**
	Pogonias cromis	Black Drum	3	21		**24**
	Sciaenops ocellatus	Red Drum		1	1	**2**
	Stellifer lanceolatus	Star Drum	427	2099	4005	**6531**
	Sciaenidae spp.	Sciaenid		1		**1**
Gobiesocidae	*Gobiesox strumosus*	Skilletfish	1			**1**
Gobiidae	*Ctenogobius boleosoma*	Darter Goby	1	2	1	**4**
	Gobioides broussonnetii	Violet Goby		3	2	**5**

Family	Scientific Name	Common Name	Sampling Year			Total Catch
			2014-2015	2016-2017	2018-2019	
	Gobionellus oceanicus	Highfin Goby	1			**1**
	Gobiosoma bosc	Naked Goby		1		**1**
Ephippidae	*Chaetodipterus faber*	Atlantic Spadefish	2	2	3	**7**
Trichiuridae	*Trichiurus lepturus*	Ribbonfish	1	6	5	**12**
Paralichthyidae	*Citharichthys spilopterus*	Bay Whiff	5	1	14	**20**
	Paralichthys lethostigma	Southern Flounder	8	1	4	**13**
	Paralichthyidae spp.	Paralichthyidae		1		**1**
Achiridae	*Achirus lineatus*	Lined Sole	5			**5**
	Gymnachirus texae	Fringed Sole			3	**3**
	Trinectes maculatus	Hogchoker	11	20	3	**34**
Cynoglossidae	*Symphurus plagiusa*	Blackcheek Tonguefish	1		7	**8**
Tetraodontidae	*Sphoeroides nephelus*	Southern Puffer		1		**1**
	Sphoeroides parvus	Least Puffer			2	**2**
Unconfirmed	*Unconfirmed*	Unconfirmed		1	2	**3**
Grand Total			**10455**	**11864**	**15590**	**37909**

Table 28. Otter trawl catch data for each sample site since 2014.

Family	Scientific Name	Common Name	Site					Total Catch
			B01	B10	B22	B31	B42	
Loliginidae	*Lolliguncula brevis*	Atlantic Brief Squid	4	1				**5**
Mysidae	*Taphromysis louisianae*	Mysid Shrimp	4					**4**
Penaeidae	*Farfantepenaeus aztecus*	Brown Shrimp	957	80				**1037**
	Farfantepenaeus duorarum	Pink Shrimp	3					**3**
	Litopenaeus setiferus	White Shrimp	523	752	112	439		**1826**
	Rimapenaeus similis	Roughback Shrimp	1					**1**
Sergestidae	*Acetes americanus*	Sergestid Shrimp	25	61	19			**105**
Palaemonidae	*Macrobrachium ohione*	Ohio River Shrimp	6	1	52	296	85	**440**
	Macrobrachium rosenbergii	River Prawn				185	68	**253**
	Palaemonetes pugio	Daggerblade Grass Shrimp	15	1	4	10	2	**32**
	Palaemonetes vulgaris	Marsh Grass Shrimp	3					**3**
	Macrobrachium spp.	Macrobrachium spp.			1	138	90	**229**
Hippolytidae	*Tozeuma carolinense*	Arrow Shrimp	1					**1**
Diogenidae	*Clibanarius vittatus*	Thinstripe Hermit Crab	1					**1**
Epialtidae	*Libinia emarginata*	Common Spider Crab	1					**1**
	Libinia spp.	Spider Crab	2					**2**
Portunidae	*Callinectes sapidus*	Blue Crab	399	22	42	35	12	**510**
Menippidae	*Menippe adina*	Gulf Stone Crab	1					**1**
Panopeidae	*Rithropanopeus harrisii*	Estuarine Mud Crab					1	**1**
Dasyatidae	*Dasyatis americana*	Southern Stingray	1					**1**
Lepisosteidae	*Atractosteus spatula*	Alligator Gar				2		**2**
Engraulidae	*Anchoa mitchilli*	Bay Anchovy	157	2659	692	427	5	**3940**
Clupeidae	*Brevoortia patronus*	Gulf Menhaden	75	40	3	19		**137**
	Dorosoma cepedianum	Gizzard Shad		8	1	33		**42**
	Dorosoma petenense	Threadfin Shad	1	1	1	30	2	**35**

Family	Scientific Name	Common Name	Site					Total Catch
			B01	B10	B22	B31	B42	
Cyprinidae	*Macrhybopsis hyostoma*	Shoal Chub				1		**1**
Cyprinidae	*Cyprinidae*	Cyprinidae					4	**4**
Catostomidae	*Ictiobus bubalus*	Smallmouth Buffalo					1	**1**
Ariidae	*Ariopsis felis*	Hardhead Catfish	173	103	18			**294**
	Bagre marinus	Gafftopsail Catfish	160	112	16	9		**297**
Ictaluridae	*Ameirus melas*	Black Bullhead					1	**1**
	Ictalurus furcatus	Blue Catfish	1	2	645	2858	193	**3699**
	Ictalurus punctatus	Channel Catfish			20	49	6	**75**
	Pylodictis olivaris	Flathead Catfish					1	**1**
Ophidiidae	*Ophidion josephi*	Crested Cusk Eel	1					**1**
Mugilidae	*Mugil cephalus*	Striped Mullet		9	3	5		**17**
Triglidae	*Prionotus tribulus*	Bighead Searobin	2					**2**
Centrarchidae	*Lepomis gulosus*	Warmouth				1		**1**
Carangidae	*Caranx hippos*	Crevalle Jack	1			1		**2**
	Chloroscombrus chrysurus	Atlantic Bumper		1	1		1	**3**
	Selene vomer	Lookdown		1				**1**
Lutjanidae	*Lutjanus griseus*	Mangrove Snapper		1	6			**7**
Gerreidae	*Eucinostomus argenteus*	Spotfin Mojarra	2	1		2		**5**
	Eucinostomus melanopterus	Flagfin Mojarra	3	1	117	2		**123**
	Gerres cinereus	Yellowfin Mojarra		1	6	1		**8**
Sparidae	*Archosargus probatocephalus*	Sheepshead	7	8	1			**16**
	Lagodon rhomboides	Pinfish	2					**2**
Polynemidae	*Polydactylus octonemus*	Atlantic Threadfin	1					**1**
Sciaenidae	*Aplodinotus grunniens*	Freshwater Drum				2		**2**
	Bairdiella chrysoura	Silver Perch	149	32	1			**182**
	Cynoscion arenarius	Sand Seatrout	204	356	39	119		**718**
	Cynoscion nebulosus	Spotted Seatrout	2	7				**9**
	Larimus fasciatus	Banded Drum	7					**7**

Family	Scientific Name	Common Name	Site					Total Catch
			B01	B10	B22	B31	B42	
	Leiostomus xanthurus	Spot	23	29	16	94		**162**
	Menticirrhus americanus	Southern Kingfish		1				**1**
	Micropogonias undulatus	Atlantic Croaker	6281	5409	4815	454	16	**16975**
	Pogonias cromis	Black Drum		20	4			**24**
	Sciaenops ocellatus	Red Drum				2		**2**
	Stellifer lanceolatus	Star Drum	5274	1222	34	1		**6531**
	Sciaenidae spp.	Sciaenid	1					**1**
Gobiesocidae	*Gobiesox strumosus*	Skilletfish	1					**1**
Gobiidae	*Ctenogobius boleosoma*	Darter Goby	2	2				**4**
	Gobioides broussonnetii	Violet Goby		3	1	1		**5**
	Gobionellus oceanicus	Highfin Goby	1					**1**
	Gobiosoma bosc	Naked Goby				1		**1**
Ephippidae	*Chaetodipterus faber*	Atlantic Spadefish	5	1	1			**7**
Trichiuridae	*Trichiurus lepturus*	Ribbonfish	6	6				**12**
Paralichthyidae	*Citharichthys spilopterus*	Bay Whiff	11	8		1		**20**
	Paralichthys lethostigma	Southern Flounder	11	2				**13**
	Paralichthyidae spp.	Paralichthyidae		1				**1**
Achiridae	*Achirus lineatus*	Lined Sole			3	1	1	**5**
	Gymnachirus texae	Fringed Sole				3		**3**
	Trinectes maculatus	Hogchoker	1	1	5	10	17	**34**
Cynoglossidae	*Symphurus plagiusa*	Blackcheek Tonguefish	8					**8**
Tetraodontidae	*Sphoeroides nephelus*	Southern Puffer		1				**1**
	Sphoeroides parvus	Least Puffer	1	1				**2**
Unconfirmed	*Unconfirmed*	Unconfirmed	2	1				**3**
Grand Total			**14523**	**10969**	**6679**	**5232**	**506**	**37909**

Table 29. Otter trawl catch data for each sample site in the GOM.

Family	Scientific Name	Common Name	Site					Total
			G1	G1D1	G1U1	G2	G3	
Engraulidae	*Anchoa hepsetus*	Broad-striped Anchovy			2			**2**
Engraulidae	*Anchoa mitchilli*	Bay Anchovy	173	10	164	3	3	**353**
Clupeidae	*Harengule jaguana*	Scaled Sardine	1					**1**
Ariidae	*Ariopsis felis*	Hardhead Catfish	4		2	8		**14**
Ariidae	*Bagre marinus*	Gafftopsail Catfish	11	1	11			**23**
Triglidae	*Prionotus tribulus*	Bighead Searobin			1			**1**
Carangidae	*Caranx latus*	Horse-eye Jack	1					**1**
Carangidae	*Chloroscombrus chrysurus*	Atlantic Bumper	2	3	2	2		**9**
Carangidae	*Selene setapinnis*	Atlantic Moonfish	43	1	27			**71**
Carangidae	*Seriola rivoliana*	Almaco Jack			1			**1**
Sciaenidae	*Cynoscion arenarius*	Sand Seatrout	62	2	39	2		**105**
Sciaenidae	*Larimus fasciatus*	Banded Drum			1	1		**2**
Sciaenidae	*Leiostomus xanthurus*	Spot	1		1			**2**
Sciaenidae	*Menticirrhus americanus*	Southern Kingfish			1			**1**
Sciaenidae	*Micropogonias undulatus*	Atlantic Croaker	223	5	141	25		**394**
Sciaenidae	*Pogonias cromis*	Black Drum			1			**1**
Sciaenidae	*Stellifer lanceolatus*	Star Drum	185	4	337	75	1	**602**
Sphyraenidae	*Sphyraena barracuda*	Great Barracuda	1	1				**2**
Trichiuridae	*Trichiurus lepturus*	Ribbonfish		1	1	2	2	**6**
Stromateidae	*Peprilus triacanthus*	Atlantic Butterfish			12			**12**
Tetraodontidae	*Sphoeroides parvus*	Least Puffer	2					**2**
Mysidae	*Taphromysis louisianae*	Mysid Shrimp	4		7			**11**
Penaeidae	*Farfantepenaeus aztecus*	Brown Shrimp	1		1			**2**
Penaeidae	*Litopenaeus setiferus*	White Shrimp	3	1		2		**6**
Penaeidae	*Xiphopenaeus kroyeri*	Seabob	1					**1**
Epialtidae	*Libinia sp.*	Spider Crab	1					**1**
Portunidae	*Callinectes sapidus*	Blue Crab	2		11	1		**14**
Loliginidae	*Lolliguncula brevis*	Atlantic Brief Squid	51	2	77	20	4	**154**
Unconfirmed	*Unconfirmed*	Unconfirmed			1			**1**
Grand Total			**772**	**31**	**841**	**141**	**10**	**1795**

Table 30. Historical nekton presence in Brazos River by study since 1977 (1 = present, 0 = absent).

Family	Scientific Name	Common Name	Johnson 1977	Emmite 1983	EIH 2012	EIH 2014-2015	EIH 2016-2017	EIH 2018-2019
Loliginidae	*Lolliguncula brevis*	Atlantic Brief Squid	1	0	1	1	1	0
Squillidae	*Squilla empusa*	Mantis Shrimp	1	1	1	0	0	0
Mysidae	*Taphromysis louisianae*	Mysid Shrimp	1	0	0	0	0	1
Penaeidae	*Farfantepenaeus aztecus*	Brown Shrimp	1	1	1	1	1	1
	Farfantepenaeus duorarum	Pink Shrimp	0	0	0	1	1	0
	Litopenaeus setiferus	White Shrimp	1	1	1	1	1	1
	Rimapenaeus similis	Roughback Shrimp	1	0	0	1	0	0
	Xiphopenaeus kroyeri	Seabob	1	0	0	0	0	0
Sergestidae	*Acetes americanus*	Sergestid Shrimp	1	0	0	1	0	0
Palaemonidae	*Macrobrachium carcinus*	Bigclaw River Shrimp	0	0	0	1	0	0
	Macrobrachium ohione	Ohio River Shrimp	1	0	1	1	1	1
	Macrobrachium rosenbergii	River Prawn	0	0	0	0	1	0
	Palaemonetes pugio	Daggerblade Grass Shrimp	0	0	1	1	1	0
	Palaemonetes vulgaris	Marsh Grass Shrimp	0	0	0	1	1	0
	Macrobrachium spp.	Macrobrachium spp.	0	1	0	0	1	0
	Palaemonetes spp.	Palaemonetes spp.	0	0	0	1	0	0
Alpheidae	*Alpheus heterochaelis*	Bigclaw Snapping Shrimp	0	0	1	0	0	0
Hippolytidae	*Tozeuma carolinense*	Arrow Shrimp	0	0	0	1	0	0
Diogenidae	*Clibanarius vittatus*	Thinstripe Hermit Crab	0	0	0	0	0	1
Epialtidae	*Libinia dubia*	Longnose Spider Crab	0	0	1	0	1	0
	Libinia emarginata	Common Spider Crab	0	0	0	0	1	0
	Libinia spp.	Spider Crab	0	0	0	0	1	1

Family	Scientific Name	Common Name	Johnson 1977	Emmitte 1983	EIH 2012	EIH 2014-2015	EIH 2016-2017	EIH 2018-2019
Portunidae	*Callinectes sapidus*	Blue Crab	1	1	1	1	1	1
	Callinectes similis	Lesser Blue Crab	0	0	1	1	0	0
Menippidae	*Menippe adina*	Gulf Stone Crab	0	0	1	0	0	1
Panopeidae	*Rithropanopeus harrisii*	Estuarine Mud Crab	0	0	0	1	0	0
Xanthoidea	*Speocarcinus lobatus*	Gulf Squareback Crab	0	0	1	0	0	0
Libellulidae	*Libellulidae spp.*	Skimmer Dragonfly	0	0	0	0	1	1
Dasyatidae	*Dasyatis americana*	Southern Stingray	0	0	0	0	1	0
	Dasyatis sabina	Atlantic Stingray	0	0	1	0	0	0
Lepisosteidae	*Atractosteus spatula*	Alligator Gar	0	0	1	0	0	1
Albulidae	*Albula vulpes*	Bonefish	0	0	0	1	0	0
Engraulidae	*Anchoa hepsetus*	Broad-striped Anchovy	0	0	1	0	0	0
	Anchoa mitchilli	Bay Anchovy	1	1	1	1	1	1
Clupeidae	*Brevoortia patronus*	Gulf Menhaden	1	1	1	1	1	1
	Dorosoma cepedianum	Gizzard Shad	1	1	1	1	1	1
	Dorosoma petenense	Threadfin Shad	0	1	1	1	1	1
	Harengule jaguana	Scaled Sardine	1	1	1	0	0	0
	Opisthonema oglinum	Atlantic Thread Herring	0	0	1	0	0	0
	Alosine spp.	Alosine spp.	0	0	1	0	1	0
Cyprinidae	*Cyprinella lutrensis*	Red Shiner	0	0	0	0	0	1
	Cyprinella venusta	Blacktail Shiner	0	0	0	0	0	1
	Lythrurus fumeus	Ribbon Shiner	0	0	0	0	1	0
	Macrhybopsis aestivalis	Speckled Chub	1	0	0	0	0	0
	Macrhybopsis hyostoma	Shoal Chub	0	0	0	0	1	1
	Notropis buchanani	Ghost Shiner	0	0	0	0	0	1
	Pimephales vigilax	Bullhead Minnow	0	0	0	1	1	1
	Cyprinidae	Cyprinidae	0	0	0	0	1	0
Catostomidae	*Erimyzon sucetta*	Lake Chubsucker	0	0	0	1	0	0

Family	Scientific Name	Common Name	Johnson 1977	Emmitte 1983	EIH 2012	EIH 2014-2015	EIH 2016-2017	EIH 2018-2019
	Ictiobus bubalus	Smallmouth Buffalo	0	0	0	1	0	0
Ariidae	*Ariopsis felis*	Hardhead Catfish	1	1	1	1	1	1
	Bagre marinus	Gafftopsail Catfish	1	1	1	1	1	1
Ictaluridae	*Ameirus melas*	Black Bullhead	0	0	0	1	0	0
	Ictalurus furcatus	Blue Catfish	1	1	1	1	1	1
	Ictalurus punctatus	Channel Catfish	1	1	1	1	1	1
	Pylodictis olivaris	Flathead Catfish	0	0	0	0	1	0
Ophidiidae	*Ophidion josephi*	Crested Cusk Eel	0	0	0	0	0	1
Batrachoididae	*Porichthys plectrodon*	Atlantic Midshipman	0	1	0	0	0	0
Antennariidae	*Histrio histrio*	Sargassum Fish	0	0	1	0	0	0
Mugilidae	*Mugil cephalus*	Striped Mullet	1	1	1	1	1	1
	Mugil curema	White Mullet	0	0	1	0	0	0
Atherinopsidae	*Menidia beryllina*	Inland Silverside	0	0	0	0	1	0
	Menidia spp.	Menidia spp.	0	1	0	0	0	0
Cyprinodontidae	*Cyprinodon variegatus*	Sheepshead Minnow	0	0	1	0	0	0
Poeciliidae	*Gambusia affinis*	Western Mosquitofish	0	0	0	1	1	0
Syngnathidae	*Hippocampus erectus*	Lined Seahorse	0	0	1	0	0	0
	Syngnathus pelagicus	Sargassum Pipefish	0	0	1	0	0	0
Triglidae	*Prionotus tribulus*	Bighead Searobin	1	0	0	1	0	0
Centropomidae	*Centropomus undecimalis*	Common Snook	0	1	0	0	0	0
Centrarchidae	*Lepomis cyanellus*	Green Sunfish	0	0	0	1	0	0
	Lepomis gulosus	Warmouth	0	0	0	1	0	0
	Lepomis macrochirus	Bluegill	0	0	0	1	0	0
	Lepomis spp.	Lepomis spp.	0	0	0	0	1	0
Carangidae	*Caranx hippos*	Crevalle Jack	1	1	1	0	1	1
	Chloroscombrus chrysurus	Atlantic Bumper	1	1	0	1	1	0
	Selene setapinnis	Atlantic Moonfish	0	0	1	0	0	0
	Selene vomer	Lookdown	1	1	0	1	0	0

Family	Scientific Name	Common Name	Johnson 1977	Emmitte 1983	EIH 2012	EIH 2014-2015	EIH 2016-2017	EIH 2018-2019
	Trachinotus carolinus	Florida Pompano	1	0	0	0	0	0
Lutjanidae	*Lutjanus griseus*	Mangrove Snapper	0	1	1	1	0	0
Gerreidae	*Eucinostomus argenteus*	Spotfin Mojarra	0	0	1	0	1	1
	Eucinostomus gula	Silver Jenny	0	0	0	0	0	0
	Eucinostomus melanopterus	Flagfin Mojarra	0	0	1	1	0	0
	Gerres cinereus	Yellowfin Mojarra	0	0	0	1	0	0
Haemulidae	*Orthopristis chrysoptera*	Pigfish	0	1	0	0	0	0
Sparidae	*Archosargus probatocephalus*	Sheepshead	0	1	0	1	1	0
	Lagodon rhomboides	Pinfish	1	1	1	0	0	1
Polynemidae	*Polydactylus octonemus*	Atlantic Threadfin	1	1	1	0	1	0
Sciaenidae	*Aplodinotus grunniens*	Freshwater Drum	1	0	0	0	1	1
	Bairdiella chrysoura	Silver Perch	1	1	1	1	1	1
	Cynoscion arenarius	Sand Seatrout	1	1	1	1	1	1
	Cynoscion nebulosus	Spotted Seatrout	0	0	1	1	0	1
	Larimus fasciatus	Banded Drum	1	1	0	1	0	1
	Leiostomus xanthurus	Spot	1	1	1	1	1	1
	Menticirrhus americanus	Southern Kingfish	1	0	1	0	0	1
	Micropogonias undulatus	Atlantic Croaker	1	1	1	1	1	1
	Pogonias cromis	Black Drum	0	1	1	1	1	0
	Sciaenops ocellatus	Red Drum	0	1	0	0	1	1
	Stellifer lanceolatus	Star Drum	1	1	1	1	1	1
	Sciaenidae spp.	Sciaenid	0	0	1	0	1	0
Uranoscopidae	*Astroscopus y-graecum*	Southern Stargazer	1	0	0	0	0	0
Gobiesocidae	*Gobiesox strumosus*	Skilletfish	0	0	0	1	0	0

Family	Scientific Name	Common Name	Johnson 1977	Emmitte 1983	EIH 2012	EIH 2014-2015	EIH 2016-2017	EIH 2018-2019
Eleotridae	*Eleotris amblyopsis*	Large-scaled Spinycheek Sleeper	0	0	1	0	0	0
Gobiidae	*Ctenogobius shufeldti*	Freshwater Goby	0	0	1	1	0	0
	Ctenogobius boleosoma	Darter Goby	1	0	1	1	1	1
	Gobiosoma bosc	Naked Goby	0	0	1	1	1	0
	Gobioides broussonnetii	Violet Goby	0	0	0	0	1	1
	Gobionellus oceanicus	Highfin Goby	1	0	1	1	0	0
	Gobiosoma bosc	Naked Goby	0	0	1	0	1	0
	Gobiidae spp.	Gobiidae spp.	0	0	1	1	0	0
Ephippidae	*Chaetodipterus faber*	Atlantic Spadefish	1	0	1	1	1	1
Trichiuridae	*Trichiurus lepturus*	Ribbonfish	1	0	1	1	1	1
Scombridae	*Scomberomorus maculatus*	Atlantic Spanish Mackerel	0	1	0	0	0	0
Stromateidae	*Peprilus paru*	Harvestfish	1	0	0	0	0	0
	Peprilus triacanthus	Atlantic Butterfish	0	1	0	0	0	0
Paralichthyidae	*Citharichthys spilopterus*	Bay Whiff	1	0	1	1	1	1
	Paralichthys lethostigma	Southern Flounder	1	1	1	1	1	1
	Paralichthyidae spp.	Paralichthyidae	0	0	1	0	1	0
Achiridae	*Achirus lineatus*	Lined Sole	0	0	1	1	0	0
	Gymnachirus texae	Fringed Sole	0	0	1	0	0	1
	Trinectes maculatus	Hogchoker	0	0	0	1	1	1
Cynoglossidae	*Symphurus plagiusa*	Blackcheek Tonguefish	0	0	1	1	0	1
Tetraodontidae	*Sphoeroides nephelus*	Southern Puffer	0	0	0	0	1	0
	Sphoeroides parvus	Least Puffer	1	0	0	0	0	1
Unconfirmed	*Unconfirmed*	Unconfirmed	0	0	0	0	1	1
Total Taxa			44	37	63	61	59	49

Table 31. Cumulative nekton taxa richness for each method during each sampling period and sample site. Identifiable species would be considered all taxa that were identified to the species level.

	Method	Species Richness	Identifiable Species
2014-2015	BT	37	34
	OT	49	49
2016-2017	BT	28	23
	OT	50	45
2018-2019	BT	20	19
	OT	43	41
B01	BT	25	22
	OT	50	48
B10	BT	25	23
	OT	41	39
B22	BT	25	25
	OT	30	29
B31	BT	25	23
	OT	33	32
B42	BT	25	24
	OT	18	17

Table 32. Formulas and definitions for diversity indices calculated from nekton data.

Variable	Definition/Formula
Shannon-Wiener Diversity Index (H´)	$H' = -\sum p_i * \ln(p_i)$
Shannon Evenness (*J'*)	$J' = \frac{H'}{\ln(S)}$
Margalef Richness Index (MR)	$MR = \frac{(S-1)}{\ln(N)}$
p_i	The proportion of the entire community/sample made up of species *i*
S^*	Species richness: the number of unique species present in a community/sample.
N	Total number of individuals in the sample.
*Species that could not be identified down to the lowest taxonomic level (e.g. *Macrobrachium spp., etc.*) were still treated as individual species when calculating diversity indices.	

Table 33. Summary table of community metrics for beam trawl collections.

Date	Season	Flow Tier	Site	Total Catch (*N*)	Species Richness	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (*H´*)	Shannon Evenness (*J´*)
11/12/2014	Winter	Avg-Sub	B01	57	8	1.616667	35.25773	1.731366	1.329767	0.639483
			B10	165	5	1.683333	98.0198	0.7834	0.541566	0.336494
			B22	65	4	1.65	39.39394	0.718668	0.295163	0.212915
			B31	2	1	1.65	1.212121	0	0	0
			B42	7	3	1.65	4.242424	1.027797	0.9557	0.869916
12/10/2014	Winter	Avg-Sub	B01	6	3	2.45	2.44898	1.116221	1.011404	0.92062
			B10	9	3	1.733333	5.192308	0.910239	0.683739	0.622366
			B22	19	4	2.15	8.837209	1.01887	1.164365	0.839911
			B31	13	6	1.516667	8.571429	1.949356	1.697734	0.947523
			B42	341	6	2.95	115.5932	0.857356	0.307954	0.171872
1/7/2015	Winter	Avg-Base	B01	1368	10	2.1	651.4286	1.246347	0.236133	0.102551
			B10	13	3	2.35	5.531915	0.779742	0.687092	0.625418
			B22	148	8	1.916667	77.21739	1.400781	1.018552	0.48982
			B31	26	5	1.916667	13.56522	1.227711	1.244001	0.772941
			B42	6	4	1.95	3.076923	1.674332	1.329661	0.959148
2/5/2015	Winter	Avg-Base	B01	580	8	2	290	1.100105	0.547854	0.263462
			B10	192	5	1.966667	97.62712	0.760819	0.62395	0.387682
			B22	17	6	2.233333	7.61194	1.764781	1.542676	0.860984
			B31	18	6	2.133333	8.4375	1.729881	1.351039	0.754029
			B42	6	4	2.633333	2.278481	1.674332	1.329661	0.959148
2/19/2015	Winter	Avg-Sub	B01	210	8	2.3	91.30435	1.309119	0.614251	0.295392
			B10	38	4	1.916667	19.82609	0.824723	0.573146	0.413437
			B22	90	9	1.75	51.42857	1.777853	1.484688	0.67571
			B31	37	9	1.616667	22.8866	2.215503	1.54609	0.703656
			B42	79	5	1.65	47.87879	0.915447	0.320244	0.198979
4/2/2015	Spring	Avg-3ps	B01	21	3	1.866667	11.25	0.656917	0.835937	0.760903
			B10	25	3	2.016667	12.39669	0.621335	0.529644	0.482102
			B22	40	5	1.733333	23.07692	1.08434	0.687207	0.426986
			B31	36	5	1.9	18.94737	1.116221	1.155998	0.718262

Date	Season	Flow Tier	Site	Total Catch (*N*)	Species Richness	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (*H´*)	Shannon Evenness (*J´*)
			B42	12	6	1.85	6.486486	2.012148	1.632631	0.911189
4/28/2015	Spring	Avg-3ps	B01	92	7	1.833333	50.18182	1.326909	0.785452	0.403642
			B10	218	7	2.25	96.88889	1.114311	1.224572	0.629306
			B22	20	8	2.4	8.333333	2.336657	1.567181	0.753655
			B31	32	4	1.966667	16.27119	0.865617	1.180305	0.85141
			B42	34	3	2.483333	13.69128	0.567157	0.354599	0.32277
5/7/2015	Spring	Wet-2ps	B01	81	2	1.483333	54.60674	0.22756	0.294175	0.424405
			B10	95	6	1.766667	53.77358	1.097966	0.791814	0.44192
			B22	19	4	1.9	10	1.01887	0.826405	0.596125
			B31	20	4	1.75	11.42857	1.001425	0.799903	0.577008
			B42	28	2	1.866667	15	0.300102	0.154076	0.222285
12/1/2016	Winter	Wet-Sub	B01	27	3	1.466667	18.40909	0.606826	0.419556	0.381896
			B10	26	1	1.633333	15.91837	0	0	0
			B22	44	3	1.166667	37.71429	0.528515	0.638494	0.581182
			B31	3	2	1.283333	2.337662	0.910239	0.636514	0.918296
			B42	6	4	1.016667	5.901639	1.674332	1.329661	0.959148
12/20/2016	Winter	Wet-Sub	B01	43	2	0.983333	43.72881	0.265873	0.671081	0.968165
			B10	10	3	0.95	10.52632	0.868589	0.639032	0.581672
			B22	0	0	0.916667	0	0	0	0
			B31	1	1	0.966667	1.034483	0	0	0
			B42	18	3	1.183333	15.21127	0.691953	0.98099	0.892935
1/31/2017	Winter	Wet-Base	B01	80	3	1.666667	48	0.45641	0.490293	0.446284
			B10	47	8	1.616667	29.07216	1.818112	1.542444	0.741759
			B22	2	2	1.2	1.666667	1.442695	0.693147	1
			B31	11	6	1.316667	8.35443	2.085162	1.594167	0.889721
			B42	109	5	1.583333	68.84211	0.852633	0.570584	0.354524
3/15/2017	Spring	Wet-Base	B01	5	2	0.8	6.25	0.621335	0.500402	0.721928
			B10	29	2	0.8	36.25	0.296974	0.149995	0.216397
			B22	74	5	0.9	82.22222	0.929354	0.285218	0.177216
			B31	13	3	1.133333	11.47059	0.779742	0.790268	0.719333
			B42	23	4	1.15	20	0.956787	1.075027	0.775468

Date	Season	Flow Tier	Site	Total Catch (N)	Species Richness	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (H')	Shannon Evenness (J')
5/1/2017	Spring	Wet-Base	B01	1	1	1.35	0.740741	0	0	0
			B10	4	4	1.166667	3.428571	2.164043	1.386294	1
			B22	6	3	1.233333	4.864865	1.116221	0.867563	0.78969
			B31	9	4	1.183333	7.605634	1.365359	1.14906	0.828871
			B42	12	3	1.183333	10.14085	0.804859	0.721464	0.656705
5/24/2017	Spring	Wet-Sub	B01	1	1	1.383333	0.722892	0	0	0
			B10	6	2	1.183333	5.070423	0.558111	0.636514	0.918296
			B22	6	4	1.066667	5.625	1.674332	1.329661	0.959148
			B31	3	3	1.466667	2.045455	1.820478	1.098612	1
			B42	5	5	1.566667	3.191489	2.48534	1.609438	1
6/27/2017	Spring	Wet-Base	B01	1	1	1.483333	0.674157	0	0	0
			B10	1	1	1.3	0.769231	0	0	0
			B22	6	1	1.183333	5.070423	0	0	0
			B31	2	1	1.233333	1.621622	0	0	0
			B42	36	4	1.433333	25.11628	0.837166	0.678434	0.489387
7/31/2017	Summer	Avg-Base	B01	0	0	1.116667	0	0	0	0
			B10	0	0	0.95	0	0	0	0
			B22	0	0	1.1	0	0	0	0
			B31	0	0	1.133333	0	0	0	0
			B42	2	1	1.15	1.73913	0	0	0
9/20/2017	Summer	Avg-3ps	B01	0	0	1.15	0	0	0	0
			B10	3	2	1.433333	2.093023	0.910239	0.636514	0.918296
			B22	2	1	1.116667	1.791045	0	0	0
			B31	15	3	1.45	10.34483	0.738539	0.627705	0.571362
			B42	27	4	1.65	16.36364	0.910239	0.950516	0.685653
10/18/2017	Summer	Avg-3ps	B01	2	1	1.583333	1.263158	0	0	0
			B10	0	0	1.1	0	0	0	0
			B22	3	2	1.166667	2.571429	0.910239	0.636514	0.918296
			B31	9	1	1.533333	5.869565	0	0	0
			B42	3	3	1.566667	1.914894	1.820478	1.098612	1

Date	Season	Flow Tier	Site	Total Catch (*N*)	Species Richness	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (*H*´)	Shannon Evenness (*J*´)
9/27/2018	Summer	Avg-Sub	B01	1	1	1.466667	0.681818	0	0	0
			B10	0	0	1.283333	0	0	0	0
			B22	29	5	1.65	17.57576	1.187897	1.171033	0.727604
			B31	0	0	1.55	0	0	0	0
3/12/2019	Spring	Wet-Base	B01	1	1	0.966667	1.034483	0	0	0
			B10	312	2	1.1	283.6364	0.174125	0.054227	0.078232
			B22	10	4	1	10	1.302883	1.0889	0.785475
			B31	124	3	1.116667	111.0448	0.414914	0.326566	0.297254
7/11/2019	Summer	Wet-2ps	B01	0	0	1.116667	0	0	0	0
			B10	1	1	1.366667	0.731707	0	0	0
			B22	19	7	1.766667	10.75472	2.03774	1.689245	0.8681
			B31	73	6	1.45	50.34483	1.165376	0.713838	0.398401
7/31/2019	Summer	Wet-Base	B01	0	0	1.033333	0	0	0	0
			B10	0	0	1.433333	0	0	0	0
			B22	0	0	1.7	0	0	0	0
			B31	0	0	3.166667	0	0	0	0
9/5/2019	Summer	Wet-Sub	B01	0	0	1.133333	0	0	0	0
			B10	1	1	1.6	0.625	0	0	0
			B22	0	0	1.483333	0	0	0	0
			B31	0	0	1.483333	0	0	0	0
10/17/2019	Summer	Wet-Sub	B01	0	0	1.583333	0	0	0	0
			B10	0	0	1.45	0	0	0	0
			B22	0	0	1.5	0	0	0	0
			B31	3	1	1.233333	2.432432	0	0	0
12/5/2019	Winter	Avg-Sub	B01	5	1	1	5	0	0	0
			B10	6	2	0.833333	7.2	0.558111	0.450561	0.650022
			B22	7	2	0.916667	7.636364	0.513898	0.410116	0.591673
			B31	10	4	0.85	11.76471	1.302883	1.0889	0.785475

Table 34. Summary table of community metrics for otter trawl collections.

