Annapolis River Estuary Monitoring Project: planning for the recovery of anadromous species in the Annapolis River estuary

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Estuary Monitoring in the Annapolis River, Nova Scotia

The Annapolis River estuary provides important spawning, rearing and overwintering habitat for anadromous fish species during their migration upstream from the Atlantic Ocean. Historically, thriving populations of anadromous fish persisted in the river, but increased anthropogenic disturbances in recent decades has put local populations and their key habitats at risk. Three species of particular interest are striped bass (*Morone saxatilis*) Atlantic salmon (*Salmo salar*), and Atlantic sturgeon (*Acipenser oxyrhynchus oxyrhynchus*); the Annapolis River populations of all three species are listed as threatened or endangered by COSEWIC, and were estimated to experience the greatest population-level impacts due to turbine mortalities during the operation of the Annapolis Tidal Generating Station (ATGS) (Gibson et al. 2019).

To address these threats, the Clean Annapolis River Project (CARP) has established its estuary monitoring program: a multi-faceted program aimed at the recovery of anadromous species in the Annapolis estuary. In its initial stages, it will provide baseline population and habitat data which will be used to identify key areas for restoration and enhancement. The findings will also be used to inform management decisions regarding the decommissioning of the ATGS, which ceased operation in 2019 following a notice from DFO to provide authorization under the Fisheries Act.

In 2021, CARP completed egg tow and beach seine surveys at sites on the Annapolis River, Allain's Creek and Bear River, Nova Scotia, targeting striped bass. Water quality sampling was conducted at locations along the river to quantify current conditions and create a profile of the thermal and saline stratification that has resulted from obstructed tidal flow around the ATGS. CARP is in the initial stages of establishing an acoustic monitoring network in the estuary, and the status of those efforts are reported here. The acoustic work aims to fill critical data gaps regarding the habitat use and movement of striped bass, Atlantic salmon, and Atlantic sturgeon in the Annapolis River estuary.

No striped bass eggs were collected during surveys in 2021. This is consistent with surveys conducted by CARP in 2010-2011 and 2013-2015 and supports the theory that the Annapolis River spawning population is extirpated. Beach seines were conducted at 17 sites on the Annapolis River, Allain's Creek and Bear River, and returned 21 different species, but no evidence of striped bass. Reports submitted through CARP's volunteer angler program indicate that adult striped bass can still be found in the Annapolis River system in low numbers. Water quality sampling was conducted throughout the estuary, including the deployment of two pressure sensors, and three temperature sensor arrays. A profile of the thermal and saline stratification in the Annapolis River was produced, showing that stable stratification may persist as far upstream as Bridgetown. These results provide the groundwork for continued monitoring of the thermocline and halocline at different points in the seasonal and tidal cycles.

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1. Introduction

The Annapolis River flows 120km from its source in Berwick to the Annapolis basin, encompassing a drainage area of almost 1600km^2 . Bordered by silt and clay Acadian soils, the Annapolis River valley produces rich and fertile marshland suitable for agricultural uses; as of 1984, approximately 1500 hectares of this land was used for agricultural purposes (Rice 1984). Historically, a system of dykes protected those agricultural lands from flood risk, but in the 1950s, construction of a 225m long tidal dam and causeway began in an effort to reclaim upland agricultural land and eliminate the need to maintain the already deteriorating dyke system upstream. This tidal dam imposed a physical barrier to tidal flow in the estuary, significantly reducing tidal range upstream from 10m down to only 0.5m (Gibson et al. 2019). Tidal exchange that was once uninhibited, became limited solely to water exchange through the sluice gates, 4x4m fishway, and leakage through the rockfill barrier. Such severe tidal restriction can drive changes in habitat structure, water chemistry, and community composition (Ritter et al. 2008). No environmental impact assessments were performed prior, but studies conducted since its establishment in 1960 indicated changes to the upstream microclimate and anadromous fish populations (Tidmarsh 1984).

Estuaries are defined by the mixing of freshwater and saltwater. They are highly productive ecosystems, combining the physiochemical conditions required by marine, brackish and freshwater organisms. These conditions however are highly variable and depend on the balance between fresh and saltwater input, tidal regimes, and other seasonal or physical determinants of mixing such as wind and rainfall. Some estuaries, due to high tidal exchange and turbulent motion, efficiently mix the fresh and saltwater inputs, creating a near-homogenous water column. In contrast, conditions of high freshwater input and low tidal exchange, will produce a stratified water column, known as a salt wedge. In the Annapolis River, the tidal dam and ATGS act as a physical barrier reducing tidal exchange upstream. Prior to the construction of the dam in 1960, the Annapolis estuary was vertically homogenous, and tidal influence extended as far upstream as Paradise (Daborn 1979). Since then, reduced tidal flow upstream of the barrier has resulted in a stable salt wedge estuary, with distinct stratification between the upper freshwater layer and lower dense saltwater layer (Redden et al. 1982, Rice 1984, Gibson et al. 2019, Daborn 1979). This salt wedge has been observed at least 31km upstream of the causeway near Bridgetown, with the thermocline often falling between 1.5-2m depth (Jessop 1976), though both metrics have demonstrated notable seasonal and annual fluctuation (Daborn 1979, Rice 1984).

The ecological characteristics of salt wedge estuaries are well-documented, with consistent patterns of lower turbidity, lower levels of dissolved oxygen in bottom saline waters, and higher primary production compared to their mixed counterparts (Jeong et al. 2014, Wells 1999). Excessive primary production, particularly when compounded by high nutrient inputs from agricultural runoff (which is a known concern in the Annapolis River; River Guardians reports) or other human activities, can deplete oxygen levels in the lower saline layers to levels that become harmful to aquatic life. This pattern of depressed oxygen has been observed at times in the Annapolis River (Daborn 1979, Sharpe 2007), and demonstrates the potential for severe habitat alteration as a result of changing hydrology. Additionally, benthic diversity is reported to be highest in mixed waters downstream of the Annapolis basin, while phytoplankton is most abundant in the stable stratified waters upstream (Redden et al. 1982), suggesting possible trophic effects and changes in the distribution and abundance of food resources.

These physio-chemical effects may have been drivers of population decline in the Annapolis Estuary; however, it is known that tidal barrages and turbines have direct impacts on the behaviour and survival of migrating fish (Viehman and Zydlewski 2015, Eicher 1993). Since the construction of the causeway and tidal dam, declines have been observed in many native fish populations, and several studies have reported on the mortalities attributed specifically to turbine strikes (Dadswell et al. 2018, Gibson et al. 2019, Dadswell and Rulifson 1994, Stokesbury and Dadswell 1991). Most notable are striped bass, Atlantic salmon, and Atlantic sturgeon: the only three species predicted to experience extreme or high population-level impacts from turbine mortality in the Annapolis system (Gibson et al. 2019). All three of these species demonstrate a high degree of uncertainty with respect to their current population size, structure, and life history in the area. Addressing this gap in knowledge is thus imperative for the conservation and preservation of these species in the Annapolis Estuary.

Atlantic Salmon (Salmo salar)

Atlantic Salmon are a medium-sized salmonid with a pointed head and long streamlined body shape. Their coloration changes throughout their life cycle, depending on age and spawning status. Spawning and early life stages take place in well-oxygenated freshwater streams. At the smolt stage, they migrate to the ocean to mature for 1-4 years before returning to their natal rivers to spawn (COSEWIC 2010).

The Annapolis River population falls under the Southern Upland population designatable unit (DU) assigned by COSEWIC. Since 1996, salmon in this DU have declined by 61%, and as of 2000, the Department of Fisheries and Oceans predicted that 55% of rivers in this DU were extirpated, with an additional 36% at risk of extirpation (COSEWIC 2010). This population was listed as endangered by COSEWIC in 2010, citing altered hydrology, invasive fish species, and habitat fragmentation due to dams and culverts among the primary freshwater threats. Salmonid aquaculture and changes in marine ecosystems also pose a threat to their survival in marine environments, but the specific changes are not well understood. Based on their migration patterns, it is expected that the entire Annapolis River population of Atlantic salmon would have encountered the turbine in their lifetime (Gibson et al. 2019), making it a significant threat to their survival. Through CARP's fish habitat restoration program, salmon parr have been observed in the freshwater tributaries of the Annapolis River following habitat enhancement and restoration efforts, but much is still unknown about the population size and movement of these fish throughout the watershed.

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

Atlantic Sturgeon are the largest anadromous species in the Northwest Atlantic. Females, the larger of the sexes, can reach up to 3m in length and 200kg (COSEWIC 2011). With an ancestry dating back over 200 million years, Atlantic sturgeon are of great ecological importance. Spawning occurs in rocky substrates of shallow freshwater, and young fish spend up to 6 years in fresh and brackish water before migrating to the ocean. Atlantic sturgeon are a long-lived and late-maturing species, with a generation time of about 40 years: this makes them particularly susceptible to threats. Once matured, they may return to upstream sites in the fall or spring preceding spawning, and often overwinter in the deep estuarine channels downstream of spawning sites (COSEWIC 2011).

The Annapolis River population of Atlantic sturgeon belongs to the Maritime designatable unit (DU), however little is known about Atlantic sturgeon in the Annapolis River. Prior to the operation of the ATGS, there was no knowledge of an existing current population of Atlantic sturgeon. Between 1985 and 2018, 21 mortalities were reported, including some ripe and spent females (Dadswell et al. 2018). The origin of those individuals is unknown, but their high fidelity to natal rivers suggests that they comprised a native population. Juveniles and reproductive adults have both historically been reported in the system, and a small spawning population is still thought to persist (Dadswell 2006, Dadswell and Rulifson 1994). The Maritime population of Atlantic sturgeon was listed by COSEWIC as threatened in 2011, citing threats as habitat modification, barriers to migration, poor water quality, and a general lack of quantitative data. The long lifespan and late maturity of this species, as well as the predicted small population size only increase the severity of these threats. Likelihood of turbine strike is increased due to the large size of Atlantic sturgeon (Collins 1984), and is estimated to be between 47-100%, with small increases in mortality resulting in large population-level effects (Dadswell et al. 2018). No juveniles have been observed in the system in recent years, but no surveys have specifically targeted this life stage in the Annapolis River.

Striped bass (Morone saxatilis)

Striped bass are large-bodied fish belonging to the temperate bass family. The striped bass has a dark olive green back, sides that fade to a silvery colour and a white belly (COSEWIC 2012, Scott and Scott 1988). They have an elongate body form, with a triangular head, large mouth, and small teeth. Adult striped bass are characterized by the seven to eight dark horizontal stripes along their sides. Reaching up to 180cm in length, striped bass are high-trophic predators in estuary and coastal ecosystems, preying on various invertebrates, Atlantic silversides, clupeids, and herring, among other species (COSEWIC 2012).

Spawning, incubation, and early larval development often occur in fresh or brackish water while juvenile and adult fish make use of coastal, estuarine, and saltwater habitats (COSEWIC 2012). Winter is spent in the warmer waters of estuaries or freshwater habitats and in the spring, fish return to their natal river to spawn. Spawning is triggered by a rise in water temperature in the spring and lasts 2-4 weeks. Fertilized eggs remain suspended in the water column for their 2-3 day incubation period (COSEWIC 2012). Larvae develop in near-shore freshwater environments, feeding and growing until they reach the juvenile stage and migrate downstream to saltwater: there, they spend several years maturing into reproductive adults.

Striped bass can be found distributed along the Atlantic Coast of North America from the St. Lawrence River to the St. John’s River in northeast Florida (COSEWIC, 2012). Striped bass in Canadian waters are divided into three populations: the Bay of Fundy, the Southern Gulf of St. Lawrence, and the St. Lawrence River. Historically in Canada, striped bass are known to have spawned in five river systems:

the Saint John and Miramichi rivers in New Brunswick, the Annapolis and Shubenacadie rivers in Nova Scotia and the St. Lawrence River in Quebec.

