Ecosystem-Based Approach to Assess Black Drum in Baffin Bay

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Interim Technical Report

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Executive Summary

The Black Drum, *Pogonias cromis*, is a large-bodied sciaenid fish species of both recreational and commercial importance to the Texas coastal-bend. In 2012, a large proportion of Black Drum landed by both recreational and commercial fisheries in the Baffin Bay estuary exhibited abnormal physical characteristics. These included below average weights, transparent tissue morphology, and empty guts. Following the design of previous studies in the Baffin Bay estuary, we reinstituted a standardized benthic sampling program to understand the spatial and temporal patterns in the abundance of potential Black Drum prey (i.e., benthic invertebrates) (Objective 1). To examine Black Drum reliance on these potential resources and spatial variability in trophic role, the research group conducted comparative diet analyses from specimens collected from Baffin Bay and adjacent areas (Objective 2). The final component of this project examined movement patterns of Black Drum (e.g., fidelity to Baffin Bay) and how they relate to the environmental regime. Twenty-five Black Drum were fitted with coded acoustic transmitters and tracked across receiver arrays deployed in Baffin Bay and adjacent water bodies (Objective 3). Coupled with a concurrent, spatially explicit water quality study in Baffin Bay, the project attempted to integrate fine-scale environmental monitoring with tracking data and build a comprehensive picture of ecosystem dynamics in the Baffin Bay system. Benthic sampling efforts revealed spatial density and biomass gradients in potential Black Drum prey, with both parameters apparently increasing towards the extremities of all three “arms” that empty into this system. Stomach content analysis revealed heavy reliance of Black Drum on many of these food sources, with particularly strong affinity for bivalve species such as the pointed venus clam, *Anomalocardia auberiana*, and the dwarf surf clam, *Mulinia lateralis*. Acoustic telemetry monitoring data showed that Black Drum exhibit relatively high mobility and do not appear constrained to a single sub-embayment or arm within this ecosystem. However, we also observed potential egress in at least three individuals, which indicates that the residency and fidelity to this water body may be variable in this species. Additional acoustic downloads this spring (2015) should shed further light on the importance of the Baffin Bay complex to Black Drum. In summary, our ecosystem-based approach has allowed us to develop a more comprehensive understanding of trophic linkages between benthic communities and an important regional fishery. Our continued monitoring efforts will allow us to examine further temporal impacts on these dynamics in the upcoming year.

Introduction

The Black Drum, *Pogonias cromis*, is a large-bodied sciaenid fish species that occurs throughout warm-temperate to subtropical estuaries in the northwest Atlantic Ocean, including the Gulf of Mexico (Leard et al. 1993). In Texas, Black Drum are an important commercial and recreational fish species. In 2010 alone, ~1.7 million pounds of Black Drum were landed in Texas, valued (ex-vessel) at ~$1.6 M, second only to Red Snapper (TPWD 2012). Despite this species' wide distribution and important fishery status, the ecology of Black Drum remains poorly characterized in the vast majority of its range, particularly along the Texas coast.

Black Drum are known to be primarily benthic, aggregating around a variety of bottom habitats such as seagrass, oyster reef, sand and mud bottoms (Leard et al. 1993). In these habitats, Black Drum diet varies ontogenetically, with smaller individuals preferring crustaceans and worms and larger individuals consuming large, hard-shelled mollusks such as eastern oyster, *Crassostrea virginica* (Leard et al. 1993). Due to their ability to impact oyster communities via predation, a considerable amount of research has been devoted to methods of deterring Black Drum from oyster lease areas off Louisiana (Brown et al. 2003, Brown et al. 2006) including studies of Black Drum feeding effects and fine-scale habitat use (George 2007, Brown et al. 2008). Unfortunately, despite the rather ubiquitous nature of this species, there have been no studies of Black Drum movement behavior in other habitats (sand and mud bottoms) or over large spatial scales (>10 km^2). As such, the factors explaining Black Drum spatial distributions (aside from oyster density) remain unknown, though studies of this type are sorely needed (Brown et al. 2008).

The Baffin Bay Complex (BBC, **Fig. 1**; comprising Baffin Bay, Alazan Bay, Cayo De Grullo, and Laguna Salada) and Upper Laguna Madre (ULM) appear to support some of the highest catches of Black Drum throughout Texas bay systems, with abundances steadily increasing since the 1980's and saturating over the last decade (TPWD, unpublished data; **Fig. 2**). However, in 2012, a large proportion of Black Drum landed by both recreational and commercial fisheries have exhibited abnormal physical characteristics. These include below average weights, transparent tissue morphology, and empty guts (Grubbs et al. 2013).

Figure 1. Map of the Baffin Bay Complex

The factors explaining the current condition of Black Drum in the BBC is an area of active debate. However, many researchers agree that these abnormal characteristics are due to some degree of resource limitation. For example, the saturating trend in abundance patterns in the nearby ULM may be indicative of the population reaching its carrying capacity. With few predators to control Black

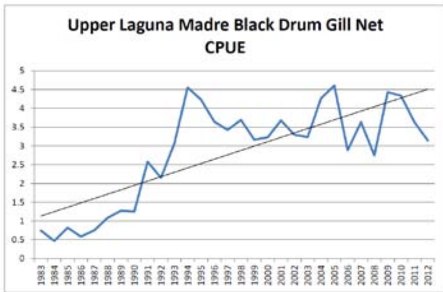

Figure 2. Black Drum catch per unit effort (fish/net/hr) from TPWD gillnet surveys (1983-present).

Drum populations in the hypersaline waters of the ULM and demonstrated fidelity of Black Drum to specific embayments elsewhere (Osburn & Matlock 1984), this species may have reached maximum abundance in this protected water body. Alternatively, or perhaps coincidentally, altered water quality may have played a large role in reducing populations of Black Drum food resources or accessibility to these resources. For example, intermittent hypoxia, which has been noted in Baffin Bay in recent years, can concentrate demersal sciaenid fish in suboptimal (prey-deficient) habitats, thus reducing overall carrying capacity (Eby et al. 2005). In the BBC, populations of dwarf surf clam (*Mulinia lateralis*), a potentially major prey item of Black Drum (Breuer 1962, Simmons & Breuer 1962, Martin 1979), have not been assessed in nearly a decade. However, anecdotal evidence suggests major unpredicted die-offs of surf clams in recent years (**Fig. 3**) that may be related to deteriorating water quality conditions, and which may have led to sub-lethal effects on Black Drum. These findings clearly indicated a need for a comprehensive multi-trophic level study in the BBC as there are potentially strong linkages between water quality of this system and Black Drum condition. This need was supported by the Texas Parks and Wildlife Department (TPWD), who in their report on the “Emaciated Black Drum Event” made the following recommendation: “Additional information on the current status of the benthic community, including *M. lateralis,* in Baffin Bay as well as gut content or tissue analysis (elemental or stable isotope) of *P. cromis* could be beneficial in further tracking the impact of a potential decline in food sources or an ecosystem-wide trophic shift in its feeding mode of the species” (Grubbs et al. 2013). Initial seed funding for very limited preliminary assessment work (via Coastal Bend and Bays Estuaries Program) allowed us to test the feasibility of conducting benthic sampling and acoustic telemetry in this region and its applicability to Black Drum. Funding from Sea Grant will allow us to expand our initial work that is temporally/spatially restricted to a more comprehensive ecosystem-based approach over multiple seasons and years. This support will allow us to develop a concrete understanding of the linkages between water quality, benthic invertebrates, and Black Drum ecology in the BBC. Our working hypothesis was that Black Drum exhibit strong fidelity to the BBC and prefer feeding on *M. lateralis*, which in turn exhibit distribution patterns related to the local environmental regime and water quality conditions.

Figure 3. Shell remnants of dwarf surf clams along the Baffin Bay shoreline 2012. (photo: S. Murray)

Methods

Following the design of previous work by Dr. Paul Montagna and guidance from the Texas Parks and Wildlife Department, we reinstituted a standardized benthic sampling program to understand the spatial and temporal patterns in the abundance of potential Black Drum prey (i.e., benthic invertebrates) across Baffin Bay (Objective 1). To examine Black Drum reliance on these potential resources and spatial variability in trophic role, the research group conducted comparative diet analyses from specimens collected from Baffin Bay and adjacent areas (Objective 2). The final component of this project examined movement patterns of Black Drum (e.g., fidelity to Baffin Bay) and how they relate to the environmental regime. Twenty-five Black Drum were fitted with coded acoustic transmitters and tracked across receiver arrays deployed in Baffin Bay and adjacent water bodies (Objective 3). To do this, an existing acoustic array deployed throughout the coastal bend was modified to examine Black Drum fidelity to Baffin Bay and potential connectivity with other embayments. Coupled with a concurrent, spatially explicit water quality study by Dr. Mike Wetz in Baffin Bay, the project attempted to integrate fine-scale environmental monitoring with tracking data and build a comprehensive picture of ecosystem dynamics in the Baffin Bay system.