Date	Season	Flow Tier	Site	Total Catch (*N*)	Species Richness (*S*)	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (*H´*)	Shannon Evenness (*J´*)
11/12/2014	Winter	Avg-Sub	B01	151	12	15	10.06667	2.192423	1.650998	0.66441
			B10	189	13	15	12.6	2.289313	1.477811	0.576156
			B22	600	10	15	40	1.406925	0.339091	0.147265
			B31	326	5	9.5	34.31579	0.691217	0.116237	0.072222
			B42	12	3	15	0.8	0.804859	0.918428	0.835989
12/10/2014	Winter	Avg-Sub	B01	82	8	15	5.466667	1.588483	0.818924	0.393819
			B10	29	11	15	1.933333	2.969742	2.097655	0.87479
			B22	43	12	15	2.866667	2.924598	1.799437	0.724147
			B31	400	9	14.5	27.58621	1.335233	0.659077	0.299959
			B42	82	5	15	5.466667	0.907705	0.728304	0.452521
1/7/2015	Winter	Avg-Base	B01	253	11	15	16.86667	1.807211	0.501339	0.209075
			B10	10	4	15	0.666667	1.302883	1.168282	0.842738
			B22	2785	10	15	185.6667	1.134644	0.260873	0.113296
			B31	15	3	15	1	0.738539	0.485094	0.441552
			B42	5	5	15	0.333333	2.48534	1.609438	1
2/5/2015	Winter	Avg-Base	B01	28	6	15	1.866667	1.500508	1.346511	0.751502
			B10	14	7	15	0.933333	2.273539	1.72982	0.888952
			B22	190	3	15	12.66667	0.381168	0.307192	0.279618
			B31	17	3	15	1.133333	0.705912	0.677909	0.617059
			B42	14	3	15	0.933333	0.757846	1.078992	0.982141
2/19/2015	Winter	Avg-Sub	B01	1186	11	15	79.06667	1.41276	0.211075	0.088025
			B10	136	10	15	9.066667	1.832003	1.220907	0.530233
			B22	655	7	15	43.66667	0.925264	0.154736	0.079518
			B31	328	5	14.5	22.62069	0.690487	0.577778	0.358994
			B42	6	4	5	1.2	1.674332	1.242453	0.896241
4/2/2015	Spring	Avg-3ps	B01	210	5	15	14	0.748068	0.926536	0.575689

Date	Season	Flow Tier	Site	Total Catch (N)	Species Richness (S)	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (H')	Shannon Evenness (J')
			B10	37	4	15	2.466667	0.830814	0.524448	0.378309
			B22	31	4	15	2.066667	0.87362	0.424254	0.306035
			B31	20	4	15	1.333333	1.001425	0.96726	0.697731
			B42	16	3	15	1.066667	0.721348	0.601924	0.547895
4/29/2015	Spring	Avg-3ps	B01	3	3	15	0.2	1.820478	1.098612	1
			B10	9	4	15	0.6	1.365359	1.14906	0.828871
			B22	13	4	15	0.866667	1.169614	1.204793	0.869075
			B31	2	1	14.83333	0.134831	0	0	0
			B42	8	2	15	0.533333	0.480898	0.37677	0.543564
5/7/2015	Spring	Wet-2ps	B01	24	6	15	1.6	1.57329	1.567971	0.875101
			B10	40	7	15	2.666667	1.62651	1.048301	0.53872
			B22	23	5	15	1.533333	1.275716	1.068006	0.66359
			B31	12	4	15	0.8	1.207289	1.075139	0.775549
			B42	42	3	15	2.8	0.535093	0.224451	0.204304
8/12/2015	Summer	Wet-2ps	B01	192	10	15	12.8	1.711842	1.49876	0.650903
			B10	1735	11	15	115.6667	1.340705	1.010103	0.421246
			B22	107	8	15	7.133333	1.498022	1.526104	0.733901
			B31	344	4	15	22.93333	0.513642	0.74222	0.535398
			B42	31	2	15	2.066667	0.291207	0.239217	0.345117
12/1/2016	Winter	Wet-Sub	B01	233	15	15.06667	15.39823	2.568318	1.140835	0.421276
			B10	210	9	15.08333	13.92265	1.496136	1.507554	0.686118
			B22	391	5	15.11667	25.86549	0.670162	0.464003	0.288301
			B31	240	8	15.16667	15.82418	1.277223	1.230751	0.591866
			B42	99	4	14.3	6.923077	0.652867	0.551566	0.397871
12/20/2016	Winter	Wet-Sub	B01	2737	13	15.41667	177.5351	1.516182	0.361046	0.140761
			B10	318	12	15.35	20.71661	1.909042	0.726496	0.292364
			B22	1093	6	15.31667	71.36017	0.714624	0.05422	0.030261

Date	Season	Flow Tier	Site	Total Catch (*N*)	Species Richness (*S*)	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (*H´*)	Shannon Evenness (*J´*)
			B31	65	5	15.01667	4.328524	0.958224	1.063085	0.660532
			B42	19	3	15.33333	1.23913	0.679247	1.045978	0.95209
1/31/2017	Winter	Wet-Base	B01	241	9	15.65	15.39936	1.458577	0.814442	0.370668
			B10	37	6	15.35	2.410423	1.384689	1.528123	0.852862
			B22	11	2	15.23333	0.722101	0.417032	0.304636	0.439497
			B31	2	1	15.23333	0.131291	0	0	0
			B42	5	5	15.25	0.327869	2.48534	1.609438	1
3/15/2017	Spring	Wet-Base	B01	383	9	15.13333	25.30837	1.344982	1.106024	0.503373
			B10	42	6	15.1	2.781457	1.337732	1.474406	0.822882
			B22	4	2	15.06667	0.265487	0.721348	0.562335	0.811278
			B31	23	2	15.08333	1.524862	0.318929	0.295439	0.426229
			B42	5	1	14.78333	0.338219	0	0	0
5/1/2017	Spring	Wet-Base	B01	68	9	15	4.533333	1.895956	1.532275	0.697369
			B10	16	6	14	1.142857	1.803369	1.700165	0.94888
			B22	76	3	15	5.066667	0.461816	0.753993	0.686314
			B31	76	4	15.16667	5.010989	0.692723	0.444736	0.320809
			B42	5	2	14.66667	0.340909	0.621335	0.500402	0.721928
5/24/2017	Spring	Wet-Sub	B01	986	14	15.15	65.08251	1.885792	0.526943	0.199671
			B10	661	13	15.21667	43.43921	1.84793	1.084001	0.422621
			B22	7	2	15.25	0.459016	0.513898	0.682908	0.985228
			B31	216	6	15.35	14.07166	0.930184	0.53687	0.299633
			B42	75	3	14.33333	5.232558	0.463232	0.408785	0.372092
6/27/2017	Spring	Wet-Base	B01	408	10	15.13333	26.96035	1.497188	1.053923	0.457713
			B10	163	10	15.05	10.83056	1.766871	0.929092	0.4035
			B22	336	6	15.01667	22.37514	0.859533	0.424213	0.236758
			B31	58	3	15	3.866667	0.492557	0.816738	0.743427
			B42	12	2	15	0.8	0.40243	0.636514	0.918296

Date	Season	Flow Tier	Site	Total Catch (N)	Species Richness (S)	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (H')	Shannon Evenness (J')
7/31/2017	Summer	Avg-Base	B01	1011	12	15.15	66.73267	1.589895	0.75056	0.302048
			B10	18	6	15.1	1.192053	1.729881	1.406678	0.785082
			B22	91	7	15.11667	6.019846	1.330123	1.508544	0.775238
			B31	327	12	14.26667	22.92056	1.89984	1.675201	0.67415
			B42	52	5	15.13333	3.436123	1.012339	1.09566	0.680772
9/20/2017	Summer	Avg-3ps	B01	175	7	15.1	11.5894	1.161713	0.980881	0.504073
			B10	61	6	15.16667	4.021978	1.216286	1.309902	0.73107
			B22	22	2	15.08333	1.458564	0.323515	0.304636	0.439497
			B31	163	3	12.3	13.25203	0.392638	0.15243	0.138748
			B42	8	1	15.13333	0.528634	0	0	0
10/18/2017	Summer	Avg-3ps	B01	74	10	15.16667	4.879121	2.091046	0.914849	0.397314
			B10	269	11	15.06667	17.85398	1.787402	1.230709	0.513246
			B22	6	2	15.15	0.39604	0.558111	0.693147	1
			B31	256	6	14.96667	17.10468	0.901684	0.372682	0.207998
			B42	10	3	15.05	0.664452	0.868589	0.801819	0.729847
9/19/2018	Summer	Avg-Base	G1D1	31	11	15	43.26667	2.912067	2.056999	0.857835
			G1	649	15	15.01667	2.064373	2.162018	1.753066	0.647353
			G1U1	402	15	15.1	26.62252	2.334714	1.822928	0.673152
			G2	8	4	15.2	0.526316	1.442695	1.320888	0.95282
			G3	3	1	15	0.2	0	0	0
9/27/2018	Summer	Avg-Sub	B01	259	11	15.13333	17.11454	1.799588	1.190087	0.496305
			B10	338	12	15.03333	22.48337	1.889046	1.529286	0.61543
			B22	0	0	15.01667	0	0	0	0
			B31	468	11	14.91667	31.3743	1.626421	1.536541	0.640787
3/12/2019	Spring	Wet-Base	B01	1378	10	15.01667	91.76471	1.245091	0.162699	0.070659
			B10	2827	10	15	188.4667	1.132507	0.203937	0.088569
			B22	4	3	15.06667	0.265487	1.442695	1.039721	0.946395

Date	Season	Flow Tier	Site	Total Catch (*N*)	Species Richness (*S*)	Haul Time (Minutes)	CPUE	Margalef Richness	Shannon-Wiener Diversity Index (*H´*)	Shannon Evenness (*J´*)
			B31	10	4	13.05	0.766284	1.302883	1.0889	0.785475
7/11/2019	Summer	Wet-2ps	B01	909	13	15.15	60	1.761508	0.655132	0.255417
			B10	254	6	15.11667	16.80265	0.902962	1.461519	0.815689
			B22	47	2	15.26667	3.078603	0.25973	0.420859	0.607172
			B31	38	2	14.98333	2.536151	0.274908	0.642422	0.926819
7/31/2019	Summer	Wet-Base	B01	2597	13	15.05	172.5581	1.526307	0.553881	0.215942
			B10	622	11	15.25	40.78689	1.554499	1.351838	0.56376
			B22	19	7	13.9	1.366906	2.03774	1.708656	0.878075
			B31	93	3	15.23333	6.105033	0.441248	0.953849	0.86823
9/5/2019	Summer	Wet-Sub	B01	498	15	15.08333	33.01657	2.254211	2.003461	0.739817
			B10	564	9	15.1	37.35099	1.262815	1.109534	0.50497
			B22	3	2	14.11333	0.212565	0.910239	0.636514	0.918296
			B31	1571	12	15.15	103.6964	1.494673	0.588232	0.236722
10/17/2019	Summer	Wet-Sub	B01	143	13	15.58333	9.176471	2.417968	1.861053	0.725571
			B10	1837	11	15.16667	121.1209	1.330515	0.85539	0.356725
			B22	81	2	10.15	7.980296	0.22756	0.158411	0.228538
			B31	0	0	0	0	0	0	0
12/4/2019	Winter	Avg-Sub	G1D1	0	0	15.55	7.909968	0	0	0
			G1	123	12	15.16667	0	2.285864	1.627035	0.654767
			G1U1	439	12	15.3	28.69281	1.807873	1.047327	0.421475
			G2	133	10	15.33333	8.673913	1.840359	1.384535	0.601296
			G3	7	3	15.58333	0.449198	1.027797	0.9557	0.869916
12/5/2019	Winter	Avg-Sub	B01	294	8	15.06667	19.51327	1.231618	1.634105	0.785838
			B10	533	11	15.05	35.41528	1.592732	1.00916	0.420852
			B22	41	7	14.18333	2.890717	1.615695	1.501064	0.771394
			B31	162	12	10.01667	16.17304	2.162121	1.686087	0.678531

APPENDIX H:

STATISTICAL OUTPUT FOR HYDROLOGY RESULTS

Table 35. Descriptive Statistics for Extreme Flow Event Analysis (Figure 6).

Left Panel	
Mean Daily Average Discharge (cfs)	8394.02
Median Daily Average Discharge (cfs)	3190
Extreme Flow (cfs)	33869.90
Right Panel	
Mean Days with Extreme Flow	21.69388
Median Days with Extreme Flow	13
Outlier Days (red line)	80.84652

Table 36. Summary table for Extreme Flow Event Analysis (Figure 6).

Year	Annual Average Discharge (cfs)	Days exceeding mean daily average discharge (8,394.02 cfs)	Days exceeding median daily average discharge (3,190 cfs)	Days with extreme flow ()
1967		6	37	0
1968	14300	195	274	36
1969	8051	112	177	19
1970	6942	111	217	5
1971	2756	37	95	0
1972	3125	27	113	0
1973	12620	182	309	26
1974	8994	116	208	24
1975	9865	155	242	14
1976	7784	108	212	5
1977	8166	107	181	16
1978	1780	11	59	0
1979	11680	150	261	30
1980		38	102	5
1981		0	0	
1982		0	0	
1983		0	0	
1984		37	70	6
1985	7374	106	235	6
1986	8914	123	279	13
1987	10350	155	258	17
1988	1500	3	41	0
1989	5488	69	118	3
1990	7777	82	139	26
1991	10720	141	254	22
1992	26990	239	291	132
1993	9747	151	223	18
1994	7139	80	175	13
1995	9787	158	245	2
1996	2363	21	76	0
1997	14700	178	262	44
1998	12710	172	224	36
1999	2926	24	116	0
2000	2478	31	70	4
2001	10280	163	260	20
2002	6981	86	204	10
2003	5810	59	176	8
2004	14790	168	337	52
2005	6522	93	159	6

Year	Annual Average Discharge (cfs)	Days exceeding mean daily average discharge (8,394.02 cfs)	Days exceeding median daily average discharge (3,190 cfs)	Days with extreme flow ()
2006	2138	16	48	0
2007	20800	246	313	91
2008	3196	36	133	0
2009	4998	87	121	6
2010	8443	110	224	13
2011	637.4	0	5	0
2012	4578	60	102	11
2013	2457	24	67	3
2014	1990	12	40	2
2015	18900	204	292	90
2016	21080	231	320	100
2017	8929	75	247	14
2018	9690	92	135	45
2019	15790	167	240	75
*Blank cells indicate no data was available for the listed year.				

Table 37. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) of each month from 1967-2019 (Top panel of Figure 7).

Group	N	Median	Mean Rank	Z-Value
January	1488	5115	10329.0	10.45
February	1356	5485	10469.3	10.98
March	1488	6385	10758.3	13.79
April	1476	5515	10297.7	10.17
May	1550	6620	10802.8	14.45
June	1500	4605	9929.6	7.38
July	1550	1810	7408.7	-12.50
August	1550	1260	5995.5	-23.73
September	1499	1860	6958.9	-15.78
October	1519	1840	7283.4	-13.35
November	1470	2715	8689.6	-2.26
December	1519	3260	9165.3	1.43
Overall	17965		8983.0	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	11	1776.83	0.000
Adjusted for ties	11	1776.83	0.000

Comparisons: 66
Ties: 15525
Family Alpha: 0.367
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table of P-values (adjusted for ties)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	1.00000	*	*	*	*	*	*	*	*	*	*	*
Feb	0.47130	1.00000	*	*	*	*	*	*	*	*	*	*
Mar	0.02398	0.13777	1.00000	*	*	*	*	*	*	*	*	*
Apr	0.86955	0.37921	0.01564	1.00000	*	*	*	*	*	*	*	*
May	0.01183	0.08372	0.81292	0.00741	1.00000	*	*	*	*	*	*	*
Jun	0.03529	0.00548	0.00001	0.05284	0.00000	1.00000	*	*	*	*	*	*
Jul	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	*	*	*	*	*
Aug	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	*	*	*	*
Sep	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01666	0.00000	1.00000	*	*	*
Oct	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.50325	0.00000	0.08573	1.00000	*	*
Nov	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	*
Dec	0.00000	0.00000	0.00000	0.00000	0.00000	0.00005	0.00000	0.00000	0.00000	0.00000	0.01218	1

Table 38. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) of each month from 1967-2019 (Bottom panel of Figure 7).

Group	N	Median	Mean Rank	Z-Value
January	279	2740	1896.2	4.64
February	254	3205	1759.0	2.01
March	279	4700	1861.0	3.99
April	270	5250	1824.9	3.27
May	279	2590	1858.9	3.95
June	270	2900	1698.6	0.99
July	279	2000	1516.4	-2.35
August	279	894	1213.6	-7.92
September	270	1510	1371.6	-4.92
October	279	1420	1411.4	-4.28
November	270	2430	1658.6	0.26
December	279	2050	1667.4	0.43
Overall	3287		1644.0	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	11	164.70	0.000
Adjusted for ties	11	164.70	0.000

Comparisons: 66
Ties: 1731
Family Alpha: 0.367
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table of P-values (adjusted for ties)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Jan	1.00000	*	*	*	*	*	*	*	*	*	*	*
Feb	0.09555	1.00000	*	*	*	*	*	*	*	*	*	*
Mar	0.66155	0.21518	1.00000	*	*	*	*	*	*	*	*	*
Apr	0.37904	0.42682	0.65596	1.00000	*	*	*	*	*	*	*	*
May	0.64269	0.22478	0.97913	0.67482	1.00000	*	*	*	*	*	*	*
Jun	0.01475	0.46680	0.04504	0.12207	0.04790	1.00000	*	*	*	*	*	*
Jul	0.00000	0.00321	0.00002	0.00014	0.00002	0.02452	1.00000	*	*	*	*	*
Aug	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00016	1.00000	*	*	*	*
Sep	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006	0.07394	0.05106	1.00000	*	*	*
Oct	0.00000	0.00002	0.00000	0.00000	0.00000	0.00039	0.19099	0.01384	0.62408	1.00000	*	*
Nov	0.00337	0.22638	0.01250	0.04178	0.01344	0.62444	0.07920	0.00000	0.00044	0.00227	1.00000	*
Dec	0.00440	0.26556	0.01595	0.05182	0.01713	0.69956	0.06032	0.00000	0.00026	0.00144	0.91427	1

Table 39. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) of each year from 2011-2019 (Figure 8).

Group	N	Median	Mean Rank	Z-Value
2011	365	442	531.3	-23.76
2012	366	1025	1260.5	-8.20
2013	365	725	1014.3	-13.44
2014	365	1080	1142.0	-10.72
2015	365	11700	2384.2	15.80
2016	366	11650	2541.9	19.20
2017	365	4470	2061.5	8.91
2018	365	1960	1713.9	1.49
2019	365	6720	2145.0	10.70
Overall	3287		1644.0	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	8	1548.36	0.000
Adjusted for ties	8	1548.36	0.000

Comparisons: 36
Ties: 1731
Family Alpha: 0.2
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table of P-values (adjusted for ties)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
2011	1.00000	*	*	*	*	*	*	*	*
2012	0.00000	1.00000	*	*	*	*	*	*	*
2013	0.00000	0.00045	1.00000	*	*	*	*	*	*
2014	0.00000	0.09131	0.06911	1	*	*	*	*	*
2015	0.00000	0.00000	0.00000	0.00000	1.00000	*	*	*	*
2016	0.00000	0.00000	0.00000	0.00000	0.02468	1.00000	*	*	*
2017	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	*	*
2018	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	1.00000	*
2019	0.00000	0.00000	0.00000	0.00000	0.00066	0.00000	0.23446	0.00000	1

Table 40. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) of each season from 1967-2019 (Top panel of Figure 9).

Group	N	Median	Mean Rank	Z-Value
Spring	6014	5580	10450.0	26.90
Summer	6118	1690	6909.4	-38.51
Winter	5833	4190	9645.4	11.87
Overall	17965		8983.0	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	1554.47	0.000
Adjusted for ties	2	1554.47	0.000

Comparisons: 3
Ties: 15525
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table of Z-values (adjusted for ties)

	Spring	Summer	Winter
Spring	0.0000	*	*
Summer	37.5973	0.0000	*
Winter	8.4422	28.8288	0.0000

Table of P-values (adjusted for ties)

	Spring	Summer	Winter
Spring	1.0000	*	*
Summer	0.0000	1.0000	*
Winter	0.0000	0.0000	1.0000

Table 41. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) of each season from 2011-2019 (Bottom panel of Figure 9).

Group	N	Median	Mean Rank	Z-Value
Spring	1098	4205	1811.7	7.17
Summer	1107	1490	1378.3	-11.44
Winter	1082	2590	1745.7	4.30
Overall	3287		1644.0	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	133.46	0.000
Adjusted for ties	2	133.46	0.000

Comparisons: 3
Ties: 1731
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table of Z-values (adjusted for ties)

	Spring	Summer	Winter
Spring	0.0000	*	*
Summer	10.7212	0.00000	*
Winter	1.6227	9.05556	0.00000

Table of P-values (adjusted for ties)

	Spring	Summer	Winter
Spring	1.0000	*	*
Summer	0.0000	1.0000	*
Winter	0.10465	0.0000	1.0000

Table 42. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) during the summer season of each year from 2011-2019 (Figure 10).

Group	N	Median	Mean Rank	Z-Value
2011	123	333	146.6	-14.99
2012	123	920	408.4	-5.36
2013	123	398	301.6	-9.29
2014	123	912	392.6	-5.94
2015	123	5470	784.6	8.48
2016	123	10700	916.4	13.33
2017	123	4070	797.1	8.94
2018	123	1230	545.8	-0.30
2019	123	2910	692.8	5.11
Overall	1107		554.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	8	649.65	0.000
Adjusted for ties	8	649.65	0.000

Comparisons: 36

Ties: 339

Family Alpha: 0.2

Bonferroni Individual Alpha: 0.006

Bonferroni Z-value (2-sided): 2.773

Table of P-values (adjusted for ties)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
2011	1.00000	*	*	*	*	*	*	*	*
2012	0.00000	1.00000	*	*	*	*	*	*	*
2013	0.00014	0.00879	1.00000	*	*	*	*	*	*
2014	0.00000	0.69796	0.02561	1.00000	*	*	*	*	*
2015	0.00000	0.00000	0.00000	0.00000	1.00000	*	*	*	*
2016	0.00000	0.00000	0.00000	0.00000	0.00122	1.00000	*	*	*
2017	0.00000	0.00000	0.00000	0.00000	0.75898	0.00342	1.00000	*	*
2018	0.00000	0.00075	0.00000	0.00017	0.00000	0.00000	0.00000	1.00000	*
2019	0.00000	0.00000	0.00000	0.00000	0.02443	0.00000	0.01055	0.00031	1.00000

Table 43. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) during the winter season of each year from 2011-2019 (Figure 11).

Group	N	Median	Mean Rank	Z-Value
2011	120	889	246.4	-10.97
2012	121	711	328.8	-7.94
2013	120	2345	503.4	-1.42
2014	120	1100	336.0	-7.64
2015	120	14800	810.9	10.02
2016	121	6010	737.0	7.30
2017	120	3000	600.0	2.17
2018	120	12350	707.6	6.17
2019	120	2735	603.7	2.31
Overall	1082		541.5	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	8	396.13	0.000
Adjusted for ties	8	396.13	0.000

Comparisons: 36
Ties: 353
Family Alpha: 0.2
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table of P-values (adjusted for ties)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
2011	1.00000	*	*	*	*	*	*	*	*
2012	0.04050	1.00000	*	*	*	*	*	*	*
2013	0.00000	0.00001	1.00000	*	*	*	*	*	*
2014	0.02632	0.85922	0.00003	1.00000	*	*	*	*	*
2015	0.00000	0.00000	0.00000	0.00000	1.00000	*	*	*	*
2016	0.00000	0.00000	0.00000	0.00000	0.06619	1.00000	*	*	*
2017	0.00000	0.00000	0.01666	0.00000	0.00000	0.00067	1.00000	*	*
2018	0.00000	0.00000	0.00000	0.00000	0.01042	0.46547	0.00764	1.00000	*
2019	0.00000	0.00000	0.01290	0.00000	0.00000	0.00093	0.92651	0.01002	1.00000

Table 44. Results of Kruskal-Wallis test and Dunn's multiple comparisons test between median daily average discharge (cfs) during the spring season of each year from 2011-2019 (Figure 12).

Group	N	Median	Mean Rank	Z-Value
2011	122	305.5	125.1	-15.68
2012	122	2735.0	501.2	-1.78
2013	122	559.0	224.5	-12.01
2014	122	1440.0	392.3	-5.81
2015	122	23000.0	819.7	9.98
2016	122	41050.0	927.4	13.96
2017	122	6050.0	643.9	3.49
2018	122	2045.0	461.1	-3.27
2019	122	26450.0	850.4	11.12
Overall	1098		549.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	8	771.41	0.000
Adjusted for ties	8	771.42	0.000

Comparisons: 36

Ties: 268

Family Alpha: 0.2

Bonferroni Individual Alpha: 0.006

Bonferroni Z-value (2-sided): 2.773

Table of P-values (adjusted for ties)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
2011	1.00000	*	*	*	*	*	*	*	*
2012	0.00000	1.00000	*	*	*	*	*	*	*
2013	0.01438	0.00000	1.00000	*	*	*	*	*	*
2014	0.00000	0.00727	0.00004	1.00000	*	*	*	*	*
2015	0.00000	0.00000	0.00000	0.00000	1.00000	*	*	*	*
2016	0.00000	0.00000	0.00000	0.00000	0.00803	1.00000	*	*	*
2017	0.00000	0.00044	0.00000	0.00000	0.00001	0.00000	1.00000	*	*
2018	0.00000	0.32236	0.00000	0.09013	0.00000	0.00000	0.00001	1.00000	*
2019	0.00000	0.00000	0.00000	0.00000	0.45065	0.05792	0.00000	0.00000	1.00000

APPENDIX I:

STATISTICAL OUTPUT FOR WATER QUALITY RESULTS

Table 45. Results of linear regression analysis between field discharge and continuous discharge (left) and daily average discharge (right) for Figure 13.

Continuous Model Summary

Field Discharge (cfs) = 455.6
+ 0.9207 Continuous Discharge

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	455.6	452	1.01	0.324	
Continuous Discharge	0.9207	0.0765	12.04	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
1222.13	86.30%	85.71%	84.29%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	216447148	216447148	144.92	0.000
Continuous Discharge	1	216447148	216447148	144.92	0.000
Error	23	34352659	1493594		
Total	24	250799807			

Daily Average Model Summary

Field Discharge (cfs) = 469.1
+ 0.9180 Daily Average Discharge

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	469.1	453	1.04	0.311	
Daily Average Discharge	0.9180	0.0765	11.99	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
1226.12	86.21%	85.61%	84.17%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	216222265	216222265	143.82	0.000
Daily Average Discharge	1	216222265	216222265	143.82	0.000
Error	23	34577542	1503371		
Total	24	250799807			

Table 46. Results of polynomial regression analysis between daily average temperature (°C) and Julian day for each site (Figure 14).

Lower Model Summary

Lower = 7.761 + 0.2198 Julian Day - 0.000560 Julian Day^2

Source	DF	SS	F	P
Linear	1	2037.7	50.09	0.000
Quadratic	1	28036.9	3326.35	0.000

S	R-sq	R-sq(adj)
2.90323	80.43%	80.39%

ANOVA

Source	DF	SS	MS	F	P
Regression	2	30074.7	15037.3	1784.05	0.000
Error	868	7316.2	8.4		
Total	870	37390.8			

Middle Model Summary

Middle = 6.741 + 0.2291 Julian Day - 0.000579 Julian Day^2

Source	DF	SS	F	P
Linear	1	2557.8	56.53	0.000
Quadratic	1	33150.3	3369.23	0.000

S	R-sq	R-sq(adj)
3.13674	79.51%	79.47%

ANOVA

Source	DF	SS	MS	F	P
Regression	2	35708.1	17854.0	1814.60	0.000
Error	935	9199.6	9.8		
Total	937	44907.6			

Upper Model Summary

Upper = 7.339 + 0.2225 Julian Day - 0.000570 Julian Day^2

Source	DF	SS	F	P
Linear	1	1394.2	32.56	0.000
Quadratic	1	23095.8	3093.77	0.000

S	R-sq	R-sq(adj)
2.73226	83.42%	83.37%

ANOVA

Source	DF	SS	MS	F	P
Regression	2	24490.0	12245.0	1640.27	0.000
Error	652	4867.3	7.5		
Total	654	29357.4			

Table 47. Results of combined polynomial regression analysis between daily average temperature (°C) and Julian day (Figure 15).

Model Summary

Daily Average Temperature(°C) = 7.272 + 0.2240 Julian Day - 0.000570 Julian Day^2

Source	DF	SS	F	P
Linear	1	5948.4	138.47	0.000
Quadratic	1	84236.1	9631.87	0.000

S	R-sq	R-sq(adj)
2.95729	80.73%	80.72%

ANOVA

Source	DF	SS	MS	F	P
Regression	2	90184	45092.2	5156.02	0.000
Error	2461	21523	8.7		
Total	2463	111707			

Table 48. Results of linear regression analysis between log transformed daily average salinity (psu) and daily average discharge (cfs) (Top panel of Figure 16).

Lower Model Summary

Log Salinity (ppt) = 2.953 - 0.6649 Log [Daily Avg Discharge (cfs)]

S	R-sq	R-sq(adj)
0.189692	80.98%	80.96%

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.5379	0.0715	35.48	0.000	
Log [Daily Avg Discharge (cfs)]	0.7271	0.0185	-39.24	0.000	1.00

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	132.957	132.957	3694.99	0.000
Log Daily Avg Discharge (cfs)	1	132.957	132.957	3694.99	0.000
Error	868	31.233	0.036		
Lack-of-Fit	649	24.444	0.038	1.21	0.043
Pure Error	219	6.790	0.031		
Total	869	164.190			

Middle Model Summary

Log [Salinity (ppt)] = 2.538 - 0.7271 Log [Daily Avg Discharge (cfs)]

S	R-sq	R-sq(adj)
0.341319	61.92%	61.88%

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	2.5379	0.0715	35.48	0.000	
Log [Daily Avg Discharge (cfs)]	0.7271	0.0185	-39.24	0.000	1.00

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	179.42	179.417	1540.08	0.000
Log Daily Avg Discharge (cfs)]	1	179.42	179.417	1540.08	0.000
Error	947	110.32	0.116		
Lack-of-Fit	689	87.23	0.127	1.41	0.001
Pure Error	258	23.10	0.090		
Total	948	289.74			

Upper Model Summary

Log [Salinity (ppt)] = 1.078 - 0.3764 Log [Daily Avg Discharge (cfs)]

S	R-sq	R-sq(adj)
0.352311	28.68%	28.57%

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	1.0783	0.0908	11.87	0.000	
Log [Daily Avg Discharge (cfs)]	0.3764	0.0232	-16.24	0.000	1.00

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	32.74	32.7423	263.79	0.000
Log Daily Avg Discharge (cfs)]	1	32.74	32.7423	263.79	0.000
Error	656	81.42	0.1241		
Lack-of-Fit	518	71.39	0.1378	1.90	0.000
Pure Error	138	10.03	0.0727		
Total	657	114.17			

Table 49. Results of nonlinear regression analysis between daily average salinity (psu) and daily average discharge (cfs) (Bottom panel of Figure 16).

Lower Model Summary

Daily Average Salinity (ppt) = 2759.14 * 'Daily Average Discharge (cfs)' ^ -0.802789 + 0.303508

Lack of Fit

Source	DF	SS	MS	F	P
Error	867	6339.09	7.31152		
Lack of Fit	648	5081.35	7.84159	1.37	0.003
Pure Error	219	1257.74	5.74309		

Iterations	9
Final SSE	6339.09
DFE	867
MSE	7.31152
S	2.70398

Middle Model Summary

Daily Average Salinity (ppt) = 2904.51 * 'Daily Average Discharge (cfs)' ^ -0.928827 - 0.194236

Lack of Fit

Source	DF	SS	MS	F	P
Error	946	2673.65	2.82627		
Lack of Fit	688	1894.70	2.75392	0.91	0.819
Pure Error	258	778.96	3.01921		

Iterations	4
Final SSE	2673.65
DFE	946
MSE	2.82627
S	1.68115

Upper Model Summary

Daily Average Salinity (ppt) = 3950.97 * 'Daily Average Discharge (cfs)' ^ -1.09618 + 0.159433

Lack of Fit

Source	DF	SS	MS	F	P
Error	655	603.797	0.921828		
Lack of Fit	517	500.075	0.967263	1.29	0.037
Pure Error	138	103.722	0.751610		

Iterations	6
Final SSE	603.797
DFE	655
MSE	0.921828
S	0.960119

Table 50. Results of linear regression analysis between daily average depth (m) and daily average discharge (cfs) (Top panel of Figure 17).

Lower Model Summary

Daily Avg Depth (m) = 0.64503 + 0.000013 Daily Avg Discharge

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.64503	0.00826	78.06	0.000	
Daily Avg Discharge	0.000013	0.000000	38.82	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
0.177210	66.83%	66.79%	66.58%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	47.331	47.3314	1507.21	0.000
Daily Avg Discharge	1	47.331	47.3314	1507.21	0.000
Error	748	23.490	0.0314		
Lack-of-Fit	571	18.451	0.0323	1.14	0.157
Pure Error	177	5.039	0.0285		
Total	749	70.821			

Middle Model Summary

Daily Avg Depth (m) = 0.6135 + 0.000043 Daily Avg Discharge

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.6135	0.0140	43.79	0.000	
Daily Average Discharge	0.000043	0.000001	71.05	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
0.336945	83.62%	83.60%	83.55%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	573.08	573.076	5047.72	0.000
Daily Avg Discharge	1	573.08	573.076	5047.72	0.000
Error	989	112.28	0.114		
Lack-of-Fit	708	90.48	0.128	1.65	0.000
Pure Error	281	21.80	0.078		
Total	990	685.36			

Upper Model Summary

Daily Avg Depth (m) = 0.00979 + 0.000070 Daily Avg Discharge

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.0098	0.0318	0.31	0.759	
Daily Avg Discharge	0.000070	0.000001	59.25	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
0.494158	89.68%	89.65%	89.21%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	857.290	857.290	3510.72	0.000
Daily Avg Discharge	1	857.290	857.290	3510.72	0.000
Error	404	98.654	0.244		
Lack-of-Fit	339	94.666	0.279	4.55	0.000
Pure Error	65	3.988	0.061		
Total	405	955.944			

Table 51. Results of nonlinear regression analysis between daily average depth (m) and daily average discharge (cfs) (Bottom panel of Figure 17).

Lower Model Summary	Middle Model Summary	Upper Model Summary
Daily Average Depth (m) = 4.60357 / (1 + 5.92829 * exp(-1.65945e-05 * 'Daily Average Discharge))	Daily Average Depth (m) = 5.32958 / (1 + 6.73765 * exp(-4.11167e-05 * 'Daily Average Discharge))	Daily Average Depth (m) = 5.01312 / (1 + 26.3028 * exp(-9.89552e-05 * 'Daily Average Discharge))

Lack of Fit — Lower Model

Source	DF	SS	MS	F	P
Error	747	21.9501	0.0293844		
Lack of Fit	570	16.9115	0.0296693	1.04	0.376
Pure Error	177	5.0386	0.0284668		

Lack of Fit — Middle Model

Source	DF	SS	MS	F	P
Error	988	97.9778	0.099168		
Lack of Fit	707	76.1788	0.107749	1.39	0.001
Pure Error	281	21.7990	0.077577		

Lack of Fit — Upper Model

Source	DF	SS	MS	F	P
Error	403	31.3227	0.0777238		
Lack of Fit	338	27.3351	0.0808730	1.32	0.088
Pure Error	65	3.9876	0.0613476		

	Lower	Middle	Upper
Iterations	3	4	4
Final SSE	21.9501	97.9778	31.3227
DFE	747	988	403
MSE	0.0293844	0.0991678	0.0777238
S	0.171419	0.314909	0.278790

Table 52. Results of regression analysis for daily average DO (mg/L) at the Lower site.