The Annapolis River once supported a healthy population of striped bass, knowledge which is substantiated by community reports, as well as data on historical landings (Jessop 1976) and annual angling tournaments hosted at Dunromin Campground in Granville Ferry (Harris 1988). Since the 1970s however, population numbers have been in decline, and reports indicate that there has been no evidence of successful spawning or recruitment in the Annapolis River since 1976 (COSEWIC 2012). What was once a booming recreational and sport fishery began to decline, and minimum size limits of 46cm then 68.5cm were imposed in 1994 and 1997, respectively. The annual Dunromin angling tournaments ended in 2008 due to reduced interest and a decrease in the number of large striped bass (>4.0 kg) in the area; prior to the turbine installation, 70% of striped bass catches were large individuals, compared to 51% in 1986 and 37% in 1987 (Harris 1988). This data, as well as the observed increase in average length and weight of striped bass between 1975 and 2000 indicated an aging population structure and little, if any, recruitment (Jessop 1980). Eggs were obtained from the Annapolis River in several years between 1976 and 1994; but the last larvae captured were in a 1976 study (Jessop 1995).

While these reports indicate a declining population even prior to the ATGS, the trends continued post-ATGS, and were compounded by the direct effects of the turbine which could selectively remove large individuals from the population; striped bass greater than 4.0kg are estimated to have a strike rate of 20-40% (Von Raben 1957). This value may have been even higher in the Annapolis River because striped bass were known to congregate around the high flow and prey-rich areas surrounding the tidal station (Andrews et al. 2019b). This behaviour suggests that feeding adults would have passed through the turbine multiple times per year. For these reasons, the entire population of Annapolis River adult striped bass would be expected to encounter the turbine within their lifetime (Gibson et al. 2019).

The last recorded evidence of spawning activity in the Annapolis River was in the summer of 1994, when 400 eggs were found (Jessop 1995), however the absence of juveniles during those and subsequent surveys suggest that survival beyond the egg stage is low. Fisheries and Oceans Canada (DFO) has considered the Annapolis River striped bass spawning population to be extirpated since 2006 because of repeated spawning failures and negligible survival of larvae to the juvenile stage (DFO 2006). This is owing to changes in water chemistry and circulation in the downstream portion of the river, attributed to the construction of the causeway and subsequent tidal power generating station in Annapolis Royal (DFO 2014).

Historically, striped bass were known to overwinter in the deep estuarine pools downstream of Bridgetown (Rulifson and Dadswell 1995). Overwintering aggregations, which are often dense and minimally active, are particularly susceptible to local conditions, making habitat suitability of overwintering grounds a crucial determinant of survival (Andrews et al. 2019a). This warrants more research on habitat use, as well as behaviour and movement of striped bass in the Annapolis River.

Since 2010, CARP has been collaborating with the Striped Bass Research Team, based out of Acadia University, to support monitoring and research efforts in the Annapolis River watershed. In 2010, 2011, 2013, 2014 and 2015, CARP conducted a variety of surveys for both adult and juvenile striped bass as well as striped bass eggs. No eggs, juvenile or adult striped bass have been collected during CARP's surveys. The COSEWIC assessment and status report for striped bass was last examined in 2012, in which the Bay of Fundy DU was designated as endangered. Threats to striped bass include overfishing, habitat loss and degradation, contaminants, and migration barriers. In a 2014 scientific advisory report (DFO 2014), it was stated that the Annapolis River may now serve as only foraging habitat, as spawning and nursery habitat features have been significantly degraded (Bradford et al. 2015).

Objective

In its initial stages, the estuary monitoring project will provide baseline population and habitat data which will be used to identify key areas for restoration and enhancement, as well as inform management decisions regarding the decommissioning of the Annapolis Tidal Generating Station, which ceased operation in 2019 following a notice from DFO to provide authorization under the Fisheries Act.

To date, most work that has been conducted as part of the estuary monitoring project focuses on striped bass. The primary objective in 2021 was to investigate the population structure of striped bass in the river. This was achieved through a combination of egg tows and beach seine surveys conducted by CARP staff, as well as community angler catch data contributed through CARP's volunteer angler program. Collectively, these sampling methods target striped bass at all developmental stages, providing a comprehensive overview of the local population structure; egg tows target the egg and larval stage, and may suggest the presence of a successful local spawning population, whereas beach seines and community angling data target the juvenile and adult stages, respectively.

In addition to surveys targeting live striped bass, CARP has implemented survey techniques to quantify suitable habitat for striped bass populations and other species at risk including Atlantic salmon and Atlantic sturgeon. This is being accomplished through both passive and active water quality sampling throughout the Annapolis River and estuary. Passive data collection methods include the deployment of temperature and pressure loggers. These data loggers present a simple way to track changes in temperature and water level at consistent time intervals throughout the spawning season. By deploying sensors at targeted locations both above and below the Annapolis Royal causeway, the current differences in tidal regime and tidal exchange attributed to the causeway can be quantified. Active sampling was conducted in the upstream portions of the river, with the primary goal being to create a current profile of the thermal and saline stratification in the estuary.

This summary reports on the activities that took place in 2021 and provides recommendations for future years.

2. Methods

From June to October 2021, CARP conducted field surveys targeting striped bass, as well as active and passive water quality monitoring. Striped bass surveys included egg tows and beach seines, which were supplemented by catch data collected through CARP's volunteer angler program (see Section 5: Additional Activities). Water quality monitoring consisted of the deployment of passive temperature and pressure data loggers both upstream and downstream of the decommissioned Annapolis Tidal Generating Station (ATGS), and active water sampling to define the thermocline and halocline gradients above the Annapolis Royal causeway.

2.1 Egg tows

Site selection

Egg tow surveys were conducted at three sites along the Annapolis River, targeting striped bass eggs. The sites were located between Bridgetown and Paradise, near the confluences of Paradise Creek, Daniel's Brook, and Bloody Creek. Past studies have shown striped bass to spawn at the upper limit of the freshwater-saltwater boundary of an estuary (Raney 1952). In the Annapolis River, this boundary can be found up to 40 km upstream from Annapolis Royal around Bridgetown, NS, and has been identified as a historical striped bass spawning area (Williams et al. 1984).

Sampling design

Egg tows were conducted by slowly trailing a fine-meshed plankton net (<2mm) through the water column. Mesh size was selected in accordance with egg size; striped bass eggs are only 1.3mm in diameter when first released, and within 12 hours of fertilization, will reach 3.4-3.8mm in diameter (Pearson 1938). The plankton net was supported by a 50cm diameter hoop, and secured to the back of a 4.3m aluminum boat using a 10m rope and U-shaped rebar structure to minimize interference from the motor (Figure 1). A mechanical flowmeter, model 2030R (General Oceanics, Inc.) was positioned near the opening of the plankton net.

Each sampling event consisted of two duplicate egg tows, and each sample site was visited a minimum of two times throughout the season. The start and end flow counts, as read on the mechanical flowmeter, were recorded for each tow. GPS coordinates were taken at the start and end locations of each tow, and the tracks were recorded using a fish finder (Navico, Lowrance Elite Ti). To maximize coverage, tows were conducted in a zig zag pattern across the width of the river, maintaining a speed of 2.0 to 2.5kms/hour which was slow enough to prevent the net from breaking the surface of the water. Egg tows lasted between 8 and 32 minutes, after which the plankton net was rinsed using a squirt bottle and observed for the presence of striped bass eggs. Egg samples were flushed into a 500mL glass jar and preserved in a cooler. Water quality data were collected at 1m depth during each survey with a YSI multiparameter sonde, and physical weather data were recorded.

Once all egg tows were complete, GPS coordinates and tracks were uploaded to ArcGIS for mapping. Data were entered into Microsoft Excel, and the total distance travelled for each tow was calculated as:

$$\textit{distance (m)} = [(\textit{final count} - \textit{initial count}) \times \textit{Rotor Constant}] / 999\,999$$

where the rotor constant is 26873 (Standard speed rotor constant, as listed in the General Oceanics Flow Meter 2030 series model manual)

$$\textit{Volume } (m^3) = \pi * (\textit{Net mouth radius}(m))^2 \times \textit{Distance (m)}$$

The above calculation was used to determine the total volume of water filtered during each egg tow.

Figure 1. *U-shaped rebar structure (left) and plankton net (right) used to conduct boat-based egg tow sampling.*

2.2 Beach seines

Site selection

Beach seines were conducted at 12 sites in the Annapolis River, 4 sites in Bear River, and 1 site in Allain's Creek (Figure 2). The eight sites above the Annapolis Royal causeway were selected and sampled by the Department of Fisheries and Oceans (DFO) in 2001 and 2002 (Douglas et al. 2003), Labenski in 2010 (Labenski 2011), and CARP in 2011, 2013, 2014, and 2015. Prior to the 2021 field season, 2015 marked the most recent beach seine surveys conducted by CARP. The location of AR2 was modified prior to the start of the 2015 sampling because of steep slope. Supplemental sites in Bear River were added to the sampling array in 2013 in collaboration with the Bear River First Nations, and the Allain's Creek site was added during the 2014 monitoring season. All sites were accessible either by foot, or by boat, and when possible, sites were visited around high tide. Tide times were determined using those given for Annapolis Royal at tide-forecast.com and adjusted by 2-3 hours for sites above the causeway to accommodate for the gradual delay in tides further upstream (because of constricted flow around the Annapolis Royal causeway). However, based on recommendations from CARP's 2011 survey, sites AR1, AR3, AR4, and AR5 were sampled at lower tide levels to accommodate for the steep shoreline slope or lack of beach at high tide.

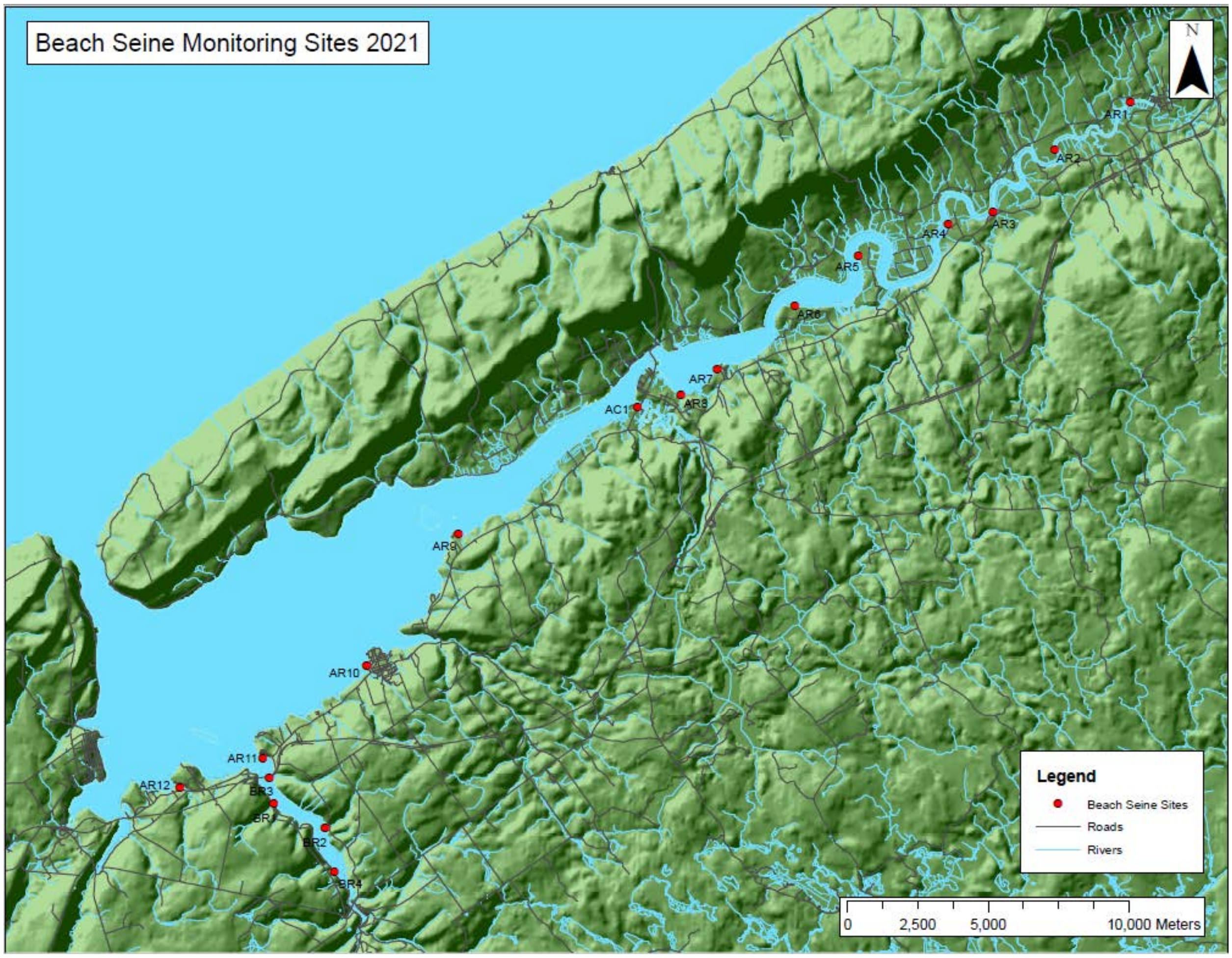


Figure 2. *Beach seine samples sites, sorted by colour, where blue represents Annapolis River sites, green represents Allain's Creek, orange represents Bear River.*