Benthic Sampling

Seasonal benthic surveys of bio-indicating benthic communities were conducted to determine the distribution and abundance of potential infaunal prey items for Black Drum in Baffin Bay. Currently the TPWD conducts seasonal trawl surveys in this region, but buried infauna (e.g., *M. lateralis*) are generally not susceptible to this gear type. The plan was therefore to use cores to assess populations of these benthic species across the Baffin Bay complex (BBC).

Ten uniformly spatially distributed sampling stations were sampled from March - December of 2014 (**Fig. 4**). Actual dates included 3/20/2014 (this trip was conducted using Harvey Weil funds), 6/11/2014, 7/16/2014, 9/10/2014, and 12/10/2014. Stations were distributed along this gradient to allow for spatial interpolation of invertebrate abundance and spatial distribution patterns in ArcGIS (ESRI, Inc.). Six of these sites were surveyed previously from 1989 to 1993 by Montagna et al. (1993) and Street et al. (1997) and are currently being surveyed by Texas A&M University-Center for Coastal Studies with the resumption of the Regional Coastal Assessment Program (RCAP) sampling plan across multiple water bodies of the coastal-bend area. The goal was to supplement this coverage with more focused sampling within the BBC to answer more system-specific questions on finer spatial and temporal scales. On each benthic sampling date, hydrographic measurements (salinity, temperature, dissolved oxygen, and pH) were taken at the water surface and 10 cm from the bay floor at each station and benthic macrofauna were collected for assessments of abundance and diversity. In the laboratory, organisms were extracted on a 0.5 mm sieve, sorted using a stereo microscope, identified to the lowest practical identifiable level (usually species), and enumerated. Biomass measurements were obtained after combining individual macrofauna into higher taxa levels (Crustacea, Mollusca, Polychaeta, and others), dried at 55 °C for 24 h, and then weighed. Mollusk shells were removed with 1 N HCl prior to drying and weighing.

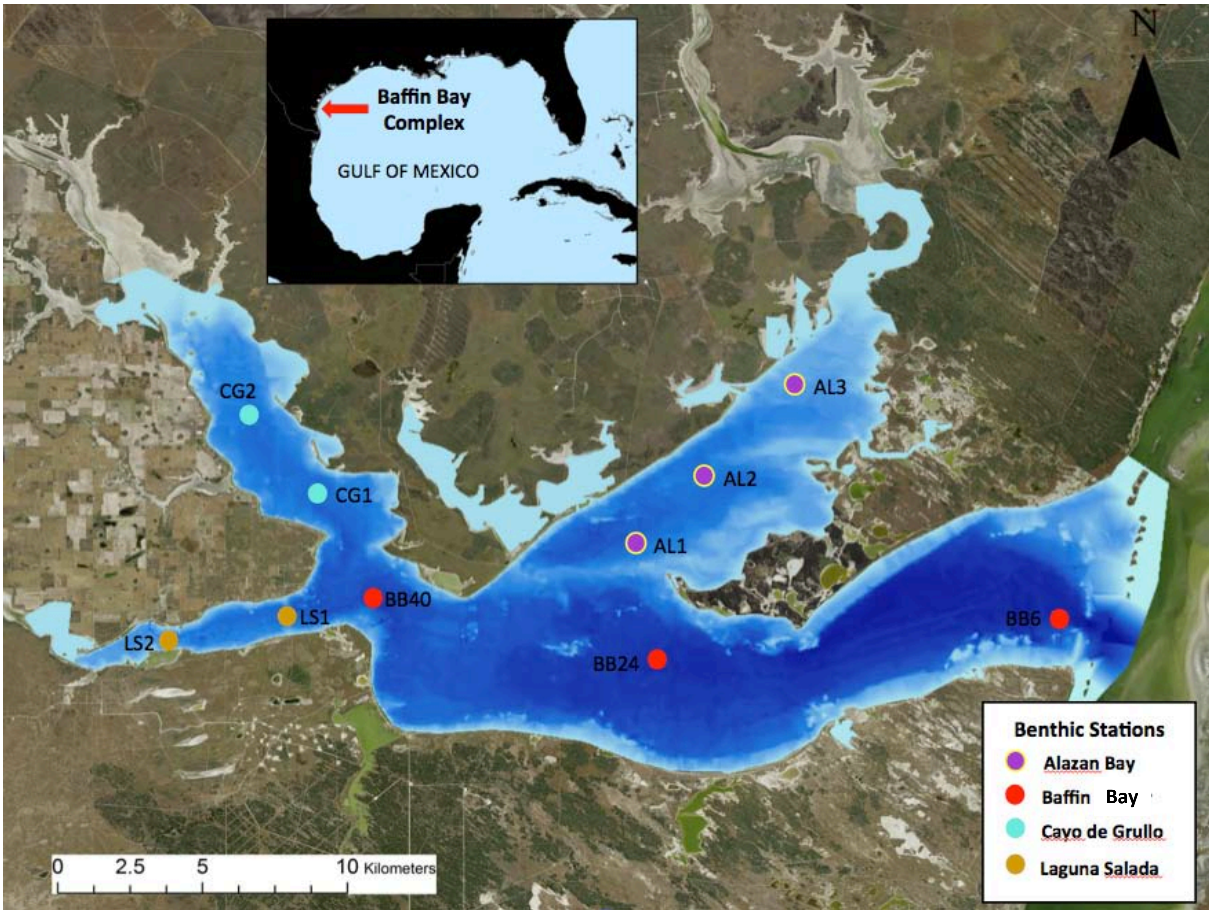

Figure 4. Map of the Baffin Bay Complex with benthic coring stations. Stations are color-coded by arm.

Gut Content and Stable Isotope Analysis

We collected 138 Black Drum carcasses opportunistically from the TPWD and commercial and recreational fishermen during spring 2014 for trophic analyses. Whole digestive tracts were removed beginning with the esophagus ending with the anal vent. Excised digestive tracts were fixed in solutions of 10% formalin. After a 48 hr fixation period, tracts were transferred to jars with 70% ethanol until further processing. Categories of prey items were determined for presence, classified to the lowest possible taxonomic level, enumerated (if possible), weighed, and recorded on the appropriate form.

Epaxial muscle tissue samples for carbon and nitrogen stable isotope analysis were removed from the anterior portion of the fish fillet using a clean stainless steel scalpel and rinsed with deionized water between each sample. Tissue samples were placed in individual WhirlPak® bags and stored at -80 °C until further analysis. A subset of these muscle tissue samples were selected to represent the size class of the main fish cohort collected. Individual samples were homogenized with a ball-mill grinder or mortar and pestle and stored in clean glass scintillation vials in preparation for chemical analysis in an external laboratory.

<u>Acoustic Telemetry</u>

In 2014, 25 Black Drum were surgically implanted with Vemco V13 coded acoustic tags between 23-April and 20-May. All individuals were tagged and released at the capture location. While we successfully released tagged individuals from all major arms of the BBC, we had the greatest success in Alazan Bay (n=17). Additional tagged animals were released from Cayo De Grullo (n=3), Baffin Bay (n=3), and Laguna Salada (n=2). No animals died during surgery, and all swam off without any major struggle.

An array of 15 moored acoustic receivers (Vemco VR2W) was deployed throughout the BBC to remotely monitor movements and distribution of these tagged individuals (**Fig. 5**). Due to the large size of the BBC, the array was positioned in a broad format to maximize coverage. An additional array of acoustic receivers was in place in several regions outside of BBC to monitor individuals that leave the system and thus examine the connected nature of the BBC and other water bodies along the south Texas coast. This broader scale array, the Texas Acoustic Array Network (TEXAAN), had the ability to track animals on the order of 100s of kilometers if necessary. A data download of the BBC passive monitoring array (i.e., 15 receiver stations) was conducted with CBBEP Staff (R. Martinez) on 8/5/2014.