Simple Linear Model (Flow)

Lower DO = 7.841 – 0.000014 Lower

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	7.841	0.158	49.75	0.000	
Lower	0.000014	0.000019	0.75	0.455	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
2.86299	0.09%	0.00%	0.00%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	4.57	4.575	0.56	0.455
Lower	1	4.57	4.575	0.56	0.455
Error	597	4893.42	8.197		
Lack-of-Fit	449	3526.71	7.855	0.85	0.893
Pure Error	148	1366.72	9.235		
Total	598	4898.00			

Simple Linear Model (Temperature)

Lower = 13.16 – 0.2360 Lower Temp

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	13.156	0.351	37.43	0.000	
Lower Temp	-0.2360	0.0153	-15.43	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
2.16506	36.52%	36.37%	35.87%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	1117	1116.67	238.22	0.000
Lower Temp	1	1117	1116.67	238.22	0.000
Error	414	1941	4.69		
Total	415	3057			

Multiple Linear Regression Model

Daily Average DO (mg/L) = 14.871 – 0.2815 Lower Temp - 0.000115 Lower Flow

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	14.871	0.409	36.35	0.000	
Lower Temp	-0.2815	0.0158	-17.85	0.000	1.19
Lower Flow	-0.000115	0.000016	-7.17	0.000	1.19

S	R-sq	R-sq(adj)	R-sq(pred)
2.04417	43.55%	43.28%	42.74%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	1331.5	665.76	159.32	0.000
Lower Temp	1	1331.5	1331.52	318.65	0.000
Lower Flow	1	214.8	214.84	51.41	0.000
Error	413	1725.8	4.18		
Total	415	3057.3			

Table 53. Results of regression analysis for daily average DO (mg/L) at the Middle site.

Simple Linear Model (Flow)

Middle DO = 7.488 – 0.000012 Middle

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	7.488	0.105	71.35	0.000	
Middle	-0.000012	0.000007	-1.81	0.071	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
2.27405	0.47%	0.32%	0.00%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	16.95	16.950	3.28	0.071
Middle	1	16.95	16.950	3.28	0.071
Error	701	3625.09	5.171		
Lack-of-Fit	543	2872.58	5.290	1.11	0.215
Pure Error	158	752.52	4.763		
Total	702	3642.04			

Simple Linear Model (Temperature)

Middle = 11.29 – 0.1785 Middle Temp

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	11.295	0.252	44.83	0.000	
Middle Temp	-0.1785	0.0107	-16.64	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
1.91477	31.21%	31.10%	30.78%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	1015	1014.65	276.74	0.000
Middle Temp	1	1015	1014.65	276.74	0.000
Error	610	2236	3.67		
Total	611	3251			

Multiple Linear Regression Model

Daily Average DO (mg/L) = 11.770 – 0.1874 Middle Temp - 0.000029 Middle Flow

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	11.770	0.263	44.76	0.000	
Middle Temp	-0.1874	0.0106	-17.60	0.000	1.03
Middle Flow	-0.000029	0.000006	-5.22	0.000	1.03

S	R-sq	R-sq(adj)	R-sq(pred)
1.87486	34.16%	33.94%	33.62%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	1110.43	555.22	157.95	0.000
Middle Temp	1	1089.32	1089.32	309.90	0.000
Middle Flow	1	95.79	95.79	27.25	0.000
Error	609	2140.69	3.52		
Total	611	3251.13			

Table 54. Results of regression analysis for daily average DO (mg/L) at the Upper site.

Simple Linear Model (Flow)

Upper DO = 8.834 – 0.000065 Upper Temp

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	8.834	0.201	43.84	0.000	
Upper	-0.000065	0.000017	-3.78	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
2.43311	4.91%	4.57%	3.82%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	84.44	84.439	14.26	0.000
Upper	1	84.44	84.439	14.26	0.000
Error	276	1633.93	5.920		
Lack-of-Fit	242	1507.78	6.230	1.68	0.036
Pure Error	34	126.15	3.710		
Total	277	1718.37			

Simple Linear Model (Temperature)

Upper = 12.29 – 0.2296 Upper Temp

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	12.290	0.367	33.45	0.000	
Upper Temp	-0.2296	0.0170	-13.51	0.000	1.00

S	R-sq	R-sq(adj)	R-sq(pred)
1.66891	48.36%	48.09%	47.16%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	508.6	508.551	182.59	0.000
Upper Temp	1	508.6	508.551	182.59	0.000
Error	195	543.1	2.785		
Total	196	1051.7			

Multiple Linear Regression Model

Daily Average DO (mg/L) = 13.497 – 0.2250 Upper Temp - 0.000069 Upper Flow

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	13.497	0.402	33.55	0.000	
Upper Temp	-0.2550	0.0164	-15.54	0.000	1.08
Upper Flow	-0.000069	0.000012	-5.67	0.000	1.08

S	R-sq	R-sq(adj)	R-sq(pred)
1.54988	55.69%	55.23%	54.33%

ANOVA

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	585.66	292.831	121.91	0.000
Upper Temp	1	580.44	580.438	241.64	0.000
Upper Flow	1	77.11	77.112	32.10	0.000
Error	194	466.01	2.402		
Total	196	1051.67			

Table 55. Summary results of two-way ANOVA for each water quality variable.

Water Quality Variable	Df_n	Df_d	F-statistic	P-value	Interaction?	Group	Df_n	Df_d	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
Temperature (°C)	40	1161	0.066899	1.000	Not Significant	Site	8	1206	0.433753	0.901224	No significant differences between sites
						Flow Tier	5	1209	64.76315	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Avg-Sub"), ("Avg-3ps"-"Wet-2ps"), ("Avg-3ps"-"Wet-Base"), ("Avg-Base"-"Avg-Sub"), ("Avg-Base"-"Wet-2ps"), ("Avg-Base"-"Wet-Base"), ("Avg-Base"-"Wet-Sub"), ("Avg-Sub"-"Wet-2ps"), ("Avg-Sub"-"Wet-Base"), ("Avg-Sub"-"Wet-Sub"), ("Wet-2ps"-"Wet-Base"), ("Wet-2ps"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
Salinity (psu)	40	1161	2.184657	<0.001	Significant	Site	8				
						Flow Tier	5				

Water Quality Variable	Df_n	Df_d	F-statistic	P-value	Interaction?	Group	Df_n	Df_d	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
DO (mg/L)	40	1161	0.746308	0.876472	Not Significant	Site	8	1206	8.310488	<0.001	(B01-B10), (B01-B15), (B05-B36), (B05-B42), (B10-B25), (B10-B31), (B10-B36), (B10-42), (B15-B31), (B15-B36), (B15-B42), (B22-B31), (B22-B36), (B22-B42); all other pairings not significantly different ($p>0.05$)
						Flow Tier	5	1209	14.39575	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Wet-Base"), ("Avg-Base"-"Avg-Sub"), ("Avg-Base"-"Wet-2ps"), ("Avg-Base"-"Wet-Sub"), ("Avg-Sub"-"Wet-Base"), ("Wet-2ps"-"Wet-Base"), ("Wet-Base"-"Wet-Sub"); all other pairings not significantly different ($p\geq0.05$)
pH	40	1161	2.521501	<0.001	Significant	Site					
						Flow Tier					

Water Quality Variable	**Df_n**	**Df_d**	**F-statistic**	**P-value**	**Interaction?**	**Group**	**Df_n**	**Df_d**	**F-statistic**	**P-value**	**Comments (Post-hoc Tukey Pairwise comparisons)**
Turbidity (NTU)	40	1133	0.862056	0.714253	Not Significant	Site	8	1178	4.697756	<0.001	(B01-B15), (B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B36), (B05-B42), (B10-B36), (B10-B42); all other pairings not significantly different (p>0.05)
						Flow Tier	5	1181	21.74872	<0.001	(“Avg-3ps”-“Avg-Base”), (“Avg-3ps”-“Avg-Sub”), (“Avg-3ps”-“Wet-Sub”), (“Avg-Base”-“Avg-Sub”), (“Avg-Base”-“Wet-Sub”), (“Avg-Sub”-“Wet-2ps”), (“Avg-Sub”-“Wet-Base”), (“Wet-2ps”-“Wet-Base”), (“Wet-Base”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)
Mid-channel Total Depth (m)	40	189	1.163914	0.24873	Not Significant	Site	8	234	26.14108	<0.001	(B01-B05), (B01-B15), (B01-B22), (B01-B42), (B05-B10), (B05-B15), (B05-B25), (B05-

Water Quality Variable	Df_n	Df_d	F-statistic	P-value	Interaction?	Group	Df_n	Df_d	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
											B31), (B10-B15), (B10-B22), (B10-B42), (B15-B25), (B15-B31), (B15-B36), (B22-B25), (B22-B31), (B22-B36), (B25-B31), (B25-B36), (B25-B42), (B31-B42), (B36-B42); all other pairings significantly not different ($p \geq 0.05$)
						Flow Tier	5	237	7.299393	0.001856	(“Wet-2ps”-“Avg-Base”), (“Wet-Base”-“Avg-Base”), (“Wet-Sub”-“Avg-Base”), (“Wet-2ps”-“Avg-Sub”), (“Wet-Base”-“Avg-Sub”); all other pairings not significantly different ($p>0.05$)
Secchi (m)	40	148	0.430	0.9999	Not Significant	Site	8	193	3.76	<0.001	(B01-B22), (B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B31), (B05-B36), (B05-B42), (B10-B42); all other pairings not

Water Quality Variable	Df$_n$	Df$_d$	F-statistic	P-value	Interaction?	Group	Df$_n$	Df$_d$	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
											significantly different ($p \geq 0.05$)
						Flow Tier	5	196	23.33	<0.001	("Avg-3ps"-"Avg-Sub"), ("Avg-Base"-"Avg-Sub"), ("Avg-Sub"-"Wet-2ps"), ("Avg-Sub"-"Wet-Base"), ("Avg-Sub"-"Wet-Sub"), ("Wet-2ps"-"Wet-Sub"), ("Wet-Base"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)

Table 56. Results of two-way ANOVA for water temperature (°C) versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Hydrologic Condition-Flow Tier	Fixed	6	Avg-3ps, Avg-Base, Avg-Sub, Wet-2ps, Wet-Base, Wet-Sub

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	119.9	14.99	0.46	0.885
Hydrologic Condition-Flow Tier	5	10515.5	2103.11	64.44	0.000
Error	1201	39196.1	32.64		
Lack-of-Fit	40	100.9	2.52	0.07	1.000
Pure Error	1161	39095.2	33.67		
Total	1214	49824.8			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping
B15	135	24.5378	A
B22	135	24.3685	A
B10	135	24.2854	A
B05	135	23.9873	A
B25	135	23.9685	A
B31	135	23.9587	A
B36	135	23.8009	A
B42	135	23.7656	A
B01	135	23.4648	A

Means that do not share a letter are significantly different.

Grouping Information for Flow Tier Using the Tukey Method and 95% Confidence

Hydrologic Condition-Flow Tier	N	Mean	Grouping				
Wet-2ps	91	31.4503	A				
Avg-3ps	224	25.0429		B			
Wet-Sub	225	24.0662		B	C		
Wet-Base	315	23.5330			C		
Avg-Sub	225	21.1379				D	
Avg-Base	135	18.8614					E

Means that do not share a letter are significantly different.

Table 57. Results of two-way ANOVA for dissolved oxygen (DO [mg/L]) versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Hydrologic Condition-Flow Tier	Fixed	6	Avg-3ps, Avg-Base, Avg-Sub, Wet-2ps, Wet-Base, Wet-Sub

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	293.3	36.668	8.32	0.000
Hydrologic Condition-Flow Tier	5	316.5	63.300	14.36	0.000
Error	1201	5294.6	4.409		
Lack-of-Fit	40	131.2	3.281	0.74	0.886
Pure Error	1161	5163.4	4.447		
Total	1214	5904.2			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping			
B42	135	7.30718	A			
B36	135	7.04614	A			
B31	135	6.77155	A	B		
B01	135	6.76246	A	B		
B25	135	6.68703	A	B	C	
B05	135	6.17718		B	C	D
B22	135	5.96763			C	D
B15	135	5.96392			C	D
B10	135	5.89081				D

Means that do not share a letter are significantly different.

Grouping Information for Flow Tier Using the Tukey Method and 95% Confidence

Hydrologic Condition-Flow Tier	N	Mean	Grouping	
Avg-Base	135	7.50452	A	
Wet-Base	315	7.01048	A	
Avg-3ps	224	6.41422		B
Wet-Sub	225	6.20196		B
Avg-Sub	225	6.08596		B
Wet-2ps	91	5.83215		B

Means that do not share a letter are significantly different.

Table 58. Results of two-way ANOVA for turbidity (NTU) versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Hydrologic Condition-Flow Tier	Fixed	6	Avg-3ps, Avg-Base, Avg-Sub, Wet-2ps, Wet-Base, Wet-Sub

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	996349	124544	5.43	0.000
Hydrologic Condition-Flow Tier	5	2625873	525175	22.91	0.000
Error	1173	26887116	22922		
Lack-of-Fit	40	791822	19796	0.86	0.719
Pure Error	1133	26095294	23032		
Total	1186	30454549			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping		
B42	135	114.465	A		
B36	135	107.313	A		
B31	135	104.465	A	B	
B15	130	102.164	A	B	
B25	133	96.448	A	B	
B22	130	82.189	A	B	C
B05	130	47.164		B	C
B10	129	46.953		B	C
B01	130	33.685			C

Means that do not share a letter are significantly different.

Grouping Information for Flow Tier Using the Tukey Method and 95% Confidence

Hydrologic Condition-Flow Tier	N	Mean	Grouping		
Avg-3ps	224	141.743	A		
Wet-Base	315	114.521	A	B	
Wet-2ps	91	100.250	A	B	
Avg-Base	135	87.320		B	
Wet-Sub	224	26.521			C
Avg-Sub	198	19.542			C

Means that do not share a letter are significantly different.

Table 59. Results of two-way ANOVA for mid-channel total depth (m) versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Hydrologic Condition-Flow Tier	Fixed	6	Avg-3ps, Avg-Base, Avg-Sub, Wet-2ps, Wet-Base, Wet-Sub

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	246.54	30.817	26.16	0.000
Hydrologic Condition-Flow Tier	5	41.81	8.362	7.10	0.000
Error	229	269.72	1.178		
Lack-of-Fit	40	53.79	1.345	1.18	0.234
Pure Error	189	215.93	1.142		
Total	242	556.93			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping				
B15	27	8.08043	A				
B42	27	7.51169	A	B			
B22	27	7.46021	A	B			
B05	27	6.80951		B	C		
B36	27	6.33003			C	D	
B31	27	5.80984				D	
B01	27	5.69852				D	E
B10	27	5.69610				D	E
B25	27	4.82414					E

Means that do not share a letter are significantly different.

Grouping Information for Flow Tier Using the Tukey Method and 95% Confidence

Hydrologic Condition-Flow Tier	N	Mean	Grouping		
Wet-2ps	19	7.16939	A		
Wet-Base	63	6.89330	A		
Wet-Sub	45	6.53700	A	B	
Avg-3ps	44	6.38176	A	B	C
Avg-Sub	45	6.06620		B	C
Avg-Base	27	5.76600			C

Means that do not share a letter are significantly different.

Table 60. Results of two-way ANOVA for secchi disk transparency (m) versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Flow Tier	Fixed	6	Average-3ps, Average-Base, Average-Subsistence, Wet-2ps, Wet-Base, Wet-Subsistence

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	0.5200	0.065001	6.47	0.000
Flow Tier	5	1.4355	0.287091	28.60	0.000
Error	188	1.8873	0.010039		
Lack-of-Fit	40	0.1970	0.004924	0.43	0.999
Pure Error	148	1.6903	0.011421		
Total	201	3.8402			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping			
B01	27	0.267776	A			
B05	17	0.254122	A	B		
B10	27	0.221110	A	B	C	
B15	17	0.210946	A	B	C	D
B22	27	0.175665		B	C	D
B25	17	0.162711		B	C	D
B31	26	0.151212			C	D
B36	17	0.139064			C	D
B42	27	0.114851				D

Means that do not share a letter are significantly different.

Grouping Information for Flow Tier Using the Tukey Method and 95% Confidence

Flow Tier	N	Mean	Grouping		
Average-Subsistence	33	0.358280	A		
Wet-Subsistence	45	0.221733		B	
Average-Base	19	0.162412		B	C
Average-3ps	32	0.156152		B	C
Wet-2ps	14	0.118816			C
Wet-Base	59	0.114244			C

Means that do not share a letter are significantly different.

Table 61. Results of two-way ANOVA for salinity(psu) versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Hydrologic Condition-Flow Tier	Fixed	6	Avg-3ps, Avg-Base, Avg-Sub, Wet-2ps, Wet-Base, Wet-Sub

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	39822	4977.81	80.79	0.000
Hydrologic Condition-Flow Tier	5	14316	2863.22	46.47	0.000
Error	1201	73997	61.61		
Lack-of-Fit	40	5295	132.37	2.24	0.000
Pure Error	1161	68702	59.18		
Total	1214	128212			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping				
B01	27	0.267776	A				
B05	17	0.254122	A	B			
B10	27	0.221110		B	C		
B15	17	0.210946			C	D	
B22	27	0.175665				D	
B25	17	0.162711					E
B31	26	0.151212					E
B36	17	0.139064					E
B42	27	0.114851					E

Means that do not share a letter are significantly different.

Grouping Information Using the Tukey Method and 95% Confidence

Hydrologic Condition-Flow Tier	N	Mean	Grouping			
Avg-Sub	225	13.3780	A			
Wet-Sub	225	9.9420		B		
Avg-Base	135	7.8296		B		
Wet-2ps	91	7.7728		B	C	
Wet-Base	315	5.3673			C	
Avg-3ps	224	3.3582				D

Means that do not share a letter are significantly different.

Table 62. Results of two-way ANOVA for pH versus site and flow tier.

Factor Information

Factor	Type	Levels	Values
Site	Fixed	9	B01, B05, B10, B15, B22, B25, B31, B36, B42
Hydrologic Condition-Flow Tier	Fixed	6	Avg-3ps, Avg-Base, Avg-Sub, Wet-2ps, Wet-Base, Wet-Sub

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Site	8	2.510	0.31375	9.31	0.000
Hydrologic Condition-Flow Tier	5	7.753	1.55058	46.01	0.000
Error	1201	40.476	0.03370		
Lack-of-Fit	40	3.256	0.08139	2.54	0.000
Pure Error	1161	37.220	0.03206		
Total	1214	50.780			

Grouping Information for Site Using the Tukey Method and 95% Confidence

Site	N	Mean	Grouping		
B01	27	0.267776	A		
B05	17	0.254122	A	B	
B10	27	0.221110		B	C
B15	17	0.210946		B	C
B22	27	0.175665		B	C
B25	17	0.162711		B	C
B31	26	0.151212		B	C
B36	17	0.139064			C
B42	27	0.114851			C

Means that do not share a letter are significantly different.

Grouping Information for Site Using the Tukey Method and 95% Confidence

Hydrologic Condition-Flow Tier	N	Mean	Grouping		
Wet-Sub	225	7.82880	A		
Wet-2ps	91	7.82580	A	B	
Wet-Base	315	7.82378	A		
Avg-Sub	225	7.77133		B	
Avg-Base	135	7.67630			C
Avg-3ps	224	7.62563			C

Means that do not share a letter are significantly different.

Table 63. Results of reduced ANOVA of significant differences in salinity (psu) between flow tiers for each sample site.

Interaction Group	Df_n	Df_d	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
B01	5	129	5.050726	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-3ps”-“Wet-2ps”); all other pairings not significantly different (p≥0.05)
B05	5	129	5.050726	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-3ps”-“Wet-2ps”), (“Avg-3ps”-“Wet-Sub”), (“Avg-Sub”-“Wet-Base”); all other pairings not significantly different (p≥0.05)
B10	5	129	5.050726	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-3ps”-“Wet-Sub”), (“Avg-Sub”-“Wet-Base”), (“Wet-Base”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)
B15	5	129	6.520119	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-3ps”-“Wet-Sub”), (“Avg-Sub”-“Wet-Base”), (“Wet-Base”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)
B22	5	129	8.818094	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-3ps”-“Wet-Sub”), (“Avg-Sub”-“Wet-2ps”), (“Avg-Sub”-“Wet-Base”), (“Wet-Base”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)
B25	5	129	10.80585	<0.001	(“Avg-3ps”-“Avg-Base”), (“Avg-3ps”-“Avg-Sub”), (“Avg-Sub”-“Wet-2ps”), (“Avg-Sub”-“Wet-Base”), (“Avg-Sub”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)
B31	5	129	6.167829	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-Sub”-“Wet-2ps”), (“Avg-Sub”-“Wet-Base”); all other pairings not significantly different (p≥0.05)
B36	5	129	7.689152	<0.001	(“Avg-3ps”-“Avg-Sub”), (“Avg-Base”-“Avg-Sub”), (“Avg-Sub”-“Wet-2ps”), (“Avg-Sub”-“Wet-Base”), (“Avg-Sub”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)
B42	5	129	3.663706	0.003922	(“Avg-3ps”-“Avg-Sub”), (“Avg-Base”-“Avg-Sub”), (“Avg-Sub”-“Wet-Base”), (“Avg-Sub”-“Wet-Sub”); all other pairings not significantly different (p≥0.05)

Table 64. Results of reduced ANOVA of significant differences in salinity (psu) between sample sites for each flow tier.

Interaction Group	Df_n	Df_d	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
"Avg-3ps"-Site	8	216	9.718348	<0.001	(B01-B15), (B01-B22), (B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B25), (B05-B31), (B05-B36), (B05-B42), (B10-B25), (B10-B31), (B10-B36), (B10-B42); all other pairings not significantly different ($p \geq 0.05$)
"Avg-Base"-Site	8	126	5.550799	<0.001	(B01-B36), (B01-B42), (B05-B31), (B05-B36), (B05-B42), (B10-B36), (B10-B42); all other pairings not significantly different ($p \geq 0.05$)
"Avg-Sub"-Site	8	216	20.84745	<0.001	(B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B25), (B05-B31), (B05-B36), (B05-B42), (B10-B25), (B10-B31), (B10-B36), (B10-B42), (B15-B25), (B15-B31), (B15-B36), (B15-B42), (B22-B31), (B22-B36), (B22-B42), (B25-B42); all other pairings not significantly different ($p \geq 0.05$)
"Wet-2ps"-Site	8	81	10.06727	<0.001	(B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B25), (B05-B31), (B05-B36), (B05-B42), (B10-B25), (B10-B31), (B10-B36), (B10-B42), (B15-B25), (B15-B31), (B15-B36), (B15-B42), (B22-B31), (B22-B36), (B22-B42), (B25-B42); all other pairings not significantly different ($p \geq 0.05$)
"Wet-Base"-Site	8	306	24.83494	<0.001	(B01-B10), (B01-B15), (B01-B22), (B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B15), (B05-B22), (B05-B25), (B05-B31), (B05-B36), (B05-B42), (B10-B22), (B10-B25), (B10-B31), (B10-B36), (B10-B42), (B15-B25), (B15-B31), (B15-B36), (B15-B42); all other pairings not significantly different ($p \geq 0.05$)
"Wet-Sub"-Site	8	216	21.32549	<0.001	(B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B25), (B05-B31), (B05-B36), (B05-B42), (B10-B25), (B10-B31), (B10-B36), (B10-B42), (B15-B25), (B15-B31), (B15-B36), (B15-B42), (B22-B25), (B22-B31), (B22-B36), (B22-B42); all other pairings not significantly different ($p \geq 0.05$)

Table 65. Results of reduced ANOVA of significant differences in pH between flow tiers for each sample site.

Interaction Group	Df_n	Df_d	F-statistic	P-value	Comments (Post-hoc Tukey Pairwise comparisons)
B01	5	129	10.43957	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Avg-Sub"), ("Avg-3ps"-"Wet-2ps"), ("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B05	5	129	11.36416	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Avg-Sub"), ("Avg-3ps"-"Wet-2ps"), ("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B10	5	129	5.212597	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Avg-Sub"), ("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B15	5	129	6.901875	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Avg-Sub"), ("Avg-3ps"-"Wet-2ps"), ("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B22	5	129	4.142086	0.0016	("Avg-3ps"-"Wet-Base"); all other pairings not significantly different ($p \geq 0.05$)
B25	5	129	4.152296	0.00157	("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B31	5	129	5.953704	<0.001	("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"), ("Avg-Base"-"Wet-2ps"), ("Avg-Base"-"Wet-Base"), ("Avg-Base"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B36	5	129	7.24328	<0.001	("Avg-3ps"-"Wet-Base"), ("Avg-3ps"-"Wet-Sub"), ("Avg-Base"-"Wet-Base"), ("Avg-Base"-"Wet-Sub"), ("Avg-Sub"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)
B42	5	129	16.23891	<0.001	("Avg-3ps"-"Avg-Base"), ("Avg-3ps"-"Wet-2ps"), ("Avg-3ps"-"Wet-Sub"), ("Avg-Base"-"Avg-Sub"), ("Avg-Base"-"Wet-2ps"), ("Avg-Base"-"Wet-Base"), ("Avg-Base"-"Wet-Sub"), ("Avg-Sub"-"Wet-Sub"); all other pairings not significantly different ($p \geq 0.05$)

Table 66. Results of reduced ANOVA of significant differences in pH between sample sites for each flow tier.

Interaction Group	**Df_n**	**Df_d**	**F-statistic**	**P-value**	**Comments (Post-hoc Tukey Pairwise comparisons)**
"Avg-3ps"-Site	8	216	5.360723	<0.001	(B01-B15), (B01-B22), (B15-B25), (B15-B31), (B15-B42), (B22-B42); all other pairings not significantly different ($p \geq 0.05$)
"Avg-Base"-Site	8	126	4.024329	<0.001	(B01-B31), (B01-B42), (B05-B42), (B10-B42), (B15-B42); all other pairings not significantly different ($p \geq 0.05$)
"Avg-Sub"-Site	8	216	6.056401	<0.001	(B01-B10), (B01-15), (B01-B22), (B01-B25), (B01-B31), (B01-B36), (B01-B42), (B05-B15), (B05-B22), (B05-B36); all other pairings not significantly different ($p \geq 0.05$)
"Wet-2ps"-Site	8	81	0.648222	0.734925	No significant differences between sites ($p \geq 0.05$)
"Wet-Base"-Site	8	306	1.714807	0.094258	No significant differences between sites ($p \geq 0.05$)
"Wet-Sub"-Site	8	216	3.371165	0.001153	(B15-B42), (B22-B42); all other pairings not significantly different ($p \geq 0.05$)

Table 67. Results of Principal Component Analysis (PCA) for bottom water quality profile sample sites in the river (Figure 28).

Principal Component Analysis

Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	2.19	54.7	54.7
2	1.07	26.8	81.4
3	0.538	13.5	94.9
4	0.204	5.1	100.0

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4
Temp (˚C)	-0.452	0.641	-0.320	-0.531
Salinity (psu)	-0.519	-0.361	0.666	-0.395
DO (mg/L)	0.613	-0.234	-0.093	-0.749
USGS Daily Avg. Discharge (cfs)	0.387	0.635	0.668	0.035

Table 68. Results of Principal Component Analysis (PCA) for surface water quality profile of sample sites in the river (Figure 29).

Principal Component Analysis

Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	1.78	44.5	44.5
2	1.4	34.9	79.4
3	0.632	15.8	95.2
4	0.192	4.8	100.0

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4
Temperature (˚C)	0.690	0.106	-0.292	0.654
Salinity (psu)	0.157	-0.692	0.662	0.242
DO (mg/L)	-0.706	-0.069	-0.156	0.687
USGS Daily Average Discharge (cfs)	-0.019	0.711	0.673	0.205

Table 69. Results of Principal Component Analysis (PCA) for bottom water quality profile of GOM sites (Figure 30).

Principal Component Analysis

Data worksheet
Name: Data1
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	2.74	68.6	68.6
2	1.21	30.2	98.8
3	0.0328	0.8	99.6
4	0.0146	0.4	100.0

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4
Temperature (˚C)	-0.596	0.105	-0.403	-0.687
Salinity (psu)	-0.577	-0.247	-0.374	0.682
DO (mg/L)	0.537	-0.398	-0.738	-0.094
Mid-channel Total Depth (m)	-0.153	-0.877	0.391	-0.232

Table 70. Results of Principal Component Analysis (PCA) for surface water quality profile of GOM sites (Figure 30).

Principal Component Analysis

Data worksheet
Name: Data4
Data type: Environmental
Sample selection: All
Variable selection: All

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	1.62	40.5	40.5
2	1.35	33.7	74.2
3	0.746	18.6	92.9
4	0.284	7.1	100.0

Eigenvectors
(Coefficients in the linear combinations of variables making up PC's)

Variable	PC1	PC2	PC3	PC4
Temperature (˚C)	-0.673	0.270	0.266	0.635
Salinity (psu)	0.722	0.118	0.095	0.675
DO (mg/L)	0.159	0.702	0.585	-0.375
Mid-channel Total Depth (m)	-0.023	0.649	-0.760	0.018

APPENDIX J:

STATISTICAL OUTPUT FOR NEKTON RESULTS

Table 71. Pearson correlation analysis p-values for bottom profile data (Figure 31).

	River.Kilometer	Julian.Day	Temperature..C.	Salinity..psu.	DO..mg.L.	pH
River.Kilometer	0	1	1	8.36E-08	0.620211028	1
Julian.Day	0.067302468	0	0.368941364	0.119949866	0.274549575	1
Temperature..C.	0.125356915	0.002132609	0	0.472194478	7.37E-05	0.009738952
Salinity..psu.	2.97E-10	0.000615128	0.002914781	0	0.000229573	1
DO..mg.L.	0.004042013	0.001542413	2.77E-07	8.90E-07	0	0.000181633
pH	0.757954739	0.10766049	4.23E-05	0.061702323	6.99E-07	0
Turbidity..NTU.	6.85E-05	0.00013339	0.006796547	5.15E-09	1.43E-06	0.017498774
Mid.channel.Total.Depth..m.	0.003067059	0.055218765	0.990108812	0.009883555	0.325474418	0.380773912
Secchi..m.	1.69E-05	5.37E-07	0.000419965	4.55E-10	5.48E-06	0.092033366
Field.Discharge..cfs.	0.027194714	6.29E-14	0.002172821	5.52E-05	0.000128461	0.053511874
USGS.Instantaneous.Discharge..cfs.	0.015018831	1.00E-12	0.000721028	1.50E-05	3.37E-05	0.042261949
USGS.Daily.Average.Discharge..cfs.	0.014196818	1.26E-12	0.000703202	1.31E-05	2.99E-05	0.040707411
Tidal.Height..ft.	0.858242817	0.132585647	0.012118917	0.63035574	0.423540948	0.735785953
Total..OT.	9.56E-05	0.157855534	0.795926343	0.00056735	0.091419603	0.779817427
Species.Richness..OT.	7.72E-11	0.001516068	0.052036472	1.30E-11	0.000635182	0.535470869
Margaleff.Richness..OT.	7.73E-09	0.005487823	0.051460154	1.14E-09	0.000466119	0.365568262
Shannon.Wiener..OT.	0.003444123	0.020090635	0.013179212	0.000340402	0.000940089	0.080244508
Shannon.Evenness..OT.	0.241639513	0.731911008	0.323970618	0.512639214	0.546285628	0.106924694
Total..BT.	0.63317807	0.004444412	0.002639477	0.237114694	0.211479895	0.296763456
Species.Richness..BT.	4.52E-06	0.000133203	0.00037356	2.34E-08	0.00015451	0.279960281
Margaleff.Richness..BT.	1.38E-06	0.002186786	0.00338755	1.17E-07	0.000670762	0.493145143
Shannon.Wiener..BT.	1.75E-06	0.003878434	0.003142076	2.65E-07	0.000776084	0.504426601
Shannon.Evenness..BT.	5.83E-06	0.012888361	0.001817573	1.54E-06	0.000676913	0.458749164
CPUE..OT.	9.56E-05	0.154607006	0.786295344	0.000541983	0.08745991	0.794978164
CPUE..BT.	0.803661709	0.012292171	0.005074548	0.363928649	0.295788277	0.317121428

	Turbidity. NTU.	Mid.channel Total.Depth .m.	Secchi..m.	Field Discharge. cfs.	USGS.Instantaneous Discharge. cfs.	USGS.Daily.Average Discharge .cfs.
River.Kilometer	0.015546043	0.493796475	0.004005168	1	1	1
Julian.Day	0.029038258	1	0.000141181	1.83E-11	2.90E-10	3.63E-10
Temperature..C.	0.992295889	1	0.08567283	0.371552461	0.136995343	0.134311651
Salinity..psu.	1.43E-06	1	1.27E-07	0.012587211	0.003588398	0.003167779
DO..mg.L.	0.000361553	1	0.001331055	0.02813295	0.007773465	0.006936853
pH	1	1	1	1	1	1
Turbidity..NTU.	0	1	4.27E-06	0.000516472	0.000190187	0.000165943
Mid.channel.Total.Depth..m.	0.022066463	0	1	1	1	1
Secchi..m.	1.55E-08	0.009538659	0	1.00E-06	6.89E-08	5.83E-08
Field.Discharge..cfs.	2.07E-06	0.025076618	3.60E-09	0	3.41E-22	5.20E-22
USGS.Instantaneous.Discharge..cfs.	7.34E-07	0.021349311	2.44E-10	1.15E-24	0	6.03E-49
USGS.Daily.Average.Discharge..cfs.	6.33E-07	0.021088492	2.06E-10	1.76E-24	2.02E-51	0
Tidal.Height..ft.	0.688820849	0.789521703	0.261922458	0.249606826	0.186918917	0.192729363
Total..OT.	0.015183458	0.003850807	0.013317624	0.061643966	0.049771769	0.048520314
Species.Richness..OT.	2.25E-06	4.85E-05	6.77E-08	0.000208778	7.74E-05	7.12E-05
Margaleff.Richness..OT.	1.24E-06	0.000410835	9.15E-07	0.00087212	0.000343038	0.000318884
Shannon.Wiener..OT.	0.000157654	0.059556435	0.000588051	0.008586349	0.004183214	0.004027344
Shannon.Evenness..OT.	0.907606527	0.113265685	0.601334173	0.705509942	0.774281982	0.774372696
Total..BT.	0.283064173	0.880153208	0.038860314	0.034869993	0.032053538	0.032376373
Species.Richness..BT.	2.98E-05	0.013838797	8.41E-08	8.42E-05	1.53E-05	1.49E-05
Margaleff.Richness..BT.	0.000175277	0.018471693	2.72E-06	0.001246185	0.000339944	0.000334268
Shannon.Wiener..BT.	0.000233959	0.019115223	5.25E-06	0.0021379	0.000597403	0.000587522
Shannon.Evenness..BT.	0.000772777	0.046395458	2.45E-05	0.007444319	0.002276121	0.002241077
CPUE..OT.	0.014424477	0.003738633	0.01281442	0.059391658	0.047830138	0.046613215
CPUE..BT.	0.425319448	0.969660596	0.081560417	0.074815495	0.070979935	0.07154225

	Tidal Height..ft.	Total..OT.	Species Richness..OT.	Margaleff Richness..OT.	Shannon Wiener..OT.	Shannon.Evenness..OT.
River.Kilometer	1	0.021325446	2.19E-08	2.13E-06	0.544171512	1
Julian.Day	1	1	0.271376153	0.81768562	1	1
Temperature..C.	1	1	1	1	1	1
Salinity..psu.	1	0.112902733	3.72E-09	3.19E-07	0.071048226	1
DO..mg.L.	1	1	0.123225351	0.094622199	0.172976413	1
pH	1	1	1	1	1	1
Turbidity..NTU.	1	1	0.000558532	0.000315207	0.033895563	1
Mid.channel.Total.Depth..m.	1	0.600725942	0.011096456	0.084221109	1	1
Secchi..m.	1	1	1.83E-05	0.000235097	0.116329428	1
Field.Discharge..cfs.	1	1	0.044469617	0.16221439	1	1
USGS.Instantaneous.Discharge..cfs.	1	1	0.017404399	0.071048226	0.635848521	1
USGS.Daily.Average.Discharge..cfs.	1	1	0.016099272	0.067284544	0.620211028	1
Tidal.Height..ft.	0	1	1	1	1	1
Total..OT.	0.926808925	0	0.005106081	0.890312438	1	0.025073449
Species.Richness..OT.	0.610001218	2.17E-05	0	3.27E-10	0.152802395	1
Margaleff.Richness..OT.	0.679795507	0.006056547	1.14E-12	0	9.17E-05	1
Shannon.Wiener..OT.	0.549945279	0.942256847	0.000817125	3.46E-07	0	0.426570451
Shannon.Evenness..OT.	0.73525252	0.000113455	0.209882519	0.843661454	0.002569702	0
Total..BT.	0.162845591	0.102918662	0.408904012	0.28546346	0.036663877	0.175066581
Species.Richness..BT.	0.016052931	0.001985217	1.84E-08	5.22E-07	0.000886819	0.615094841
Margaleff.Richness..BT.	0.029832497	0.000509144	3.96E-08	9.47E-07	0.002518986	0.501913933
Shannon.Wiener..BT.	0.026599882	0.001055837	7.97E-08	6.86E-07	0.001380084	0.645936204
Shannon.Evenness..BT.	0.0278909	0.002647745	1.28E-06	4.54E-06	0.001954652	0.742860102
CPUE..OT.	0.926661223	4.14E-52	2.06E-05	0.005841548	0.931968014	0.000119768
CPUE..BT.	0.246722489	0.051077595	0.589287194	0.404287641	0.049635513	0.132943123

	Total..BT.	Species Richness .BT.	Margaleff Richness..BT.	Shannon Wiener..BT.	Shannon Evenness..BT.	CPUE..OT.	CPUE..BT.
River.Kilometer	1	0.001111846	0.000349449	0.000437761	0.00141169	0.021325446	1
Julian.Day	0.671106249	0.029038258	0.371753561	0.601157216	1	1	1
Temperature..C.	0.43287422	0.076953286	0.538620395	0.502732141	0.3217105	1	0.761182232
Salinity..psu.	1	6.38E-06	3.14E-05	7.07E-05	0.000387257	0.108396638	1
DO..mg.L.	1	0.033374182	0.129456998	0.146054798	0.129967309	1	1
pH	1	1	1	1	1	1	1
Turbidity..NTU.	1	0.006932726	0.037509301	0.049599226	0.146054798	1	1
Mid.channel.Total.Depth..m.	1	1	1	1	1	0.586965437	1
Secchi..m.	1	2.26E-05	0.000672091	0.001281496	0.005738774	1	1
Field.Discharge..cfs.	1	0.018868788	0.225559412	0.368941364	1	1	1
USGS.Instantaneous.Discharge..cfs	1	0.003634849	0.071048226	0.117090945	0.38238827	1	1
USGS.Daily.Average.Discharge.cfs.	1	0.00356901	0.070196238	0.116329428	0.378741933	1	1
Tidal.Height..ft.	1	1	1	1	1	1	1
Total..OT.	1	0.345427795	0.102337859	0.192162343	0.43287422	1.24E-49	1
Species.Richness..OT.	1	5.05E-06	1.08E-05	2.15E-05	0.000324528	0.004855196	1
Margaleff.Richness..OT.	1	0.000137895	0.000242509	0.000179043	0.001111846	0.864549154	1
Shannon.Wiener..OT.	1	0.164061447	0.420670648	0.248415149	0.34206418	1	1
Shannon.Evenness..OT.	1	1	1	1	1	0.026349028	1
Total..BT.	0	1	1	1	1	1	1.34E-23
Species.Richness..BT.	0.085856525	0	4.60E-14	2.21E-13	5.84E-10	0.341781241	1
Margaleff.Richness..BT.	0.383947561	1.58E-16	0	1.42E-25	4.91E-16	0.100835375	1
Shannon.Wiener..BT.	0.38278006	7.61E-16	4.75E-28	0	2.07E-18	0.189570824	1
Shannon.Evenness..BT.	0.449545491	2.04E-12	1.68E-18	7.03E-21	0	0.428956784	1
CPUE..OT.	4.14E-52	2.06E-05	0.005841548	0.931968014	0.000119768	0.102559125	
CPUE..BT.	0.051077595	0.589287194	0.404287641	0.049635513	0.132943123	4.51E-26	

Table 72. Pearson correlation analysis correlation coefficients (R) for bottom profile data (Figure 31).