Sampling design

Beach seines were conducted using a 24.3m long and 2.10m tall seine net, with a purse mesh diameter of approximately 0.3cm. With one end of the net held at the shoreline, one person waded slightly downstream with the other end of the net, and then waded upstream parallel to the bank, pulling the float line along the water surface, and keeping the lead line on the river bottom. Once the net was fully extended in the water, it was guided back towards shore in a wide arc (Figure 3). The contents of the purse were collected by simultaneously pulling both ends of the net onto shore, overlapping the two sides to prevent any individuals from escaping under the net. Samples collected in the purse were counted and identified to family level, then held in aerated water while a second duplicate seine was conducted. In addition to count data, all individuals in the second seine were identified to species level, and total length (measured from the tip of the snout to the tip of the longer lobe of the caudal fin) and fork length (if applicable; measured from the tip of the snout to the center of the fork in the tail) was recorded for each specimen, up to a maximum of 20 individuals per species. After both seines were complete, all organisms were released, except for herring species, which were preserved in 70% ethanol and transported back to the lab for further identification. Water quality data was collected at each site using a YSI multiparameter sonde, and physical weather data were recorded.

***Figure 3**. Conducting beach seines in the Annapolis River by walking the seine net out parallel to shore. The ‘purse’ is identified by the cluster of floats in the middle of the float line.*

2.3 Water Quality Monitoring

2.3.1 Temperature and Pressure sensor arrays

Temperature and Pressure sensors were deployed in early July, at five locations in the Annapolis River from Paradise to Granville Ferry (Figure 4). All equipment was deployed by foot at low tide, except for the array in Bridgetown, which was deployed by boat. The pressure sensor setup consisted of a single water level logger (Onset, HOBO U20-001-01-Ti; range: 0-9m, accuracy: +/- 0.05% C, resolution: <0.02kPa, 0.21cm) positioned and secured inside a PVC tube using zipties. The PVC tube at the upstream locations was 30cm long by 5cm in diameter, and the downstream location was 25cm long by 9cm in diameter. The PVC tube was then secured to the inside of a cinder block using rope, which was either tied off at shore or connected to a buoy for later relocation. Water level loggers collected absolute pressure (measured in kPa) and temperature (measured in degrees Celsius) data. These setups were deployed at two sites in Granville Ferry: one upstream of the Annapolis Royal causeway, and one downstream. Temperature loggers (Onset, HOBO UA-002-64 Data Logger; range: -20 – 70C, accuracy: +/- 0.53C, resolution 0.14C @ 25C) were deployed in arrays of three to five sensors. Light/temperature sensors collected temperature (measured in degrees Celsius) and light data (measured in Lux) at 30-minute intervals for the entire duration of time they were deployed.

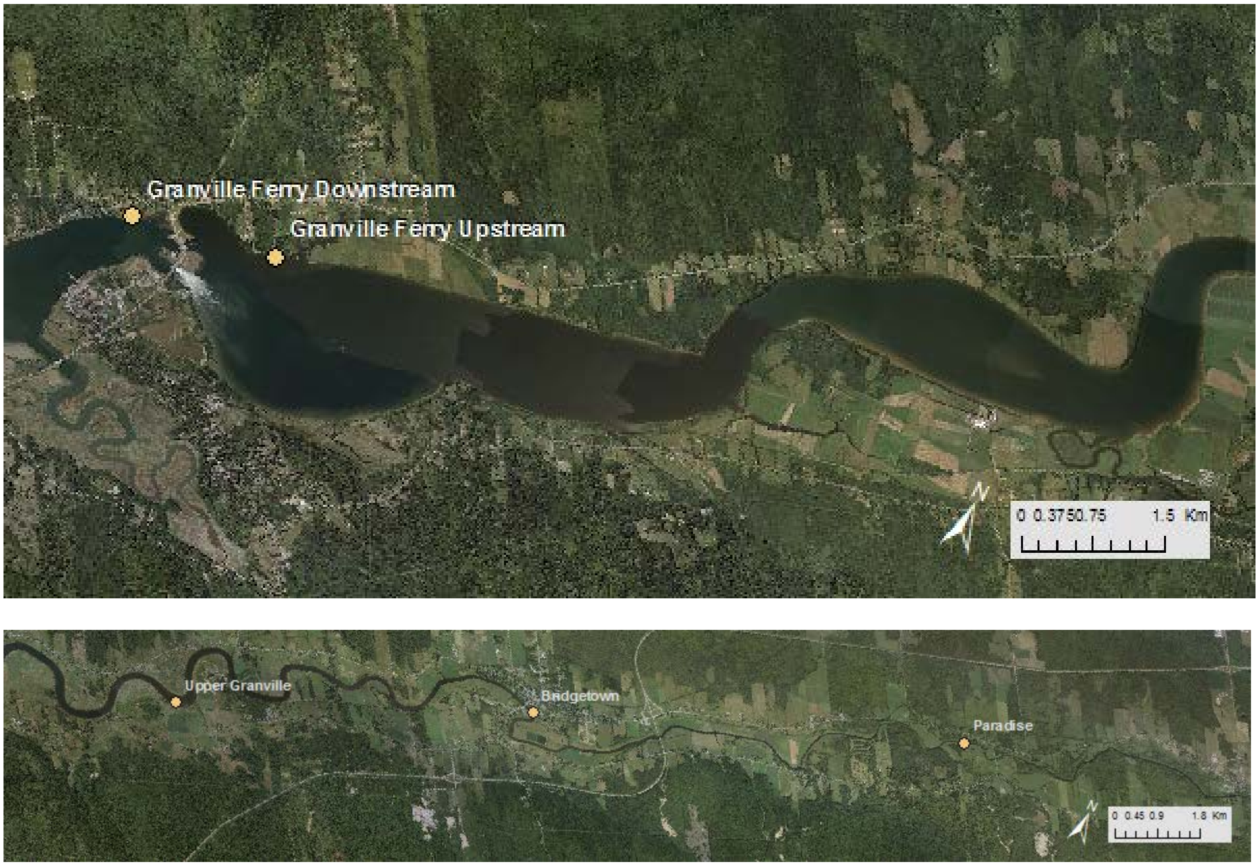


Figure 5. *Water quality sampling stations for pressure sensor arrays (top panel) and temperature/light sensors (bottom panel).*

In Bridgetown, four sensors were positioned along a length of rope using zip ties. One end of the rope was anchored to the river bottom using cinder blocks, and the other end was secured to a buoy to keep the sensor array fully extended in the water column. A similar setup was deployed at the Upper Granville site, with the addition of a fifth sensor attached directly to the concrete anchor. At Upper Granville, high tide can reach 3.1m, and so to account for tidal fluctuation, the array extended just over 2m from the top to the bottom sensor (not including the sensor attached directly to the cinder block). The array in Paradise consisted of three sensors attached directly to a rebar post. The rebar was anchored by a concrete base and positioned mid-river. Diagrams of the arrays can be seen in Figure 6. On August 4th, three sensors on the Bridgetown array and one sensor on the Upper Granville array were replaced, and the data from the removed sensors were extracted. Three sensor arrays were retrieved in mid November, but the Bridgetown and Paradise arrays could not be located due to lost buoys and high water levels, respectively. The seven sensors that were successfully retrieved were sent to collaborators from the Applied Geomatics Research Group at Nova Scotia Community College, where the data were extracted.

Figure 4. *Pressure sensor setup consisting of a single HOBO water level logger secured inside a PVC tube and anchored by a concrete block.*

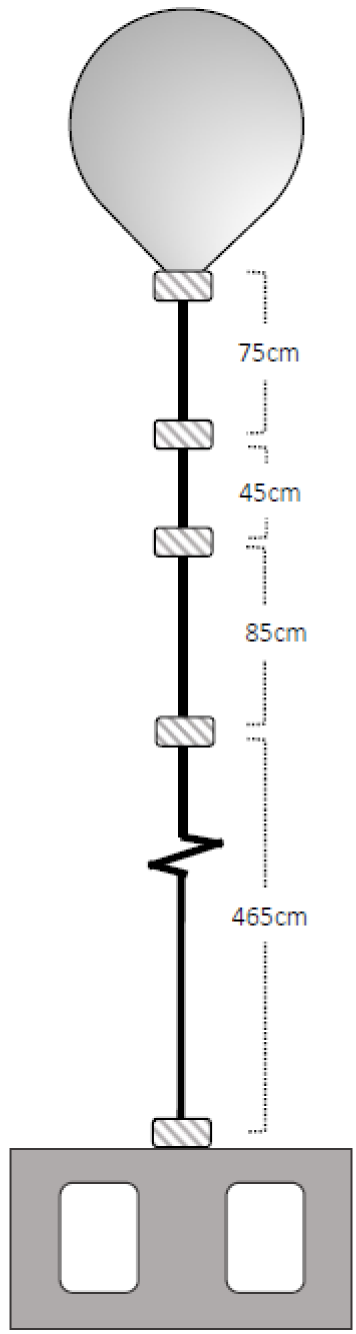


Figure 6*. Illustration of the temperature sensor array deployed at the Upper Granville site, indicating the position of the buoy, concrete block, and sensors. Sensor positions are indicated by striped rectangles, and distances between sensors are denoted to the right.*