Table 1. Location and capture information for 25 Black Drum fitted with acoustic transmitters. LAT/LON = Latitude/Longitude (decimal degrees). Collection Gear types; GN = gillnet, HL = hook-and-line. TL = total length in millimeters, W = weight in kilograms. Embayment codes: AL = Alazan Bay, BB = Baffin Bay, CG = Cayo De Grullo, LS = Laguna Salada.

DATE	LAT	LON	Collection_Gear	TL_mm	W_kg	Acoustic_ID	Dart_TagID	Embayment
4/23/2014	27.369	-97.497	GN	538	2.2	16456	1951	AL
4/23/2014	27.369	-97.497	GN	505	1.7	16457	1990	AL
4/23/2014	27.369	-97.497	GN	460	1.4	16458	1974	AL
4/23/2014	27.369	-97.497	GN	375	0.7	16459	1973	AL
4/23/2014	27.341	-97.529	GN	476	1.4	16460	1972	AL
4/23/2014	27.295	-97.548	HL	362	0.7	16465	1971	AL
4/23/2014	27.295	-97.548	GN	478	1.75	16464	1970	AL
4/24/2014	27.264	-97.728	GN	514	2.3	16463	1969	LS
4/25/2014	27.233	-97.536	GN	367	0.75	16466	1968	BB
4/25/2014	27.233	-97.536	GN	461	1.5	16462	1967	BB
4/25/2014	27.233	-97.536	GN	347	0.7	16461	1981	BB
5/14/2014	27.263	-97.728	GN	372	0.7	16467	1988	LS
5/15/2014	27.386	-97.487	HL	369	0.75	16468	1987	AL
5/15/2014	27.386	-97.487	HL	418	1	16469	1982	AL
5/15/2014	27.386	-97.487	HL	391	0.85	16470	1986	AL
5/15/2014	27.373	-97.497	GN	412	1.1	16471	1983	AL
5/15/2014	27.373	-97.497	GN	371	0.8	16472	1966	AL
5/15/2014	27.373	-97.497	GN	351	0.6	16473	1984	AL
5/15/2014	27.373	-97.497	GN	354	0.7	16474	1985	AL
5/15/2014	27.373	-97.497	GN	375	0.75	16475	1952	AL
5/15/2014	27.374	-97.705	GN	888	11.1	16476	1965	CG
5/15/2014	27.374	-97.705	GN	345	0.75	16477	1964	CG
5/15/2014	27.377	-97.709	HL	370	0.7	16478	1963	CG
5/20/2014	27.355	-97.486	GN	489	1.75	16479	1953	AL
5/20/2014	27.334	-97.485	GN	382	0.75	16480	1954	AL

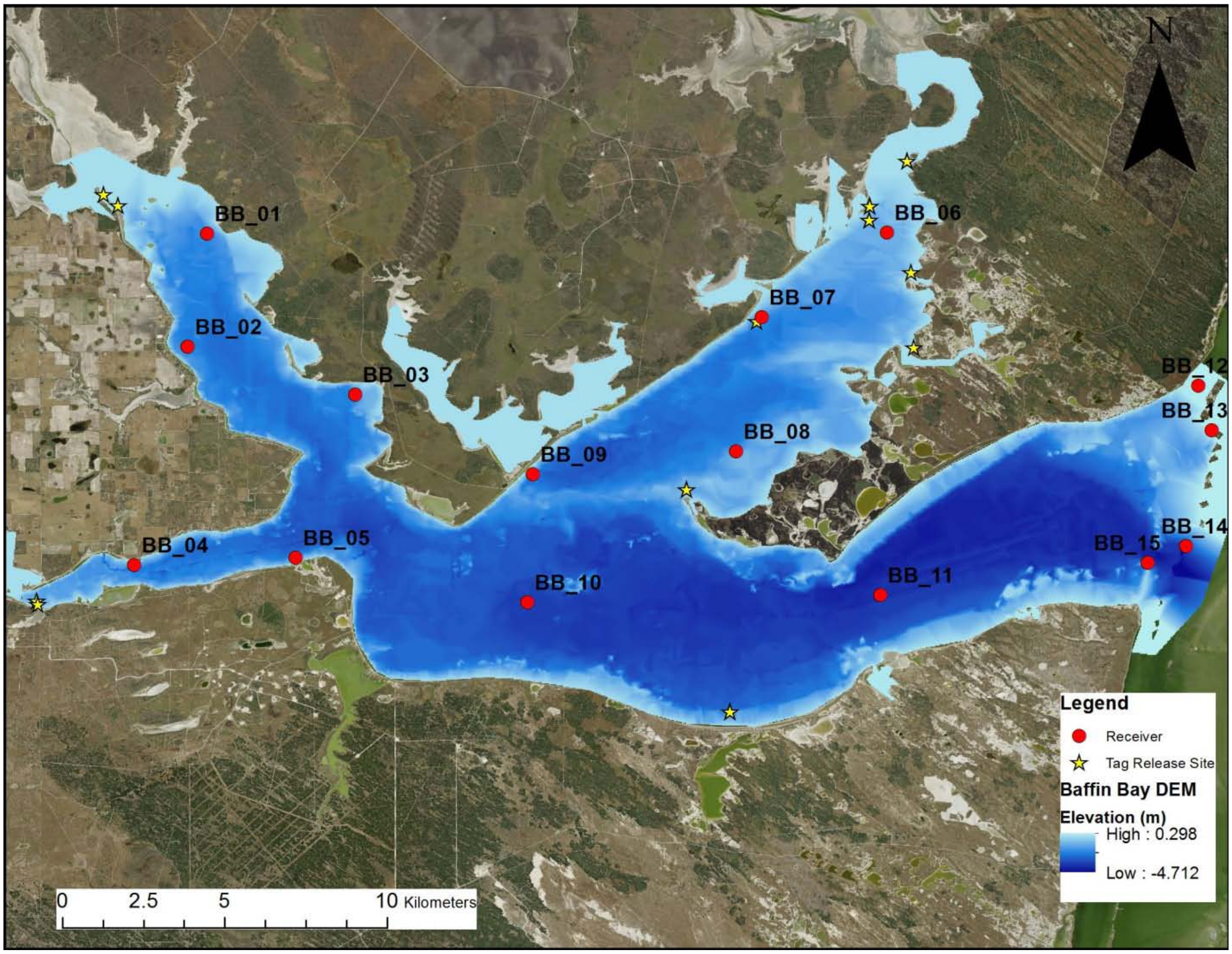

Figure 5. Map of the Baffin Bay Complex showing location of acoustic receivers (red circles) and release sites for acoustically tagged fish (yellow stars).

The passive acoustic monitoring array was supplemented with opportunistic active tracking surveys. These surveys involved the attachment of a Vemco mobile transceiver (VMT) to Dr. Mike Wetz's Autonomous Underwater Vehicle (AUV) during his concurrent fine-scale water quality surveys. These AUV-based active tracking surveys would allow the research team to understand the relationship between Black Drum fine-scale habitat use and the environmental regime of the BBC. The AUV logged position at the surface using an onboard GPS unit and estimated locations at depth using "dead-reckoning" techniques. Thus, using the synchronized timestamp between the AUV and VMT, all tag detections could be accompanied by water quality and position information. However, the two tracking days dedicated to these active telemetry efforts (9/8/2014, 9/25/2014) yielded no tag detections in the areas surveyed (center axis of Alazan Bay, junction between Laguna Salada and Cayo De Grullo). As such, we do not have sufficient active tracking data to analyze for this report.

Results

Water Quality Monitoring

Dr. Mike Wetz's group collected and shared monthly water quality data from the following dates: 3/19/2014, 4/16/2014, 5/16/2014, 6/27/2014, 7/17/2014, 8/14/2014, 9/26/ 2014, 10/16/2014, 11/20/2014, and 12/18/2014. This data set documented spatial (Table 2) and temporal (Figure 6) heterogeneity in the environmental conditions of the Baffin Bay Complex in 2014. With all samples pooled (March – December 2014), the upper reaches and western half of the system (BB1-BB6) generally exhibited saltier conditions, higher turbidities, higher dissolved oxygen levels, and higher concentrations of chlorophyll a than the eastern third of the bay adjacent to the Upper Laguna Madre (BB7-9). This disparity was most apparent between these two major regions during the months of May – September in 2014. Temperature and dissolved oxygen levels appeared to be generally stable across sites, although both parameters were strongly correlated with time of year, with maximum temperatures and minimum dissolved oxygen levels both occurring in August. The coolest temperatures and maximum dissolved oxygen levels occurred in November. Variation in pH had no clear pattern with season, although elevated values were often observed at BB1 and BB2 relative to other sites.