	River.Kilometer	Julian.Day	Temperature..C.	Salinity..psu.	DO..mg.L.	pH
River.Kilometer	1	-0.005776496	-0.027098028	-0.748144194	0.193143581	-0.089439176
Julian.Day	-0.005776496	1	0.190080397	0.251883651	-0.18674952	-0.091636025
Temperature..C.	-0.027098028	0.190080397	1	0.238445328	-0.644992748	-0.518407078
Salinity..psu.	-0.748144194	0.251883651	0.238445328	1	-0.550148236	-0.253352986
DO..mg.L.	0.193143581	-0.18674952	-0.644992748	-0.550148236	1	0.746540448
pH	-0.089439176	-0.091636025	-0.518407078	-0.253352986	0.746540448	1
Turbidity..NTU.	0.324933349	-0.236922721	-0.111836223	-0.504399094	0.404754994	0.26506092
Mid.channel.Total.Depth..m.	0.173652669	-0.093269786	0.108447191	-0.088377711	-0.04338449	-0.148360177
Secchi..m.	-0.47673138	0.406606287	0.349210677	0.581079637	-0.39789242	-0.052293716
Field.Discharge..cfs.	0.020553566	-0.73284459	-0.2256172	-0.359809812	0.331686497	0.177494909
USGS.Instantaneous.Discharge..cfs.	0.034078766	-0.676235227	-0.300486166	-0.395602095	0.402881958	0.191591937
USGS.Daily.Average.Discharge..cfs.	0.040047071	-0.673127996	-0.303605616	-0.40216719	0.408617784	0.195263937
Tidal.Height..ft.	0.072516374	0.120190579	0.281487727	-0.115366091	0.045312637	0.029431461
Total..OT.	-0.398487489	0.075128507	-0.096693389	0.370781844	-0.105499734	0.078036181
Species.Richness..OT.	-0.666408965	0.249797304	0.069866769	0.655622798	-0.278885838	0.058381181
Margaleff.Richness..OT.	-0.555531472	0.135480266	-0.009745368	0.572738071	-0.250274706	-0.005845159
Shannon.Wiener..OT.	-0.26835534	0.118830585	0.11571811	0.327387497	-0.301984192	-0.116065943
Shannon.Evenness..OT.	0.13196587	-0.055747586	0.098257442	-0.079742645	-0.098925281	-0.182629837
Total..BT.	0.042117854	-0.323981824	-0.358917069	-0.11101886	0.027393854	0.047659194
Species.Richness..BT.	0.381613575	-0.337778778	-0.379206473	-0.506299344	0.307252366	0.067694048
Margaleff.Richness..BT.	0.417631334	-0.267147486	-0.268880121	-0.500352349	0.268896783	-0.012759166
Shannon.Wiener..BT.	0.425635146	-0.208730391	-0.306457118	-0.465521447	0.258697939	-0.026895166
Shannon.Evenness..BT.	0.362634578	-0.10828738	-0.375252927	-0.404740785	0.320266775	-0.040610731
CPUE..OT.	-0.395461067	0.075812529	-0.094709985	0.370509296	-0.111477505	0.074300616
CPUE..BT.	0.019285442	-0.301406196	-0.360195427	-0.099558729	0.018034431	0.047791113

	Turbidity. NTU.	Mid.channel Total.Depth .m.	Secchi....m.	Field Discharge. cfs.	USGS. Instantaneous Discharge. cfs.	USGS.Daily. Average Discharge .cfs.
River.Kilometer	0.324933349	0.173652669	-0.47673138	0.020553566	0.034078766	0.040047071
Julian.Day	-0.236922721	-0.093269786	0.406606287	-0.73284459	-0.676235227	-0.673127996
Temperature..C.	-0.111836223	0.108447191	0.349210677	-0.2256172	-0.300486166	-0.303605616
Salinity..psu.	-0.504399094	-0.088377711	0.581079637	-0.359809812	-0.395602095	-0.40216719
DO..mg.L.	0.404754994	-0.04338449	-0.39789242	0.331686497	0.402881958	0.408617784
pH	0.26506092	-0.148360177	-0.052293716	0.177494909	0.191591937	0.195263937
Turbidity..NTU.	1	0.121678618	-0.427592313	0.425649354	0.445265665	0.448585976
Mid.channel.Total.Depth..m.	0.121678618	1	-0.140313041	0.16763105	0.199466386	0.199328503
Secchi..m.	-0.427592313	-0.140313041	1	-0.583429285	-0.638336947	-0.639514444
Field.Discharge..cfs.	0.425649354	0.16763105	-0.583429285	1	0.941510563	0.941799017
USGS.Instantaneous.Discharge..cfs.	0.445265665	0.199466386	-0.638336947	0.941510563	1	0.999787566
USGS.Daily.Average.Discharge..cfs.	0.448585976	0.199328503	-0.639514444	0.941799017	0.999787566	1
Tidal.Height..ft.	0.069879071	0.095714561	0.053812883	-0.043419743	-0.079027314	-0.073776763
Total..OT.	-0.141033807	-0.195418752	0.155108683	-0.125546936	-0.146757259	-0.149856482
Species.Richness..OT.	-0.327349281	-0.418703516	0.50691346	-0.338081673	-0.363367491	-0.367276607
Margaleff.Richness..OT.	-0.333395697	-0.292272748	0.409751232	-0.248345976	-0.261784107	-0.264703878
Shannon.Wiener..OT.	-0.308353556	-0.17230305	0.266729403	-0.160617051	-0.20876202	-0.211627373
Shannon.Evenness..OT.	-0.055598287	0.197725716	-0.105702142	0.071672157	0.037113778	0.036262267
Total..BT.	0.043141725	0.013887256	-0.209793523	0.219698444	0.244628549	0.24454565
Species.Richness..BT.	0.326450005	0.178572435	-0.41410412	0.386406101	0.441555793	0.442745827
Margaleff.Richness..BT.	0.248327852	0.121771034	-0.389207604	0.26713174	0.338090346	0.335397585
Shannon.Wiener..BT.	0.251097651	0.146942852	-0.37622351	0.246697627	0.314779314	0.313485105
Shannon.Evenness..BT.	0.191728965	0.074660889	-0.345691582	0.145226222	0.234688651	0.233336878
CPUE..OT.	-0.144157001	-0.198225776	0.157029227	-0.128083216	-0.149848332	-0.152876101
CPUE..BT.	0.009969719	0.000754376	-0.185007602	0.181211188	0.200396765	0.200167885

	Tidal Height..ft.	Total..OT.	Species Richness..OT.	Margaleff Richness..OT.	Shannon Wiener..OT.	Shannon.Evenness..OT.
River.Kilometer	0.072516374	-0.398487489	-0.666408965	-0.555531472	-0.26835534	0.13196587
Julian.Day	0.120190579	0.075128507	0.249797304	0.135480266	0.118830585	-0.055747586
Temperature..C.	0.281487727	-0.096693389	0.069866769	-0.009745368	0.11571811	0.098257442
Salinity..psu.	-0.115366091	0.370781844	0.655622798	0.572738071	0.327387497	-0.079742645
DO..mg.L.	0.045312637	-0.105499734	-0.278885838	-0.250274706	-0.301984192	-0.098925281
pH	0.029431461	0.078036181	0.058381181	-0.005845159	-0.116065943	-0.182629837
Turbidity..NTU.	0.069879071	-0.141033807	-0.327349281	-0.333395697	-0.308353556	-0.055598287
Mid.channel.Total.Depth..m.	0.095714561	-0.195418752	-0.418703516	-0.292272748	-0.17230305	0.197725716
Secchi..m.	0.053812883	0.155108683	0.50691346	0.409751232	0.266729403	-0.105702142
Field.Discharge..cfs.	-0.043419743	-0.125546936	-0.338081673	-0.248345976	-0.160617051	0.071672157
USGS.Instantaneous.Discharge..cfs.	-0.079027314	-0.146757259	-0.363367491	-0.261784107	-0.20876202	0.037113778
USGS.Daily.Average.Discharge..cfs.	-0.073776763	-0.149856482	-0.367276607	-0.264703878	-0.211627373	0.036262267
Tidal.Height..ft.	1	-0.017127615	-0.037880661	-0.026264383	-0.00224018	0.055613209
Total..OT.	-0.017127615	1	0.555111754	0.232613276	-0.22275385	-0.476162244
Species.Richness..OT.	-0.037880661	0.555111754	1	0.837261369	0.425851145	-0.209191826
Margaleff.Richness..OT.	-0.026264383	0.232613276	0.837261369	1	0.699969127	0.167369223
Shannon.Wiener..OT.	-0.00224018	-0.22275385	0.425851145	0.699969127	1	0.67422626
Shannon.Evenness..OT.	0.055613209	-0.476162244	-0.209191826	0.167369223	0.67422626	1
Total..BT.	-0.084695036	0.34520897	-0.059382579	-0.02949972	-0.159204603	-0.065427571
Species.Richness..BT.	-0.310915178	-0.318421151	-0.521026171	-0.39987365	-0.27521492	0.055550157
Margaleff.Richness..BT.	-0.227580496	-0.338166504	-0.500556802	-0.394299995	-0.239947136	0.069166334
Shannon.Wiener..BT.	-0.232934865	-0.297792282	-0.496584213	-0.426454036	-0.282506526	0.002484399
Shannon.Evenness..BT.	-0.18364923	-0.221510318	-0.40740292	-0.361561406	-0.252482066	0.009945475
CPUE..OT.	-0.016772078	0.999759658	0.557450945	0.235052853	-0.219929038	-0.476265261
CPUE..BT.	-0.029962964	0.380791089	-0.039725999	-0.031407101	-0.162726273	-0.074281196

	Total..BT.	Species Richness .BT.	Margaleff Richness..BT.	Shannon Wiener..BT.	Shannon Evenness..BT.	CPUE..OT.	CPUE..BT.
River.Kilometer	0.042117854	0.381613575	0.417631334	0.425635146	0.362634578	-0.395461067	0.019285442
Julian.Day	-0.323981824	-0.337778778	-0.267147486	-0.208730391	-0.10828738	0.075812529	-0.301406196
Temperature..C.	-0.358917069	-0.379206473	-0.268880121	-0.306457118	-0.375252927	-0.094709985	-0.360195427
Salinity..psu.	-0.11101886	-0.506299344	-0.500352349	-0.465521447	-0.404740785	0.370509296	-0.099558729
DO..mg.L.	0.027393854	0.307252366	0.268896783	0.258697939	0.320266775	-0.111477505	0.018034431
pH	0.047659194	0.067694048	-0.012759166	-0.026895166	-0.040610731	0.074300616	0.047791113
Turbidity..NTU.	0.043141725	0.326450005	0.248327852	0.251097651	0.191728965	-0.144157001	0.009969719
Mid.channel.Total.Depth..m.	0.013887256	0.178572435	0.121771034	0.146942852	0.074660889	-0.198225776	0.000754376
Secchi..m.	-0.209793523	-0.41410412	-0.389207604	-0.37622351	-0.345691582	0.157029227	-0.185007602
Field.Discharge..cfs.	0.219698444	0.386406101	0.26713174	0.246697627	0.145226222	-0.128083216	0.181211188
USGS.Instantaneous.Discharge..cfs	0.244628549	0.441555793	0.338090346	0.314779314	0.234688651	-0.149848332	0.200396765
USGS.Daily.Average.Discharge.cfs.	0.24454565	0.442745827	0.335397585	0.313485105	0.233336878	-0.152876101	0.200167885
Tidal.Height..ft.	-0.084695036	-0.310915178	-0.227580496	-0.232934865	-0.18364923	-0.016772078	-0.029962964
Total..OT.	0.34520897	-0.318421151	-0.338166504	-0.297792282	-0.221510318	0.999759658	0.380791089
Species.Richness..OT.	-0.059382579	-0.521026171	-0.500556802	-0.496584213	-0.40740292	0.557450945	-0.039725999
Margaleff.Richness..OT.	-0.02949972	-0.39987365	-0.394299995	-0.426454036	-0.361561406	0.235052853	-0.031407101
Shannon.Wiener..OT.	-0.159204603	-0.27521492	-0.239947136	-0.282506526	-0.252482066	-0.219929038	-0.162726273
Shannon.Evenness..OT.	-0.065427571	0.055550157	0.069166334	0.002484399	0.009945475	-0.476265261	-0.074281196
Total..BT.	1	0.299078085	0.055991855	0.050972373	0.016951359	0.348184736	0.988642998
Species.Richness..BT.	0.299078085	1	0.848486252	0.873305769	0.711218904	-0.317575836	0.248651262
Margaleff.Richness..BT.	0.055991855	0.848486252	1	0.957416913	0.867200804	-0.336951914	0.02906314
Shannon.Wiener..BT.	0.050972373	0.873305769	0.957416913	1	0.906468804	-0.297355887	0.016713093
Shannon.Evenness..BT.	0.016951359	0.711218904	0.867200804	0.906468804	1	-0.222698153	0.000691678
CPUE..OT.	0.348184736	-0.317575836	-0.336951914	-0.297355887	-0.222698153	1	0.384072857
CPUE..BT.	0.988642998	0.248651262	0.02906314	0.016713093	0.000691678	0.384072857	1

Table 73. Pearson correlation analysis p-values for surface profile data (Figure 32).

	River.Kilometer	Julian.Day	Temperature..C.	Salinity..psu.	DO..mg.L.	pH
River.Kilometer	0	1	1	1.63E-09	1	1
Julian.Day	0.044951388	0	1	0.117537793	1	1
Temperature..C.	0.133061622	0.040993036	0	1	8.39E-09	1
Salinity..psu.	5.76E-12	0.000565086	0.038560745	0	1	1
DO..mg.L.	0.337459792	0.524331353	3.00E-11	0.226508306	0	0.046187917
pH	0.27772073	0.011513886	0.059380535	0.160380531	0.000210904	0
Turbidity..NTU.	6.19E-05	8.16E-09	0.00407338	4.60E-08	0.149842864	0.048484146
Mid.channel.Total.Depth..m.	0.002222055	0.019802007	0.898440823	0.001217573	0.299182135	0.001082773
Secchi..m.	7.66E-06	1.18E-06	0.001923024	3.65E-11	0.049525916	0.216326289
Field.Discharge..cfs.	0.020878797	8.25E-15	0.057388137	9.39E-05	0.656544968	0.004199159
USGS.Instantaneous.Discharge..cfs.	0.012746201	1.59E-13	0.025086722	4.03E-05	0.467310959	0.006293871
USGS.Daily.Average.Discharge..cfs.	0.012173508	1.88E-13	0.024699404	3.71E-05	0.463515225	0.006451239
Tidal.Height..ft.	0.646908253	0.159439108	0.000539423	0.574819012	0.002672533	0.483477344
Total..OT.	0.000142127	0.116277019	0.892320107	0.000879534	0.582377336	0.039724081
Species.Richness..OT.	6.55E-11	0.000747388	0.103942346	1.10E-12	0.528296131	0.026453295
Margaleff.Richness..OT.	7.54E-09	0.002709015	0.135983697	1.50E-09	0.565251059	0.028314645
Shannon.Wiener..OT.	0.003442963	0.011453013	0.059114736	0.001006196	0.287181183	0.135200203
Shannon.Evenness..OT.	0.199859046	0.690132632	0.467640669	0.24145777	0.413422726	0.53478676
Total..BT.	0.514530656	0.006473804	0.002237941	0.125184907	0.018765563	0.729690018
Species.Richness..BT.	6.85E-06	9.14E-05	0.001139751	4.24E-07	0.060159413	0.095574917
Margaleff.Richness..BT.	1.63E-06	0.001392486	0.005790317	7.83E-07	0.103080214	0.10580602
Shannon.Wiener..BT.	2.14E-06	0.002512479	0.004584614	1.59E-06	0.087356189	0.120822559
Shannon.Evenness..BT.	6.87E-06	0.009910607	0.001912165	8.67E-06	0.039758613	0.255714516
CPUE..OT.	0.000144416	0.113756349	0.890669478	0.000872185	0.580625949	0.038498024
CPUE..BT.	0.51453038	0.006527729	0.002265511	0.12546353	0.018925684	0.730858807

	Turbidity. NTU.	Mid.channel Total.Depth .m.	Secchi..m.	Field Discharge. cfs.	USGS.Instantaneous Discharge. cfs.	USGS.Daily.Average Discharge .cfs.
River.Kilometer	0.014057602	0.404414046	0.00185264	1	1	1
Julian.Day	2.21E-06	1	0.000299967	2.39E-12	4.58E-11	5.40E-11
Temperature..C.	0.688401211	1	0.359605463	1	1	1
Salinity..psu.	1.23E-05	0.233774009	1.02E-08	0.021031939	0.009343592	0.008654712
DO..mg.L.	1	1	1	1	1	1
pH	1	0.212366483	1	0.705458688	0.981143761	0.993490739
Turbidity..NTU.	0	0.738211421	2.47E-10	5.83E-08	3.42E-09	2.93E-09
Mid.channel.Total.Depth..m.	0.004447057	0	1	0.993490739	0.924089188	0.914754806
Secchi..m.	8.65E-13	0.006941457	0	1.20E-05	1.56E-06	1.37E-06
Field.Discharge..cfs.	2.11E-10	0.006458508	4.49E-08	0	6.00E-22	7.67E-22
USGS.Instantaneous.Discharge..cfs.	1.22E-11	0.005739684	5.68E-09	2.03E-24	0	1.11E-50
USGS.Daily.Average.Discharge..cfs.	1.04E-11	0.005646635	4.99E-09	2.60E-24	3.73E-53	0
Tidal.Height..ft.	0.053400873	0.664135759	0.168720336	0.277143546	0.185671825	0.188972461
Total..OT.	0.004830445	0.00271946	0.015012302	0.047709059	0.039918364	0.039103712
Species.Richness..OT.	7.13E-08	1.70E-05	6.63E-08	0.000118576	5.06E-05	4.72E-05
Margaleff.Richness..OT.	2.14E-06	0.000104843	1.27E-06	0.000516299	0.000251991	0.000238052
Shannon.Wiener..OT.	0.001057459	0.023463018	0.000775913	0.006289383	0.003620303	0.003529748
Shannon.Evenness..OT.	0.502679469	0.1465491	0.503362577	0.613618369	0.659001263	0.657822603
Total..BT.	0.052092173	0.835339374	0.024920599	0.035193099	0.027680022	0.027683225
Species.Richness..BT.	7.90E-09	0.007346239	1.55E-07	6.95E-05	1.24E-05	1.22E-05
Margaleff.Richness..BT.	4.99E-07	0.01053558	2.67E-06	0.000849863	0.000239543	0.000236574
Shannon.Wiener..BT.	1.23E-06	0.011362424	5.18E-06	0.001477112	0.000423444	0.000417752
Shannon.Evenness..BT.	1.31E-05	0.031236325	2.21E-05	0.006200975	0.00197089	0.001947017
CPUE..OT.	0.004651297	0.002596832	0.014672568	0.04608585	0.038516663	0.037726506
CPUE..BT.	0.052404931	0.834507655	0.025110978	0.035432633	0.027878514	0.02788181

	Tidal Height..ft.	Total..OT.	Species Richness..OT.	Margaleff Richness..OT.	Shannon Wiener..OT.	Shannon.Evenness..OT.
River.Kilometer	1	0.031410138	1.82E-08	2.06E-06	0.592189676	1
Julian.Day	1	1	0.152467248	0.476786664	1	1
Temperature..C.	0.112739416	1	1	1	1	1
Salinity..psu.	1	0.175906738	3.14E-10	4.15E-07	0.200232936	1
DO..mg.L.	0.47303831	1	1	1	1	1
pH	1	1	1	1	1	1
Turbidity..NTU.	1	0.787362611	1.88E-05	0.000533434	0.209376925	1
Mid.channel.Total.Depth..m.	1	0.476786664	0.004037736	0.023379886	1	1
Secchi..m.	1	1	1.76E-05	0.000319939	0.157510255	1
Field.Discharge..cfs.	1	1	0.02632394	0.10893907	0.981143761	1
USGS.Instantaneous.Discharge..cfs.	1	1	0.011646897	0.054178153	0.615451551	1
USGS.Daily.Average.Discharge..cfs.	1	1	0.010894139	0.051657235	0.603586976	1
Tidal.Height..ft.	0	1	1	1	1	1
Total..OT.	0.83765553	0	0.005968837	0.934510853	1	0.012073976
Species.Richness..OT.	0.508158901	2.55E-05	0	2.05E-10	0.142957969	1
Margaleff.Richness..OT.	0.582016012	0.005914626	7.14E-13	0	9.69E-05	1
Shannon.Wiener..OT.	0.453915874	0.941631299	0.000693971	3.71E-07	0	0.73760674
Shannon.Evenness..OT.	0.677815118	5.27E-05	0.171855732	0.968805152	0.004416807	0
Total..BT.	0.133569461	0.132864693	0.331809221	0.234095891	0.02464973	0.16395337
Species.Richness..BT.	0.010637267	0.002013618	1.88E-08	4.35E-07	0.000581711	0.598956824
Margaleff.Richness..BT.	0.023864815	0.000520783	2.82E-08	5.02E-07	0.001442921	0.503718966
Shannon.Wiener..BT.	0.02197786	0.001097271	6.00E-08	3.65E-07	0.000726243	0.656701053
Shannon.Evenness..BT.	0.020362339	0.002931886	1.15E-06	3.16E-06	0.001161149	0.759320698
CPUE..OT.	0.836574576	7.14E-54	2.46E-05	0.005765412	0.93442106	5.45E-05
CPUE..BT.	0.134075691	0.132498122	0.331884415	0.23366098	0.024492653	0.163091448

	Total..BT.	Species Richness .BT.	Margaleff Richness..BT.	Shannon Wiener..BT.	Shannon Evenness..BT.	CPUE..OT.	CPUE..BT.
River.Kilometer	1	0.001670808	0.000406686	0.000533434	0.001670808	0.031771604	1
Julian.Day	0.993490739	0.020571234	0.265964902	0.449733691	1	1	0.993490739
Temperature..C.	0.405067355	0.221111699	0.924089188	0.756461328	0.35948697	1	0.40779205
Salinity..psu.	1	0.000110305	0.000200427	0.000398047	0.002089677	0.175309217	1
DO..mg.L.	1	1	1	1	1	1	1
pH	1	1	1	1	1	1	1
Turbidity..NTU.	1	2.15E-06	0.000128847	0.000310082	0.003111865	0.762812727	1
Mid.channel.Total.Depth..m.	1	1	1	1	1	0.462236183	1
Secchi..m.	1	4.08E-05	0.000659162	0.001269714	0.005213739	1	1
Field.Discharge..cfs.	1	0.01570553	0.171672302	0.279174257	0.973553042	1	1
USGS.Instantaneous.Discharge..cfs	1	0.002972966	0.051741183	0.090193598	0.364614689	1	1
USGS.Daily.Average.Discharge.cfs.	1	0.002921331	0.051573237	0.089399031	0.362145174	1	1
Tidal.Height..ft.	1	1	1	1	1	1	1
Total..OT.	1	0.368492034	0.109364505	0.213967937	0.507216314	2.14E-51	1
Species.Richness..OT.	1	5.09E-06	7.58E-06	1.60E-05	0.000293939	0.005769331	1
Margaleff.Richness..OT.	1	0.000112778	0.000128938	9.55E-05	0.000778173	0.924089188	1
Shannon.Wiener..OT.	1	0.120414102	0.274155084	0.148879822	0.224101775	1	1
Shannon.Evenness..OT.	1	1	1	1	1	0.012434894	1
Total..BT.	0	1	1	1	1	1	5.76E-65
Species.Richness..BT.	0.066954636	0	4.94E-14	1.65E-13	5.23E-10	0.364614689	1
Margaleff.Richness..BT.	0.339122443	1.69E-16	0	1.03E-25	6.78E-16	0.108455632	1
Shannon.Wiener..BT.	0.333238553	5.68E-16	3.48E-28	0	2.24E-18	0.212366483	1
Shannon.Evenness..BT.	0.388406559	1.84E-12	2.31E-18	7.60E-21	0	0.50295389	1
CPUE..OT.	0.132537812	0.001976656	0.000511583	0.001078002	0.00289054	0	1
CPUE..BT.	1.92E-67	0.067065061	0.339384944	0.333388964	0.388617188	0.132170333	0

Table 74. Pearson correlation analysis correlation coefficients (R) for surface profile data (Figure 32).

	River.Kilometer	Julian.Day	Temperature..C.	Salinity..psu.	DO..mg.L.	pH
River.Kilometer	1	-0.017988179	-0.019602128	-0.774141788	0.055975444	0.015381705
Julian.Day	-0.017988179	1	0.10414743	0.228260374	0.013129536	0.227683372
Temperature..C.	-0.019602128	0.10414743	1	0.125093829	-0.794809269	-0.406643292
Salinity..psu.	-0.774141788	0.228260374	0.125093829	1	-0.081192775	-0.008239911
DO..mg.L.	0.055975444	0.013129536	-0.794809269	-0.081192775	1	0.683654792
pH	0.015381705	0.227683372	-0.406643292	-0.008239911	0.683654792	1
Turbidity..NTU.	0.425694242	-0.555919697	-0.321415572	-0.446788961	0.159454453	-0.108485793
Mid.channel.Total.Depth..m.	0.180613114	-0.107815872	0.097965268	-0.172597788	-0.136290849	-0.281294405
Secchi..m.	-0.478294841	0.408229176	0.302650604	0.721734772	-0.326264016	-0.041815285
Field.Discharge..cfs.	0.033287011	-0.739456621	-0.135660875	-0.338643949	-0.033212072	-0.314339917
USGS.Instantaneous.Discharge..cfs.	0.039362123	-0.676929381	-0.238530626	-0.366958176	0.032659547	-0.341703515
USGS.Daily.Average.Discharge..cfs.	0.045109358	-0.673813502	-0.242237919	-0.369120973	0.035353717	-0.339891403
Tidal.Height..ft.	0.071703425	0.098790212	0.30428734	-0.103237974	-0.277827151	-0.059231535
Total..OT.	-0.394923785	0.070156114	-0.056185605	0.320290885	0.142760341	0.203172025
Species.Richness..OT.	-0.668008156	0.256044145	0.071324462	0.708362608	-0.008382248	0.206113481
Margaleff.Richness..OT.	-0.557556805	0.142816248	-0.011880777	0.577856927	0.059409067	0.200962076
Shannon.Wiener..OT.	-0.276231289	0.13809722	0.110480424	0.281368546	-0.033983838	0.181007827
Shannon.Evenness..OT.	0.12640401	-0.045680362	0.096992803	-0.150455815	-0.058132609	0.016044708
Total..BT.	0.040195502	-0.316709868	-0.338698158	-0.152550554	0.260897163	0.073795311
Species.Richness..BT.	0.385114822	-0.343795157	-0.374535048	-0.371884868	0.248351619	-0.145017181
Margaleff.Richness..BT.	0.422214732	-0.27792274	-0.260758862	-0.414432905	0.198584045	-0.114163078
Shannon.Wiener..BT.	0.430287678	-0.220958556	-0.303092027	-0.38703366	0.212730589	-0.122531619
Shannon.Evenness..BT.	0.368204475	-0.123526069	-0.377979392	-0.345476171	0.286450459	-0.075542222
CPUE..OT.	-0.391881348	0.070786031	-0.054305771	0.317852836	0.143843054	0.205985983
CPUE..BT.	0.040121844	-0.316326569	-0.338018303	-0.152429836	0.26014046	0.073398353

	Turbidity. NTU.	Mid.channel Total.Depth .m.	Secchi....m.	Field Discharge. cfs.	USGS. Instantaneous Discharge. cfs.	USGS.Daily. Average Discharge .cfs.
River.Kilometer	0.425694242	0.180613114	-0.478294841	0.033287011	0.039362123	0.045109358
Julian.Day	-0.555919697	-0.107815872	0.408229176	-0.739456621	-0.676929381	-0.673813502
Temperature..C.	-0.321415572	0.097965268	0.302650604	-0.135660875	-0.238530626	-0.242237919
Salinity..psu.	-0.446788961	-0.172597788	0.721734772	-0.338643949	-0.366958176	-0.369120973
DO..mg.L.	0.159454453	-0.136290849	-0.326264016	-0.033212072	0.032659547	0.035353717
pH	-0.108485793	-0.281294405	-0.041815285	-0.314339917	-0.341703515	-0.339891403
Turbidity..NTU.	1	0.162769268	-0.618175599	0.684960603	0.712100114	0.715472991
Mid.channel.Total.Depth..m.	0.162769268	1	-0.144089923	0.181651688	0.205035862	0.204721023
Secchi..m.	-0.618175599	-0.144089923	1	-0.582328706	-0.639340898	-0.640424012
Field.Discharge..cfs.	0.684960603	0.181651688	-0.582328706	1	0.937621476	0.937934233
USGS.Instantaneous.Discharge..cfs.	0.712100114	0.205035862	-0.639340898	0.937621476	1	0.999783109
USGS.Daily.Average.Discharge..cfs.	0.715472991	0.204721023	-0.640424012	0.937934233	0.999783109	1
Tidal.Height..ft.	-0.233730752	0.104114434	0.050426816	-0.015494614	-0.064106923	-0.058568826
Total..OT.	-0.252850343	-0.191452825	0.153719078	-0.119514373	-0.144765594	-0.147737197
Species.Richness..OT.	-0.490946253	-0.422211389	0.508212287	-0.343204541	-0.366266013	-0.369904802
Margaleff.Richness..OT.	-0.373719743	-0.296447209	0.411276702	-0.254348551	-0.26492577	-0.267593849
Shannon.Wiener..OT.	-0.257551284	-0.184679556	0.270089488	-0.180100275	-0.215718618	-0.218388365
Shannon.Evenness..OT.	0.062832034	0.189828483	-0.102694343	0.060691882	0.033078527	0.032121872
Total..BT.	0.172427828	0.0114728	-0.208551584	0.213128233	0.242547726	0.242507889
Species.Richness..BT.	0.529159998	0.184605258	-0.41580604	0.391818033	0.444341155	0.445330119
Margaleff.Richness..BT.	0.457546031	0.131004359	-0.391320378	0.278457254	0.342597229	0.339548102
Shannon.Wiener..BT.	0.440753928	0.156239895	-0.378436059	0.258894919	0.319500269	0.317914008
Shannon.Evenness..BT.	0.366503623	0.085641889	-0.348161992	0.160659341	0.240399716	0.238736747
CPUE..OT.	-0.255357066	-0.194210385	0.155622652	-0.12196694	-0.147828781	-0.150728625
CPUE..BT.	0.171851488	0.011857173	-0.207609195	0.212621588	0.241893977	0.241850595