2.3.2 Estuary water quality sampling

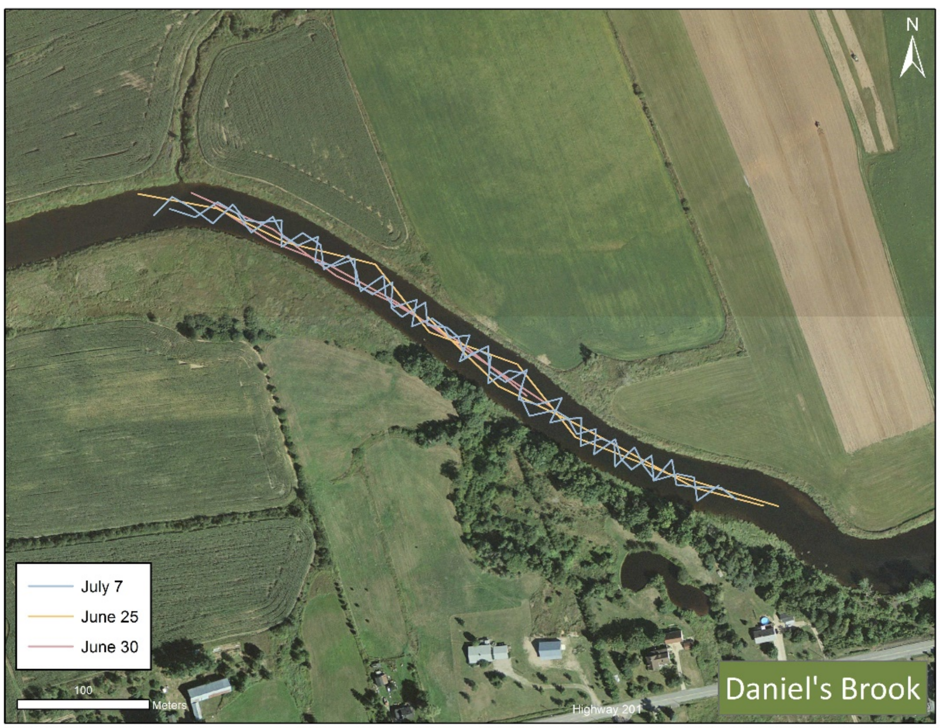
Water quality monitoring was conducted at twelve pre-determined sites along the Annapolis River, upstream of the Annapolis Royal causeway (Figure 4). All sites were accessed by boat and were marked by GPS points located mid-river. Sampling began around high tide at the site furthest upstream and continued in the downstream direction. At each site, anchors were used to maintain the boat's position while sampling was conducted. Date, time, and physical weather data observations were documented at each site. Using a YSI multiparameter sonde, water quality parameters were recorded at 1m depth intervals to a maximum of 10m. Total maximum depth and secchi depth were also recorded. In addition, the thermocline and halocline depths were measured (if applicable), by slowly lowering the YSI probe into the water column and recording the depth at which each the salinity (halocline) and temperature (thermocline) values showed a rapid change. Sampling was repeated five times throughout the season between June and November.

3. Results

3.1 Egg tows

A total of 30 egg tows were conducted across three sample sites (Figure 7). One tow was stopped early because the plankton net snagged on the river bottom. Of the remaining 29 tows, 5 were conducted at Paradise Creek (two duplicate tows plus one single tow), 12 at Daniel's Brook (six duplicate tows), and 12 at Bloody Creek (six duplicate tows). No striped bass eggs were collected in these surveys. Over 1600 cubic meters of water was sampled, though this value is likely a severe underestimate; inaccurate flow meter readings were reported for 11 egg tows, resulting in an absence of volume data for over one third of the sampling events, and 42% of time spent actively sampling. Tables of results and water quality data are available in Appendix A. Four fish were caught in the net during the egg tow surveys, but as they were not species of interest, they were released and excluded from sampling results.

N
Highway 1
June 11
June 25
June 25
100
Meters
Paradise Creek



N
July 7
June 25
June 30
100
Meters
Highway 201
Daniel's Brook

Figure 7. *GPS tracks from egg tow sampling, sorted by sampling date, and ordered based on upstream position, with Paradise Creek being the most upstream site, and Bloody Creek being the most downstream site.*

3.2 Beach Seines

Beach seines were conducted at 12 sites in the Annapolis River, 4 sites in Bear River, and 1 site in Allain's Creek. No striped bass of any age were found. From July to November 2021, a total of 34 beach seine surveys were conducted. Four sampling events were conducted with a smaller seine net; three of those sites were resampled with the correct 24.3m net later in the season, and the data from the smaller net were omitted from the analysis. All sites were sampled twice except for AR11, AR12, and BR2 which were sampled only once due to time and logistical constraints, and BR3 which was sampled three times. The full tables of abundance data sorted by site, are available in Appendix B and full morphometric data are available in Appendix C.

A total of 15296 individuals were recorded, belonging to 21 species. No evidence of striped bass was observed. Sand shrimp, the most abundant species, accounted for 39% of all observations. Removing sand shrimp observations, the total count dropped to 9324 individuals, and the relative abundance of each species is illustrated in Figure 8. The most common fish species was Atlantic silverside, totalling 5344 individuals (Table 1). Some of the less common species collected included blacknose dace and ninespine stickleback, each with only 1 individual observed. Rainbow smelt, Atlantic tomcod and smallmouth bass were also among the less common species. 123 individuals could only be identified to the family level, including 110 herring (Clupeidae), 3 flounder (Pleuronectidae), and 10 stickleback (Gasterosteidae). An additional 16 individuals remained unidentified.

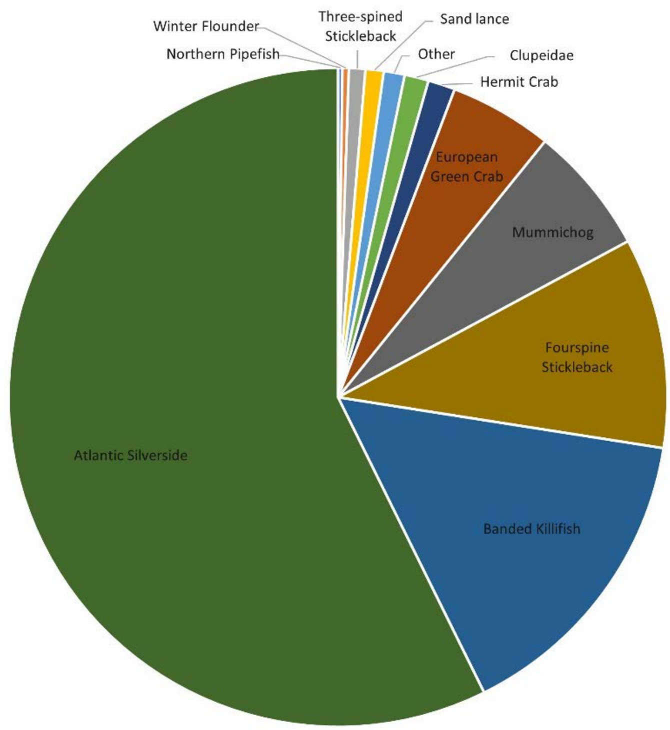


Figure 8. *Cumulative results from all beach seine surveys showing relative species composition. "Other" includes blacknose dace, unknown crab spp., ninespine stickleback, smelt spp., rainbow smelt, flounder spp., Atlantic tomcod, smallmouth bass, white perch, stickleback, American eel, Atlantic rock crab, smooth flounder, and other unidentified individuals.*

On average, smallmouth bass, Northern pipefish and rainbow smelt displayed the greatest total length of any species observed, although sample sizes for all three species are relatively low. Sticklebacks, both fourspine and three-spined, displayed the smallest average lengths. Average, maximum and minimum total length for each species is reported in Table 2.

The greatest species richness was observed at sites AR2 and AR3, each recording 13 species. AR2 also recorded the greatest abundance of individuals (*n*= 2352; Table 3), and AR3 recorded the greatest diversity of species (Shannon's Diversity Index *H* = 1.57, E = 0.612; Table 3). Contrarily, AR6, AR11, and BR2 all reported the lowest diversity scores (*H = 0.18*, *H* = 0.09, H = 0.00, respectively). Sand shrimp are of particular importance in the diet of juvenile striped bass less than 50mm in length (Robichaud et al. 1997), and therefore could be an indicator of suitable habitat. Of the 17 sites, sand shrimp were observed at 10. The highest abundance of sand shrimp was observed at AR4, AR5, AR7, AR8, and AC1, and may indicate likely areas for juvenile striped bass habitat (Figure 9).

Table 1. *Total count of each species collected. Data includes all beach seine surveys across Allain's Creek, Annapolis River, and Bear River sites.*

Species	*n*
American Eel	14
Atlantic Rock Crab	15
Atlantic Silverside	5344
Atlantic Tomcod	5
Banded Killifish	1419
Blacknose Dace	1
Clupeidae spp.	110
Crab spp.	1
European Green Crab	472
Flounder spp.	3
Fourspine Stickleback	963
Hermit Crab	124
Mummichog	589
Ninespine Stickleback	1
Northern Pipefish	20
Rainbow Smelt	2
Sand lance	83
Sand Shrimp	5972
Smallmouth Bass	5
Smelt spp.	1
Smooth Flounder	15
Stickleback spp.	10
Three-spined Stickleback	75
Unknown	16
White Perch	7
Winter Flounder	29
Grand Total	**15296**

Table 2*. Length data grouped by species. Data come from the duplicate seine survey conducted during each beach seine sampling event (see methods).*

Species	*n*	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
American Eel	7	103.14	128	70
Atlantic Silverside	400	75.08	159	31
Atlantic Tomcod	1	79.00	79	79
Banded Killifish	45	48.89	84	25
Clupeidae spp.	42	52.64	67	32
Fourspine Stickleback	107	32.24	52	12
Mummichog	34	42.59	70	31
Northern Pipefish	8	138.50	165	113
Rainbow Smelt	1	126.00	126	126
Sand lance	20	93.20	107	80
Smallmouth Bass	5	166.00	180	145
Smooth Flounder	12	57.67	80	38
Three-spined Stickleback	20	33.90	45	16
Unknown	16	46.00	83	30
White Perch	4	43.00	52	37
Winter Flounder	7	47.43	60	32
Grand Total	**729**	**64.03**	**180**	**12**

Table 3. *Measures of community composition at the 17 beach seine sampling sites. Abundance is the total number of individuals, richness is the total number of species, and diversity and evenness are measures of composition that account for relative abundance of each species at a site. Shannon's index was used to calculate diversity and evenness scores. Higher Shannon's diversity index scores indicate greater diversity of species, and an evenness score closer to 1 indicates that species abundance is similar across all species, with a value of 1 indicating that all species are present in equal proportions.*

Site	Abundance (*n*)	Richness	Diversity (H)	Evenness (E)
AC1	559	7	1.013404	0.520787
AR1	481	7	1.202301	0.617860
AR2	2352	13	1.291088	0.503358
AR3	412	13	1.571574	0.612712
AR4	333	10	0.930314	0.404030
AR5	943	9	0.224107	0.101995
AR6	909	7	0.179373	0.092180
AR7	1035	8	0.444694	0.213853
AR8	1048	9	0.437207	0.198981
AR9	345	3	0.647965	0.589803
AR10	122	6	0.956737	0.533965
AR11	116	2	0.087100	0.125658
AR12	17	2	0.545595	0.787127
BR1	26	2	0.666278	0.961237
BR2	14	1	0.000000	NA
BR3	158	5	0.578332	0.359338
BR4	454	5	0.255388	0.158682

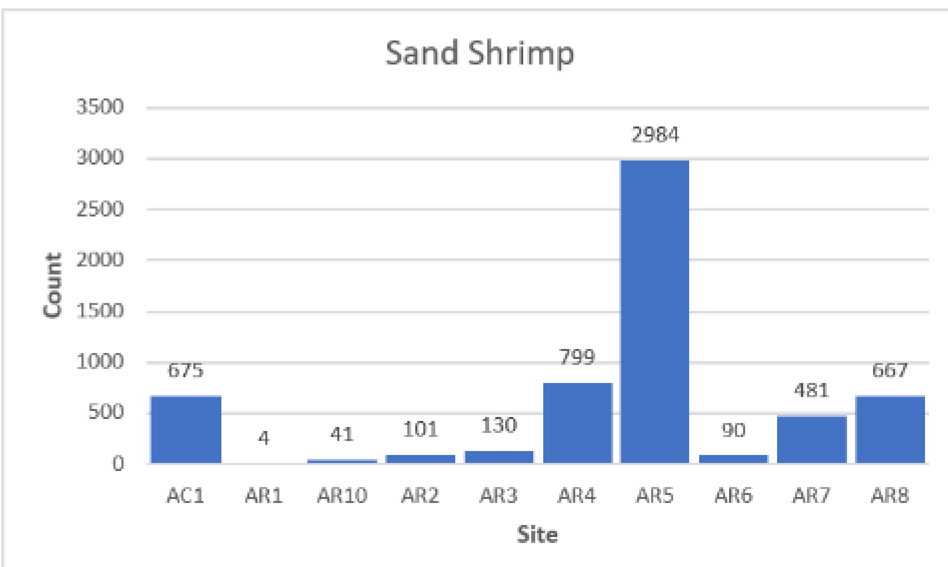


Figure 9. *Abundance of sand shrimp: a possible habitat suitability indicator for juvenile striped bass. Only the 10 sites in which sand shrimp were collected are included in the above graph.*

3.3 Water Quality Monitoring

3.3.1 Temperature and Pressure sensor arrays

Pressure data collected by the water level loggers indicate a notable difference in pressure, and therefore water depth, fluctuation between upstream and downstream sites. The downstream sensor experiences a greater tidal amplitude than that of its upstream counterpart. Downstream of the Annapolis Royal causeway, the pressure values encompass a range from 99.384 kPa to 179.881 kPa across the entire season, corresponding to a change in water level of 8.02m. Whereas the upstream location experienced a range from 101.257 kPa to 120.491 kPa, corresponding to a change in water level of 1.91m: only about one quarter of the tidal amplitude experienced downstream (Figure 10).