Table 2 – Summary of the environmental conditions by site (mean values) over the project period (March – December 2014).

Station	Name	LAT	LON	Chl a (mg/L)	Salinity (ppt)	DO (mg/L)	pH	Temp (Deg C)	Turbidity (NTU)
BB 1	Drum Point (Cayo del Grullo)	27.368	-97.702	25.7	50.1	6.1	8.3	22.9	29.9
BB 2	Site 55 (Laguna Salada)	27.269	-97.723	30.1	54.3	5.4	8.3	22.9	17.6
BB 3	Marker 36	27.277	-97.625	26.3	50.8	5.6	8.2	23.1	23.3
BB 4	Alazan mouth	27.277	-97.582	26.7	50.4	5.7	8.1	23.2	23.9
BB 5	Petronilla (Alazan)	27.353	-97.515	23.1	51.4	5.7	8.1	23.1	32.2
BB 6	Marker 14	27.266	-97.494	25.6	48.2	5.4	8.2	22.8	12.2
BB 7	South mouth	27.265	-97.420	14.5	43.0	5.8	8.2	22.9	8.4
BB 8	Middle mouth-Marker 2	27.278	-97.413	17.5	44.2	5.8	8.2	23.0	7.2
BB 9	North mouth	27.320	-97.410	20.0	44.0	5.5	8.1	22.5	12.5
			Grand Mean	**23.3**	**48.5**	**5.7**	**8.2**	**22.9**	**18.6**

Figure 6 – Time-series scatter plots of the environmental conditions in Baffin Bay over the project period. Data provided by M. Wetz.

Benthic Sampling

Benthic cores at the ten predetermined sites have been processed for the 2014 spring and summer seasons. In terms of macrofaunal abundance, benthic cores were dominated by polychaete worms, with cores from AL2 and AL3 having the highest abundance of all sites. There was a general trend of increasing macrofaunal abundance moving from Baffin Bay upstream into each BBC arm (**Fig. 7**). A similar increasing trend was seen in macrofauna biomass measurements (**Fig. 8**). Mollusks (gastropods, bivalves, and others) were dominant in terms of overall biomass, with stations CG2 and LS2 having the highest macrofaunal biomass. Of the ten surveyed sites, both Cayo de Grullo sites contain the highest *Mulinia lateralis* abundance per square meter (**Fig. 9**).

Table 3 displays the variety of species and taxonomic groups that have been found at each station. Currently, species of regular occurrence (>6 stations) over both seasons include *Acteocina canaliculata*, *Eulimastoma harbisonae*, *Mulinia lateralis*, and *Streblospio benedicti.* Station AL3 has the highest diversity, having identified ten different macrofauna species.

Combination of benthic macrofauna into higher taxonomic levels reveals overall core composition being dominated by Bivalvia (44.7%) and other mollusks, predominantly gastropods (40.9%) (Figure 10) across all benthic survey sites and both spring and summer seasons. Identifiable organisms in the 'Bivalvia' class include *Mulinia lateralis*, *Macrotoma fragilis*, and *Anomalocardia auberiana*. The 40.9% 'Other Mollusca' phylum includes *Anomalocardia canaliculata*, *Bittiolum varium*, *Mitrella lunata*, *Fargoa gibbosa*, *Eulimastoma harbisonae*, *Rissoella galba*, and *Eulimastoma didyum*. 'Polychaeta' includes the families Orbiniidae, Nereididae, and Phyllodocidae, and the species *Streblospio benedicti* and *Scoloplos foliocis*. 'Crustacea's 0.5% is composed of the order Amphipoda, and species *Hargeria rapax* and *Sphaeroma terebrans*. 'Other' taxa identified include insects.

The EPA benthic condition index for northern Gulf of Mexico estuaries (Engle and Summers 1999) has yet to be used to characterize the community, as proposed in the project QAPP. This index will yield the most information when a complete year of sampling encompassing all four seasons has occurred.

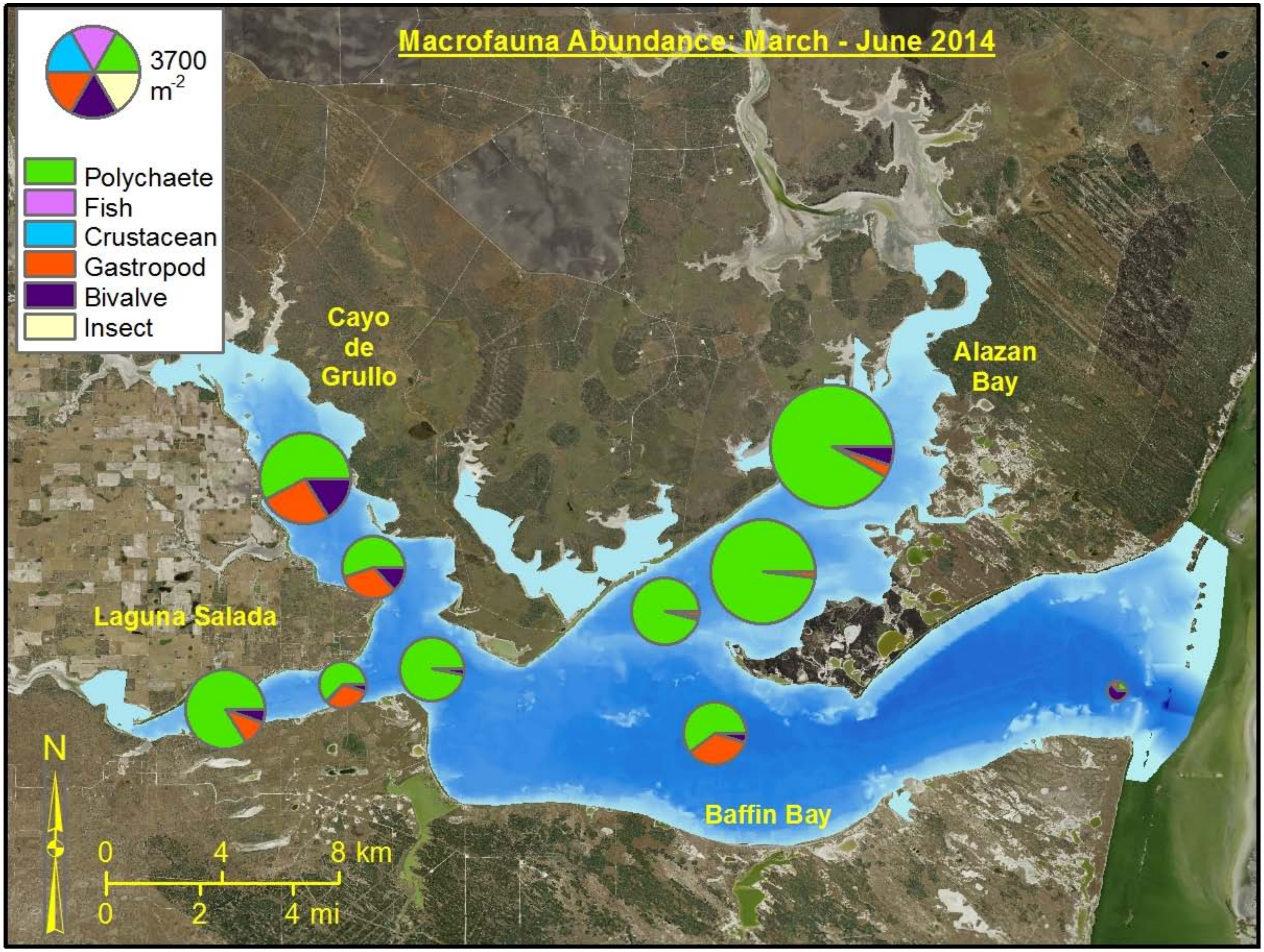

Figure 7. Map of macrofaunal abundance (m^{-2}) by station (includes top 10 cm).