	Tidal Height..ft.	Total..OT.	Species Richness..OT.	Margaleff Richness..OT.	Shannon Wiener..OT.	Shannon.Evenness..OT.
River.Kilometer	0.071703425	-0.394923785	-0.668008156	-0.557556805	-0.276231289	0.12640401
Julian.Day	0.098790212	0.070156114	0.256044145	0.142816248	0.13809722	-0.045680362
Temperature..C.	0.30428734	-0.056185605	0.071324462	-0.011880777	0.110480424	0.096992803
Salinity..psu.	-0.103237974	0.320290885	0.708362608	0.577856927	0.281368546	-0.150455815
DO..mg.L.	-0.277827151	0.142760341	-0.008382248	0.059409067	-0.033983838	-0.058132609
pH	-0.059231535	0.203172025	0.206113481	0.200962076	0.181007827	0.016044708
Turbidity..NTU.	-0.233730752	-0.252850343	-0.490946253	-0.373719743	-0.257551284	0.062832034
Mid.channel.Total.Depth..m.	0.104114434	-0.191452825	-0.422211389	-0.296447209	-0.184679556	0.189828483
Secchi..m.	0.050426816	0.153719078	0.508212287	0.411276702	0.270089488	-0.102694343
Field.Discharge..cfs.	-0.015494614	-0.119514373	-0.343204541	-0.254348551	-0.180100275	0.060691882
USGS.Instantaneous.Discharge..cfs.	-0.064106923	-0.144765594	-0.366266013	-0.26492577	-0.215718618	0.033078527
USGS.Daily.Average.Discharge..cfs.	-0.058568826	-0.147737197	-0.369904802	-0.267593849	-0.218388365	0.032121872
Tidal.Height..ft.	1	-0.009758637	-0.039827734	-0.02668931	-0.016820613	0.049505352
Total..OT.	-0.009758637	1	0.55212343	0.23052145	-0.224183573	-0.476727872
Species.Richness..OT.	-0.039827734	0.55212343	1	0.837874125	0.429679671	-0.204534862
Margaleff.Richness..OT.	-0.02668931	0.23052145	0.837874125	1	0.700103664	0.17040632
Shannon.Wiener..OT.	-0.016820613	-0.224183573	0.429679671	0.700103664	1	0.674763008
Shannon.Evenness..OT.	0.049505352	-0.476727872	-0.204534862	0.17040632	0.674763008	1
Total..BT.	-0.084728893	0.344416565	-0.057850968	-0.028115114	-0.15437264	-0.063946242
Species.Richness..BT.	-0.305769955	-0.315630917	-0.523157314	-0.402396892	-0.28182491	0.051000826
Margaleff.Richness..BT.	-0.22792583	-0.333724444	-0.503372273	-0.397603864	-0.250535891	0.062637289
Shannon.Wiener..BT.	-0.228636571	-0.293358795	-0.4994737	-0.429600674	-0.292863766	-0.003811867
Shannon.Evenness..BT.	-0.173969065	-0.217046577	-0.411122654	-0.365361723	-0.264370244	0.003027072
CPUE..OT.	-0.009385477	0.999759786	0.55443401	0.232936209	-0.2214293	-0.476844894
CPUE..BT.	-0.084448207	0.344460893	-0.058216214	-0.028739344	-0.154938367	-0.064628364

	Total..BT.	Species Richness .BT.	Margaleff Richness..BT.	Shannon Wiener..BT.	Shannon Evenness..BT.	CPUE..OT.	CPUE..BT.
River.Kilometer	0.040195502	0.385114822	0.422214732	0.430287678	0.368204475	-0.391881348	0.040121844
Julian.Day	-0.316709868	-0.343795157	-0.27792274	-0.220958556	-0.123526069	0.070786031	-0.316326569
Temperature..C.	-0.338698158	-0.374535048	-0.260758862	-0.303092027	-0.377979392	-0.054305771	-0.338018303
Salinity..psu.	-0.152550554	-0.371884868	-0.414432905	-0.38703366	-0.345476171	0.317852836	-0.152429836
DO..mg.L.	0.260897163	0.248351619	0.198584045	0.212730589	0.286450459	0.143843054	0.26014046
pH	0.073795311	-0.145017181	-0.114163078	-0.122531619	-0.075542222	0.205985983	0.073398353
Turbidity..NTU.	0.172427828	0.529159998	0.457546031	0.440753928	0.366503623	-0.255357066	0.171851488
Mid.channel.Total.Depth..m.	0.0114728	0.184605258	0.131004359	0.156239895	0.085641889	-0.194210385	0.011857173
Secchi..m.	-0.208551584	-0.41580604	-0.391320378	-0.378436059	-0.348161992	0.155622652	-0.207609195
Field.Discharge..cfs.	0.213128233	0.391818033	0.278457254	0.258894919	0.160659341	-0.12196694	0.212621588
USGS.Instantaneous.Discharge..cfs	0.242547726	0.444341155	0.342597229	0.319500269	0.240399716	-0.147828781	0.241893977
USGS.Daily.Average.Discharge.cfs.	0.242507889	0.445330119	0.339548102	0.317914008	0.238736747	-0.150728625	0.241850595
Tidal.Height..ft.	-0.084728893	-0.305769955	-0.22792583	-0.228636571	-0.173969065	-0.009385477	-0.084448207
Total..OT.	0.344416565	-0.315630917	-0.333724444	-0.293358795	-0.217046577	0.999759786	0.344460893
Species.Richness..OT.	-0.057850968	-0.523157314	-0.503372273	-0.4994737	-0.411122654	0.55443401	-0.058216214
Margaleff.Richness..OT.	-0.028115114	-0.402396892	-0.397603864	-0.429600674	-0.365361723	0.232936209	-0.028739344
Shannon.Wiener..OT.	-0.15437264	-0.28182491	-0.250535891	-0.292863766	-0.264370244	-0.2214293	-0.154938367
Shannon.Evenness..OT.	-0.063946242	0.051000826	0.062637289	-0.003811867	0.003027072	-0.476844894	-0.064628364
Total..BT.	1	0.296691104	0.053500627	0.048408404	0.01435754	0.347381278	0.999995971
Species.Richness..BT.	0.296691104	1	0.849200382	0.87376947	0.712896094	-0.314764596	0.296712613
Margaleff.Richness..BT.	0.053500627	0.849200382	1	0.957848026	0.868614563	-0.332484239	0.053584277
Shannon.Wiener..BT.	0.048408404	0.87376947	0.957848026	1	0.907514614	-0.292892047	0.048596661
Shannon.Evenness..BT.	0.01435754	0.712896094	0.868614563	0.907514614	1	-0.218191511	0.014409141
CPUE..OT.	0.347381278	-0.314764596	-0.332484239	-0.292892047	-0.218191511	1	0.347429575
CPUE..BT.	0.999995971	0.296712613	0.053584277	0.048596661	0.014409141	0.347429575	1

Table 75. Results of SIMPER analysis for otter trawl collection resemblance matrix between sample sites.

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data2
Data type: Other
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Factor Groups

Sample	Site
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
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B01	B01
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B01	B01
B01	B01
B10	B10
B10	B10
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B22	B22
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B31	B31
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B31	B31
B31	B31
B31	B31
B42	B42
B42	B42

B42	B42
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B42	B42
B42	B42
B42	B42
B42	B42
B42	B42
B42	B42
B42	B42
B42	B42
G1D1	G1D1
G1D1	G1D1
G1	G1
G1	G1
G1U1	G1U1
G1U1	G1U1
G2	G2
G2	G2
G3	G3
G3	G3

Group B01
Average similarity: 45.36

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	3.82	14.07	2.28	31.02	31.02
Stellifer lanceolatus	3.39	9.02	1.02	19.88	50.91
Litopenaeus setiferus	2.20	6.38	1.44	14.07	64.98
Callinectes sapidus	1.60	5.00	1.44	11.03	76.01

Group B10
Average similarity: 41.43

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%

Micropogonias undulatus	3.64	16.24	2.81	39.20	39.20
Stellifer lanceolatus	2.32	6.33	0.97	15.27	54.47
Litopenaeus setiferus	1.81	3.90	0.82	9.41	63.88
Anchoa mitchilli	2.11	3.32	0.59	8.02	71.90

Group B22
Average similarity: 19.94

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ictalurus furcatus	1.49	7.98	0.54	39.99	39.99
Micropogonias undulatus	1.76	4.19	0.53	21.00	60.99
Litopenaeus setiferus	0.83	2.31	0.39	11.57	72.56

Group B31
Average similarity: 28.06

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ictalurus furcatus	3.12	17.20	1.21	61.30	61.30
Macrobrachium ohione	1.34	6.09	0.51	21.71	83.01

Group B42
Average similarity: 35.08

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ictalurus furcatus	1.75	21.69	1.36	61.83	61.83
Macrobrachium ohione	1.01	11.25	0.63	32.07	93.91

Group G1D1
All the similarities are zero

Group G1
Average similarity: 52.18

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Stellifer lanceolatus	4.37	13.58	SD=0!	26.02	26.02
Micropogonias undulatus	4.47	13.41	SD=0!	25.70	51.72
Lolliguncula brevis	3.25	10.75	SD=0!	20.60	72.32

Group G1U1
Average similarity: 49.17

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	4.23	13.08	SD=0!	26.60	26.60
Lolliguncula brevis	3.55	10.13	SD=0!	20.60	47.20
Anchoa mitchilli	3.94	9.62	SD=0!	19.56	66.76
Stellifer lanceolatus	4.30	9.43	SD=0!	19.17	85.93

Group G2
Average similarity: 28.06

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Lolliguncula brevis	2.14	12.24	SD=0!	43.62	43.62
Micropogonias undulatus	2.14	9.70	SD=0!	34.57	78.19

Group G3
All the similarities are zero

Groups B01 & B10
Average dissimilarity = 58.35

Species	Group B01 Av.Abund	Group B10 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	3.39	2.32	7.38	1.30	12.65	12.65
Micropogonias undulatus	3.82	3.64	5.60	1.12	9.59	22.24
Anchoa mitchilli	0.98	2.11	5.30	1.18	9.08	31.32
Litopenaeus setiferus	2.20	1.81	4.97	1.34	8.52	39.85
Cynoscion arenarius	1.22	1.48	3.89	1.31	6.67	46.52
Callinectes sapidus	1.60	0.44	3.67	1.23	6.29	52.81
Ariopsis felis	1.04	1.10	3.40	1.12	5.83	58.63
Bagre marinus	0.86	1.04	3.11	1.08	5.33	63.96
Bairdiella chrysoura	1.08	0.52	2.96	1.01	5.07	69.04
Farfantepenaeus aztecus	0.82	0.47	2.76	0.69	4.73	73.77

Groups B01 & B22
Average dissimilarity = 80.28

	Group B01	Group B22

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.82	1.76	12.13	1.46	15.11	15.11
Stellifer lanceolatus	3.39	0.33	10.84	1.41	13.51	28.62
Litopenaeus setiferus	2.20	0.83	6.51	1.43	8.10	36.72
Ictalurus furcatus	0.03	1.49	6.00	0.77	7.47	44.19
Callinectes sapidus	1.60	0.42	5.23	1.24	6.51	50.70
Anchoa mitchilli	0.98	0.88	4.97	0.86	6.20	56.90
Cynoscion arenarius	1.22	0.37	3.93	1.12	4.90	61.79
Ariopsis felis	1.04	0.27	3.60	0.89	4.49	66.28
Bairdiella chrysoura	1.08	0.03	3.34	0.89	4.16	70.44

Groups B10 & B22
Average dissimilarity = 80.06

	Group B10	Group B22				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.64	1.76	12.89	1.61	16.10	16.10
Stellifer lanceolatus	2.32	0.33	8.47	1.28	10.58	26.68
Anchoa mitchilli	2.11	0.88	7.74	1.06	9.67	36.35
Ictalurus furcatus	0.04	1.49	6.87	0.80	8.58	44.93
Litopenaeus setiferus	1.81	0.83	6.38	1.25	7.97	52.90
Cynoscion arenarius	1.48	0.37	5.06	1.13	6.32	59.22
Ariopsis felis	1.10	0.27	4.35	1.05	5.44	64.65
Bagre marinus	1.04	0.29	3.68	0.95	4.60	69.25
Callinectes sapidus	0.44	0.42	2.65	0.77	3.31	72.56

Groups B01 & B31
Average dissimilarity = 89.28

	Group B01	Group B31				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.82	0.93	11.84	1.46	13.26	13.26
Stellifer lanceolatus	3.39	0.03	10.56	1.38	11.83	25.09
Ictalurus furcatus	0.03	3.12	10.13	1.44	11.34	36.43
Litopenaeus setiferus	2.20	0.76	7.00	1.63	7.84	44.27
Macrobrachium ohione	0.07	1.34	5.13	0.78	5.75	50.02
Callinectes sapidus	1.60	0.44	4.92	1.20	5.51	55.53
Anchoa mitchilli	0.98	0.61	4.31	0.80	4.83	60.36
Cynoscion arenarius	1.22	0.36	3.80	1.16	4.25	64.61
Ariopsis felis	1.04	0.00	3.27	0.82	3.66	68.27
Bairdiella chrysoura	1.08	0.00	3.17	0.87	3.55	71.83

Groups B10 & B31
Average dissimilarity = 89.45

Species	Group B10 Av.Abund	Group B31 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.64	0.93	12.43	1.60	13.90	13.90
Ictalurus furcatus	0.04	3.12	11.30	1.46	12.63	26.53
Stellifer lanceolatus	2.32	0.03	8.18	1.25	9.14	35.67
Anchoa mitchilli	2.11	0.61	6.87	0.96	7.68	43.36
Litopenaeus setiferus	1.81	0.76	6.35	1.22	7.10	50.45
Macrobrachium ohione	0.03	1.34	5.82	0.79	6.50	56.96
Cynoscion arenarius	1.48	0.36	4.78	1.10	5.34	62.30
Ariopsis felis	1.10	0.00	4.10	1.02	4.59	66.89
Bagre marinus	1.04	0.16	3.36	0.90	3.76	70.64

Groups B22 & B31
Average dissimilarity = 79.13

Species	Group B22 Av.Abund	Group B31 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.49	3.12	15.08	1.17	19.05	19.05
Macrobrachium ohione	0.35	1.34	9.54	0.81	12.06	31.12
Micropogonias undulatus	1.76	0.93	9.41	0.90	11.89	43.01
Anchoa mitchilli	0.88	0.61	6.88	0.62	8.70	51.71
Litopenaeus setiferus	0.83	0.76	6.05	0.81	7.65	59.36
Callinectes sapidus	0.42	0.44	3.47	0.73	4.38	63.74
Ictalurus punctatus	0.23	0.44	3.46	0.60	4.37	68.12
Cynoscion arenarius	0.37	0.36	2.85	0.54	3.60	71.71

Groups B01 & B42
Average dissimilarity = 96.43

Species	Group B01 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.82	0.15	15.59	2.00	16.17	16.17
Stellifer lanceolatus	3.39	0.00	12.45	1.48	12.91	29.08
Litopenaeus setiferus	2.20	0.00	8.20	1.87	8.50	37.58
Ictalurus furcatus	0.03	1.75	7.67	1.19	7.95	45.53
Callinectes sapidus	1.60	0.26	5.97	1.39	6.19	51.73

Macrobrachium ohione	0.07	1.01	4.97	0.76	5.15	56.88
Cynoscion arenarius	1.22	0.00	4.25	1.20	4.41	61.29
Anchoa mitchilli	0.98	0.09	4.19	0.82	4.34	65.63
Ariopsis felis	1.04	0.00	3.84	0.85	3.99	69.62
Bairdiella chrysoura	1.08	0.00	3.69	0.90	3.83	73.45

Groups B10 & B42
Average dissimilarity = 96.81

Species	Group B10 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.64	0.15	16.65	2.52	17.20	17.20
Stellifer lanceolatus	2.32	0.00	9.85	1.38	10.18	27.37
Ictalurus furcatus	0.04	1.75	8.80	1.27	9.09	36.47
Anchoa mitchilli	2.11	0.09	7.35	1.02	7.60	44.06
Litopenaeus setiferus	1.81	0.00	6.86	1.23	7.08	51.15
Macrobrachium ohione	0.03	1.01	5.74	0.81	5.93	57.07
Cynoscion arenarius	1.48	0.00	5.38	1.12	5.56	62.64
Ariopsis felis	1.10	0.00	4.96	1.09	5.12	67.76
Bagre marinus	1.04	0.00	3.86	0.89	3.98	71.74

Groups B22 & B42
Average dissimilarity = 80.94

Species	Group B22 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.49	1.75	14.94	1.16	18.46	18.46
Macrobrachium ohione	0.35	1.01	10.76	0.81	13.30	31.76
Micropogonias undulatus	1.76	0.15	10.31	0.83	12.74	44.50
Anchoa mitchilli	0.88	0.09	6.99	0.62	8.64	53.14
Litopenaeus setiferus	0.83	0.00	5.62	0.74	6.94	60.08
Callinectes sapidus	0.42	0.26	3.86	0.73	4.77	64.86
Ictalurus punctatus	0.23	0.16	3.16	0.53	3.90	68.76
Trinectes maculatus	0.11	0.30	2.77	0.57	3.43	72.19

Groups B31 & B42
Average dissimilarity = 71.18

Species	Group B31 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%

Ictalurus furcatus	3.12	1.75	16.00	1.28	22.48	22.48
Macrobrachium ohione	1.34	1.01	12.19	0.96	17.12	39.60
Micropogonias undulatus	0.93	0.15	4.68	0.66	6.58	46.18
Macrobrachium spp.	0.41	0.35	3.98	0.45	5.59	51.77
Macrobrachium rosenbergii	0.24	0.29	3.81	0.40	5.35	57.12
Anchoa mitchilli	0.61	0.09	3.68	0.41	5.17	62.29
Ictalurus punctatus	0.44	0.16	3.68	0.63	5.16	67.45
Callinectes sapidus	0.44	0.26	3.66	0.74	5.14	72.59

Groups B01 & G1D1
Average dissimilarity = 83.25

Species	Group B01 Av.Abund	Group G1D1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.82	0.90	13.79	1.29	16.57	16.57
Stellifer lanceolatus	3.39	0.80	11.48	1.32	13.79	30.36
Litopenaeus setiferus	2.20	0.35	7.44	1.47	8.94	39.29
Callinectes sapidus	1.60	0.00	6.90	1.16	8.29	47.58
Anchoa mitchilli	0.98	1.20	5.39	1.01	6.47	54.06
Cynoscion arenarius	1.22	0.55	3.93	1.07	4.72	58.77
Ariopsis felis	1.04	0.00	3.81	0.81	4.58	63.35
Bairdiella chrysoura	1.08	0.00	3.65	0.86	4.38	67.73
Bagre marinus	0.86	0.35	3.13	0.92	3.76	71.49

Groups B10 & G1D1
Average dissimilarity = 81.68

Species	Group B10 Av.Abund	Group G1D1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.64	0.90	14.64	1.19	17.92	17.92
Stellifer lanceolatus	2.32	0.80	9.16	1.15	11.21	29.14
Anchoa mitchilli	2.11	1.20	8.05	1.19	9.86	39.00
Litopenaeus setiferus	1.81	0.35	6.65	1.15	8.14	47.14
Cynoscion arenarius	1.48	0.55	5.40	1.16	6.61	53.75
Ariopsis felis	1.10	0.00	5.05	0.97	6.18	59.93
Bagre marinus	1.04	0.35	4.02	0.95	4.92	64.85
Bairdiella chrysoura	0.52	0.00	2.91	0.52	3.56	68.41
Brevoortia patronus	0.61	0.00	2.89	0.62	3.54	71.95

Groups B22 & G1D1

Average dissimilarity = 89.84

Species	Group B22 Av.Abund	Group G1D1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.49	0.00	15.88	0.73	17.67	17.67
Micropogonias undulatus	1.76	0.90	11.92	0.93	13.27	30.94
Anchoa mitchilli	0.88	1.20	11.36	0.77	12.64	43.59
Litopenaeus setiferus	0.83	0.35	7.32	0.61	8.14	51.73
Stellifer lanceolatus	0.33	0.80	4.97	0.97	5.54	57.26
Cynoscion arenarius	0.37	0.55	4.70	0.58	5.23	62.49
Macrobrachium ohione	0.35	0.00	3.63	0.39	4.04	66.53
Chloroscombrus chrysurus	0.03	0.69	3.56	0.96	3.96	70.49

Groups B31 & G1D1
Average dissimilarity = 95.78

Species	Group B31 Av.Abund	Group G1D1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	3.12	0.00	21.53	1.28	22.48	22.48
Macrobrachium ohione	1.34	0.00	13.51	0.65	14.10	36.59
Anchoa mitchilli	0.61	1.20	7.63	0.77	7.97	44.56
Micropogonias undulatus	0.93	0.90	6.82	1.02	7.12	51.67
Litopenaeus setiferus	0.76	0.35	4.08	0.73	4.26	55.93
Stellifer lanceolatus	0.03	0.80	3.86	0.94	4.03	59.97
Cynoscion arenarius	0.36	0.55	3.38	0.95	3.52	63.49
Macrobrachium rosenbergii	0.24	0.00	3.37	0.22	3.52	67.01
Chloroscombrus chrysurus	0.00	0.69	3.30	0.92	3.44	70.45

Groups B42 & G1D1
Average dissimilarity = 98.82

Species	Group B42 Av.Abund	Group G1D1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.75	0.00	22.97	1.05	23.24	23.24
Macrobrachium ohione	1.01	0.00	17.43	0.68	17.64	40.88
Anchoa mitchilli	0.09	1.20	7.69	0.87	7.78	48.66
Micropogonias undulatus	0.15	0.90	5.85	0.89	5.92	54.58
Stellifer lanceolatus	0.00	0.80	4.63	0.97	4.68	59.26
Chloroscombrus chrysurus	0.04	0.69	4.29	0.97	4.34	63.61
Macrobrachium spp.	0.35	0.00	3.24	0.30	3.28	66.89
Cynoscion arenarius	0.00	0.55	3.16	0.97	3.20	70.09

Groups B01 & G1
Average dissimilarity = 57.00

Species	Group B01 Av.Abund	Group G1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.08	3.25	6.90	3.80	12.10	12.10
Anchoa mitchilli	0.98	2.92	4.92	1.36	8.63	20.73
Stellifer lanceolatus	3.39	4.37	4.69	1.07	8.23	28.96
Cynoscion arenarius	1.22	2.99	4.33	1.66	7.59	36.55
Micropogonias undulatus	3.82	4.47	3.68	1.23	6.45	43.00
Selene setapinnis	0.00	1.89	3.43	0.97	6.02	49.03
Litopenaeus setiferus	2.20	0.90	3.17	1.53	5.56	54.59
Bagre marinus	0.86	1.24	2.62	1.16	4.60	59.18
Ariopsis felis	1.04	0.80	2.46	1.14	4.31	63.49
Callinectes sapidus	1.60	0.69	2.14	1.09	3.76	67.26
Bairdiella chrysoura	1.08	0.00	2.08	0.88	3.66	70.91

Groups B10 & G1
Average dissimilarity = 58.69

Species	Group B10 Av.Abund	Group G1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.03	3.25	7.52	3.76	12.82	12.82
Stellifer lanceolatus	2.32	4.37	5.91	1.38	10.06	22.88
Anchoa mitchilli	2.11	2.92	5.81	1.39	9.89	32.78
Cynoscion arenarius	1.48	2.99	4.77	1.62	8.13	40.91
Micropogonias undulatus	3.64	4.47	3.95	1.48	6.73	47.63
Selene setapinnis	0.00	1.89	3.63	0.96	6.18	53.81
Litopenaeus setiferus	1.81	0.90	3.14	1.38	5.34	59.15
Bagre marinus	1.04	1.24	2.80	1.13	4.76	63.91
Ariopsis felis	1.10	0.80	2.35	1.24	4.00	67.91
Taphromysis louisianae	0.00	0.80	2.27	0.93	3.87	71.78

Groups B22 & G1
Average dissimilarity = 82.10

Species	Group B22 Av.Abund	Group G1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.33	4.37	11.76	3.25	14.32	14.32

Micropogonias undulatus	1.76	4.47	10.21	2.15	12.44	26.76
Lolliguncula brevis	0.00	3.25	9.46	4.19	11.52	38.28
Cynoscion arenarius	0.37	2.99	7.34	2.84	8.94	47.22
Anchoa mitchilli	0.88	2.92	6.87	1.45	8.37	55.59
Ictalurus furcatus	1.49	0.00	4.42	0.84	5.38	60.97
Selene setapinnis	0.00	1.89	4.32	0.97	5.26	66.23
Bagre marinus	0.29	1.24	2.97	1.10	3.62	69.85
Taphromysis louisianae	0.00	0.80	2.94	0.95	3.58	73.43

Groups B31 & G1
Average dissimilarity = 91.09

Species	Group B31 Av.Abund	Group G1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.03	4.37	11.92	4.16	13.08	13.08
Micropogonias undulatus	0.93	4.47	10.38	2.13	11.39	24.48
Lolliguncula brevis	0.00	3.25	9.01	3.75	9.89	34.36
Ictalurus furcatus	3.12	0.00	7.90	1.62	8.67	43.04
Cynoscion arenarius	0.36	2.99	7.34	2.83	8.05	51.09
Anchoa mitchilli	0.61	2.92	6.79	1.39	7.45	58.54
Selene setapinnis	0.00	1.89	4.15	0.97	4.55	63.09
Macrobrachium ohione	1.34	0.00	3.81	0.85	4.18	67.28
Litopenaeus setiferus	0.76	0.90	3.23	1.91	3.55	70.82

Groups B42 & G1
Average dissimilarity = 97.53

Species	Group B42 Av.Abund	Group G1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.00	4.37	13.85	7.05	14.20	14.20
Micropogonias undulatus	0.15	4.47	13.64	4.93	13.99	28.19
Lolliguncula brevis	0.00	3.25	10.43	5.16	10.70	38.89
Cynoscion arenarius	0.00	2.99	8.96	7.51	9.19	48.07
Anchoa mitchilli	0.09	2.92	7.69	1.56	7.89	55.96
Ictalurus furcatus	1.75	0.00	5.53	1.48	5.67	61.63
Selene setapinnis	0.00	1.89	4.66	0.98	4.78	66.41
Macrobrachium ohione	1.01	0.00	3.40	0.91	3.49	69.90
Ariopsis felis	0.00	0.80	3.29	0.98	3.37	73.27

Groups G1D1 & G1

Average dissimilarity = 77.14

Species	Group G1D1 Av.Abund	Group G1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.80	4.37	11.61	1.94	15.05	15.05
Micropogonias undulatus	0.90	4.47	11.58	1.88	15.01	30.06
Lolliguncula brevis	0.55	3.25	8.89	1.92	11.52	41.58
Cynoscion arenarius	0.55	2.99	7.43	1.90	9.63	51.21
Anchoa mitchilli	1.20	2.92	7.18	1.47	9.31	60.51
Selene setapinnis	0.35	1.89	4.75	1.02	6.16	66.67
Ariopsis felis	0.00	0.80	3.26	0.82	4.22	70.90

Groups B01 & G1U1
Average dissimilarity = 61.65

Species	Group B01 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.08	3.55	7.04	4.55	11.42	11.42
Anchoa mitchilli	0.98	3.94	6.15	2.12	9.98	21.40
Stellifer lanceolatus	3.39	4.30	5.24	1.16	8.50	29.89
Litopenaeus setiferus	2.20	0.00	4.15	1.78	6.74	36.63
Cynoscion arenarius	1.22	2.79	3.82	1.67	6.19	42.82
Selene setapinnis	0.00	1.67	3.14	0.96	5.09	47.91
Micropogonias undulatus	3.82	4.23	3.12	1.19	5.07	52.98
Callinectes sapidus	1.60	1.24	2.78	1.41	4.51	57.49
Bagre marinus	0.86	1.24	2.57	1.16	4.16	61.65
Peprilus triacanthus	0.00	1.28	2.41	0.96	3.92	65.56
Taphromysis louisianae	0.08	1.04	2.30	0.97	3.73	69.30
Ariopsis felis	1.04	0.55	2.06	1.12	3.33	72.63

Groups B10 & G1U1
Average dissimilarity = 62.22

Species	Group B10 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.03	3.55	7.61	4.66	12.24	12.24
Anchoa mitchilli	2.11	3.94	6.14	1.55	9.86	22.10
Stellifer lanceolatus	2.32	4.30	6.10	1.20	9.81	31.91
Cynoscion arenarius	1.48	2.79	4.18	1.58	6.72	38.63
Litopenaeus setiferus	1.81	0.00	3.42	1.15	5.49	44.12
Selene setapinnis	0.00	1.67	3.32	0.96	5.34	49.46

Micropogonias undulatus	3.64	4.23	3.32	1.39	5.33	54.79
Callinectes sapidus	0.44	1.24	2.87	1.13	4.62	59.41
Bagre marinus	1.04	1.24	2.71	1.13	4.35	63.75
Peprilus triacanthus	0.00	1.28	2.56	0.96	4.11	67.86
Taphromysis louisianae	0.00	1.04	2.47	0.95	3.97	71.83

Groups B22 & G1U1
Average dissimilarity = 84.33

Species	Group B22 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.33	4.30	11.17	1.87	13.25	13.25
Lolliguncula brevis	0.00	3.55	9.34	6.56	11.08	24.33
Micropogonias undulatus	1.76	4.23	8.93	2.28	10.59	34.91
Anchoa mitchilli	0.88	3.94	8.66	2.44	10.27	45.18
Cynoscion arenarius	0.37	2.79	6.47	2.75	7.67	52.85
Ictalurus furcatus	1.49	0.00	3.98	0.87	4.72	57.57
Selene setapinnis	0.00	1.67	3.98	0.97	4.72	62.29
Callinectes sapidus	0.42	1.24	3.67	1.10	4.35	66.64
Taphromysis louisianae	0.00	1.04	3.07	0.97	3.64	70.28

Groups B31 & G1U1
Average dissimilarity = 91.72

Species	Group B31 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.03	4.30	11.31	2.05	12.33	12.33
Micropogonias undulatus	0.93	4.23	9.07	2.19	9.89	22.22
Anchoa mitchilli	0.61	3.94	9.03	2.65	9.85	32.06
Lolliguncula brevis	0.00	3.55	8.93	5.26	9.74	41.80
Ictalurus furcatus	3.12	0.00	7.24	1.71	7.89	49.70
Cynoscion arenarius	0.36	2.79	6.52	2.87	7.10	56.80
Selene setapinnis	0.00	1.67	3.82	0.96	4.16	60.97
Macrobrachium ohione	1.34	0.00	3.45	0.88	3.76	64.73
Callinectes sapidus	0.44	1.24	3.45	1.06	3.76	68.49
Peprilus triacanthus	0.00	1.28	2.94	0.96	3.21	71.69

Groups B42 & G1U1
Average dissimilarity = 97.79

Species	Group B42 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.00	4.30	13.04	2.22	13.33	13.33
Micropogonias undulatus	0.15	4.23	11.85	5.42	12.12	25.45
Anchoa mitchilli	0.09	3.94	10.88	4.75	11.13	36.58
Lolliguncula brevis	0.00	3.55	10.20	14.04	10.43	47.01
Cynoscion arenarius	0.00	2.79	7.90	6.23	8.08	55.08
Ictalurus furcatus	1.75	0.00	4.95	1.59	5.06	60.15
Selene setapinnis	0.00	1.67	4.31	0.98	4.41	64.56
Callinectes sapidus	0.26	1.24	3.96	1.06	4.05	68.60
Taphromysis louisianae	0.00	1.04	3.38	0.98	3.45	72.05

Groups G1D1 & G1U1
Average dissimilarity = 77.81

Species	Group G1D1 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	0.80	4.30	10.93	1.34	14.04	14.04
Micropogonias undulatus	0.90	4.23	9.92	2.00	12.75	26.79
Lolliguncula brevis	0.55	3.55	8.73	2.43	11.22	38.01
Anchoa mitchilli	1.20	3.94	8.15	1.37	10.47	48.48
Cynoscion arenarius	0.55	2.79	6.47	1.91	8.32	56.79
Selene setapinnis	0.35	1.67	4.31	0.99	5.54	62.33
Callinectes sapidus	0.00	1.24	3.97	0.83	5.10	67.43
Taphromysis louisianae	0.00	1.04	3.32	0.83	4.27	71.70

Groups G1 & G1U1
Average dissimilarity = 36.43

Species	Group G1 Av.Abund	Group G1U1 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Anchoa mitchilli	2.92	3.94	4.16	1.30	11.43	11.43
Selene setapinnis	1.89	1.67	3.23	0.96	8.88	20.31
Stellifer lanceolatus	4.37	4.30	2.61	1.92	7.17	27.48
Callinectes sapidus	0.69	1.24	2.27	1.66	6.22	33.70
Bagre marinus	1.24	1.24	2.16	0.86	5.92	39.62
Peprilus triacanthus	0.00	1.28	2.11	0.85	5.79	45.41
Taphromysis louisianae	0.80	1.04	1.84	1.15	5.05	50.47
Cynoscion arenarius	2.99	2.79	1.78	1.22	4.89	55.35
Litopenaeus setiferus	0.90	0.00	1.53	7.72	4.21	59.57
Ariopsis felis	0.80	0.55	1.47	1.17	4.03	63.60

Micropogonias undulatus	4.47	4.23	1.23	1.77	3.38	66.98
Chloroscombrus chrysurus	0.55	0.55	0.95	0.86	2.62	69.59
Lolliguncula brevis	3.25	3.55	0.91	1.16	2.49	72.08

Groups B01 & G2
Average dissimilarity = 68.55

Species	Group B01 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	3.39	2.17	9.10	1.11	13.28	13.28
Micropogonias undulatus	3.82	2.14	7.68	1.14	11.21	24.48
Lolliguncula brevis	0.08	2.14	6.96	2.15	10.15	34.64
Litopenaeus setiferus	2.20	0.55	5.90	1.40	8.61	43.25
Callinectes sapidus	1.60	0.35	4.62	1.16	6.75	50.00
Ariopsis felis	1.04	1.10	4.08	1.08	5.95	55.94
Cynoscion arenarius	1.22	0.55	3.27	1.08	4.77	60.71
Anchoa mitchilli	0.98	0.90	3.26	1.07	4.75	65.46
Bairdiella chrysoura	1.08	0.00	3.11	0.87	4.54	70.01

Groups B10 & G2
Average dissimilarity = 69.84

Species	Group B10 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	2.32	2.17	8.75	1.32	12.53	12.53
Lolliguncula brevis	0.03	2.14	8.04	2.49	11.52	24.05
Micropogonias undulatus	3.64	2.14	7.39	1.31	10.59	34.63
Anchoa mitchilli	2.11	0.90	6.58	1.53	9.42	44.05
Litopenaeus setiferus	1.81	0.55	5.34	1.16	7.65	51.70
Ariopsis felis	1.10	1.10	4.47	1.15	6.40	58.10
Cynoscion arenarius	1.48	0.55	4.43	1.15	6.35	64.45
Bagre marinus	1.04	0.00	3.20	0.86	4.59	69.04
Chloroscombrus chrysurus	0.03	0.55	3.04	0.82	4.36	73.40

Groups B22 & G2
Average dissimilarity = 83.79

Species	Group B22 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.00	2.14	12.25	2.44	14.62	14.62