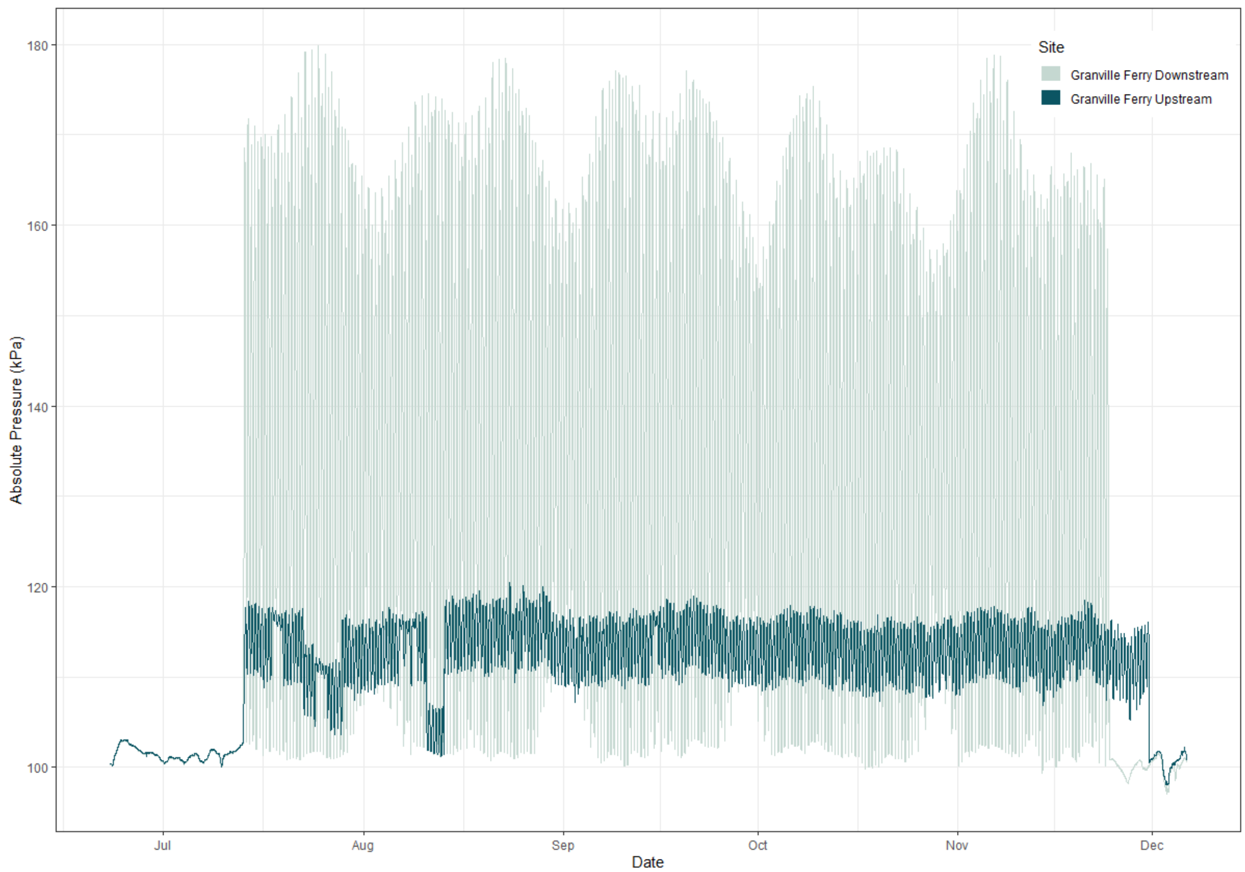


***Figure 10**. Pressure data, measured in kPa, from two sites located in the Annapolis River, around Granville Ferry: one site upstream of the Annapolis Royal causeway, and one site downstream. Sensors (Onset, HOBO U20-001-01-Ti) were deployed on July 13th and retrieved on November 24th (downstream site) and November 30th (upstream site).*

Temperature data was collected from the two water level loggers located downstream and upstream of the Annapolis Royal causeway, and one 5-piece temperature light sensor array in Upper Granville, about 20km upstream from Annapolis Royal. Like the pressure patterns observed, the downstream sensor experienced a broader range of fluctuation (and overall lower temperatures) than either of the locations upstream: most prominent between October and November (Figure 11). When considering just the sensors in the Upper Granville array, the expected patterns of warmer water near the surface, and temperatures that correlate with depth are observed (Figure 12). The sensors positioned lower in the array appear to fluctuate in temperature more than the consistently warmer surface waters.

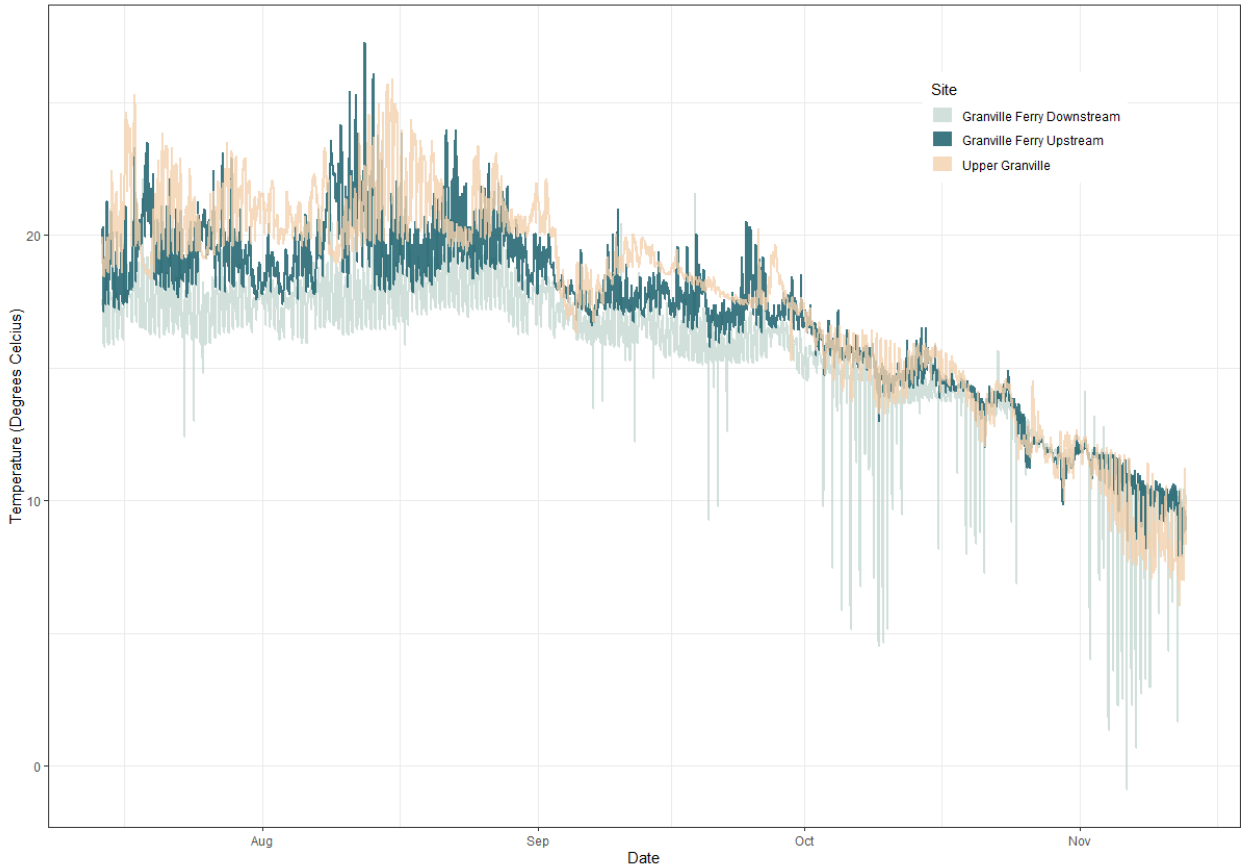


Figure 11. *Temperature data recorded by the three sensors positioned near the river bottom (Granville Ferry upstream data logger (Onset, HOBO U20-001-01-Ti), Granville Ferry downstream data logger (Onset, HOBO U20-001-01-Ti), and the lowest-positioned data logger in the Upper Granville array (Onset, HOBO UA-002-64). Data are cropped to show the only the window of time that all sensors were simultaneously active (July ^{14th} to November 13^{th}, 2021).*

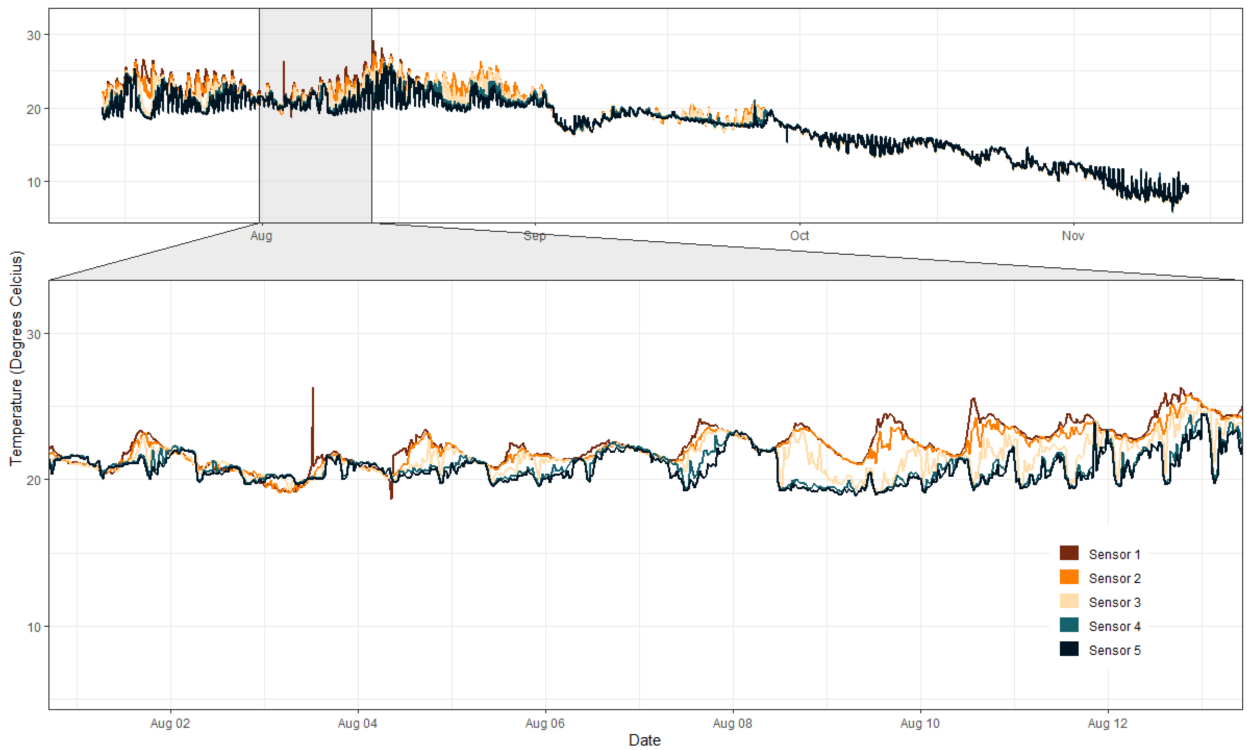


Figure 12. *Temperature data from the Upper Granville array, consisting of five HOBO UA-002-64 data loggers, numbered consecutively in order of position, top to bottom (sensor 1 is closest to the water surface, sensor 5 is closest to the river bottom). The bottom panel shows a more detailed view of the trends during a randomly selected two-week period in August. Sensor 1 spike on August 3rd represents time of sensor replacement.*