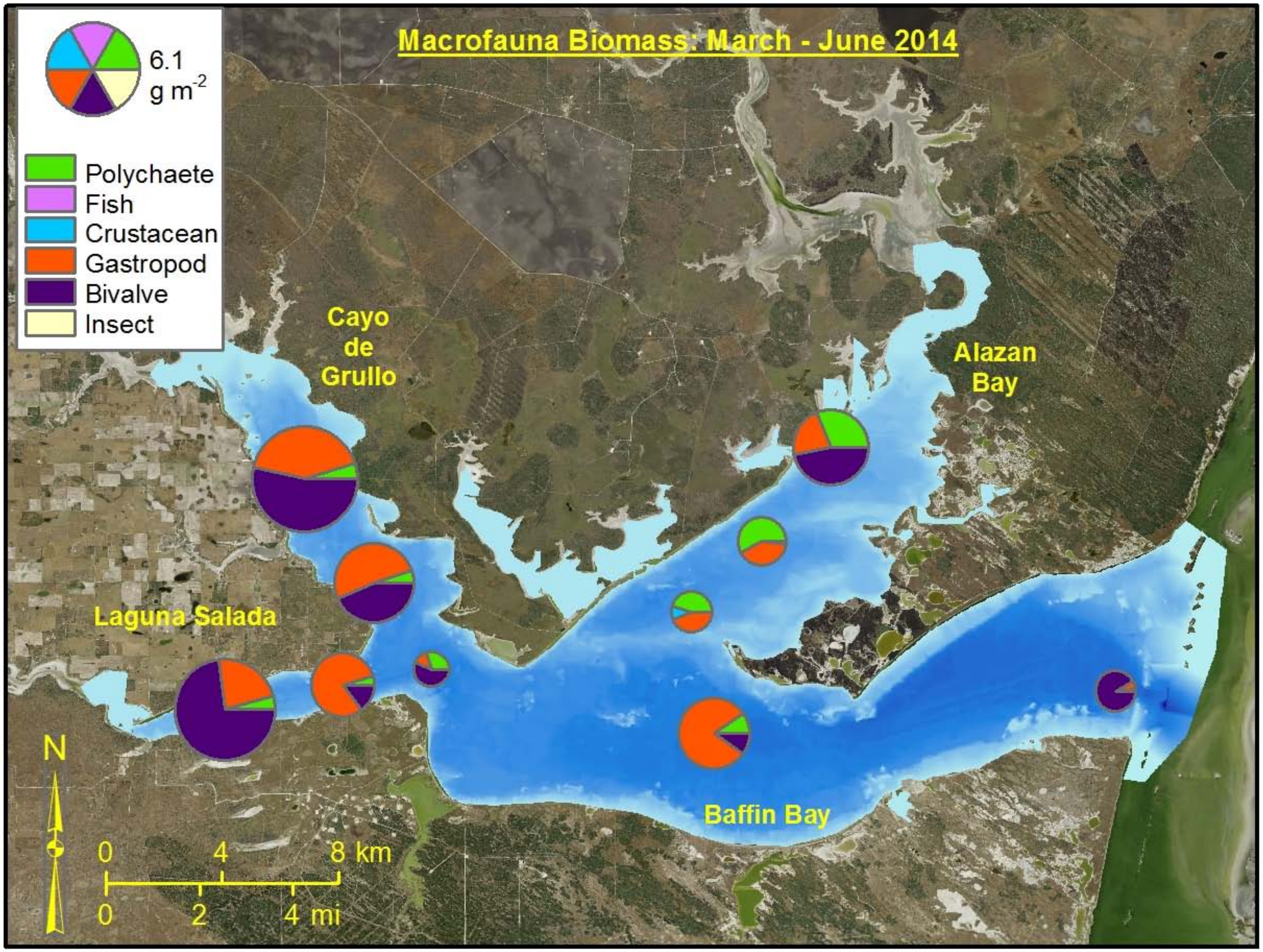

Figure 8. Map of macrofauna biomass (g m^{-2}) by station (includes top 10 cm).

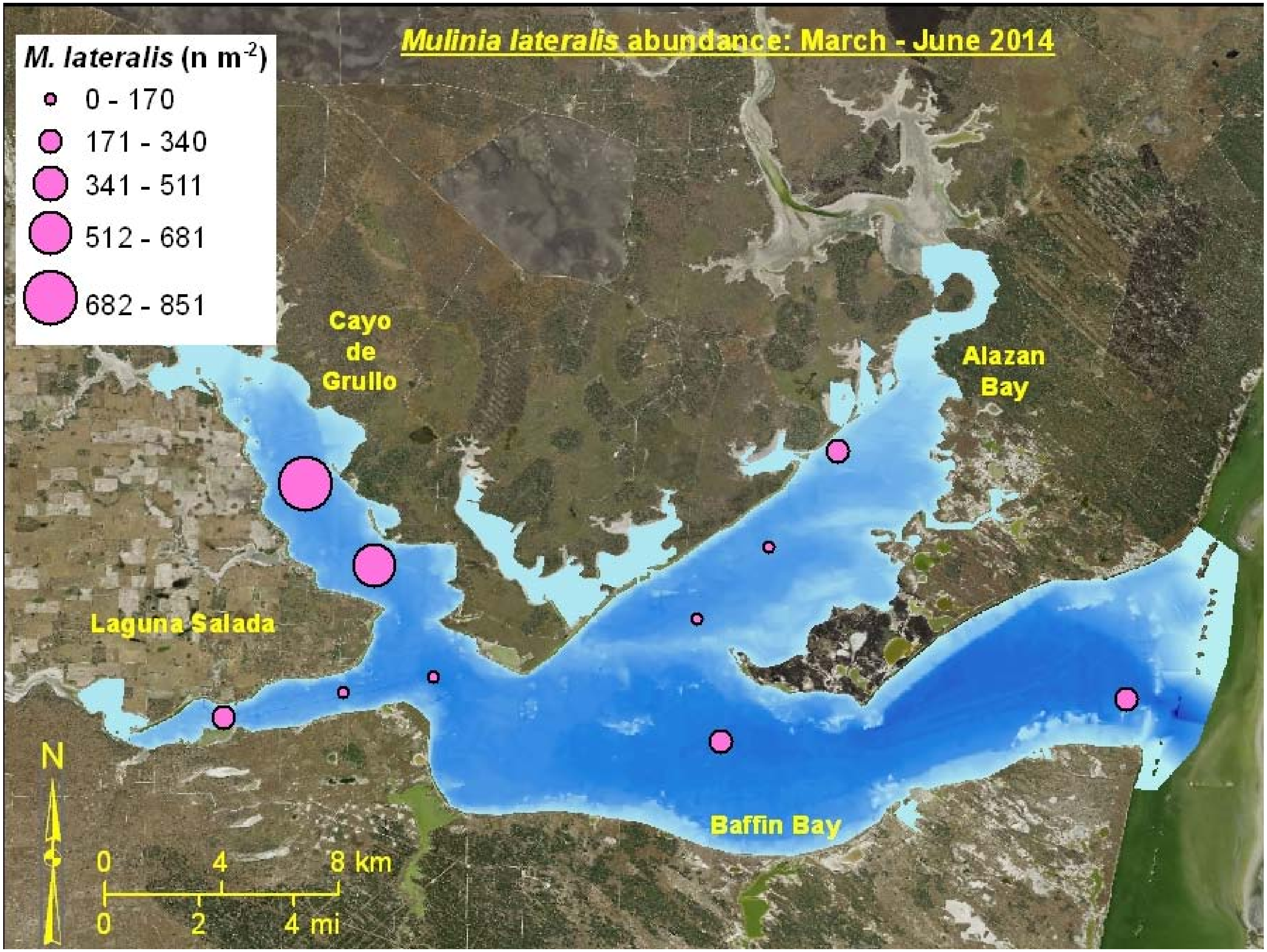

Figure 9. Map of *Mulinia lateralis* abundance (m^{-2}) by station (includes top 10 cm).

Table 3. Presence and absence of different taxonomic groups found in benthic cores across all survey sites in both spring and summer seasons.