Micropogonias undulatus	1.76	2.14	11.72	1.61	13.99	28.62
Ictalurus furcatus	1.49	0.00	9.49	0.79	11.32	39.94
Stellifer lanceolatus	0.33	2.17	8.78	1.05	10.48	50.41
Anchoa mitchilli	0.88	0.90	6.73	1.09	8.03	58.45
Chloroscombrus chrysurus	0.03	0.55	5.26	0.81	6.28	64.72
Litopenaeus setiferus	0.83	0.55	4.75	0.86	5.67	70.39

Groups B31 & G2
Average dissimilarity = 92.92

Species	Group B31 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	3.12	0.00	14.84	1.45	15.97	15.97
Lolliguncula brevis	0.00	2.14	11.37	2.11	12.23	28.20
Micropogonias undulatus	0.93	2.14	9.98	1.79	10.75	38.95
Stellifer lanceolatus	0.03	2.17	7.93	0.94	8.53	47.48
Macrobrachium ohione	1.34	0.00	7.91	0.78	8.51	55.99
Anchoa mitchilli	0.61	0.90	6.15	1.10	6.62	62.61
Chloroscombrus chrysurus	0.00	0.55	4.83	0.77	5.20	67.81
Ariopsis felis	0.00	1.10	4.01	0.93	4.32	72.13

Groups B42 & G2
Average dissimilarity = 97.19

Species	Group B42 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.00	2.14	14.36	4.39	14.78	14.78
Micropogonias undulatus	0.15	2.14	13.17	4.54	13.55	28.32
Ictalurus furcatus	1.75	0.00	12.79	1.30	13.15	41.48
Stellifer lanceolatus	0.00	2.17	9.42	0.98	9.70	51.17
Macrobrachium ohione	1.01	0.00	8.54	0.81	8.79	59.96
Anchoa mitchilli	0.09	0.90	6.50	2.71	6.69	66.65
Chloroscombrus chrysurus	0.04	0.55	6.27	0.94	6.45	73.10

Groups G1D1 & G2
Average dissimilarity = 75.41

Species	Group G1D1 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Lolliguncula brevis	0.55	2.14	13.89	1.01	18.42	18.42

Micropogonias undulatus	0.90	2.14	12.87	1.22	17.06	35.48
Stellifer lanceolatus	0.80	2.17	10.42	1.07	13.82	49.30
Anchoa mitchilli	1.20	0.90	9.08	1.70	12.03	61.34
Chloroscombrus chrysurus	0.69	0.55	7.95	0.66	10.55	71.88

Groups G1 & G2

Average dissimilarity = 55.68

Species	Group G1 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	4.37	2.17	7.66	1.03	13.76	13.76
Micropogonias undulatus	4.47	2.14	6.60	1.40	11.85	25.60
Cynoscion arenarius	2.99	0.55	6.44	1.90	11.57	37.18
Anchoa mitchilli	2.92	0.90	4.91	0.93	8.82	45.99
Selene setapinnis	1.89	0.00	4.10	0.85	7.36	53.35
Lolliguncula brevis	3.25	2.14	3.33	1.07	5.98	59.33
Ariopsis felis	0.80	1.10	3.06	1.05	5.50	64.84
Taphromysis louisianae	0.80	0.00	2.72	0.82	4.89	69.72
Bagre marinus	1.24	0.00	2.69	0.85	4.83	74.56

Groups G1U1 & G2

Average dissimilarity = 60.99

Species	Group G1U1 Av.Abund	Group G2 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Stellifer lanceolatus	4.30	2.17	8.12	1.08	13.32	13.32
Anchoa mitchilli	3.94	0.90	7.49	2.53	12.28	25.60
Cynoscion arenarius	2.79	0.55	5.69	1.91	9.33	34.93
Micropogonias undulatus	4.23	2.14	5.63	1.39	9.23	44.16
Selene setapinnis	1.67	0.00	3.77	0.85	6.18	50.34
Lolliguncula brevis	3.55	2.14	3.76	1.25	6.16	56.50
Callinectes sapidus	1.24	0.35	3.38	0.94	5.54	62.04
Peprilus triacanthus	1.28	0.00	2.90	0.85	4.76	66.80
Taphromysis louisianae	1.04	0.00	2.88	0.84	4.72	71.52

Groups B01 & G3

Average dissimilarity = 93.74

Species	Group B01 Av.Abund	Group G3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%

Micropogonias undulatus	3.82	0.00	17.95	2.14	19.15	19.15
Stellifer lanceolatus	3.39	0.35	13.13	1.54	14.01	33.15
Litopenaeus setiferus	2.20	0.00	9.03	1.88	9.63	42.79
Callinectes sapidus	1.60	0.00	7.48	1.49	7.98	50.76
Anchoa mitchilli	0.98	0.69	5.44	0.82	5.80	56.57
Cynoscion arenarius	1.22	0.00	4.66	1.20	4.98	61.54
Ariopsis felis	1.04	0.00	4.22	0.84	4.50	66.05
Lolliguncula brevis	0.08	0.80	4.07	0.76	4.34	70.39

Groups B10 & G3
Average dissimilarity = 93.53

Species	Group B10 Av.Abund	Group G3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.64	0.00	19.68	2.67	21.04	21.04
Stellifer lanceolatus	2.32	0.35	10.24	1.39	10.95	31.99
Anchoa mitchilli	2.11	0.69	9.48	1.32	10.14	42.13
Litopenaeus setiferus	1.81	0.00	7.62	1.24	8.15	50.28
Cynoscion arenarius	1.48	0.00	5.95	1.13	6.36	56.64
Ariopsis felis	1.10	0.00	5.62	1.07	6.01	62.65
Lolliguncula brevis	0.03	0.80	4.77	0.81	5.10	67.75
Bagre marinus	1.04	0.00	4.26	0.87	4.55	72.30

Groups B22 & G3
Average dissimilarity = 93.50

Species	Group B22 Av.Abund	Group G3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.49	0.00	16.57	0.88	17.72	17.72
Anchoa mitchilli	0.88	0.69	13.40	0.76	14.33	32.06
Micropogonias undulatus	1.76	0.00	11.55	0.82	12.36	44.41
Lolliguncula brevis	0.00	0.80	8.66	0.78	9.26	53.67
Litopenaeus setiferus	0.83	0.00	6.94	0.71	7.42	61.09
Trichiurus lepturus	0.00	0.55	5.91	0.78	6.32	67.41
Stellifer lanceolatus	0.33	0.35	4.96	0.91	5.31	72.72

Groups B31 & G3
Average dissimilarity = 98.41

	Group B31	Group G3

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	3.12	0.00	23.28	1.65	23.66	23.66
Macrobrachium ohione	1.34	0.00	13.59	0.84	13.81	37.46
Anchoa mitchilli	0.61	0.69	12.05	0.64	12.25	49.71
Lolliguncula brevis	0.00	0.80	7.91	0.73	8.03	57.75
Trichiurus lepturus	0.00	0.55	5.40	0.73	5.48	63.23
Micropogonias undulatus	0.93	0.00	4.66	0.62	4.73	67.96
Stellifer lanceolatus	0.03	0.35	3.41	0.73	3.47	71.43

Groups B42 & G3
Average dissimilarity = 98.75

	Group B42	Group G3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.75	0.00	23.75	1.63	24.05	24.05
Macrobrachium ohione	1.01	0.00	17.08	0.93	17.29	41.34
Anchoa mitchilli	0.09	0.69	12.80	0.91	12.97	54.31
Lolliguncula brevis	0.00	0.80	10.50	0.93	10.63	64.94
Trichiurus lepturus	0.00	0.55	7.17	0.93	7.26	72.20

Groups G1D1 & G3
Average dissimilarity = 87.48

	Group G1D1	Group G3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Anchoa mitchilli	1.20	0.69	30.47	0.65	34.82	34.82
Lolliguncula brevis	0.55	0.80	14.55	0.66	16.63	51.45
Trichiurus lepturus	0.35	0.55	9.92	0.66	11.33	62.79
Stellifer lanceolatus	0.80	0.35	9.33	1.07	10.67	73.45

Groups G1 & G3
Average dissimilarity = 88.63

	Group G1	Group G3				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	4.47	0.00	15.23	7.66	17.18	17.18
Stellifer lanceolatus	4.37	0.35	13.83	4.76	15.60	32.78
Cynoscion arenarius	2.99	0.00	9.67	8.71	10.91	43.69
Lolliguncula brevis	3.25	0.80	8.56	2.05	9.66	53.36
Anchoa mitchilli	2.92	0.69	7.37	1.46	8.31	61.67

Selene setapinnis	1.89	0.00	4.94	0.87	5.58	67.25
Ariopsis felis	0.80	0.00	3.63	0.86	4.09	71.34

Groups G1U1 & G3

Average dissimilarity = 87.62

Species	Group G1U1 Av.Abund	Group G3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	4.23	0.00	13.12	14.36	14.97	14.97
Stellifer lanceolatus	4.30	0.35	12.98	1.78	14.81	29.78
Anchoa mitchilli	3.94	0.69	9.71	2.98	11.08	40.86
Lolliguncula brevis	3.55	0.80	8.49	2.58	9.69	50.55
Cynoscion arenarius	2.79	0.00	8.46	6.12	9.66	60.21
Selene setapinnis	1.67	0.00	4.59	0.87	5.24	65.44
Callinectes sapidus	1.24	0.00	4.36	0.86	4.97	70.42

Groups G2 & G3

Average dissimilarity = 74.26

Species	Group G2 Av.Abund	Group G3 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.14	0.00	16.10	6.89	21.67	21.67
Lolliguncula brevis	2.14	0.80	11.97	1.23	16.12	37.80
Stellifer lanceolatus	2.17	0.35	11.91	1.25	16.04	53.83
Chloroscombrus chrysurus	0.55	0.00	8.43	0.85	11.35	65.18
Anchoa mitchilli	0.90	0.69	6.94	1.48	9.35	74.53

Table 76. Results of SIMPER analysis for beam trawl collection resemblance matrix between sample sites.

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data1
Data type: Other
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Factor Groups

Sample	Site
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B01	B01

B01	B01
B01	B01
B01	B01
B01	B01
B01	B01
B10	B10
B10	B10
B10	B10
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B42	B42
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B42	B42
B42	B42

Group B01
Average similarity: 11.25

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	1.52	6.31	0.44	56.14	56.14
Brevoortia patronus	1.01	2.91	0.37	25.87	82.01

Group B10
Average similarity: 8.79

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	1.04	3.36	0.34	38.22	38.22
Brevoortia patronus	0.93	1.82	0.24	20.67	58.89
Litopenaeus setiferus	0.66	1.57	0.20	17.85	76.74

Group B22
Average similarity: 11.03

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Callinectes sapidus	0.54	3.30	0.41	29.90	29.90
Ctenogobius boleosoma	0.46	1.96	0.32	17.73	47.64
Micropogonias undulatus	0.66	1.35	0.29	12.21	59.85
Palaemonetes pugio	0.45	1.15	0.29	10.42	70.26

Group B31
Average similarity: 8.58

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Macrobrachium ohione	0.55	1.40	0.26	16.32	16.32
Pimephales vigilax	0.43	1.04	0.25	12.16	28.47
Anchoa mitchilli	0.24	0.94	0.16	10.94	39.41
Mugil cephalus	0.36	0.81	0.19	9.39	48.80
Palaemonetes pugio	0.32	0.80	0.19	9.30	58.10
Litopenaeus setiferus	0.17	0.79	0.12	9.21	67.30
Ctenogobius boleosoma	0.39	0.76	0.22	8.90	76.20

Group B42
Average similarity: 19.57

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Palaemonetes pugio	0.92	9.55	0.84	48.80	48.80
Macrobrachium ohione	1.14	6.05	0.47	30.94	79.74

Groups B01 & B10
Average dissimilarity = 89.14

Species	Group B01 Av.Abund	Group B10 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.52	1.04	21.25	0.95	23.84	23.84
Brevoortia patronus	1.01	0.93	15.91	0.76	17.85	41.69
Litopenaeus setiferus	0.46	0.66	11.00	0.58	12.34	54.04
Palaemonetes pugio	0.24	0.38	6.67	0.52	7.48	61.52
Anchoa mitchilli	0.29	0.13	6.03	0.38	6.76	68.28
Callinectes sapidus	0.06	0.15	3.97	0.31	4.45	72.72

Groups B01 & B22
Average dissimilarity = 91.39

Species	Group B01 Av.Abund	Group B22 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.52	0.66	17.41	0.87	19.05	19.05
Brevoortia patronus	1.01	0.52	12.24	0.74	13.40	32.44
Callinectes sapidus	0.06	0.54	9.08	0.56	9.94	42.38
Litopenaeus setiferus	0.46	0.50	8.36	0.64	9.15	51.53
Ctenogobius boleosoma	0.16	0.46	6.84	0.51	7.49	59.02
Palaemonetes pugio	0.24	0.45	6.78	0.52	7.42	66.44

Anchoa mitchilli	0.29	0.15	6.61	0.36	7.23	73.67

Groups B10 & B22
Average dissimilarity = 90.12

Species	Group B10 Av.Abund	Group B22 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.04	0.66	12.73	0.83	14.12	14.12
Brevoortia patronus	0.93	0.52	11.37	0.66	12.62	26.74
Litopenaeus setiferus	0.66	0.50	11.27	0.61	12.51	39.25
Callinectes sapidus	0.15	0.54	8.60	0.63	9.55	48.80
Palaemonetes pugio	0.38	0.45	7.02	0.70	7.80	56.59
Ctenogobius boleosoma	0.24	0.46	7.02	0.57	7.79	64.38
Mugil cephalus	0.15	0.52	5.56	0.48	6.16	70.54

Groups B01 & B31
Average dissimilarity = 93.15

Species	Group B01 Av.Abund	Group B31 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.52	0.25	16.78	0.83	18.01	18.01
Brevoortia patronus	1.01	0.47	12.12	0.72	13.02	31.03
Anchoa mitchilli	0.29	0.24	8.99	0.44	9.65	40.68
Litopenaeus setiferus	0.46	0.17	8.09	0.46	8.68	49.36
Palaemonetes pugio	0.24	0.32	6.60	0.48	7.08	56.45
Macrobrachium ohione	0.03	0.55	6.13	0.53	6.59	63.03
Pimephales vigilax	0.00	0.43	5.63	0.42	6.05	69.08
Mugil cephalus	0.00	0.36	4.47	0.43	4.80	73.88

Groups B10 & B31
Average dissimilarity = 92.75

Species	Group B10 Av.Abund	Group B31 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.04	0.25	11.95	0.76	12.88	12.88
Brevoortia patronus	0.93	0.47	11.27	0.63	12.15	25.03
Litopenaeus setiferus	0.66	0.17	10.95	0.53	11.80	36.84
Palaemonetes pugio	0.38	0.32	7.00	0.63	7.54	44.38
Anchoa mitchilli	0.13	0.24	6.39	0.38	6.89	51.27
Macrobrachium ohione	0.03	0.55	6.05	0.55	6.52	57.79

Mugil cephalus	0.15	0.36	5.33	0.54	5.75	63.53
Pimephales vigilax	0.00	0.43	5.22	0.42	5.63	69.17
Ctenogobius boleosoma	0.24	0.39	5.02	0.66	5.41	74.58

Groups B22 & B31
Average dissimilarity = 90.82

Species	Group B22 Av.Abund	Group B31 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Litopenaeus setiferus	0.50	0.17	8.56	0.50	9.42	9.42
Callinectes sapidus	0.54	0.23	8.23	0.67	9.06	18.49
Micropogonias undulatus	0.66	0.25	7.80	0.67	8.59	27.07
Brevoortia patronus	0.52	0.47	7.76	0.60	8.54	35.62
Ctenogobius boleosoma	0.46	0.39	7.70	0.64	8.48	44.10
Mugil cephalus	0.52	0.36	7.52	0.58	8.28	52.37
Palaemonetes pugio	0.45	0.32	7.04	0.62	7.75	60.12
Anchoa mitchilli	0.15	0.24	6.69	0.38	7.37	67.49
Macrobrachium ohione	0.13	0.55	6.24	0.59	6.87	74.37

Groups B01 & B42
Average dissimilarity = 94.61

Species	Group B01 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Palaemonetes pugio	0.24	0.92	14.02	0.81	14.82	14.82
Macrobrachium ohione	0.03	1.14	13.65	0.72	14.43	29.25
Micropogonias undulatus	1.52	0.38	13.32	0.89	14.08	43.33
Brevoortia patronus	1.01	0.24	8.96	0.66	9.47	52.79
Lythrurus fumeus	0.00	0.42	5.02	0.57	5.31	58.11
Litopenaeus setiferus	0.46	0.09	4.45	0.49	4.70	62.80
Anchoa mitchilli	0.29	0.19	4.39	0.51	4.64	67.45
Ctenogobius boleosoma	0.16	0.26	3.11	0.52	3.29	70.74

Groups B10 & B42
Average dissimilarity = 92.98

Species	Group B10 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Macrobrachium ohione	0.03	1.14	13.06	0.74	14.05	14.05
Palaemonetes pugio	0.38	0.92	12.96	0.81	13.93	27.98

Micropogonias undulatus	1.04	0.38	10.07	0.75	10.83	38.81
Brevoortia patronus	0.93	0.24	8.61	0.56	9.26	48.07
Litopenaeus setiferus	0.66	0.09	6.94	0.52	7.46	55.53
Lythrurus fumeus	0.00	0.42	4.80	0.58	5.17	60.70
Ctenogobius boleosoma	0.24	0.26	3.75	0.61	4.03	64.73
Callinectes sapidus	0.15	0.23	3.30	0.53	3.55	68.28
Anchoa mitchilli	0.13	0.19	3.17	0.41	3.41	71.69

Groups B22 & B42
Average dissimilarity = 90.92

Species	Group B22 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Macrobrachium ohione	0.13	1.14	12.58	0.75	13.83	13.83
Palaemonetes pugio	0.45	0.92	12.46	0.81	13.70	27.53
Micropogonias undulatus	0.66	0.38	6.85	0.63	7.53	35.06
Callinectes sapidus	0.54	0.23	6.23	0.78	6.85	41.92
Brevoortia patronus	0.52	0.24	5.67	0.49	6.24	48.15
Litopenaeus setiferus	0.50	0.09	5.42	0.50	5.96	54.11
Ctenogobius boleosoma	0.46	0.26	5.40	0.75	5.94	60.06
Lythrurus fumeus	0.00	0.42	4.56	0.58	5.01	65.07
Mugil cephalus	0.52	0.04	3.87	0.42	4.26	69.33
Anchoa mitchilli	0.15	0.19	3.53	0.39	3.88	73.21

Groups B31 & B42
Average dissimilarity = 89.05

Species	Group B31 Av.Abund	Group B42 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Macrobrachium ohione	0.55	1.14	14.17	0.85	15.92	15.92
Palaemonetes pugio	0.32	0.92	12.87	0.85	14.45	30.37
Brevoortia patronus	0.47	0.24	5.49	0.45	6.16	36.53
Micropogonias undulatus	0.25	0.38	5.14	0.51	5.77	42.31
Pimephales vigilax	0.43	0.19	5.08	0.68	5.70	48.01
Anchoa mitchilli	0.24	0.19	4.89	0.48	5.50	53.51
Lythrurus fumeus	0.03	0.42	4.89	0.62	5.49	58.99
Ctenogobius boleosoma	0.39	0.26	4.76	0.68	5.34	64.33
Litopenaeus setiferus	0.17	0.09	3.69	0.41	4.14	68.47
Mugil cephalus	0.36	0.04	3.53	0.49	3.96	72.44

Table 77. Results of SIMPER analysis for otter trawl collection resemblance matrix between seasons- data from site B42 was excluded.

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data2
Data type: Other
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Factor Groups

Sample	Season
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B22	Winter

B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B31	Winter
B31	Winter
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B01	Spring
B01	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
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B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B31	Spring
B31	Spring

B31	Spring
B31	Spring
B31	Spring
B31	Spring
B31	Spring
B31	Spring
B01	Summer
B01	Summer
B01	Summer
B01	Summer
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B01	Summer
B01	Summer
B01	Summer
B01	Summer
B10	Summer
B10	Summer
B10	Summer
B10	Summer
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B10	Summer
B22	Summer
B22	Summer
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B22	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer

Group Winter

Average similarity: 27.15

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	3.36	12.27	1.21	45.20	45.20
Litopenaeus setiferus	1.27	2.59	0.57	9.55	54.75
Anchoa mitchilli	1.33	2.09	0.41	7.71	62.46
Ictalurus furcatus	1.02	2.08	0.27	7.67	70.13

Group Spring
Average similarity: 21.71

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	1.79	5.36	0.68	24.69	24.69
Ictalurus furcatus	1.14	5.32	0.49	24.50	49.20
Callinectes sapidus	0.93	2.95	0.60	13.59	62.79
Macrobrachium ohione	0.74	2.94	0.34	13.52	76.31

Group Summer
Average similarity: 32.06

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Litopenaeus setiferus	2.49	7.05	1.11	22.00	22.00
Micropogonias undulatus	2.53	6.15	0.95	19.17	41.17
Stellifer lanceolatus	2.58	5.16	0.69	16.10	57.27
Cynoscion arenarius	1.63	2.90	0.73	9.03	66.30
Ictalurus furcatus	1.42	2.82	0.31	8.79	75.09

Groups Winter & Spring
Average dissimilarity = 79.12

	Group Winter	Group Spring				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.36	1.79	12.13	1.28	15.33	15.33
Ictalurus furcatus	1.02	1.14	7.93	0.86	10.02	25.34
Anchoa mitchilli	1.33	0.61	6.00	0.76	7.58	32.92
Stellifer lanceolatus	1.01	1.05	5.58	0.91	7.06	39.98
Litopenaeus setiferus	1.27	0.44	4.85	0.98	6.13	46.10
Macrobrachium ohione	0.10	0.74	4.34	0.58	5.48	51.59
Callinectes sapidus	0.69	0.93	4.14	1.02	5.23	56.82
Ariopsis felis	0.74	0.45	3.44	0.83	4.34	61.16

Cynoscion arenarius	0.51	0.48	2.76	0.80	3.49	64.65
Brevoortia patronus	0.33	0.37	2.15	0.66	2.72	67.36
Farfantepenaeus aztecus	0.06	0.66	2.08	0.49	2.63	69.99
Ictalurus punctatus	0.25	0.16	2.06	0.46	2.60	72.59

Groups Winter & Summer
Average dissimilarity = 73.52

Species	Group Winter Av.Abund	Group Summer Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.36	2.53	9.01	1.09	12.25	12.25
Stellifer lanceolatus	1.01	2.58	7.38	1.17	10.03	22.29
Ictalurus furcatus	1.02	1.42	7.07	0.75	9.62	31.90
Litopenaeus setiferus	1.27	2.49	6.47	1.29	8.80	40.70
Anchoa mitchilli	1.33	1.39	5.82	0.89	7.92	48.62
Cynoscion arenarius	0.51	1.63	4.27	1.16	5.81	54.43
Bagre marinus	0.32	1.28	3.45	1.14	4.69	59.12
Ariopsis felis	0.74	0.63	2.93	0.88	3.98	63.10
Callinectes sapidus	0.69	0.61	2.69	0.97	3.67	66.77
Macrobrachium ohione	0.10	0.57	2.58	0.46	3.51	70.28

Groups Spring & Summer
Average dissimilarity = 78.46

Species	Group Spring Av.Abund	Group Summer Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.79	2.53	8.75	1.20	11.15	11.15
Ictalurus furcatus	1.14	1.42	8.71	0.83	11.10	22.25
Stellifer lanceolatus	1.05	2.58	8.68	1.12	11.06	33.31
Litopenaeus setiferus	0.44	2.49	7.96	1.41	10.15	43.46
Macrobrachium ohione	0.74	0.57	5.41	0.61	6.89	50.35
Anchoa mitchilli	0.61	1.39	5.25	0.89	6.69	57.04
Cynoscion arenarius	0.48	1.63	5.15	1.08	6.56	63.59
Bagre marinus	0.18	1.28	3.96	1.08	5.04	68.64
Callinectes sapidus	0.93	0.61	3.75	0.87	4.79	73.42

Table 78. Results of SIMPER analysis for beam trawl collection resemblance matrix between seasons- data from site B42 was excluded.

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data1
Data type: Other
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Factor Groups

Sample	Season
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B01	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B10	Winter
B22	Winter

B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B22	Winter
B31	Winter
B31	Winter
B31	Winter
B31	Winter
B31	Winter
B31	Winter
B31	Winter
B31	Winter
B31	Winter
B01	Spring
B01	Spring
B01	Spring
B01	Spring
B01	Spring
B01	Spring
B01	Spring
B01	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B10	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B22	Spring
B31	Spring
B31	Spring

B31	Spring
B31	Spring
B31	Spring
B31	Spring
B31	Spring
B31	Spring
B01	Summer
B01	Summer
B01	Summer
B01	Summer
B01	Summer
B01	Summer
B01	Summer
B01	Summer
B10	Summer
B10	Summer
B10	Summer
B10	Summer
B10	Summer
B10	Summer
B10	Summer
B10	Summer
B22	Summer
B22	Summer
B22	Summer
B22	Summer
B22	Summer
B22	Summer
B22	Summer
B22	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer
B31	Summer

Group Winter
Average similarity: 20.63

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	1.86	9.78	0.68	47.39	47.39
Litopenaeus setiferus	0.94	4.21	0.38	20.39	67.78
Ctenogobius boleosoma	0.63	2.06	0.44	9.97	77.75

Group Spring
Average similarity: 16.26

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Brevoortia patronus	1.45	6.20	0.47	38.16	38.16
Palaemonetes pugio	0.48	3.04	0.41	18.69	56.85
Anchoa mitchilli	0.27	1.75	0.18	10.77	67.62
Micropogonias undulatus	0.57	1.47	0.26	9.06	76.68

Group Summer
Average similarity: 1.56

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Anchoa mitchilli	0.17	0.56	0.13	35.89	35.89
Callinectes sapidus	0.10	0.29	0.08	18.64	54.53
Ctenogobius boleosoma	0.06	0.15	0.06	9.43	63.96
Libellulidae spp.	0.11	0.13	0.10	8.61	72.57

Groups Winter & Spring
Average dissimilarity = 87.21

	Group Winter	Group Spring				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.86	0.57	15.45	1.05	17.71	17.71
Brevoortia patronus	0.74	1.45	12.94	0.88	14.84	32.55
Litopenaeus setiferus	0.94	0.23	9.83	0.68	11.27	43.82
Palaemonetes pugio	0.39	0.48	6.00	0.73	6.87	50.70
Mugil cephalus	0.32	0.45	5.47	0.56	6.27	56.97
Ctenogobius boleosoma	0.63	0.21	5.23	0.80	6.00	62.97
Callinectes sapidus	0.45	0.15	5.09	0.60	5.84	68.81
Anchoa mitchilli	0.16	0.27	4.19	0.41	4.81	73.61

Groups Winter & Summer
Average dissimilarity = 96.71

Species	Group Winter Av.Abund	Group Summer Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.86	0.03	23.10	1.01	23.88	23.88
Litopenaeus setiferus	0.94	0.12	16.32	0.65	16.88	40.76
Callinectes sapidus	0.45	0.10	7.72	0.55	7.98	48.74
Ctenogobius boleosoma	0.63	0.06	6.96	0.72	7.20	55.94
Brevoortia patronus	0.74	0.00	6.80	0.60	7.03	62.98
Palaemonetes pugio	0.39	0.17	4.75	0.54	4.91	67.89
Anchoa mitchilli	0.16	0.17	3.04	0.38	3.14	71.03

Groups Spring & Summer
Average dissimilarity = 97.05

Species	Group Spring Av.Abund	Group Summer Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	1.45	0.00	19.33	0.75	19.92	19.92
Anchoa mitchilli	0.27	0.17	12.98	0.47	13.38	33.30
Palaemonetes pugio	0.48	0.17	11.23	0.61	11.58	44.87
Micropogonias undulatus	0.57	0.03	8.46	0.52	8.71	53.59
Mugil cephalus	0.45	0.00	7.40	0.49	7.63	61.22
Macrobrachium ohione	0.33	0.18	5.98	0.52	6.16	67.38
Callinectes sapidus	0.15	0.10	4.77	0.41	4.91	72.29

Table 79. Results of SIMPER analysis for otter trawl collection resemblance matrix between flow tiers- data from site B42 was excluded.

SIMPER

Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data2
Data type: Other
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Factor Groups

Sample	Hydrologic Condition-Flow Tier V2
B01	Average-Subsistence
B01	Average-Subsistence
B01	Average-Subsistence
B01	Average-Subsistence
B01	Average-Subsistence
B10	Average-Subsistence
B10	Average-Subsistence
B10	Average-Subsistence
B10	Average-Subsistence
B10	Average-Subsistence
B22	Average-Subsistence
B22	Average-Subsistence
B22	Average-Subsistence
B22	Average-Subsistence
B22	Average-Subsistence
B31	Average-Subsistence
B31	Average-Subsistence
B31	Average-Subsistence
B31	Average-Subsistence

B31	Average-Subsistence
B01	Average-Base
B01	Average-Base
B01	Average-Base
B10	Average-Base
B10	Average-Base
B10	Average-Base
B22	Average-Base
B22	Average-Base
B22	Average-Base
B31	Average-Base
B31	Average-Base
B31	Average-Base
B01	Average-3ps
B01	Average-3ps
B01	Average-3ps
B01	Average-3ps
B01	Average-3ps
B10	Average-3ps
B10	Average-3ps
B10	Average-3ps
B10	Average-3ps
B10	Average-3ps
B22	Average-3ps
B22	Average-3ps
B22	Average-3ps
B22	Average-3ps
B22	Average-3ps
B31	Average-3ps
B31	Average-3ps
B31	Average-3ps
B31	Average-3ps
B31	Average-3ps
B01	Wet-2ps
B01	Wet-2ps
B10	Wet-2ps
B10	Wet-2ps
B22	Wet-2ps
B22	Wet-2ps
B31	Wet-2ps
B31	Wet-2ps
B01	Wet-Subsistence
B01	Wet-Subsistence

B01	Wet-Subsistence
B01	Wet-Subsistence
B01	Wet-Subsistence
B10	Wet-Subsistence
B10	Wet-Subsistence
B10	Wet-Subsistence
B10	Wet-Subsistence
B10	Wet-Subsistence
B22	Wet-Subsistence
B22	Wet-Subsistence
B22	Wet-Subsistence
B22	Wet-Subsistence
B31	Wet-Subsistence
B31	Wet-Subsistence
B31	Wet-Subsistence
B31	Wet-Subsistence
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
Group Average-Subsistence	

Average similarity: 33.42

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	3.51	13.09	1.77	39.17	39.17
Anchoa mitchilli	2.28	5.25	0.65	15.71	54.88
Litopenaeus setiferus	1.75	3.68	0.73	11.01	65.89
Leiostomus xanthurus	0.97	1.89	0.63	5.65	71.55

Group Average-Base
Average similarity: 24.06

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	2.64	9.90	1.02	41.17	41.17
Callinectes sapidus	0.89	3.47	0.91	14.43	55.60
Ictalurus furcatus	1.25	2.97	0.28	12.35	67.94
Litopenaeus setiferus	1.23	2.65	0.64	11.01	78.96

Group Average-3ps
Average similarity: 20.83

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Ictalurus furcatus	1.32	5.86	0.40	28.13	28.13
Micropogonias undulatus	1.30	5.05	0.61	24.22	52.35
Macrobrachium ohione	0.55	2.75	0.43	13.22	65.56
Stellifer lanceolatus	1.17	1.72	0.28	8.26	73.83

Group Wet-2ps
Average similarity: 32.27

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	3.07	7.63	1.01	23.66	23.66
Ictalurus furcatus	1.73	5.49	0.46	17.03	40.69
Stellifer lanceolatus	2.86	4.94	0.66	15.32	56.01
Litopenaeus setiferus	2.06	4.53	0.71	14.04	70.05

Group Wet-Subsistence
Average similarity: 28.94

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%

Micropogonias undulatus	3.38	8.03	0.90	27.75	27.75
Litopenaeus setiferus	2.32	5.37	1.02	18.57	46.32
Anchoa mitchilli	2.02	3.68	0.72	12.71	59.02
Stellifer lanceolatus	1.87	3.01	0.60	10.41	69.44
Cynoscion arenarius	1.43	2.80	0.82	9.67	79.11

Group Wet-Base
Average similarity: 23.18

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	2.13	5.38	0.74	23.21	23.21
Ictalurus furcatus	1.15	5.11	0.51	22.06	45.27
Callinectes sapidus	1.07	2.80	0.64	12.10	57.37
Stellifer lanceolatus	1.81	2.61	0.44	11.24	68.61
Macrobrachium ohione	0.87	2.32	0.26	9.99	78.60

Groups Average-Subsistence & Average-Base
Average dissimilarity = 73.84

Species	Group Average-Subsistence Av.Abund	Group Average-Base Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.51	2.64	9.16	1.19	12.41	12.41
Anchoa mitchilli	2.28	0.41	7.91	0.93	10.71	23.12
Ictalurus furcatus	0.95	1.25	6.53	0.69	8.84	31.96
Litopenaeus setiferus	1.75	1.23	5.46	1.20	7.40	39.36
Stellifer lanceolatus	1.05	1.12	4.98	0.94	6.74	46.10
Cynoscion arenarius	0.87	0.98	3.86	1.05	5.23	51.33
Ariopsis felis	0.91	0.31	3.13	0.89	4.24	55.58
Leiostomus xanthurus	0.97	0.12	3.10	0.90	4.20	59.77
Callinectes sapidus	0.72	0.89	3.09	1.10	4.19	63.96
Bagre marinus	0.54	0.50	2.36	0.88	3.20	

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
						67.17
Bairdiella chrysoura	0.43	0.37	2.27	0.66	3.07	70.23

Groups Average-Subsistence & Average-3ps
Average dissimilarity = 80.16

	Group Average-Subsistence	Group Average-3ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.51	1.30	11.22	1.28	14.00	14.00
Anchoa mitchilli	2.28	0.41	9.00	0.94	11.23	25.22
Ictalurus furcatus	0.95	1.32	7.69	0.75	9.60	34.82
Litopenaeus setiferus	1.75	0.62	6.30	1.11	7.85	42.68
Stellifer lanceolatus	1.05	1.17	5.93	0.90	7.40	50.08
Ariopsis felis	0.91	0.44	3.67	0.95	4.58	54.66
Leiostomus xanthurus	0.97	0.09	3.56	0.92	4.44	59.10
Callinectes sapidus	0.72	0.36	3.20	0.87	3.99	63.09
Cynoscion arenarius	0.87	0.29	3.07	1.06	3.83	66.92
Macrobrachium ohione	0.00	0.55	2.77	0.44	3.45	70.37

Groups Average-Base & Average-3ps
Average dissimilarity = 77.53

	Group Average-Base	Group Average-3ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.64	1.30	11.36	1.33	14.66	14.66
Ictalurus furcatus	1.25	1.32	10.68	0.87	13.77	28.43
Stellifer lanceolatus	1.12	1.17	7.66	1.02	9.89	38.31
Litopenaeus setiferus	1.23	0.62	5.61	1.16	7.23	45.54
Cynoscion arenarius	0.98	0.29	4.05	0.83	5.23	50.77

Callinectes sapidus	0.89	0.36	3.96	1.25	5.11	55.88
Macrobrachium ohione	0.00	0.55	3.41	0.69	4.40	60.28
Ictalurus punctatus	0.34	0.20	3.22	0.56	4.15	64.43
Anchoa mitchilli	0.41	0.41	2.90	0.61	3.73	68.16
Bairdiella chrysoura	0.37	0.27	2.84	0.61	3.66	71.82