3.3.2 Estuary water quality sampling

Five rounds of estuary water quality sampling were conducted between June 3rd and November 12th, 2021. Due to time constraints, sampling during the second survey was split into two different sampling days, eight days apart. In addition, the first three sampling events did not include Site AR-51; this site was sampled on a different day that coincided with the regular water sampling schedule for the River Guardians monitoring program. Due to these inconsistencies in sampling date, the entire third survey that took place in July and those selected AR-51 observations were not included in analyses of the salt wedge, but all other water chemistry data were retained. Of the remaining four sampling rounds, data from November 12th provided the most complete profile of the thermocline and halocline, and was thus used to graph the salt wedge. However, the thermocline profile at that point in the season may not accurately illustrate typical conditions, as the surface waters were cooler than the rest of the water column (likely due to colder air temperatures compared to earlier in the season). Despite this, the thermal gradient and halocline depths map closely onto one another along the length of the river, providing a clear visual of the salt wedge between Annapolis Royal and Bridgetown, NS (Figure 13). At the site furthest upstream (AR 45, Bridgetown), there is no apparent boundary between fresh and saltwater, with the entire water column appearing to be minimally saline (Salinity < 0.06ppt, see Appendix D). The thermocline and halocline also are absent at the site furthest downstream (AR83, French Basin), but the full depth of the water column is highly saline (measuring between 26-30ppt on all but one occasion). The full table of water quality data can be found in Appendix D.

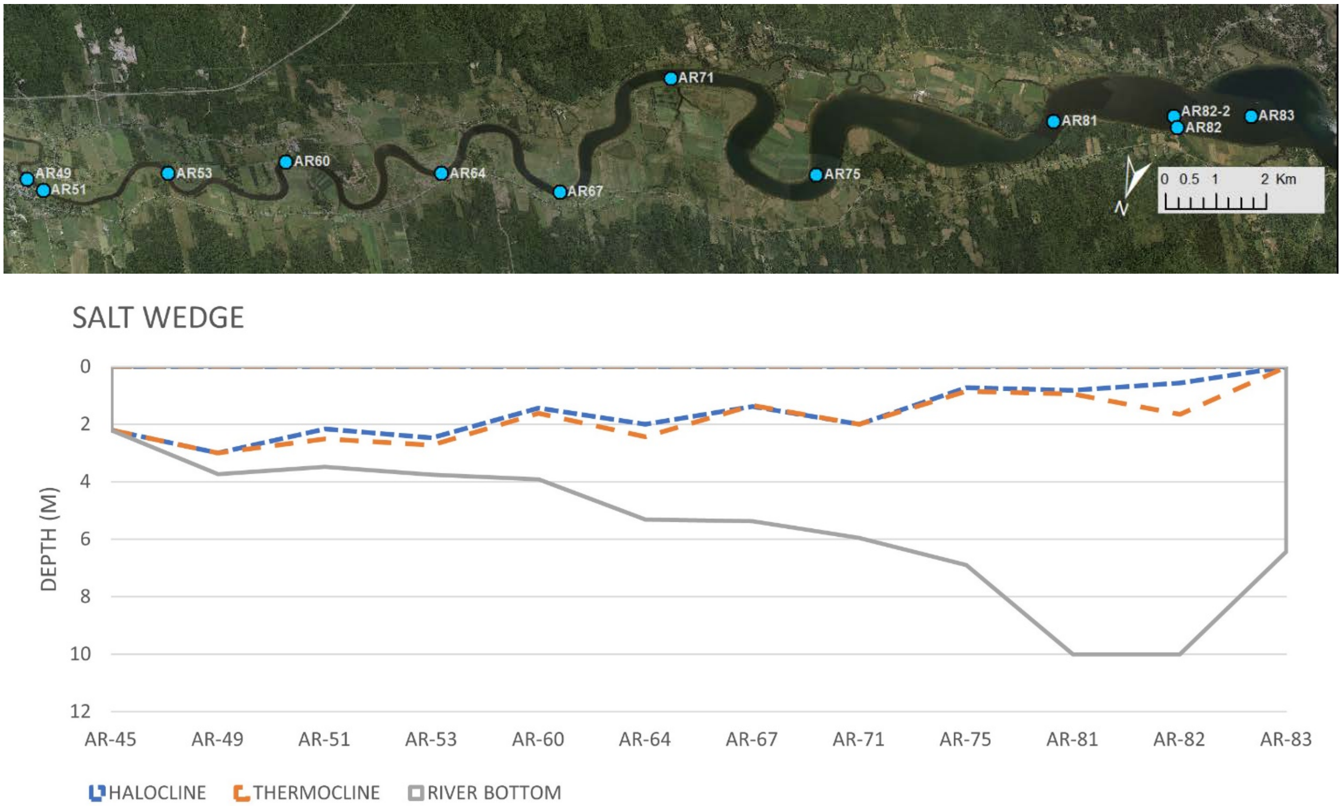


Figure 13. *profile of the salt wedge as observed at 12 sampling sites between Bridgetown and Annapolis Royal, on November 12th, 2021. The area below the dashed lines represents the salt water, and the area above the dashed lines represents freshwater, with the divide marked by both the thermocline and halocline. Maximum depth was measured using a weighted measuring tape, and salinity and temperature gradients were detected using a YSI multiparameter sonde. Boundaries shown on the map span from upstream at Bridgetown (left boundary) to downstream at Annapolis Royal (right boundary).*

In salt wedge estuaries, the extent of the salt wedge and the degree of stratification are known to change under different environmental conditions e.g., periods of greater freshwater discharge, rainfall or wind that may introduce more turbulent mixing of the saline and freshwater layers. Figures 14 and 15 illustrate the differences between the earliest water quality sampling survey conducted in June 2021, and the latest survey conducted in Early November.

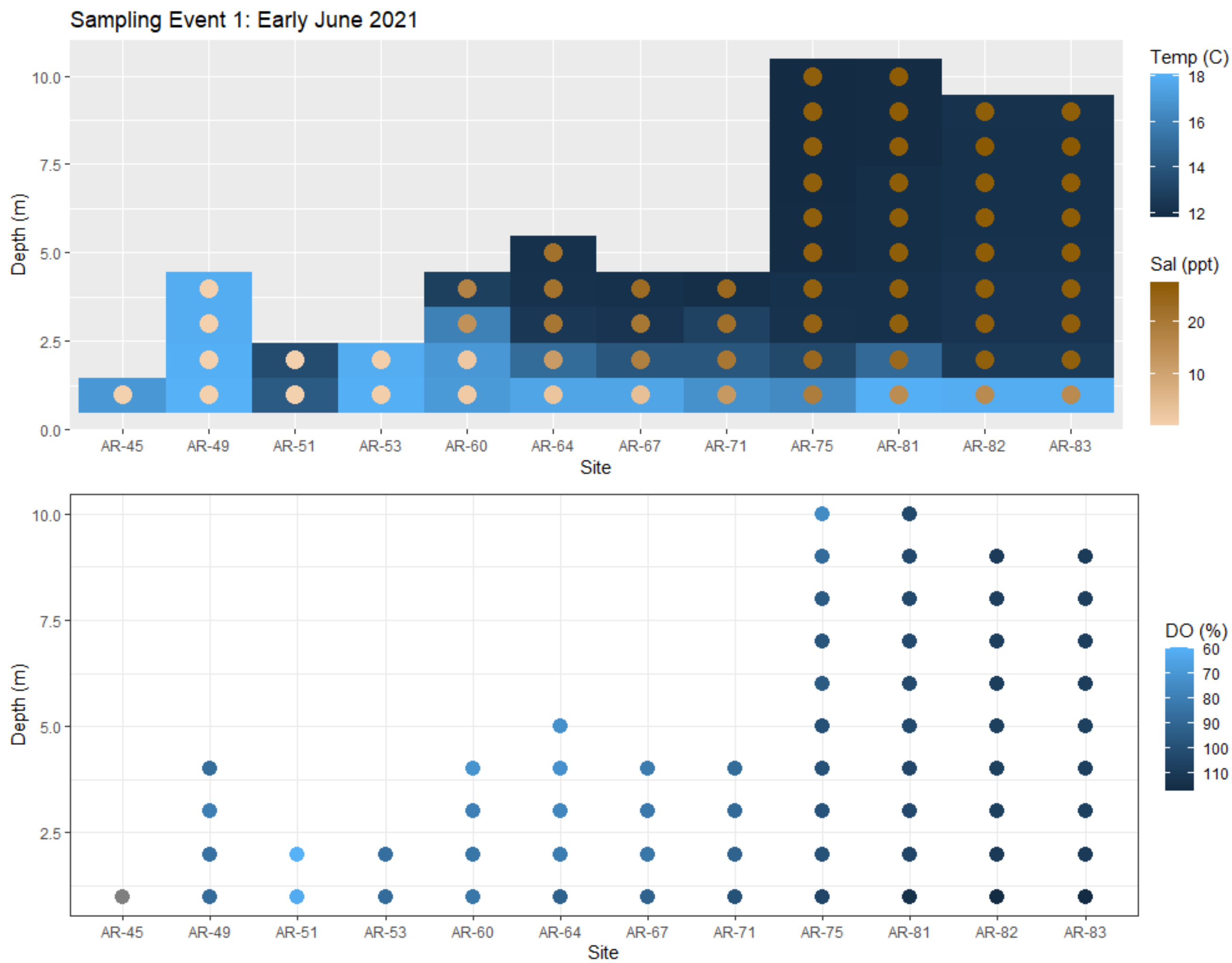


Figure 14. *Results from the first estuary water quality sampling survey conducted in 2021, in early June. The top panel illustrates salinity and temperature at each sampling point: the parameters used to identify halocline and thermocline profiles. The lower panel illustrates dissolved oxygen saturation. All data points are plotted by depth and ordered to reflect direction of river flow (left to right).*