	STATION									
TAXA IDENTIFIED	**AL1**	**AL2**	**AL3**	**BB24**	**BB40**	**BB6**	**CG1**	**CG2**	**LS1**	**LS2**
ACTEOCINA CANALICULATA		X	X	X	X		X	X	X	X
AMPHIPODA			X	X					X	X
ANOMALOCARDIA AUBERIANA			X					X		X
BITTIOLUM VARIUM										X
EULIMASTOMA DIDYMUM								X		
EULIMASTOMA HARBISONAE	X	X	X	X		X	X	X		X
FARGOA GIBBOSA										X
FISH EGG	X									
HARGERIA RAPAX	X		X							
INSECTA						X				
MACTROTOMA FRAGILIS								X	X	
MITRELLA LUNATA	X			X						
MULINIA LATERALIS		X	X	X	X	X	X	X	X	X
NEREIDIDAE SPP.							X			
ORBINIIDAE SPP.			X							
PHYLLODOCIDAE			X							
RISSOELLA GALBA			X	X					X	
SCOLOPLOS FOLIOCIS						X				
SPHAEROMA TEREBRANS	X									
SPHAEROMA TEREBRANS							X			
STREBLOSPIO BENEDICTI	X	X	X	X	X	X	X	X	X	X

Gut Content Analysis

Of the 138 Black Drum collected for stomach content analysis, 86 individuals had stomachs with content and 51 individuals had identifiable stomach contents. These fish were primarily collected from TPWD gillnet surveys in the Baffin Bay Complex conducted from March to May, 2014. The fish examined represented a relatively broad range in sizes (183-605 cm Total Length), but were mainly centered on a size targeted by both recreational and commercial fisheries (mean = 359 mm Total Length). These individuals came from Alazan Bay (n=17), the junction of Alazan and Cayo De Grullo (n=5), Baffin Bay Proper (n=20), Cayo De Grullo (n=3), and Laguna Salada (n=6).

Polychaetes were the most often occurring prey group recognized in the stomach contents across sites. Bivalves were similarly encountered with high frequency (>70% occurrence) in the gut contents from all sites (Table 4). The most conspicuous and common bivalve that could be identified from the gut contents was *Anomalocardia auberiana*, followed by *Mulinia lateralis*. Despite being encountered in the greatest densities in Cayo De Grullo from benthic sampling, there was no evidence of *M. lateralis* consumption from animals collected in this region. However, sample size from this area was also extremely low (n = 3). Gastropods were generally observed in <20% of the stomach samples from across sites, with the only positively identified species being *Rissoina punctostriata*. Crustaceans were encountered with substantially lower frequency, though were relatively common in stomach samples from Baffin Bay proper (35%). Crustacean taxa observed included amphipods, xanthid crabs, and pericaridean and tanaid shrimps. Crustaceans contributed very little to the diet in terms of biomass (<1%). Seagrass was found in the stomach samples of 11 individuals, though we speculate this was incidentally consumed while foraging for benthic invertebrates. Stomachs generally consisted of approximately 50% of visually unidentifiable material.

Table 4. Dietary data of Black Drum showing frequency of occurrence and proportional weight of various taxonomic groups consumed. Data are presented by site (column) and codes include: Alazan Bay (AL), Alazan-Cayo de Grullo junction (AL/CG), Baffin Bay Proper (BB), Cayo De Grullo (CG), and Laguna Salada (LS).

		Site				
Parameter		**AL**	**AL/CG**	**BB**	**CG**	**LS**
	Sample Size	17	5	20	3	6
Frequency of Occurrence	**Taxon**					
	BIVALVIA	0.71	0.80	0.70	1.00	0.83
	Anomalocardia auberiana	0.41	0.80	0.55	0.67	0.67
	Mulinia lateralis	0.29	0.80	0.35	0.00	0.33
	Nuculaena acuta	0.00	0.20	0.00	0.00	0.00
	GASTROPODA	0.12	0.20	0.15	0.00	0.17
	Rissoina punctostriata	0.06	0.20	0.00	0.00	0.00
	OTHER MOLLUSCA	0.24	0.20	0.10	0.00	0.00
	POLYCHAETA	0.82	1.00	0.60	1.00	0.83
	CRUSTACEA	0.06	0.00	0.35	0.00	0.17
	Pericaridea	0.00	0.00	0.20	0.00	0.00
	Amphipoda	0.06	0.00	0.10	0.00	0.17
	Xanthidae	0.00	0.00	0.05	0.00	0.00
	Tanaidacea	0.00	0.00	0.05	0.00	0.00
	SEAGRASS	0.12	0.40	0.20	0.33	0.33
Proportional Weight	**Taxon**					
	BIVALVIA	0.76	0.79	0.83	0.91	0.83
	Anomalocardia auberiana	0.06	0.04	0.03	0.07	0.04
	Mulinia lateralis	0.01	0.00	0.02	0.00	0.06
	Nuculaena acuta	0.00	0.00	0.00	0.00	0.00
	GASTROPODA	0.01	0.00	0.00	0.00	0.00
	Rissoina punctostriata	0.00	0.01	0.00	0.00	0.00
	OTHER MOLLUSCA	0.06	0.15	0.06	0.00	0.00
	POLYCHAETA	0.08	0.00	0.01	0.00	0.05
	CRUSTACEA	0.01	0.00	0.01	0.00	0.00
	Amphipoda	0.01	0.00	0.00	0.00	0.00
	Xanthidae	0.00	0.00	0.00	0.00	0.00
	Pericarida	0.00	0.00	0.00	0.00	0.00
	Tanaidacea	0.00	0.00	0.00	0.00	0.00
	SEAGRASS	0.00	0.00	0.01	0.01	0.02

A comparison of prey biomass (higher taxonomic categories) in cores (**Fig. 10**) versus prey biomass in the diet (**Fig. 11**) revealed that Black Drum appeared to generally consume benthic prey items proportional to their availability. However, there is certainly a slightly stronger bivalve component to the diet than would be expected via availability. Unfortunately, there was a large portion of unidentified mollusks

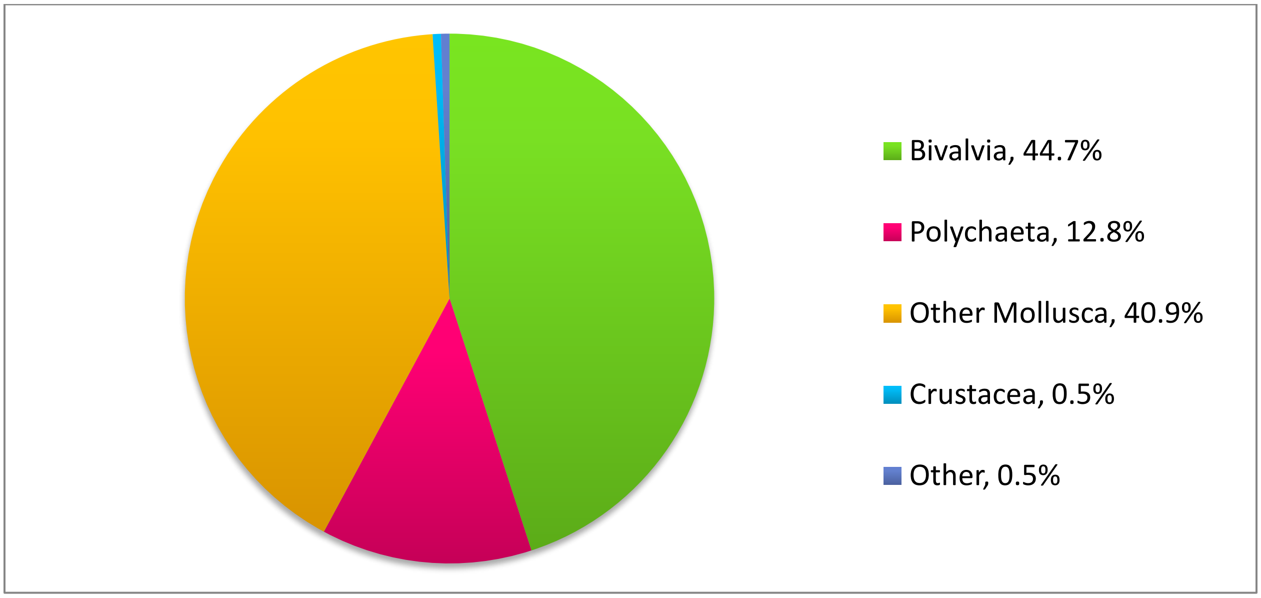

Figure 10. Pie chart of overall benthic taxa composition (by weight) in cores.