Groups Average-Subsistence & Wet-2ps
Average dissimilarity = 71.51

	Group Average-Subsistence	Group Wet-2ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.51	3.07	7.32	1.06	10.24	10.24
Ictalurus furcatus	0.95	1.73	7.23	0.80	10.12	20.36
Stellifer lanceolatus	1.05	2.86	7.01	1.23	9.80	30.16
Anchoa mitchilli	2.28	1.09	6.81	0.99	9.52	39.68
Litopenaeus setiferus	1.75	2.06	5.43	1.20	7.59	47.27
Macrobrachium ohione	0.00	1.20	5.04	0.63	7.05	54.32
Cynoscion arenarius	0.87	1.62	4.09	1.24	5.72	60.04
Bagre marinus	0.54	1.18	3.12	1.11	4.37	64.41
Ariopsis felis	0.91	0.49	2.90	0.92	4.05	68.46
Leiostomus xanthurus	0.97	0.09	2.64	0.87	3.69	72.15

Groups Average-Base & Wet-2ps
Average dissimilarity = 73.45

	Group Average-Base	Group Wet-2ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.64	3.07	8.97	1.37	12.21	12.21
Stellifer lanceolatus	1.12	2.86	8.40	1.33	11.43	23.64
Ictalurus furcatus	1.25	1.73	8.38	0.95	11.41	35.06
Macrobrachium ohione	0.00	1.20	6.39	0.68	8.70	43.75
Litopenaeus setiferus	1.23	2.06	5.95	1.30	8.10	51.85
Cynoscion arenarius	0.98	1.62	5.13	1.14	6.99	58.84
Bagre marinus	0.50	1.18	3.54	1.05	4.83	63.67
Anchoa mitchilli	0.41	1.09	3.49	0.72	4.75	68.42
Callinectes sapidus	0.89	0.55	2.95	1.28	4.02	72.44

Groups Average-3ps & Wet-2ps
Average dissimilarity = 75.02

Species	Group Average-3ps Av.Abund	Group Wet-2ps Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.32	1.73	9.91	0.92	13.21	13.21
Micropogonias undulatus	1.30	3.07	9.55	1.42	12.73	25.95
Stellifer lanceolatus	1.17	2.86	9.38	1.18	12.50	38.45
Macrobrachium ohione	0.55	1.20	7.54	0.83	10.05	48.49
Litopenaeus setiferus	0.62	2.06	6.85	1.27	9.14	57.63
Cynoscion arenarius	0.29	1.62	5.01	1.14	6.68	64.30
Anchoa mitchilli	0.41	1.09	4.17	0.80	5.55	69.86
Bagre marinus	0.25	1.18	3.96	1.05	5.28	75.13

Groups Average-Subsistence & Wet-Subsistence
Average dissimilarity = 69.12

Species	Group Average-Subsistence Av.Abund	Group Wet-Subsistence Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.51	3.38	7.83	1.01	11.33	11.33
Anchoa mitchilli	2.28	2.02	6.98	1.05	10.10	21.43
Litopenaeus setiferus	1.75	2.32	5.57	1.05	8.06	29.49
Stellifer lanceolatus	1.05	1.87	4.95	1.11	7.17	36.66
Ictalurus furcatus	0.95	1.10	4.73	0.72	6.84	43.50
Cynoscion arenarius	0.87	1.43	3.62	0.92	5.24	48.74
Ariopsis felis	0.91	0.79	2.94	0.97	4.25	53.00
Leiostomus xanthurus	0.97	0.44	2.69	0.92	3.90	56.89
Bagre marinus	0.54	0.89	2.59	0.96	3.74	60.63
Callinectes sapidus	0.72	0.70	2.48	0.98	3.58	64.22
Farfantepenaeus aztecus	0.19	0.88	2.26	0.56	3.27	67.49
Bairdiella chrysoura	0.43	0.68	2.04	0.87	2.96	70.44

Groups Average-Base & Wet-Subsistence
Average dissimilarity = 75.19

Species	Group Average-Base Av.Abund	Group Wet-Subsistence Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.64	3.38	9.78	1.15	13.01	13.01
Ictalurus furcatus	1.25	1.10	6.59	0.75	8.77	21.78
Litopenaeus setiferus	1.23	2.32	6.15	1.24	8.18	29.96
Anchoa mitchilli	0.41	2.02	6.10	1.04	8.11	38.07
Stellifer lanceolatus	1.12	1.87	6.04	1.19	8.03	46.10
Cynoscion arenarius	0.98	1.43	4.81	1.10	6.40	52.50
Callinectes sapidus	0.89	0.70	2.96	1.19	3.94	56.44
Bagre marinus	0.50	0.89	2.69	0.90	3.58	60.03
Farfantepenaeus aztecus	0.24	0.88	2.64	0.57	3.51	63.54
Ariopsis felis	0.31	0.79	2.44	0.85	3.24	66.78
Bairdiella chrysoura	0.37	0.68	2.41	0.73	3.20	69.98
Macrobrachium spp.	0.23	0.48	2.32	0.43	3.08	73.06

Groups Average-3ps & Wet-Subsistence
Average dissimilarity = 80.22

Species	Group Average-3ps Av.Abund	Group Wet-Subsistence Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.30	3.38	10.86	1.10	13.53	13.53
Ictalurus furcatus	1.32	1.10	7.69	0.80	9.59	23.12
Litopenaeus setiferus	0.62	2.32	7.48	1.27	9.32	32.44
Anchoa mitchilli	0.41	2.02	6.84	1.06	8.52	40.96
Stellifer lanceolatus	1.17	1.87	6.83	1.05	8.52	49.47
Cynoscion arenarius	0.29	1.43	4.66	0.93	5.81	55.28
Macrobrachium ohione	0.55	0.29	3.19	0.65	3.97	59.26
Ariopsis felis	0.44	0.79	2.89	0.91	3.60	62.86
Callinectes sapidus	0.36	0.70	2.79	0.91	3.48	66.34
Bagre marinus	0.25	0.89	2.73	0.82	3.41	69.75
Farfantepenaeus aztecus	0.07	0.88	2.65	0.52	3.31	73.06

Groups Wet-2ps & Wet-Subsistence
Average dissimilarity = 70.18

Group Wet-2ps Group Wet-Subsistence

Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.07	3.38	7.86	1.05	11.20	11.20
Ictalurus furcatus	1.73	1.10	6.90	0.83	9.83	21.03
Stellifer lanceolatus	2.86	1.87	6.86	1.22	9.77	30.81
Anchoa mitchilli	1.09	2.02	5.56	1.11	7.93	38.74
Litopenaeus setiferus	2.06	2.32	5.53	1.15	7.89	46.62
Macrobrachium ohione	1.20	0.29	4.98	0.65	7.09	53.71
Cynoscion arenarius	1.62	1.43	4.42	1.19	6.30	60.01
Bagre marinus	1.18	0.89	3.32	1.09	4.72	64.74
Ariopsis felis	0.49	0.79	2.28	0.86	3.25	67.98
Brevoortia patronus	0.79	0.48	2.22	0.87	3.16	71.14

Groups Average-Subsistence & Wet-Base
Average dissimilarity = 77.30

	Group Average-Subsistence	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.51	2.13	10.11	1.23	13.08	13.08
Anchoa mitchilli	2.28	0.46	7.93	0.92	10.26	23.34
Ictalurus furcatus	0.95	1.15	6.58	0.77	8.51	31.85
Stellifer lanceolatus	1.05	1.81	6.16	1.02	7.97	39.82
Litopenaeus setiferus	1.75	1.00	5.75	1.16	7.43	47.25
Callinectes sapidus	0.72	1.07	3.85	0.92	4.97	52.23
Macrobrachium ohione	0.00	0.87	3.81	0.49	4.93	57.15
Ariopsis felis	0.91	0.58	3.61	0.91	4.67	61.82
Cynoscion arenarius	0.87	0.65	3.37	1.05	4.36	66.18
Leiostomus xanthurus	0.97	0.06	3.18	0.88	4.12	70.30

Groups Average-Base & Wet-Base
Average dissimilarity = 76.55

	Group Average-Base	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.64	2.13	10.83	1.30	14.14	14.14
Ictalurus furcatus	1.25	1.15	9.00	0.92	11.76	25.90
Stellifer lanceolatus	1.12	1.81	7.67	1.12	10.01	35.92
Litopenaeus setiferus	1.23	1.00	5.34	1.17	6.98	42.89
Macrobrachium ohione	0.00	0.87	4.86	0.54	6.35	49.24
Callinectes sapidus	0.89	1.07	4.50	1.08	5.87	55.11
Cynoscion arenarius	0.98	0.65	4.29	0.87	5.61	60.72
Bagre marinus	0.50	0.57	2.81	0.81	3.68	64.40

Ariopsis felis	0.31	0.58	2.81	0.71	3.68	68.07
Bairdiella chrysoura	0.37	0.36	2.64	0.60	3.45	71.53

Groups Average-3ps & Wet-Base
Average dissimilarity = 77.92

	Group Average-3ps	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ictalurus furcatus	1.32	1.15	10.91	0.97	14.00	14.00
Micropogonias undulatus	1.30	2.13	10.29	1.17	13.21	27.21
Stellifer lanceolatus	1.17	1.81	8.78	0.99	11.27	38.48
Macrobrachium ohione	0.55	0.87	7.49	0.78	9.62	48.09
Litopenaeus setiferus	0.62	1.00	5.38	0.91	6.91	55.00
Callinectes sapidus	0.36	1.07	5.16	0.97	6.62	61.62
Ariopsis felis	0.44	0.58	3.54	0.78	4.55	66.16
Anchoa mitchilli	0.41	0.46	3.31	0.68	4.25	70.42

Groups Wet-2ps & Wet-Base
Average dissimilarity = 71.72

	Group Wet-2ps	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.07	2.13	9.02	1.34	12.58	12.58
Stellifer lanceolatus	2.86	1.81	8.78	1.21	12.25	24.82
Ictalurus furcatus	1.73	1.15	8.42	0.94	11.74	36.57
Macrobrachium ohione	1.20	0.87	6.99	0.79	9.75	46.32
Litopenaeus setiferus	2.06	1.00	6.24	1.24	8.70	55.01
Cynoscion arenarius	1.62	0.65	4.91	1.14	6.84	61.86
Bagre marinus	1.18	0.57	3.80	1.06	5.29	67.15
Anchoa mitchilli	1.09	0.46	3.69	0.81	5.15	72.30

Groups Wet-Subsistence & Wet-Base
Average dissimilarity = 77.18

	Group Wet-Subsistence	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	3.38	2.13	9.95	1.08	12.89	12.89
Stellifer lanceolatus	1.87	1.81	6.74	1.14	8.73	21.62
Litopenaeus setiferus	2.32	1.00	6.67	1.19	8.64	30.26
Ictalurus furcatus	1.10	1.15	6.57	0.84	8.51	38.77

Anchoa mitchilli	2.02	0.46	6.06	0.99	7.85	46.62
Cynoscion arenarius	1.43	0.65	4.61	0.98	5.97	52.59
Macrobrachium ohione	0.29	0.87	4.09	0.55	5.30	57.90
Callinectes sapidus	0.70	1.07	3.63	0.93	4.70	62.60
Farfantepenaeus aztecus	0.88	0.39	3.08	0.61	4.00	66.59
Bagre marinus	0.89	0.57	3.00	0.90	3.89	70.48

Table 80. Results of SIMPER analysis for beam trawl collection resemblance matrix between flow tiers- data from site B42 was excluded.

SIMPER
Similarity Percentages - species contributions

One-Way Analysis

Data worksheet
Name: Data1
Data type: Other
Sample selection: All
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity
Cut off for low contributions: 70.00%

Factor Groups

Sample	Hydrologic Condition-Flow Tier
B01	Avg-Sub
B01	Avg-Sub
B01	Avg-Sub
B01	Avg-Sub
B01	Avg-Sub
B10	Avg-Sub
B10	Avg-Sub
B10	Avg-Sub
B10	Avg-Sub
B10	Avg-Sub
B22	Avg-Sub
B22	Avg-Sub
B22	Avg-Sub
B22	Avg-Sub
B22	Avg-Sub
B31	Avg-Sub
B31	Avg-Sub
B31	Avg-Sub
B31	Avg-Sub

B31	Avg-Sub
B01	Avg-Base
B01	Avg-Base
B01	Avg-Base
B10	Avg-Base
B10	Avg-Base
B10	Avg-Base
B22	Avg-Base
B22	Avg-Base
B22	Avg-Base
B31	Avg-Base
B31	Avg-Base
B31	Avg-Base
B01	Avg-3ps
B01	Avg-3ps
B01	Avg-3ps
B01	Avg-3ps
B10	Avg-3ps
B10	Avg-3ps
B10	Avg-3ps
B10	Avg-3ps
B22	Avg-3ps
B22	Avg-3ps
B22	Avg-3ps
B22	Avg-3ps
B31	Avg-3ps
B31	Avg-3ps
B31	Avg-3ps
B31	Avg-3ps
B01	Wet-2ps
B01	Wet-2ps
B10	Wet-2ps
B10	Wet-2ps
B22	Wet-2ps
B22	Wet-2ps
B31	Wet-2ps
B31	Wet-2ps
B01	Wet-Sub
B01	Wet-Sub
B01	Wet-Sub
B01	Wet-Sub
B01	Wet-Sub
B10	Wet-Sub

B10	Wet-Sub
B10	Wet-Sub
B10	Wet-Sub
B10	Wet-Sub
B22	Wet-Sub
B22	Wet-Sub
B22	Wet-Sub
B22	Wet-Sub
B22	Wet-Sub
B31	Wet-Sub
B31	Wet-Sub
B31	Wet-Sub
B31	Wet-Sub
B31	Wet-Sub
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B01	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B10	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B22	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base
B31	Wet-Base

Group Avg-Sub
Average similarity: 16.36

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Litopenaeus setiferus	1.12	5.40	0.47	33.01	33.01
Micropogonias undulatus	1.06	4.74	0.41	28.95	61.96
Callinectes sapidus	0.69	3.31	0.42	20.22	82.18

Group Avg-Base
Average similarity: 18.19

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Micropogonias undulatus	2.21	6.63	0.65	36.42	36.42
Ctenogobius boleosoma	1.12	6.07	0.81	33.37	69.79
Brevoortia patronus	1.28	2.98	0.43	16.39	86.18

Group Avg-3ps
Average similarity: 13.27

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Brevoortia patronus	1.18	3.33	0.42	25.06	25.06
Micropogonias undulatus	0.90	3.28	0.37	24.75	49.81
Ctenogobius boleosoma	0.49	2.18	0.32	16.43	66.25
Palaemonetes pugio	0.53	1.87	0.33	14.06	80.30

Group Wet-2ps
Average similarity: 13.08

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Brevoortia patronus	1.42	4.46	0.33	34.12	34.12
Macrobrachium ohione	1.06	2.75	0.32	20.99	55.11
Libellulidae spp.	0.43	1.56	0.34	11.96	67.07
Anchoa mitchilli	0.48	1.06	0.32	8.09	75.16

Group Wet-Sub
Average similarity: 5.24

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Litopenaeus setiferus	0.52	2.43	0.23	46.36	46.36
Micropogonias undulatus	0.56	1.48	0.18	28.29	74.64

Group Wet-Base

Average similarity: 7.92

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Mugil cephalus	0.62	1.81	0.27	22.83	22.83
Palaemonetes pugio	0.37	1.69	0.26	21.31	44.14
Brevoortia patronus	0.68	1.46	0.20	18.48	62.62
Anchoa mitchilli	0.18	0.86	0.12	10.88	73.50

Groups Avg-Sub & Avg-Base
Average dissimilarity = 87.25

	Group Avg-Sub	Group Avg-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.06	2.21	18.19	1.00	20.84	20.84
Litopenaeus setiferus	1.12	0.18	12.17	0.63	13.95	34.79
Ctenogobius boleosoma	0.46	1.12	8.58	1.08	9.84	44.63
Callinectes sapidus	0.69	0.15	8.46	0.50	9.70	54.33
Brevoortia patronus	0.36	1.28	8.27	0.87	9.48	63.80
Palaemonetes pugio	0.43	0.40	4.63	0.63	5.30	69.10
Mugil cephalus	0.14	0.58	4.10	0.50	4.70	73.81

Groups Avg-Sub & Avg-3ps
Average dissimilarity = 88.21

	Group Avg-Sub	Group Avg-3ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.06	0.90	14.74	0.83	16.71	16.71
Litopenaeus setiferus	1.12	0.29	12.20	0.74	13.83	30.54
Brevoortia patronus	0.36	1.18	9.48	0.85	10.75	41.29
Callinectes sapidus	0.69	0.11	8.35	0.61	9.47	50.76
Palaemonetes pugio	0.43	0.53	7.24	0.69	8.20	58.96
Ctenogobius boleosoma	0.46	0.49	7.10	0.64	8.05	67.01
Anchoa mitchilli	0.03	0.32	5.21	0.38	5.91	72.92

Groups Avg-Base & Avg-3ps
Average dissimilarity = 84.45

	Group Avg-Base	Group Avg-3ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.21	0.90	18.17	0.94	21.51	21.51

Brevoortia patronus	1.28	1.18	12.26	1.02	14.52	36.03
Ctenogobius boleosoma	1.12	0.49	11.21	0.69	13.27	49.30
Anchoa mitchilli	0.37	0.32	6.95	0.40	8.23	57.53
Palaemonetes pugio	0.40	0.53	6.47	0.62	7.67	65.20
Pimephales vigilax	0.12	0.40	4.10	0.48	4.85	70.05

Groups Avg-Sub & Wet-2ps
Average dissimilarity = 94.45

	Group Avg-Sub	Group Wet-2ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	0.36	1.42	12.90	0.77	13.66	13.66
Litopenaeus setiferus	1.12	0.17	11.04	0.69	11.69	25.34
Micropogonias undulatus	1.06	0.35	10.62	0.72	11.25	36.59
Macrobrachium ohione	0.00	1.06	8.78	0.66	9.29	45.88
Callinectes sapidus	0.69	0.00	7.09	0.55	7.51	53.39
Libellulidae spp.	0.00	0.43	5.61	0.43	5.94	59.34
Palaemonetes pugio	0.43	0.35	5.05	0.75	5.35	64.68
Anchoa mitchilli	0.03	0.48	4.17	0.59	4.41	69.09
Ictalurus furcatus	0.05	0.50	4.07	0.59	4.31	73.40

Groups Avg-Base & Wet-2ps
Average dissimilarity = 90.65

	Group Avg-Base	Group Wet-2ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	1.28	1.42	14.87	0.83	16.40	16.40
Micropogonias undulatus	2.21	0.35	13.51	1.07	14.91	31.31
Macrobrachium ohione	0.06	1.06	9.01	0.64	9.94	41.25
Ctenogobius boleosoma	1.12	0.00	7.97	1.03	8.79	50.05
Libellulidae spp.	0.00	0.43	7.56	0.37	8.33	58.38
Ictalurus furcatus	0.21	0.50	4.92	0.71	5.42	63.80
Anchoa mitchilli	0.37	0.48	4.91	0.67	5.42	69.22
Pimephales vigilax	0.12	0.35	4.31	0.55	4.75	73.97

Groups Avg-3ps & Wet-2ps
Average dissimilarity = 87.49

	Group Avg-3ps	Group Wet-2ps				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%

Brevoortia patronus	1.18	1.42	16.12	0.93	18.43	18.43
Macrobrachium ohione	0.28	1.06	10.13	0.75	11.58	30.01
Micropogonias undulatus	0.90	0.35	9.56	0.65	10.93	40.94
Anchoa mitchilli	0.32	0.48	7.69	0.53	8.79	49.73
Palaemonetes pugio	0.53	0.35	6.43	0.71	7.35	57.08
Pimephales vigilax	0.40	0.35	6.19	0.67	7.07	64.15
Libellulidae spp.	0.00	0.43	6.14	0.43	7.02	71.17

Groups Avg-Sub & Wet-Sub
Average dissimilarity = 90.52

	Group Avg-Sub	Group Wet-Sub				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Litopenaeus setiferus	1.12	0.52	19.75	0.83	21.82	21.82
Micropogonias undulatus	1.06	0.56	18.32	0.85	20.24	42.05
Callinectes sapidus	0.69	0.17	12.19	0.64	13.47	55.53
Brevoortia patronus	0.36	0.21	5.07	0.55	5.60	61.12
Palaemonetes pugio	0.43	0.05	4.97	0.52	5.49	66.61
Ctenogobius boleosoma	0.46	0.00	4.55	0.73	5.03	71.64

Groups Avg-Base & Wet-Sub
Average dissimilarity = 94.15

	Group Avg-Base	Group Wet-Sub				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.21	0.56	21.57	1.16	22.91	22.91
Ctenogobius boleosoma	1.12	0.00	11.52	1.18	12.24	35.15
Brevoortia patronus	1.28	0.21	10.93	0.93	11.60	46.75
Litopenaeus setiferus	0.18	0.52	9.47	0.44	10.06	56.81
Mugil cephalus	0.58	0.03	5.62	0.52	5.97	62.78
Anchoa mitchilli	0.37	0.07	4.90	0.34	5.20	67.98
Callinectes sapidus	0.15	0.17	4.07	0.42	4.32	72.30

Groups Avg-3ps & Wet-Sub
Average dissimilarity = 93.59

	Group Avg-3ps	Group Wet-Sub				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	0.90	0.56	17.07	0.75	18.24	18.24
Brevoortia patronus	1.18	0.21	12.45	0.88	13.31	31.55

Anchoa mitchilli	0.32	0.07	9.96	0.46	10.64	42.19
Litopenaeus setiferus	0.29	0.52	9.26	0.52	9.90	52.09
Ctenogobius boleosoma	0.49	0.00	9.02	0.50	9.63	61.72
Palaemonetes pugio	0.53	0.05	8.04	0.61	8.60	70.32

Groups Wet-2ps & Wet-Sub
Average dissimilarity = 95.95

	Group Wet-2ps	Group Wet-Sub				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	1.42	0.21	17.56	0.80	18.30	18.30
Macrobrachium ohione	1.06	0.00	12.02	0.71	12.52	30.83
Libellulidae spp.	0.43	0.00	10.21	0.47	10.64	41.47
Micropogonias undulatus	0.35	0.56	8.63	0.63	8.99	50.46
Litopenaeus setiferus	0.17	0.52	8.16	0.48	8.50	58.96
Anchoa mitchilli	0.48	0.07	7.03	0.56	7.33	66.29
Pimephales vigilax	0.35	0.03	6.26	0.51	6.52	72.81

Groups Avg-Sub & Wet-Base
Average dissimilarity = 92.40

	Group Avg-Sub	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	1.06	0.44	14.53	0.78	15.73	15.73
Litopenaeus setiferus	1.12	0.16	14.24	0.77	15.42	31.14
Callinectes sapidus	0.69	0.14	9.62	0.63	10.41	41.56
Brevoortia patronus	0.36	0.68	9.30	0.54	10.07	51.62
Palaemonetes pugio	0.43	0.37	7.49	0.62	8.10	59.73
Mugil cephalus	0.14	0.62	6.46	0.56	6.99	66.72
Ctenogobius boleosoma	0.46	0.03	4.23	0.72	4.58	71.30

Groups Avg-Base & Wet-Base
Average dissimilarity = 91.97

	Group Avg-Base	Group Wet-Base				
Species	Av.Abund	Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Micropogonias undulatus	2.21	0.44	17.33	1.06	18.85	18.85
Brevoortia patronus	1.28	0.68	14.27	0.71	15.52	34.36
Ctenogobius boleosoma	1.12	0.03	9.88	1.10	10.74	45.10
Mugil cephalus	0.58	0.62	9.30	0.67	10.11	55.21

Palaemonetes pugio	0.40	0.37	7.26	0.49	7.89	63.10
Anchoa mitchilli	0.37	0.18	7.02	0.34	7.64	70.74

Groups Avg-3ps & Wet-Base
Average dissimilarity = 90.10

Species	Group Avg-3ps Av.Abund	Group Wet-Base Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	1.18	0.68	15.11	0.81	16.77	16.77
Micropogonias undulatus	0.90	0.44	13.27	0.71	14.73	31.50
Anchoa mitchilli	0.32	0.18	9.81	0.47	10.89	42.38
Palaemonetes pugio	0.53	0.37	9.56	0.67	10.61	52.99
Ctenogobius boleosoma	0.49	0.03	7.37	0.52	8.18	61.18
Mugil cephalus	0.04	0.62	6.56	0.54	7.28	68.45
Macrobrachium ohione	0.28	0.19	4.55	0.59	5.05	73.51

Groups Wet-2ps & Wet-Base
Average dissimilarity = 90.97

Species	Group Wet-2ps Av.Abund	Group Wet-Base Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	1.42	0.68	18.51	0.82	20.35	20.35
Macrobrachium ohione	1.06	0.19	11.49	0.78	12.63	32.98
Anchoa mitchilli	0.48	0.18	7.89	0.49	8.67	41.65
Libellulidae spp.	0.43	0.09	7.86	0.47	8.65	50.30
Palaemonetes pugio	0.35	0.37	6.70	0.60	7.36	57.66
Micropogonias undulatus	0.35	0.44	6.25	0.59	6.87	64.53
Mugil cephalus	0.00	0.62	5.85	0.51	6.43	70.95

Groups Wet-Sub & Wet-Base
Average dissimilarity = 94.77

Species	Group Wet-Sub Av.Abund	Group Wet-Base Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Brevoortia patronus	0.21	0.68	13.51	0.56	14.25	14.25
Micropogonias undulatus	0.56	0.44	12.83	0.65	13.54	27.79
Litopenaeus setiferus	0.52	0.16	11.66	0.56	12.30	40.09
Anchoa mitchilli	0.07	0.18	9.96	0.40	10.50	50.60
Mugil cephalus	0.03	0.62	9.32	0.60	9.84	60.44
Palaemonetes pugio	0.05	0.37	8.90	0.52	9.40	69.83

Callinectes sapidus	0.17	0.14	5.80	0.50	6.12	75.95

Table 81. Results of ANOSIM analysis of otter trawl resemblance matrix between sample sites.

ANOSIM
Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem15
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Site	Unordered	5

Site levels
B01
B10
B22
B31
B42

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.433
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
B01, B10	0.065	1.1	Very large	999	10
B01, B22	0.353	0.1	Very large	999	0
B01, B31	0.727	0.1	Very large	999	0
B01, B42	0.945	0.1	Very large	999	0
B10, B22	0.306	0.1	Very large	999	0
B10, B31	0.704	0.1	Very large	999	0
B10, B42	0.941	0.1	Very large	999	0
B22, B31	0.093	0.5	Very large	999	4
B22, B42	0.176	0.7	Very large	999	6
B31, B42	0.065	5.2	Very large	999	51

Table 82. Results of ANOSIM analysis of otter trawl resemblance matrix between seasons.

ANOSIM

Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem15
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Season	Unordered	3

Season levels
Winter
Spring
Summer

Tests for differences between unordered Season groups
Global Test
Sample statistic (R): 0.085
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Winter, Spring	0.097	0.3	Very large	999	2
Winter, Summer	0.048	2.5	Very large	999	24
Spring, Summer	0.114	0.3	Very large	999	2

Table 83. Results of ANOSIM analysis of otter trawl resemblance matrix between flow tiers.

ANOSIM
Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem15
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Hydrologic Condition-Flow Tier V2	Unordered	6

Hydrologic Condition-Flow Tier V2 levels
Average-Subsistence
Average-Base
Average-3ps
Wet-2ps
Wet-Subsistence
Wet-Base

Tests for differences between unordered Hydrologic Condition-Flow Tier V2 groups
Global Test
Sample statistic (R): 0.057
Significance level of sample statistic: 0.8%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 7

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Average-Subsistence, Average-Base	0.145	1.3	Very large	999	12
Average-Subsistence, Average-3ps	0.18	0.1	Very large	999	0

Average-Subsistence, Wet-2ps	0.101	11.3	28048800	999	112
Average-Subsistence, Wet-Subsistence	0.029	13.1	Very large	999	130
Average-Subsistence, Wet-Base	0.122	1.2	Very large	999	11
Average-Base, Average-3ps	0.015	27.4	Very large	999	273
Average-Base, Wet-2ps	-0.009	46.2	1307504	999	461
Average-Base, Wet-Subsistence	0.059	9.5	Very large	999	94
Average-Base, Wet-Base	0.008	40.7	Very large	999	406
Average-3ps, Wet-2ps	-0.07	89.7	52451256	999	896
Average-3ps, Wet-Subsistence	0.111	1.4	Very large	999	13
Average-3ps, Wet-Base	-0.013	63.1	Very large	999	630
Wet-2ps, Wet-Subsistence	-0.014	49.5	14307150	999	494
Wet-2ps, Wet-Base	-0.07	90.2	124403620	999	901
Wet-Subsistence, Wet-Base	0.078	3.5	Very large	999	34

Table 84. Results of ANOSIM analysis of beam trawl resemblance matrix between sample sites.

ANOSIM
Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Site	Unordered	5

Site levels
B01
B10
B22
B31
B42

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.071
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
B01, B10	-0.02	81.5	Very large	999	814
B01, B22	0.068	1.4	Very large	999	13
B01, B31	0.072	0.7	Very large	999	6
B01, B42	0.27	0.1	Very large	999	0
B10, B22	0	41.1	Very large	999	410
B10, B31	0.023	14.4	Very large	999	143
B10, B42	0.16	0.3	Very large	999	2
B22, B31	0.02	17.6	Very large	999	175
B22, B42	0.156	0.3	Very large	999	2
B31, B42	0.052	9.9	Very large	999	98

Table 85. Results of ANOSIM analysis of beam trawl resemblance matrix between seasons.

ANOSIM

Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Season	Unordered	3

Season levels
Winter
Spring
Summer

Tests for differences between unordered Season groups
Global Test
Sample statistic (R): 0.233
Significance level of sample statistic: 0.1%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Winter, Spring	0.157	0.1	Very large	999	0
Winter, Summer	0.321	0.1	Very large	999	0
Spring, Summer	0.221	0.1	Very large	999	0

Table 86. Results of ANOSIM analysis of beam trawl resemblance matrix between flow tiers.

ANOSIM
Analysis of Similarities

One-Way - A

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Factors

Place	Name	Type	Levels
A	Hydrologic Condition-Flow Tier	Unordered	6

Hydrologic Condition-Flow Tier levels
Avg-Sub
Avg-Base
Avg-3ps
Wet-2ps
Wet-Sub
Wet-Base

Tests for differences between unordered Hydrologic Condition-Flow Tier groups
Global Test
Sample statistic (R): 0.06
Significance level of sample statistic: 0.2%
Number of permutations: 999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 1

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Avg-Sub, Avg-Base	0.119	2.8	Very large	999	27
Avg-Sub, Avg-3ps	0.154	0.1	Very large	999	0

Avg-Sub, Wet-2ps	0.372	0.1	28048800	999	0
Avg-Sub, Wet-Sub	0.094	0.1	Very large	999	0
Avg-Sub, Wet-Base	0.133	0.1	Very large	999	0
Avg-Base, Avg-3ps	-0.041	86.9	Very large	999	868
Avg-Base, Wet-2ps	0.15	3.1	1307504	999	30
Avg-Base, Wet-Sub	0.01	33.9	Very large	999	338
Avg-Base, Wet-Base	-0.021	63.1	Very large	999	630
Avg-3ps, Wet-2ps	0.018	35.6	10015005	999	355
Avg-3ps, Wet-Sub	0.062	3.2	Very large	999	31
Avg-3ps, Wet-Base	-0.028	82.9	Very large	999	828
Wet-2ps, Wet-Sub	-0.022	64.5	28048800	999	644
Wet-2ps, Wet-Base	-0.072	84.7	124403620	999	846
Wet-Sub, Wet-Base	0.035	7.7	Very large	999	76

Table 87. Results of Cluster analysis of otter trawl resemblance matrix between sample sites in the Gulf of Mexico.