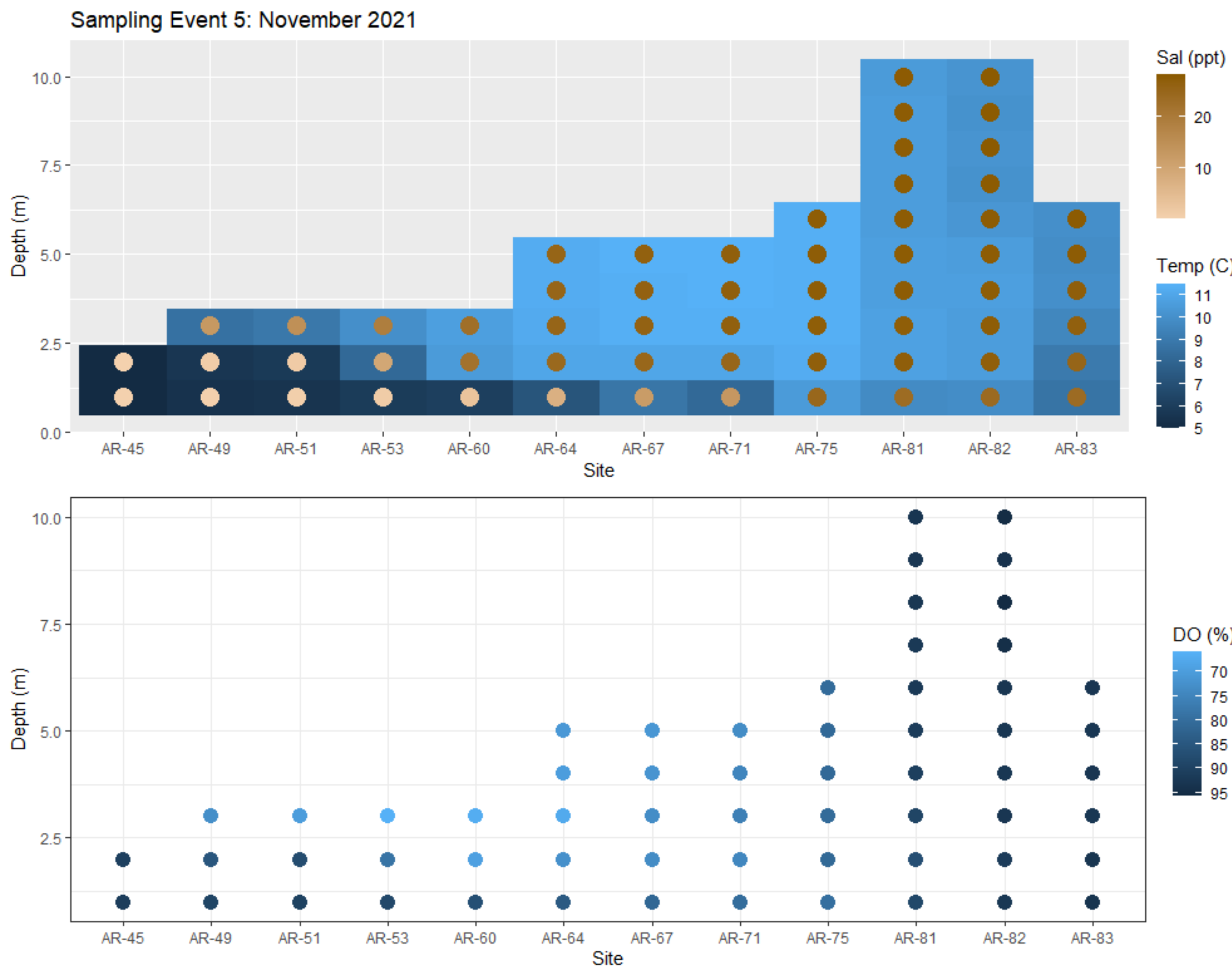


Figure 15. *Results from the fifth and final estuary water quality sampling survey conducted in 2021, in early November. The top panel illustrates salinity and temperature at each sampling point: the parameters used to identify halocline and thermocline profiles. The lower panel illustrates dissolved oxygen saturation. All data points are plotted by depth and ordered to reflect direction of river flow (left to right).*

Salinity remains relatively consistent across the season, however the locations furthest upstream are less saline in the first survey, suggesting that the salt wedge did not extend beyond AR60 in early June. The discrepancy observed at AR51 can be explained by the fact that AR51 was sampled independently, one day later than the rest of the samples, and so was not sampled under the same environmental conditions as the other sites. Late season sampling also shows lower levels of dissolved oxygen in the bottom waters of sites AR53- AR71. The most notable change between early and late-season sampling is the inversion of water temperatures between surface and bottom waters: in the early season, surface waters are warmer than the rest of the water column, but in late season surface waters become colder than the rest of the water column, particularly in the shallower upstream locations.

4. Discussion

In the summer of 2021, the Clean Annapolis River Project conducted estuary monitoring activities and data collection in the form of beach seines, egg tows, and water quality sampling. This work was conducted as part of a larger project focused on restoring the health of the Annapolis River estuary and restoring populations of anadromous species at risk in the watershed. This marked the first time since 2015 that CARP conducted surveys targeting striped bass populations in the Annapolis River and its tributaries. Consistent with results from 2015, no evidence of spawning striped bass was observed during the 2021 field season. There was, however, greater success in recreational angler outreach, resulting in striped bass catch data and scale samples submitted through CARP's volunteer angler program (see Section 5: Additional Activities).

4.1 Egg Tows

No striped bass eggs were collected during egg tow surveys. These results are consistent with surveys conducted in the Annapolis River in the past two decades (Douglas et al. 2003, CARP 2010, Labenski 2011, CARP 2015), and support the hypothesis that no successful spawning population persists in the river. Like the predictions made by DFO (DFO 2014), the observations of adult striped bass in this system suggests that the Annapolis River may still serve as foraging or overwintering grounds (reports by community and recreational anglers as part of CARP's volunteer angler program).

Striped bass are documented to begin spawning in water temperatures above 10°C, to an upper limit of 19°C, although optimal temperatures vary among populations. In the Shubenacadie River, for example, surveys for striped bass eggs were most successful in water temperatures between 18-19.9°C (Rulifson & Tull 1999), whereas in the Annapolis River, historic surveys report greatest egg abundance at surface temperatures between 19-24.4°C (Williams et al. 1984). Collectively, the Bay of Fundy populations tend to spawn in late May or early June, at temperatures around 15°C (COSEWIC 2012). All egg tow surveys in 2021 were conducted at temperatures above 15°C, and closer to the historic local range of 19°C-24.4°C which would appear to be suitable spawning conditions. In addition, most of the dissolved oxygen levels observed during the surveys also reflect suitable spawning conditions (8mg/L-10.9mg/L; Rulifson & Tull 1999).

The survey period in 2021, which began in early June at water temperatures that were already upwards of 20°C, may have missed a critical spawning period in the weeks prior. In the Annapolis River, significant numbers of striped bass eggs have been collected at temperatures around 15°C (Williams et al. 1984), which would be expected to occur around mid-May at the historic spawning locations (based on observations from the River Guardians Water Quality Monitoring Program). In addition, most sampling events were conducted in the afternoon, which is contrary to observations that most eggs are found either around dusk, or morning between 9:00am and 11:59am (Rulifson & Tull 1999, COSEWIC 2012). To capture dawn or dusk spawning events, the use of passive egg collection structures should be considered. In addition, due to their short incubation period, fertilized eggs only persist in the water column for 2-3 days before hatching and moving to near-shore habitats, making the window in which they could be observed incredibly time-sensitive. To account for this, it is recommended that sampling be conducted more regularly over a shorter period in early spring. It is worth noting though that CARP's surveys in 2015, which were conducted in May and June at temperatures between 13-21°C, also yielded no striped bass eggs or juveniles.

Earlier surveys conducted between 1994-1996 identified a strong USA genetic component (Wirgin et al. 2020), but notable differences in life-history, ecology, and physiology have been documented between USA and Canadian stocks (Rulifson and Dadswell 1995). More recent analyses have determined that Annapolis River fish appear to be of Shubenacadie origin (O'Halloran 2021). In the Shubenacadie River, surveys for striped bass eggs were most successful in water temperatures between 18-19.9°C, and dissolved oxygen values of 8-10.9mg/L (Rulifson & Tull 1999). Most CARP surveys fall within this DO range, and above the minimum dissolved oxygen requirement for most organisms, defined as 5mg/L (Bain & Bain 1982). However only 21% of observations fall within this temperature range; an overwhelming majority of sampling events occurring in waters over 20°C and up to a maximum of 25.3°C. This temperature range extends well above the threshold of 23°C, at which American populations begin to show a decline in egg viability (Morgan et al. 1987), however no such threshold has been documented for the Annapolis River population.

Striped bass eggs have a slight buoyancy in low salinities, and with a moderate current will remain suspended in the water column during the 2-3 day incubation period. In the Miramichi system, eggs were not found in any places where bottom salinities exceeded 3ppt (Robichaud et al. 1996). Early-stage larvae were found in low salinity environments, and mid-stage larvae were found to tolerate slightly higher salinities, but 94% of post-yolk-sac larvae occurred in freshwater (Robichaud et al. 1996). Egg tow surveys conducted in the Annapolis River in 1984 acknowledge the strong vertical stratification in the river upstream of the Annapolis tidal dam, and spawning was observed only in freshwater, at salinities below 0.1% (Williams et al. 1984). At CARP's two most upstream sampling sites, salinity values did not exceed 0.07ppt, however the most downstream site at Bloody Creek consistently presented higher salinity readings, ranging from 1.3-7.1ppt across the season. These results point to a higher possibility of egg mortality and may suggest that this location is not suitable spawning habitat. Thus, it may be worth relocating this egg tow site in future seasons.

4.2 Beach Seine

No evidence of striped bass was found in the beach seine surveys in 2021. Once again, these results are consistent with surveys completed in the Annapolis River in recent decades, including those conducted by CARP (Douglas et al. 2003, Labenski 2011, CARP 2013, CARP 2015). These findings could reflect a total absence of spawning activity by striped bass, unsuccessful spawning attempts, or reduced survival beyond the larval stage. The results of egg tows suggest the former, but it is worth investigating whether other barriers in this system could limit development beyond the larval stage.

The availability of food sources is thought to be a key determinant of year-class strength, as well as survival to the juvenile stage. Primary food sources however, shift in accordance with developmental stage: larvae and small juveniles feed primarily on copepods and other zooplankton, but once striped bass reach 50mm in length, sand shrimp become the principal prey source (Robichaud et al. 1997). Most beach seine sites in the survey exhibited large populations of sand shrimp, and a variety of juvenile fish species: conditions which, in theory, could support various developmental stages of striped bass. Sand shrimp were present at most beach seine sites with the exception of the Bear River sites, and the lower estuary sites AR11 and AR12 (Figure 9), suggesting an abundant food source for larger juveniles. Considering its importance for early life development in striped bass, quantifying zooplankton abundance could also prove valuable for identifying suitable striped bass habitat in the Annapolis River. In contrast, some beach seine seines presented a very low abundance and diversity of species (Table 3), namely BR1, AR11, AR12, and BR2. It is important to note that for each of the latter three sites, results come from a single seine survey conducted in mid-fall and so may not be representative.

In addition to food availability, habitat suitability is another factor that could contribute to striped bass survival beyond the larval stage. Larvae and juvenile striped bass often occupy habitat in shallow warm water that offers refuge from predators. These types of habitats are associated with wetlands, streams, and vegetated shorelines, with eelgrass reported as being of particular importance (*Weldon et al. 2007, 2009*). Sample sites in 2021 included vegetated shorelines as well as intertidal mudflats along the steep shorelines of the upper river. Juvenile striped bass can tolerate a greater range of temperature and chemical conditions than the larval or egg stages (Bain and Bain 1982). All dissolved oxygen levels recorded were between 60%-120%, water temperatures were in the range of 12°C -25°C, and 29 of the 32 observations (90.6%), showed pH readings between 6.5-8.5: the range often observed in estuarine environments. It is thus unlikely that these physiochemical parameters explain the absence of juvenile striped bass. The impact of predation, however, is not quantified and could be an additional factor contributing to the patterns that were observed.

Due to time restrictions and other fieldwork demands, beach seines were conducted following an irregular schedule. The period separating the first and second sampling events varied from days to months, meaning that some sites captured greater seasonal variation than others. To control for this, it is suggested that each site be visited once early in the season, and once late in the season, ideally sampling sites in the same order both times, but allowing for some flexibility based on tides.