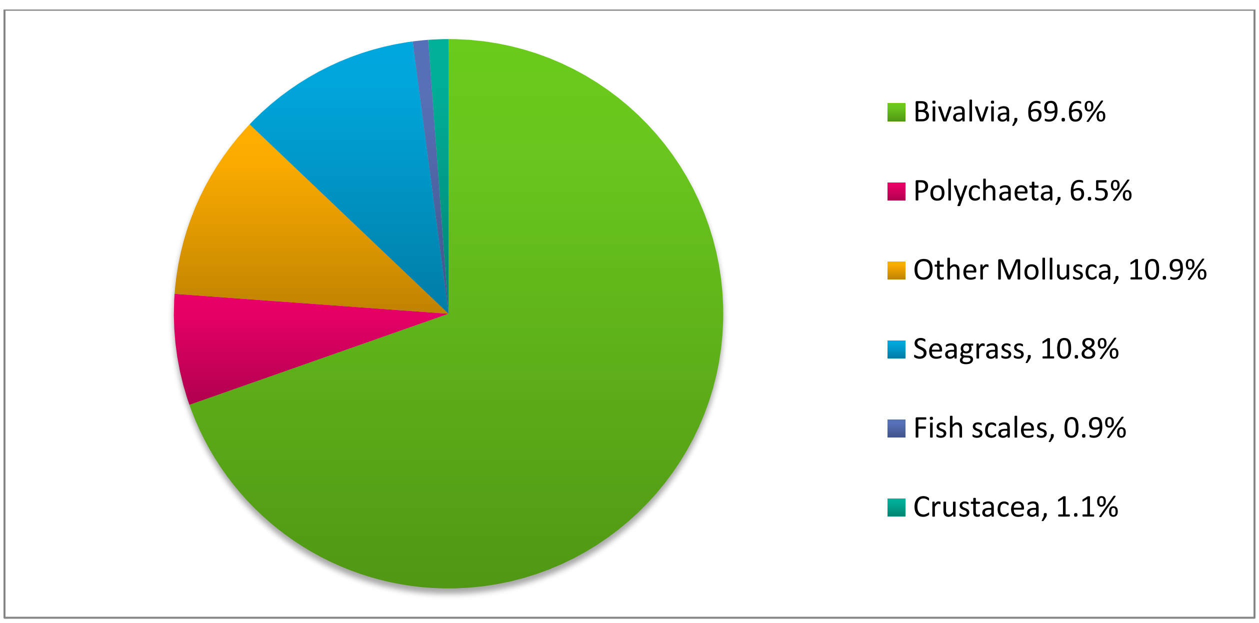

Figure 11. Pie chart of overall prey taxa composition (by weight) in Black Drum guts.

Stable Isotope Analysis

Stable isotope analysis on Black Drum tissues, Black Drum stomach contents, macrofauna tissues, and whole sediment samples were prepared for stable isotope analyses to be run. However, the chemical analysis has been delayed due to a backlog of samples at the external laboratory that the samples have been sent to. Thus, data were not included in this report.

Acoustic Telemetry

As of our last data download on 12/10/2014, we detected 23/25 of our acoustically tagged Black Drum for a total of 25,636 detections since 4/23/2014. The only animals not detected during the study period were tags 16459 and 16465, which were both released in Alazan Bay on 4/23/2014. The remaining 23 individuals were detected across a wide range of receiver stations across the area. The station receiving the greatest number of detections throughout the project period was BB_03 (Table 5; **Fig. 12**), which was situated in the southeastern portion of Cayo De Grullo. While 6 individuals were detected at this station, nearly all detections (i.e., 94%) came from two individuals – tags 16466, 16467. Other regions of high activity (>2000 detections) included a Laguna Salada station (BB_05) and Alazan Bay stations BB_06-07 (Table 5, **Fig. 12**). The greatest number of tagged individuals was recorded at BB_06-07 (10 and 11 individuals, respectively), although these stations were situated closest to the release sites in Alazan Bay (**Fig. 5**).

Only 4 individuals were detected along the Laguna Madre stations. This included tag 16456, which was tagged in Alazan Bay and only detected at BB_15, and no other stations during the monitoring period. Another individual detected at this station included tag 16460, which was also tagged in Alazan Bay on the same date as the previous individual. Tag 16460 was also detected at BB_11 prior to BB_15, but was not re-detected anywhere after 4/29/2014, suggesting potential egress from the BBC. We saw a similar pattern for Tag 16476, an exceptionally large individual that was released near the interface of San Fernando Creek on 5/15/2014 that was detected on BB_15 on 5/23/2014 but had not been re-detected in the system until late September.

With the exception of three individuals (Tags 16458, 16461, 16466), we have not detected any of the remaining 8 individuals released on our first tagging trip (4/23-4/25) since mid-May (**Fig. 13**). Many of these fish were released in Alazan Bay, were later detected in Baffin Bay, but have not been re-detected in the Baffin Bay Complex through December 2014. At this time it is still unclear as to whether these individuals have been simply avoiding detection of our receivers, left the system, or if they were removed by fishermen.

We also observed animals undertaking several inter-bay movements throughout the Baffin Bay Complex (**Fig. 13**). Interestingly, the majority of these habitat transitions appeared to occur early and late in the monitoring period, during more homogeneous environmental conditions. Inter-bay movements were minimized and or restricted within the three major arms during the summer, with generally no animals detected at Upper Laguna Madre or Baffin Bay sites between June and September.

Table 5 – Detection record data from the 15 receiver array in the Baffin Bay Complex (4/23 – 12/10/2014). CDG = Cayo de Grullo, AL = Alazan Bay, BB = Baffin Bay, LS = Laguna Salada, ULM = Upper Laguna Madre.

Receiver Station	Water Body	Number of Detections	Number of Fish
BB_03	CDG	10931	7
BB_05	LS	5676	6
BB_07	AL	2917	11
BB_06	AL	2082	10
BB_04	LS	975	5
BB_09	AL	695	7
BB_08	AL	612	8
BB_10	BB	549	8
BB_11	BB	460	9
BB_15	ULM	323	2
BB_02	CDG	315	4
BB_01	CDG	69	4
BB_12	ULM	17	1
BB_13	ULM	12	1
BB_14	ULM	3	1