Hierarchical Cluster analysis

Resemblance worksheet
Name: Resem1
Data type: Similarity
Selection: All

Parameters
Cluster mode: Group average

Simprof test

Data worksheet
Name: Data1
Data type: Other
Sample selection: All
Variable selection: All

Simprof Parameters
Type 1 (Analyse: Samples - Permute within: Variables)
Number of permutations: 999
Significance level: 5%
Resemblance:
Resemblance measure: S17 Bray-Curtis similarity

Samples
1 G1D1
2 G1D1
3 G1
4 G1
5 G1U1
6 G1U1
7 G2
8 G2
9 G3
10 G3

Combining
3+5 -> 11 at 77.18; Pi: 0 Sig(%): 100
4+8 -> 12 at 76.61
6+12 -> 13 at 71.37; Pi: 1.36 Sig(%): 58.7
11+13 -> 14 at 50.26; Pi: 6.37 Sig(%): 0.1
1+7 -> 15 at 46.59; Pi: 0 Sig(%): 100
14+15 -> 16 at 35.09; Pi: 6.41 Sig(%): 0.1
10+16 -> 17 at 23.01; Pi: 6.84 Sig(%): 0.1
9+17 -> 18 at 10.87; Pi: 8.41 Sig(%): 0.1
2+18 -> 19 at 0; Pi: 10.7 Sig(%): 0.1

Cophenetic correlation: 0.94777

Table 88. Results of Kruskal-Wallis test and Dunn's multiple comparison test between total catch of beam trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	25	5	55.0	-0.75
B10	25	9	59.6	0.02
B22	25	10	59.3	-0.03
B31	25	10	56.0	-0.58
B42	18	15	70.8	1.52
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	2.66	0.616
Adjusted for ties	4	2.68	0.613

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.62755	1.00000	*	*	*
B22	0.65276	0.97188	1.00000	*	*
B31	0.91579	0.70436	0.73070	1.00000	*
B42	0.13350	0.29074	0.27626	0.16041	1

Comparisons: 10
Ties: 63
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 89. Results of Kruskal-Wallis test and Dunn's multiple comparison test between total catch of beam trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	22.5	65.8	3.94
Spring	32	16.0	59.4	2.10
Summer	32	0.0	24.5	-6.16
Overall	100		50.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	38.71	0.000
Adjusted for ties	2	39.07	0.000

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.36353	1.00000	*
Summer	0.00000	0.00000	1

Comparisons: 3
Ties: 52
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 90. Results of Kruskal-Wallis test and Dunn's multiple comparison test between total catch of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	11.5	58.0	1.30
Avg-Base	12	17.5	56.7	0.79
Avg-3ps	16	17.5	55.7	0.78
Wet-2ps	8	19.5	61.8	1.14
Wet-Sub	20	2.0	35.4	-2.60
Wet-Base	24	5.5	46.5	-0.77
Overall	100		50.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	9.49	0.091
Adjusted for ties	5	9.58	0.088

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.89875	1.00000	*	*	*	*
Avg-3ps	0.80479	0.92399	1.00000	*	*	*
Wet-2ps	0.75938	0.70208	0.62601	1.00000	*	*
Wet-Sub	0.01312	0.04330	0.03649	0.02916	1.00000	*
Wet-Base	0.18648	0.31736	0.32588	0.19581	0.20422	1

Comparisons: 15
Ties: 52
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 91. Results of Kruskal-Wallis test and Dunn's multiple comparison test between total catch of otter trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	26	247	82.6	3.54
B10	26	176	70.5	1.56
B22	25	41	51.8	-1.47
B31	25	93	61.5	0.09
B42	19	12	29.9	-4.21
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	28.37	0.000
Adjusted for ties	4	28.37	0.000

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.21440	1.00000	*	*	*
B22	0.00174	0.05723	1.00000	*	*
B31	0.03240	0.36277	0.32616	1.00000	*
B42	0.00000	0.00013	0.04039	0.00305	1

Comparisons: 10
Ties: 23
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 92. Results of Kruskal-Wallis test and Dunn's multiple comparison test between total catch of otter trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	200.0	55.3	0.95
Spring	32	38.5	39.8	-2.70
Summer	34	223.0	58.5	1.70
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	7.53	0.023
Adjusted for ties	2	7.53	0.023

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.03111	1.00000	*
Summer	0.64584	0.01009	1

Comparisons: 3
Ties: 9
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 93. Results of Kruskal-Wallis test and Dunn's multiple comparison test between total catch of otter trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	276.5	61.3	1.65
Avg-Base	12	59.5	45.4	-0.76
Avg-3ps	16	34.0	33.1	-2.71
Wet-2ps	12	77.0	50.2	-0.16
Wet-Sub	18	354.5	68.6	2.69
Wet-Base	24	72.0	46.5	-0.94
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	15.58	0.008
Adjusted for ties	5	15.58	0.008

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.14049	1.00000	*	*	*	*
Avg-3ps	0.00448	0.27707	1.00000	*	*	*
Wet-2ps	0.30460	0.68906	0.12985	1.00000	*	*
Wet-Sub	0.45039	0.03554	0.00049	0.09614	1.00000	*
Wet-Base	0.09899	0.91278	0.15971	0.72446	0.01692	1

Comparisons: 15
Ties: 9
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 94. Results of Kruskal-Wallis test and Dunn's multiple comparison test between species richness of beam trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	25	1	48.9	-1.75
B10	25	2	52.8	-1.10
B22	25	4	64.3	0.79
B31	25	3	60.8	0.21
B42	18	4	75.1	2.10
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	7.61	0.107
Adjusted for ties	4	7.76	0.101

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.68257	1.00000	*	*	*
B22	0.10859	0.23186	1.00000	*	*
B31	0.21520	0.40629	0.71500	1.00000	*
B42	0.01244	0.03357	0.30242	0.17214	1

Comparisons: 10
Ties: 107
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 95. Results of Kruskal-Wallis test and Dunn's multiple comparison test between species richness of beam trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	4	66.2	4.05
Spring	32	3	58.2	1.81
Summer	32	0	25.2	-5.98
Overall	100		50.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	37.03	0.000
Adjusted for ties	2	37.80	0.000

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.25088	1.00000	*
Summer	0.00000	0.00000	1

Comparisons: 3
Ties: 89
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 96. Results of Kruskal-Wallis test and Dunn's multiple comparison test between species richness of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	4	61.1	1.84
Avg-Base	12	5	59.8	1.18
Avg-3ps	16	3	54.6	0.62
Wet-2ps	8	4	60.7	1.04
Wet-Sub	20	1	32.7	-3.06
Wet-Base	24	2	45.7	-0.94
Overall	100		50.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	13.41	0.020
Adjusted for ties	5	13.68	0.018

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.89692	1.00000	*	*	*	*
Avg-3ps	0.49604	0.63549	1.00000	*	*	*
Wet-2ps	0.96929	0.94551	0.62407	1.00000	*	*
Wet-Sub	0.00175	0.00984	0.02317	0.01992	1.00000	*
Wet-Base	0.07492	0.16413	0.33542	0.20007	0.13659	1

Comparisons: 15
Ties: 89
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

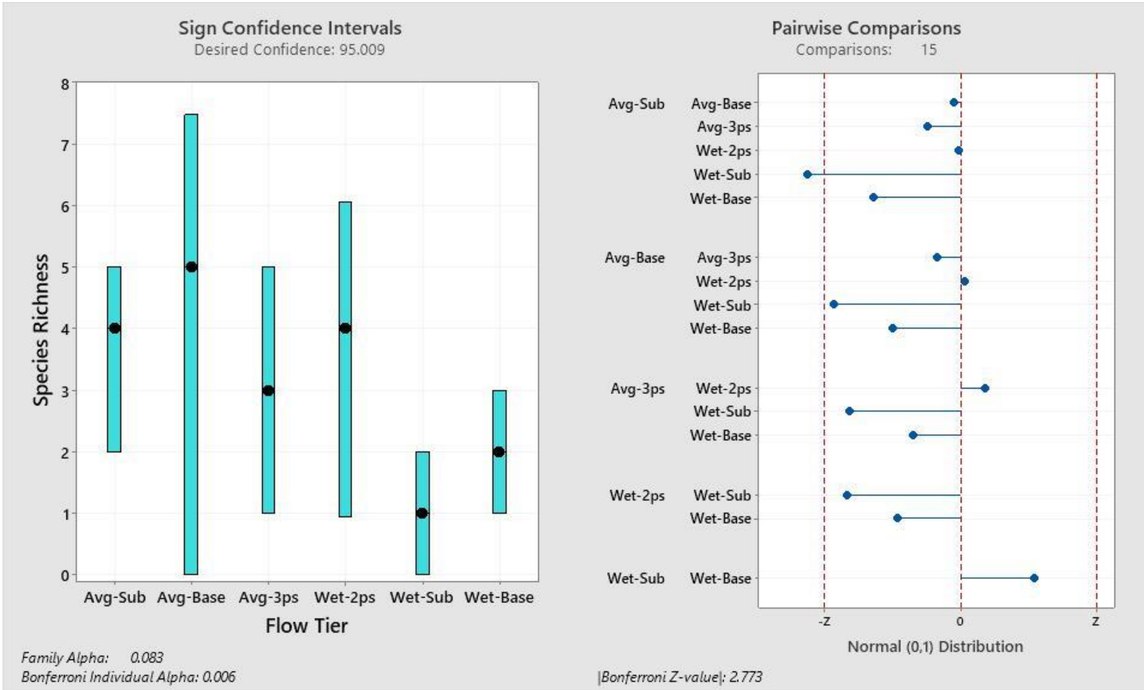

Figure 67. Dunn's multiple comparison test for significant differences in beam trawl species richness between flow tiers. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between flow tiers ($p \leq 0.006$).

Table 97. Results of Kruskal-Wallis test and Dunn's multiple comparison test between species richness of otter trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	26	10.0	91.3	4.98
B10	26	9.5	81.6	3.37
B22	25	4.0	45.1	-2.54
B31	25	4.0	49.2	-1.89
B42	19	3.0	27.8	-4.50
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	53.42	0.000
Adjusted for ties	4	53.83	0.000

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.31241	1.00000	*	*	*
B22	0.00000	0.00019	1.00000	*	*
B31	0.00002	0.00095	0.67673	1.00000	*
B42	0.00000	0.00000	0.10301	0.04360	1

Comparisons: 10
Ties: 105
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 98. Results of Kruskal-Wallis test and Dunn's multiple comparison test between species richness of otter trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	8.0	57.5	1.51
Spring	32	4.5	39.2	-2.85
Summer	34	8.5	56.8	1.27
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	8.10	0.017
Adjusted for ties	2	8.16	0.017

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.01063	1.00000	*
Summer	0.92173	0.01533	1

Comparisons: 3
Ties: 86
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 99. Results of Kruskal-Wallis test and Dunn's multiple comparison test between species richness of otter trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	10.5	67.8	2.74
Avg-Base	12	6.5	50.1	-0.18
Avg-3ps	16	4.0	31.9	-2.88
Wet-2ps	12	6.0	45.8	-0.71
Wet-Sub	18	10.0	67.2	2.48
Wet-Base	24	6.0	42.8	-1.66
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	20.68	0.001
Adjusted for ties	5	20.82	0.001

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.10034	1.00000	*	*	*	*
Avg-3ps	0.00029	0.10706	1.00000	*	*	*
Wet-2ps	0.04156	0.72404	0.21717	1.00000	*	*
Wet-Sub	0.95168	0.11943	0.00050	0.05190	1.00000	*
Wet-Base	0.00506	0.48177	0.25587	0.76740	0.00784	1

Comparisons: 15
Ties: 86
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 100. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon-Wiener diversity indices of beam trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	25	0.000000	42.1	-2.86
B10	25	0.529644	51.7	-1.29
B22	25	0.687207	66.3	1.13
B31	25	0.713838	64.8	0.88
B42	18	0.953108	77.6	2.44
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	14.41	0.006
Adjusted for ties	4	14.95	0.005

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.31420	1.00000	*	*	*
B22	0.01078	0.12275	1.00000	*	*
B31	0.01686	0.16656	0.87287	1.00000	*
B42	0.00063	0.01249	0.27761	0.21790	1

Comparisons: 10
Ties: 46
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

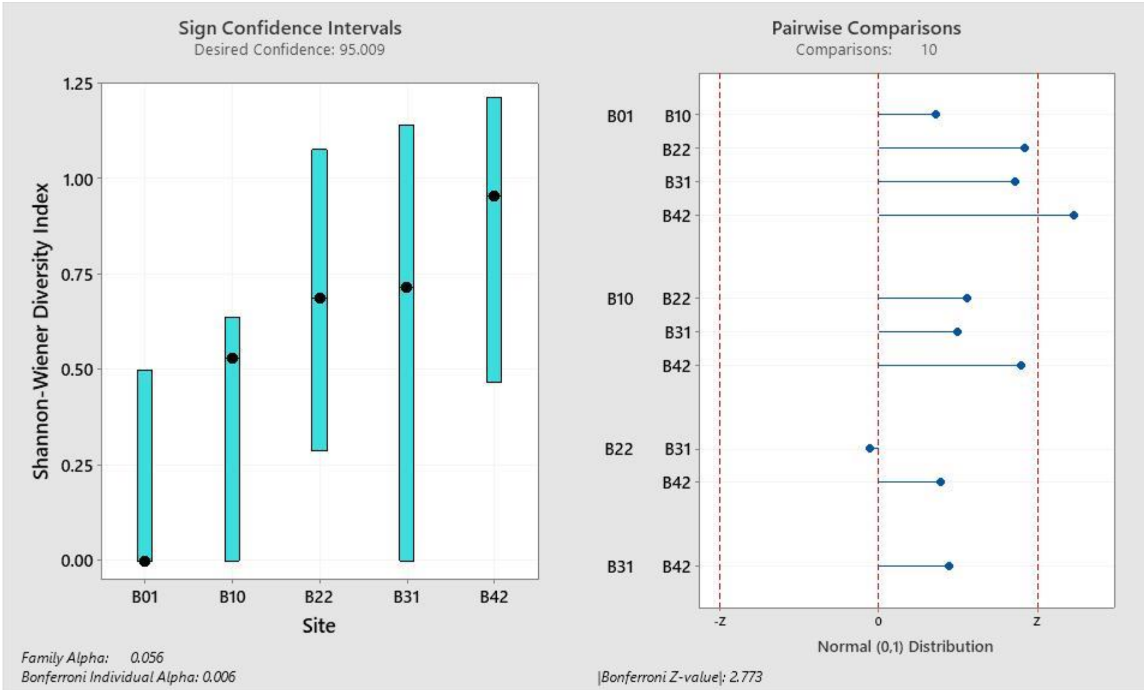

Figure 68. Dunn's multiple comparison test for significant differences in beam trawl Shannon-Wiener diversity indices between sample sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites ($p \leq 0.006$).

Table 101. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon-Wiener diversity indices of beam trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	0.638763	62.6	3.13
Spring	32	0.736330	58.1	1.81
Summer	32	0.000000	29.3	-5.02
Overall	100		50.5	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	25.65	0.000
Adjusted for ties	2	27.14	0.000

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.51545	1.00000	*
Summer	0.00000	0.00004	1

Comparisons:	3
Ties:	41
Family Alpha:	0.017
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773

Table 102. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon-Wiener diversity indices of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	0.593698	58.3	1.34
Avg-Base	12	0.585902	53.8	0.42
Avg-3ps	16	0.636514	55.6	0.77
Wet-2ps	8	0.752826	58.6	0.83
Wet-Sub	20	0.000000	38.0	-2.16
Wet-Base	24	0.217607	46.7	-0.74
Overall	100		50.5	

Null hypothesis H_0: All medians are equal

Alternative hypothesis H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	6.88	0.230
Adjusted for ties	5	7.28	0.201

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.66449	1.00000	*	*	*	*
Avg-3ps	0.77482	0.87017	1.00000	*	*	*
Wet-2ps	0.97802	0.70973	0.80397	1.00000	*	*
Wet-Sub	0.02251	0.12300	0.06216	0.07972	1.00000	*
Wet-Base	0.17386	0.47361	0.32787	0.29984	0.30620	1

Comparisons: 15
Ties: 41
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 103. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon-Wiener diversity indices of otter trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	26	1.01740	69.8	1.45
B10	26	1.22581	83.2	3.63
B22	25	0.56234	48.6	-1.99
B31	25	0.65908	50.2	-1.72
B42	19	0.63651	49.1	-1.61
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	19.71	0.001
Adjusted for ties	4	19.71	0.001

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.17129	1.00000	*	*	*
B22	0.03041	0.00043	1.00000	*	*
B31	0.04596	0.00081	0.86710	1.00000	*
B42	0.04978	0.00129	0.96272	0.91339	1

Comparisons: 10
Ties: 7
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 104. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon-Wiener diversity indices of otter trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	0.816683	49.8	-0.44
Spring	32	0.948176	47.6	-0.90
Summer	34	0.995492	57.0	1.33
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	1.86	0.394
Adjusted for ties	2	1.86	0.394

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.76274	1.00000	*
Summer	0.30549	0.19610	1

Comparisons: 3
Ties: 3
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 105. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon-Wiener diversity indices of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	1.20550	58.6	1.20
Avg-Base	12	0.95942	54.5	0.37
Avg-3ps	16	0.92069	42.4	-1.34
Wet-2ps	12	1.05815	58.3	0.85
Wet-Sub	18	0.79094	50.1	-0.22
Wet-Base	24	0.87292	47.8	-0.71
Overall	102		51.5	

Null hypothesis H_0: All medians are equal

Alternative hypothesis H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	3.85	0.572
Adjusted for ties	5	3.85	0.572

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.70433	1.00000	*	*	*	*
Avg-3ps	0.10274	0.28448	1.00000	*	*	*
Wet-2ps	0.98031	0.75098	0.15867	1.00000	*	*
Wet-Sub	0.37721	0.69062	0.44852	0.45588	1.00000	*
Wet-Base	0.22673	0.52006	0.57428	0.31264	0.79975	1

Comparisons: 15
Ties: 3
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 106. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon evenness of beam trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	25	0.000000	43.8	-2.58
B10	25	0.387682	53.1	-1.05
B22	25	0.591673	64.7	0.86
B31	25	0.577008	61.9	0.40
B42	18	0.730561	79.5	2.69
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	12.97	0.011
Adjusted for ties	4	13.45	0.009

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.32859	1.00000	*	*	*
B22	0.02809	0.22281	1.00000	*	*
B31	0.05672	0.35313	0.77139	1.00000	*
B42	0.00059	0.01105	0.15397	0.09074	1

Comparisons: 10
Ties: 46
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

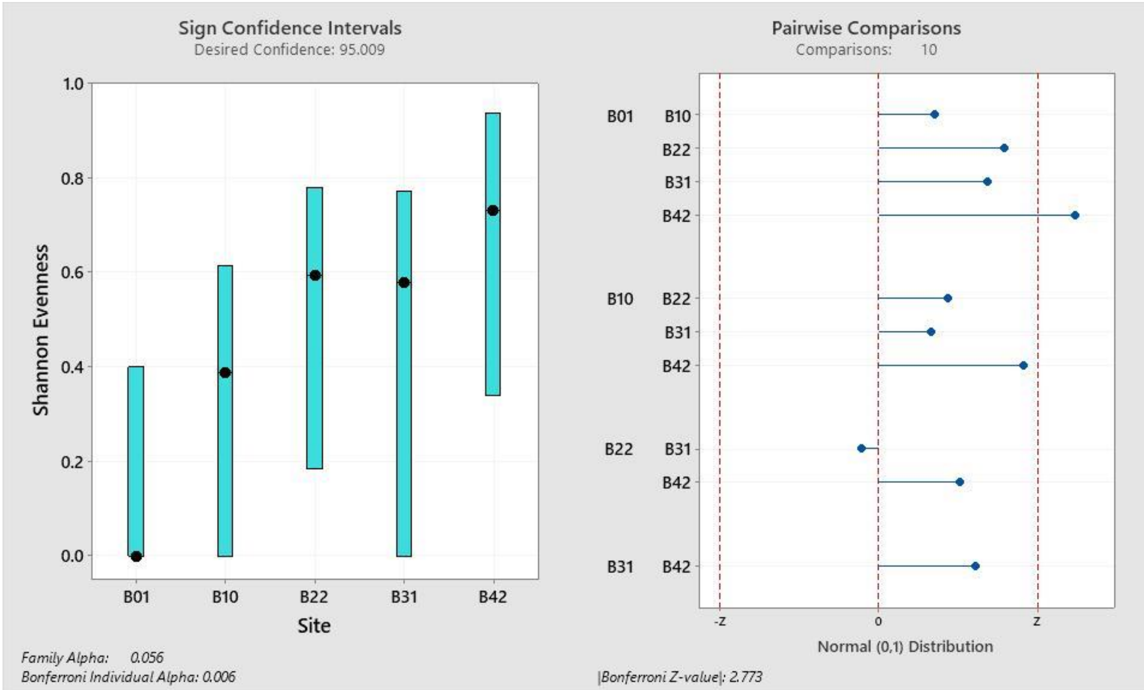

Figure 69. Dunn's multiple comparison test for significant differences in beam trawl Shannon evenness between sample sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites ($p \leq 0.006$).

Table 107. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon evenness of beam trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	44	0.623892	71.7	2.99
Spring	39	0.577008	67.1	1.70
Summer	35	0.000000	35.7	-4.91
Overall	118		59.5	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	24.52	0.000
Adjusted for ties	2	25.44	0.000

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.53223	1.00000	*
Summer	0.00000	0.00006	1

Comparisons:	3
Ties:	46
Family Alpha:	0.017
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773

Table 108. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon evenness of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	23	0.591673	62.0	0.39
Avg-Base	15	0.387682	58.4	-0.13
Avg-3ps	20	0.600334	66.4	0.99
Wet-2ps	9	0.424405	55.4	-0.37
Wet-Sub	23	0.000000	56.8	-0.43
Wet-Base	28	0.325889	56.7	-0.50
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	1.42	0.922
Adjusted for ties	5	1.48	0.916

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.74818	1.00000	*	*	*	*
Avg-3ps	0.66496	0.48418	1.00000	*	*	*
Wet-2ps	0.62072	0.83466	0.41531	1.00000	*	*
Wet-Sub	0.59831	0.88308	0.34660	0.92059	1.00000	*
Wet-Base	0.57367	0.87142	0.32067	0.92470	0.99154	1

Comparisons:	15
Ties:	46
Family Alpha:	0.083
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773

Table 109. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon evenness of otter trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	26	0.477009	52.7	-1.37
B10	26	0.569958	68.3	1.21
B22	25	0.663590	63.0	0.32
B31	25	0.535398	53.2	-1.25
B42	19	0.680772	70.0	1.22
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	5.19	0.269
Adjusted for ties	4	5.19	0.269

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.10670	1.00000	*	*	*
B22	0.29321	0.58491	1.00000	*	*
B31	0.95567	0.12314	0.32419	1.00000	*
B42	0.10076	0.87389	0.50918	0.11495	1

Comparisons: 10
Ties: 7
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 110. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon evenness of otter trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	44	0.491377	58.6	-0.57
Spring	39	0.547895	63.1	0.45
Summer	38	0.585466	61.7	0.14
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	0.36	0.835
Adjusted for ties	2	0.36	0.835

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.55873	1.00000	*
Summer	0.69186	0.85785	1

Comparisons: 3
Ties: 7
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 111. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Shannon evenness of otter trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	23	0.530233	55.4	-0.85
Avg-Base	15	0.680772	71.2	1.20
Avg-3ps	20	0.528405	58.9	-0.30
Wet-2ps	14	0.629037	66.6	0.64
Wet-Sub	21	0.421276	53.0	-1.15
Wet-Base	28	0.625037	64.8	0.65
Overall	121		61.0	

Null hypothesis H_0: All medians are equal

Alternative hypothesis H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	3.69	0.595
Adjusted for ties	5	3.69	0.595

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.17652	1.00000	*	*	*	*
Avg-3ps	0.74834	0.30486	1.00000	*	*	*
Wet-2ps	0.34581	0.72852	0.52504	1.00000	*	*
Wet-Sub	0.81983	0.12597	0.59337	0.26040	1.00000	*
Wet-Base	0.34250	0.57070	0.56369	0.87271	0.24463	1

Comparisons: 15
Ties: 7
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 112. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Margalef richness indices of beam trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	25	0.00000	44.3	-2.50
B10	25	0.55811	50.6	-1.47
B22	25	1.01887	67.7	1.35
B31	25	0.86562	62.9	0.57
B42	18	0.91284	76.7	2.32
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	12.86	0.012
Adjusted for ties	4	13.34	0.010

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.50986	1.00000	*	*	*
B22	0.01384	0.07148	1.00000	*	*
B31	0.05021	0.19389	0.61480	1.00000	*
B42	0.00181	0.01186	0.38584	0.18430	1

Comparisons: 10
Ties: 53
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

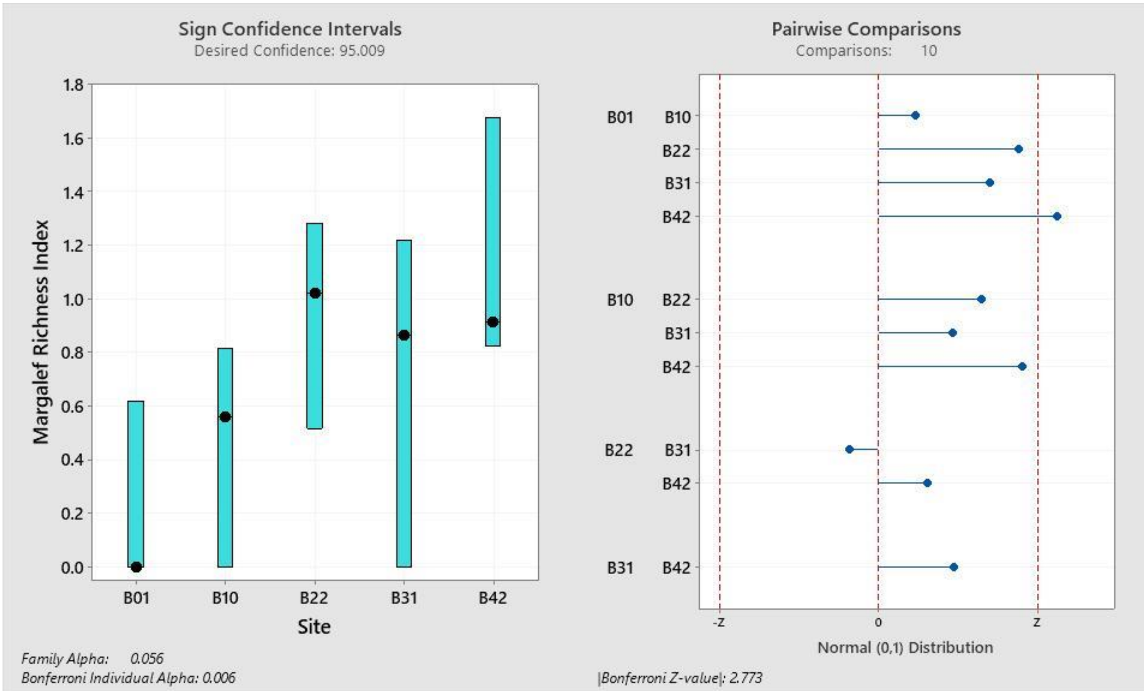

Figure 70. Dunn's multiple comparison test for significant differences in beam trawl Margalef richness indices between sample sites. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites (p≤0.006).

Table 113. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Margalef richness indices of beam trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	0.910239	63.8	3.44
Spring	32	0.822680	56.7	1.46
Summer	32	0.000000	29.3	-5.00
Overall	100		50.5	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	26.05	0.000
Adjusted for ties	2	27.57	0.000

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.29689	1.00000	*
Summer	0.00000	0.00011	1

Comparisons:	3
Ties:	47
Family Alpha:	0.017
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773

Table 114. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Margalef richness indices of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	0.86748	59.3	1.51
Avg-Base	12	0.93992	57.2	0.85
Avg-3ps	16	0.80208	52.7	0.33
Wet-2ps	8	1.01015	57.3	0.69
Wet-Sub	20	0.00000	36.2	-2.46
Wet-Base	24	0.35594	48.0	-0.48
Overall	100		50.5	

Null hypothesis H_0: All medians are equal

Alternative hypothesis H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	8.04	0.154
Adjusted for ties	5	8.51	0.131

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.84095	1.00000	*	*	*	*
Avg-3ps	0.48619	0.67467	1.00000	*	*	*
Wet-2ps	0.86789	0.99354	0.70490	1.00000	*	*
Wet-Sub	0.00967	0.04135	0.08134	0.07354	1.00000	*
Wet-Base	0.18751	0.35684	0.60818	0.41967	0.16625	1

Comparisons:	15
Ties:	47
Family Alpha:	0.083
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773

Table 115. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Margalef richness indices of otter trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	26	1.58919	87.6	4.36
B10	26	1.57362	82.9	3.60
B22	25	0.87362	46.0	-2.40
B31	25	0.73854	42.6	-2.95
B42	19	0.67925	38.6	-3.04
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	44.34	0.000
Adjusted for ties	4	44.35	0.000

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.63375	1.00000	*	*	*
B22	0.00002	0.00017	1.00000	*	*
B31	0.00000	0.00004	0.72876	1.00000	*
B42	0.00000	0.00003	0.48420	0.70596	1

Comparisons: 10
Ties: 7
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 116. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Margalef richness indices of otter trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	1.40984	56.0	1.13
Spring	32	1.22619	45.3	-1.43
Summer	34	1.41769	52.6	0.26
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	2.28	0.320
Adjusted for ties	2	2.28	0.320

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.13703	1.00000	*
Summer	0.63108	0.31706	1

Comparisons: 3
Ties: 3
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 117. Results of Kruskal-Wallis test and Dunn's multiple comparison test between Margalef richness indices of otter trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	1.60421	65.6	2.38
Avg-Base	12	1.41532	55.8	0.53
Avg-3ps	16	0.95155	37.9	-2.00
Wet-2ps	12	1.30821	46.1	-0.68
Wet-Sub	18	1.41259	57.8	0.99
Wet-Base	24	1.32031	44.6	-1.30
Overall	102		51.5	

Null hypothesis H_0: All medians are equal

Alternative hypothesis H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	10.66	0.059
Adjusted for ties	5	10.66	0.059

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.36397	1.00000	*	*	*	*
Avg-3ps	0.00531	0.11408	1.00000	*	*	*
Wet-2ps	0.07086	0.42157	0.47096	1.00000	*	*
Wet-Sub	0.41581	0.85706	0.05099	0.28890	1.00000	*
Wet-Base	0.01933	0.28667	0.48239	0.89070	0.15462	1

Comparisons: 15
Ties: 3
Family Alpha: 0.083
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

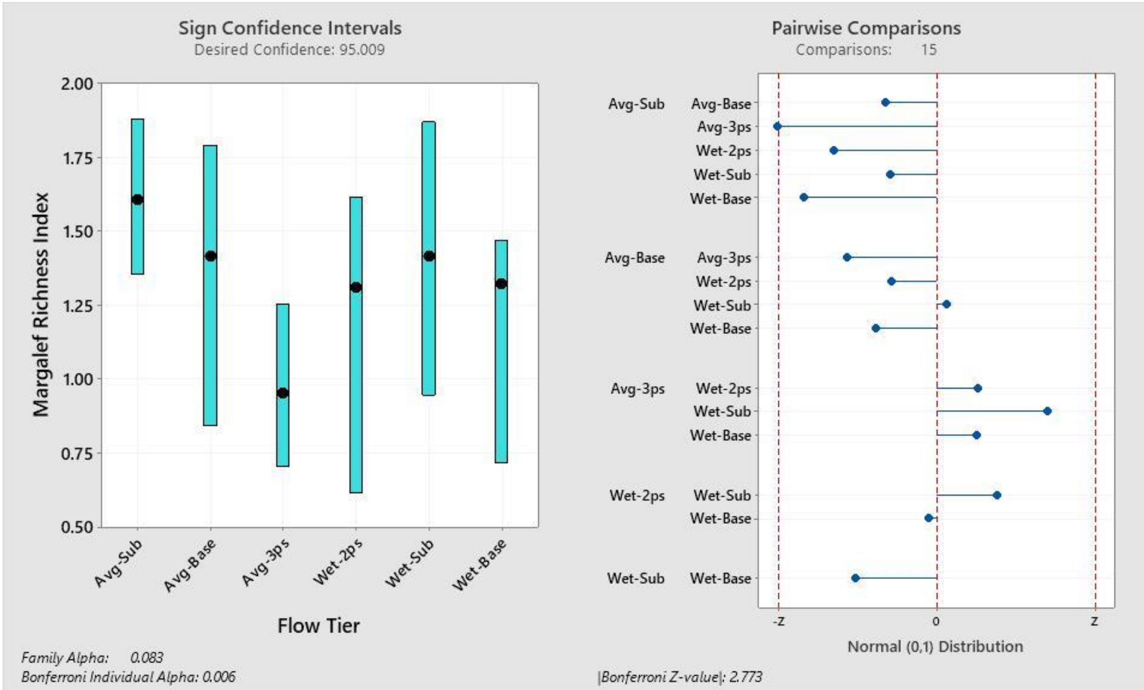

Figure 71. Dunn's multiple comparison test for significant differences in otter trawl Margalef richness indices between flow tiers. Bars signify the 95.009% confidence interval of the median (● = median). Pairwise comparisons greater than the |Bonferroni-adjusted critical Z-value| indicates a significant difference between sites (p≤0.006).

Table 118. Results of Kruskal-Wallis test and Dunn's multiple comparison test between CPUE of beam trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	25	2.4490	55.0	-0.74
B10	25	5.5319	59.7	0.04
B22	25	7.6364	58.9	-0.10
B31	25	8.3544	56.7	-0.45
B42	18	11.9161	70.1	1.43
Overall	118		59.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	2.34	0.674
Adjusted for ties	4	2.35	0.672

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.62189	1.00000	*	*	*
B22	0.68464	0.93065	1.00000	*	*
B31	0.85531	0.75594	0.82292	1.00000	*
B42	0.15145	0.32552	0.28787	0.20495	1

Comparisons: 10
Ties: 21
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 119. Results of Kruskal-Wallis test and Dunn's multiple comparison test between CPUE of beam trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	12.6650	65.4	3.86
Spring	32	10.0000	59.7	2.18
Summer	32	0.0000	24.5	-6.16
Overall	100		50.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	38.59	0.000
Adjusted for ties	2	38.90	0.000

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.41601	1.00000	*
Summer	0.00000	0.00000	1

Comparisons: 3
Ties: 21
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 120. Results of Kruskal-Wallis test and Dunn's multiple comparison test between CPUE of beam trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	8.7043	57.9	1.28
Avg-Base	12	8.0247	54.5	0.51
Avg-3ps	16	9.3391	54.2	0.55
Wet-2ps	8	11.0916	61.5	1.12
Wet-Sub	20	1.5400	36.2	-2.47
Wet-Base	24	4.9676	48.1	-0.46
Overall	100		50.5	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	7.97	0.158
Adjusted for ties	5	8.04	0.154

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.74727	1.00000	*	*	*	*
Avg-3ps	0.70168	0.97741	1.00000	*	*	*
Wet-2ps	0.76584	0.59559	0.55893	1.00000	*	*
Wet-Sub	0.01756	0.08284	0.06346	0.03635	1.00000	*
Wet-Base	0.26385	0.53262	0.51565	0.25687	0.17285	1

Comparisons:	15
Ties:	21
Family Alpha:	0.083
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773

Table 121. Results of Kruskal-Wallis test and Dunn's multiple comparison test between CPUE of otter trawl collections for each sample site.

Group	N	Median	Mean Rank	Z-Value
B01	26	16.1330	82.1	3.47
B10	26	11.7153	69.9	1.46
B22	25	2.8667	51.6	-1.51
B31	25	6.1050	62.3	0.21
B42	19	0.9333	30.6	-4.12
Overall	121		61.0	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	4	27.27	0.000
Adjusted for ties	4	27.27	0.000

Table of P-values (adjusted for ties)

	B01	B10	B22	B31	B42
B01	1.00000	*	*	*	*
B10	0.20863	1.00000	*	*	*
B22	0.00187	0.06216	1.00000	*	*
B31	0.04371	0.44015	0.27897	1.00000	*
B42	0.00000	0.00020	0.04886	0.00292	1

Comparisons: 10
Ties: 6
Family Alpha: 0.056
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 122. Results of Kruskal-Wallis test and Dunn's multiple comparison test between CPUE of otter trawl collections for each season.

Group	N	Median	Mean Rank	Z-Value
Winter	36	14.6604	55.6	1.04
Spring	32	2.5667	39.5	-2.77
Summer	34	15.0273	58.4	1.67
Overall	102		51.5	

Null hypothesis: H_0: All medians are equal

Alternative hypothesis: H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	2	7.82	0.020
Adjusted for ties	2	7.82	0.020

Table of P-values (adjusted for ties)

	Winter	Spring	Summer
Winter	1.00000	*	*
Spring	0.02477	1.00000	*
Summer	0.69515	0.00946	1

Comparisons: 3
Ties: 1
Family Alpha: 0.017
Bonferroni Individual Alpha: 0.006
Bonferroni Z-value (2-sided): 2.773

Table 123. Results of Kruskal-Wallis test and Dunn's multiple comparison test between CPUE of otter trawl collections for each flow tier.

Group	N	Median	Mean Rank	Z-Value
Avg-Sub	20	18.3139	62.3	1.81
Avg-Base	12	3.9433	45.3	-0.77
Avg-3ps	16	2.2667	33.1	-2.71
Wet-2ps	12	5.1060	49.9	-0.20
Wet-Sub	18	23.2911	68.2	2.64
Wet-Base	24	4.7722	46.1	-1.02
Overall	102		51.5	

Null hypothesis	H_0: All medians are equal
Alternative hypothesis	H_1: At least one median is different

Method	DF	H-Value	P-Value
Not adjusted for ties	5	15.91	0.007
Adjusted for ties	5	15.91	0.007

Table of P-values (adjusted for ties)

	Avg-Sub	Avg-Base	Avg-3ps	Wet-2ps	Wet-Sub	Wet-Base
Avg-Sub	1.00000	*	*	*	*	*
Avg-Base	0.11741	1.00000	*	*	*	*
Avg-3ps	0.00334	0.27995	1.00000	*	*	*
Wet-2ps	0.25365	0.70437	0.13726	1.00000	*	*
Wet-Sub	0.53443	0.03792	0.00056	0.09690	1.00000	*
Wet-Base	0.07186	0.93968	0.17342	0.71702	0.01661	1

Comparisons:	15
Ties:	1
Family Alpha:	0.083
Bonferroni Individual Alpha:	0.006
Bonferroni Z-value (2-sided):	2.773