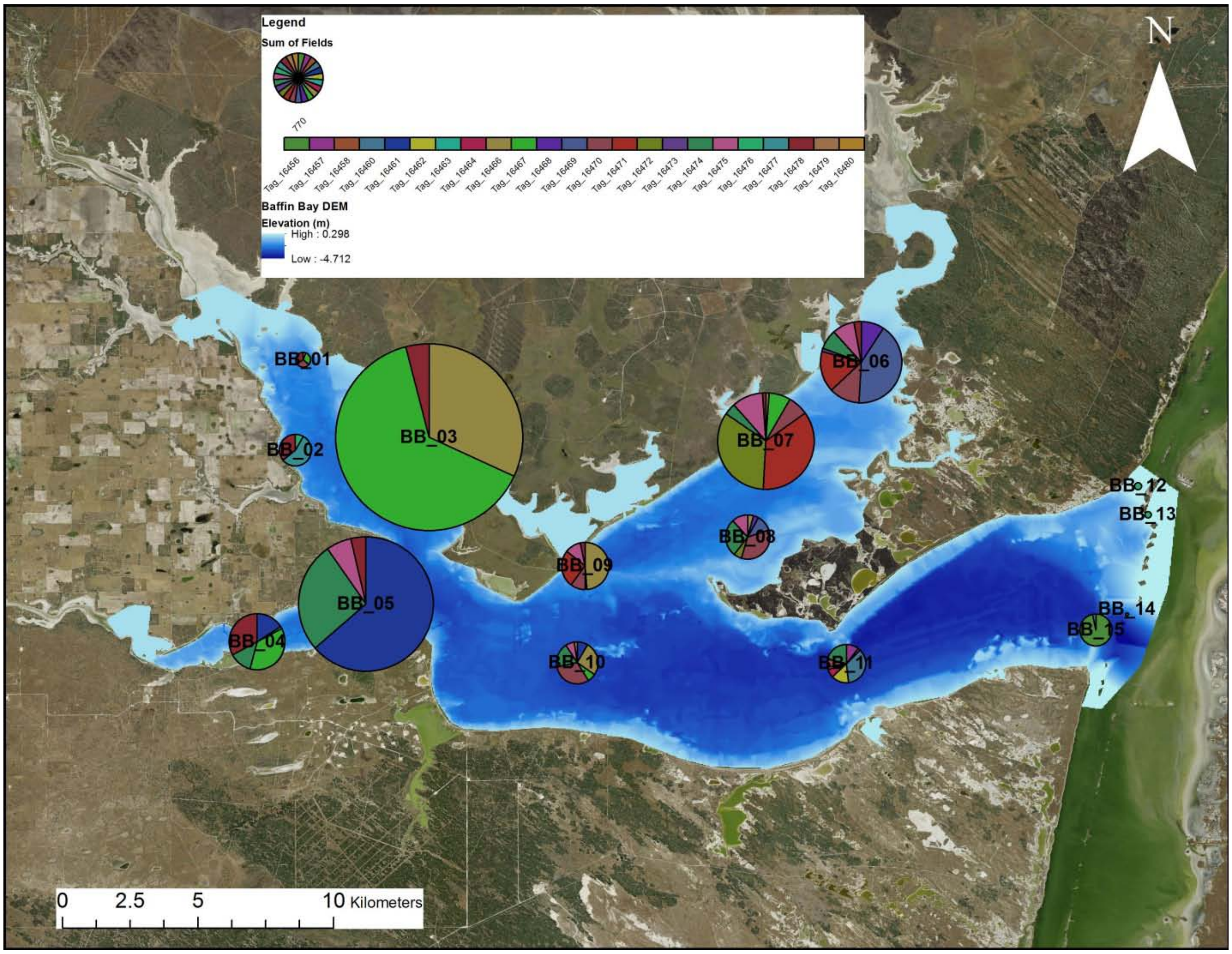

Figure 12 – Detection pie charts (scaled to detections) along the 15 receiver array in the Baffin Bay Complex (4/23 – 8/5/2014). Various colors represent different individuals.

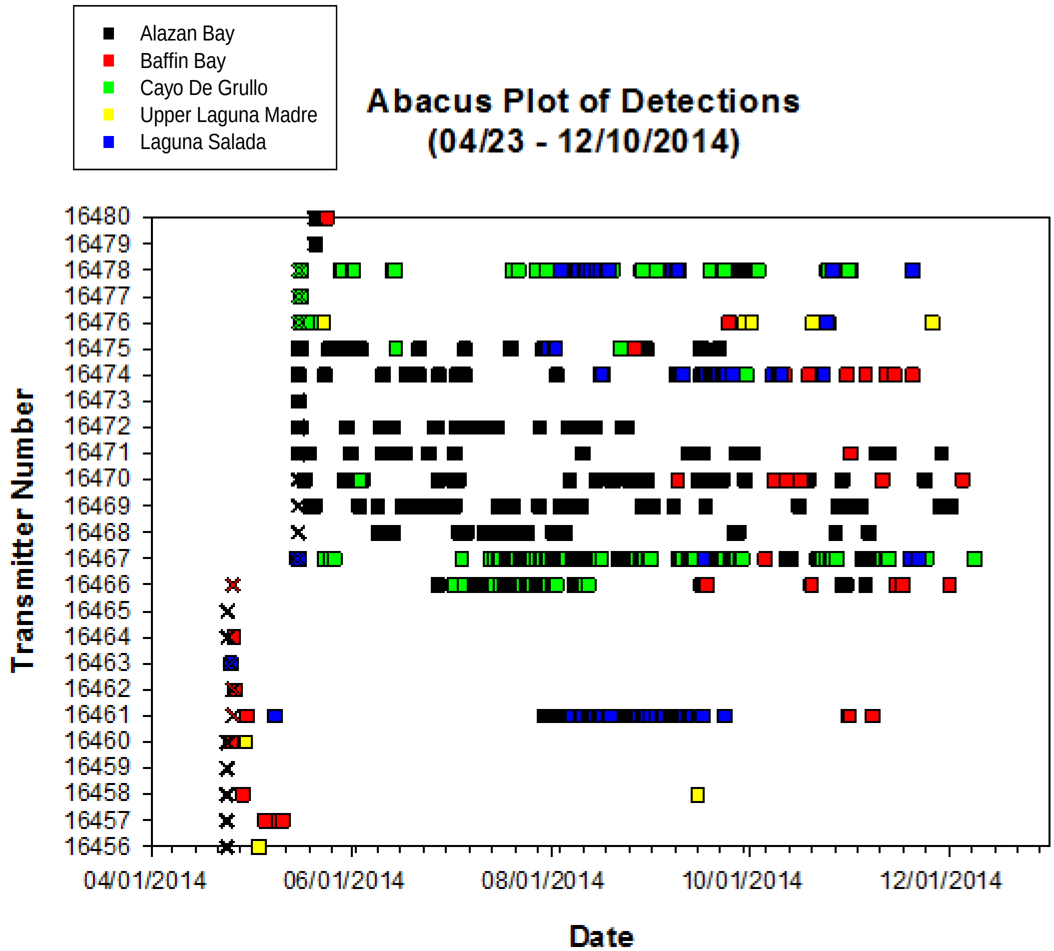

Figure13. Abacus plot of detection history for 25 transmitters released in Baffin Bay between 4/23 and 12/10/2014.

Conclusions and recommendations

Our ecosystem-based approach to assessing Black Drum in Baffin Bay has revealed important trophic and habitat linkages between this valuable commercial and recreational fishery and the benthic communities of a unique hypersaline estuary. Moreover, incorporation of water quality, benthic sampling, and fish tracking is allowing us to improve our understanding of the dynamics of this system. Thus, our group looks forward to our continued participation in this multi-faceted study.

While analyses are ongoing, benthic samples collected in March and June were dominated by polychaetes in terms of abundance, and mollusks in terms of biomass. Similarly, bivalves and other mollusks, primarily gastropods, contributed to the largest portion of prey identified in the gut contents of Black Drum. These dietary items included the dwarf surf clam, *Mulinia lateralis*, which has been previously reported to be an important food source for Black Drum in this region and elsewhere. Our observations of increasing bivalve densities (including *M. lateralis*) and biomass moving into the extremities of all three arms of Baffin Bay could be indicative of higher quality foraging habitat. Cholorophyll-a values tended to be higher in these regions, which may allow for greater production along the benthos. Black Drum are also known to utilize these far reaches for spawning activities during cooler months. Despite releasing the majority of our acoustically tagged individuals in these habitats, our detection data do not consistently show preference for the higher reaches of the BBC arms. In fact, our data currently show two major centers of activity at the “downstream” portions of both Cayo De Grullo and Laguna Salada. While we still feel limited in our ability to comment the rationale behind the use of these locations, our work thus far has clearly shown that there may be some temporal patterns in movement behavior. Specifically, we observed a period of high activity (inter-bay movements, including Upper Laguna Madre) during spring and fall, and a period of restricted movements in summer as water temperatures peaked across the system, and salinities and chlorophyll-a levels reached their maximum in the major arms and western two thirds of the bay. Further year-round monitoring is essential to confirm our grasp of the dynamics of Black Drum habitat use in the BBC, but we speculate that this seasonal stratification may restrict movements of these otherwise mobile fish. Analyses of fall cores may also lend further insights into how prey availability may influence these patterns as well.

Stable isotope analysis of fish samples is ongoing and will provide a more integrated picture of food resources utilized by black drum (e.g. over the past 3 months) compared to the snapshot view provided by gut contents.

With further sampling and analysis we hope to better resolve potential variation in diet among various sub-regions of Baffin. For example, we were only able to collect stomach contents from 3 individuals in Cayo de Grullo, where *M. lateralis* and overall mollusk abundance and biomass appeared to be highest. We plan to target fish from this region in our upcoming sampling opportunities to broaden our understanding of spatial trends in foraging behavior of Black Drum and how this relates to the ambient benthic community.

Since a second year of this project was recently funded by CBBEP (Project #1523), we will have a greater opportunity to analyze how benthic communities, Black Drum foraging behavior, and Black Drum movement patterns change over larger temporal scales and potentially greater ranges in environmental conditions. Given that the occurrence of “jelly-flesh” and other emaciated conditions appear to have tempered in the last year, it is important to have relatively long-term monitoring periods in place in to be able to better document potential environmental drivers of these events. Thus, we are confident that the continuation of our ecosystem-based approach will continue to provide strong insights into the dynamics and trophic connectivity of various components of the Baffin Bay complex.

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