Due to site-specific differences in community composition, as well as seasonal variation, it is difficult to draw any conclusions regarding size trends without conducting more rigorous statistical testing. In the future, it could be of interest to determine whether larger individuals are more commonly found in certain areas of the river, possibly indicating areas of greater food availability, or increased competition for resources.

4.3 Water Quality Monitoring

Monitoring and assessing water quality conditions in the Annapolis River can help to identify suitable habitat for striped bass and other anadromous species at risk, to determine candidate sites for habitat restoration and enhancement, and to inform management decisions. By conducting sampling at sites upstream of the ATGS, as well as sites below, a direct comparison can be drawn between flow regimes and the resulting differences in water quality.

Analyses of the physical and chemical features of the Annapolis River estuary were conducted in the mid 1970s before the establishment of the tidal generating station, but no such data exist prior to the construction of the causeway in 1960. Data from 1975 therefore provides the reference point closest to historic conditions in the area.

4.3.1 Temperature and Pressure sensor arrays

The temperature and pressure sensor arrays demonstrate the difference in tidal and thermal fluctuation on either side of the Annapolis Royal causeway. As expected, both daily and seasonal fluctuations in water level are greater at the site downstream of the Annapolis Royal causeway.

There appears to be a notable drop in temperatures between the third and fourth sensors in the Upper Granville array: a pattern that may provide further support for the presence of the salt wedge. In addition, temperatures at the deep end of the array appear to peak and fall twice throughout the day, coinciding with tidal patterns of the underlying salt wedge. Contrarily, the upper sensors show only one rise and fall each day, corresponding more closely with solar patterns affecting the surface freshwater. These observations would require further investigation before drawing firm conclusions, however, similar research conducted at Dalhousie University found that the temperature regime in the upstream portions of the Annapolis River is solar-dominated, whereas the downstream portions are tide-dominated (Bonnington 2021).

Some instances occur in which the surface water temperatures fall below those of the deeper sensors, and these patterns may be explained by coinciding weather events. For example, the inverted pattern observed around August 2-4 could be a result of the extreme rainfall event that occurred on August 2nd, disproportionately cooling the surface waters (ECCC, NAV Canada, 2021).

With the data gathered this year, recommendations can be made on sampling design and direction for the project moving forward. For example, future sampling efforts should be focused around Bridgetown, where the head of the salt wedge is predicted to be. Future arrays should also be constructed such that distances between sensors are consistent (positioned at 1m intervals up the water column), so that the thermocline can be identified and tracked accordingly. To further ensure consistency, an anchored rebar structure that stands upright in the water column, like the array deployed in Paradise, may be most suitable. Granted the rebar was firmly positioned, this structure would minimize the chance of tide and flow-induced disturbance that a rope array is susceptible to.

4.3.2 Estuary water quality sampling

The results provide a baseline description of the thermal and saline stratification present in the portion of the Annapolis River above the Atlantic Tidal Generating Station. The salt wedge, as observed on November 12th, 2021, extends as far as Bridgetown, reflecting the reduced tidal exchange upstream. Prior to the construction of the dam in 1960, the Annapolis estuary was vertically homogenous (Daborn 1979), but since at least 1975, the water column has been strongly stratified as far upstream as Bridgetown (Jessop 1976, Daborn 1979). This change in physiochemical composition can pose challenges for species that were previously adapted to a mixed estuary system, and could have implications that extend to habitat use, trophic structure, and migration patterns. In the context of striped bass, a species that relies on freshwater habitat for spawning, overwintering, and incubation, the presence of the salt wedge may disrupt these processes.

As discussed earlier, dense saline waters could threaten egg viability in striped bass; a study in the Miramichi River found that 94.3% of post yolk-sac larvae occurred in freshwater (Robichaud et al. 1996). For a life stage that depends heavily on freshwater conditions, the presence of the salt wedge in historically freshwater spawning locations could potentially disrupt the developmental process. Furthermore, zooplankton are most abundant in the surface freshwaters where stratification is most stable, but in contrast, zooplankton abundance is lowest in the mixed waters downstream (Redden et al. 1982). This could have implications for striped bass movements during early development, which are driven by prey distribution (Robichaud et al. 1997). Increased surface water temperatures resulting from stratification could drive spawning to take place earlier in the season, or drive species to seek more suitable habitat, potentially introducing new challenges like increased competition or predation risks.

The physiochemical differences observed between waters above and below the pycnocline are striking. A range of 80%-120% dissolved oxygen saturation is considered healthy, and in the surveys conducted, 26.5% of all DOSAT readings fell below this threshold. The lowest DOSAT readings were observed below the halocline at corresponding salinities upwards of 10ppt, which is consistent with the fact that saline waters have a decreased capacity to hold oxygen compared to freshwater. Surveys conducted in the 1970s in the Annapolis River found that the underlying salt layer reached oxygen saturation levels as low as 44% (Daborn 1979), which if persistent, can have serious ecological implications. Even more extreme levels of oxygen depression were observed between 2004 and 2006, when CARP conducted surveys to investigate the patterns of low dissolved oxygen in the Annapolis River. Oxygen-depleted saltwater extended over 20km in the lower estuary: below the halocline, DO levels averaged 3.52mg/L in 2005, and dropped progressively throughout the season to a low of 1.5mg/L in October 2006 (Sharpe 2007).

It is worth noting that the description of the halocline that is presented illustrates a single snapshot in time. Sampling conducted during a different point in the tide cycle or at a different time of year could yield different results. In the Fraser River, for example, the flood tide produces a salt wedge that extends further up the estuary, while the ebb tide erodes the structure (Geyer and Farmer 1989). Rainfall and freshwater discharge into estuary systems is also a strong determinant of stratification, and these parameters can show significant seasonal and annual fluctuation. The 2021 results demonstrate this as well, and show notable differences between early and late season sampling with respect to salinity gradients, surface water temperatures, and dissolved oxygen saturation. It is for these reasons that the continued monitoring of this system is so important. Conducting surveys at different points in the seasonal and tidal cycles will produce a more comprehensive profile of the salt wedge in the Annapolis estuary and aid in understanding how the salt wedge changes relative to the seasonal movements and habitat use by anadromous species.

5. Additional Activities

In addition to the work completed during the 2021 field season, several on-going projects are also underway, with results to come.

5.1 Acoustic monitoring

This project aims to fill critical data gaps in habitat use and threats to three COSEWIC-listed fish species in the Annapolis River watershed: Atlantic salmon, Atlantic sturgeon, and striped bass. Historically, the

Annapolis River supported populations of all three species, but changes to hydrology and habitat caused in part by the operation of the Annapolis Tidal Generating Station in 1984 are thought to have driven local population declines and the abandonment of the Annapolis River spawning sites. At present, the knowledge of local populations is limited: Atlantic salmon parr have been observed in freshwater tributaries of the Annapolis River, and anecdotal evidence from community anglers suggests the presence of both Atlantic sturgeon and striped bass adults, although efforts to locate striped bass juveniles and eggs have been unsuccessful.

The components of this project include i) deploying acoustic receiver equipment ii) tagging species of interest with acoustic transmitter tags and iii) registering the project with the Ocean Tracking Network.

The proposed acoustic receiver array consists of VR2W (Innovasea Systems Inc.) receiver stations located at pinch points and likely fish habitat along the river, including freshwater rivers and tributaries. Where possible, receivers will be deployed by foot at locations in the intertidal zone. In upstream areas that experience less tidal influence, receivers will be deployed closer to mid-river, anchored to the river bottom. A combination of gillnetting, fyke netting and rod and reel angling will be used to target Atlantic salmon, Atlantic sturgeon, and striped bass adults to then implant with acoustic transmitter tags. Drawing on the skills and surgical expertise of collaborators at Acadia University and the Striped Bass Research Team, as well as participation from volunteer anglers, the goal is to tag a total of 20 Atlantic salmon kelt, 30 striped bass and 20 Atlantic sturgeon in the 2022 season. Registering the project with OTN will leverage the global network of acoustic equipment, expanding data reach to include animals tagged by other OTN partners, and observations of CARP's tagged animals picked up by other OTN receivers.

At present, two acoustic receiver stations have been deployed, and the project has been registered with OTN. One attempt to catch striped bass took place in early December 2021 with no success, so field activities are scheduled to resume in spring 2022. Receivers were checked on February 22, 2022, and data were offloaded to Innovasea's Fathom software. No detections had been logged.

The overall goal of this acoustic work is to acquire baseline data on presence, movement and habitat use by anadromous species in the Annapolis River. The findings from this long-term study will supplement CARP's other ongoing efforts to identify key habitat areas for restoration and enhancement, and will inform management recommendations that will support the recovery and persistence of anadromous species in the Annapolis River.

5.2 Volunteer angler program

The volunteer angler program was established in 2019 as part of CARP's invasive species work and was adopted for the striped bass work in 2021, to broaden the scope of the research. This was accomplished by collecting observations, catch data, and scale samples from the knowledgeable and skilled anglers utilizing the Annapolis River. In the 2021 season, the volunteer angler participant list included 13 individuals. In partnership with the Striped Bass Research Team, angler kits consisting of log books, scale sample envelopes and instructions printed on rite-in-the-rain paper were distributed to all participants. Upon catching a striped bass, anglers were instructed to record date, time, location, fork and total length, weight, gear used, and fishing effort. 2021 marked the first year that CARP encouraged volunteers to submit data through MyCatch: a mobile application used to facilitate virtual angling tournaments and citizen science data collection.

In addition, anglers were provided with rite-in-the-rain envelopes to collect a scale sample of 3-4 scales and record additional information on species, age, and sex. A drop-off box was installed at the Annapolis Royal causeway boat launch in August 2021, to advertise the project and encourage data return. All data sheets and scale samples were shipped to the Striped Bass Research Team at Acadia University for genetic analysis. A total of 14 scale samples were submitted, and 153 striped bass were caught and reported through MyCatch, although all MyCatch observations come from outside the Annapolis River watershed (primarily Avon and Miramichi Rivers).
Scale samples collected through CARP's volunteer angler program will also be used to determine whether individuals in the river constitute a local population or represent migrant individuals from neighboring populations. These genetic analyses will be performed by collaborators at the Striped Bass Research Team.

5.3 Bathymetry and Hydrodynamic Modelling

The Nova Scotia Community College – Applied Geomatics Research Group (NSCC-AGRG) was contracted to conduct a multibeam echo-sounding survey near the causeway and intake-outtake areas of the station's turbine. Supplemental bathymetric data upstream of the causeway was collected using single-beam echosounder (SBES) systems. Survey data was used alongside dimensional schematics of the turbine to develop a hydrodynamic model that could simulate different opening dimensions and elevations in terms of flow velocity and volume. The model was then used to predict changes to flow patterns and tidal amplitude upstream of the causeway based on three hypothetical management scenarios. This was done in an effort to explore the potential of restoring a more natural tidal regime in the portion of the Annapolis estuary upstream of the causeway, alongside the potential risk from each hypothetical management scenario from both upstream flooding driven by freshwater inputs, and flood risk from storm surge events. A report titled "Annapolis Royal Causeway Tidal Power Station Decommissioning: Hydrodynamic Modelling of Potential Scenarios" was produced by AGRG detailing the methodology and results.

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Appendix A. Table of water quality data and weather observations during egg tows.

Site	Date	Air Temp	Water Temp	DOSAT (%)	DOmg/L	TDS (g/L)	SPC	Conduc-tivity	Salinity	pH	Rain (L3D)	Rain (today)	Wind	Cloud Cover (%)
Bloody Creek	11-Jun-21	20	21.1	85.5	7.61	1677	2590	2321	1.46	6.77	5.6	heavy	none	moderate
	24-Jun-21	26	23.3	80.6	6.87	2483	3826	3764	2.01	7.7	-52	heavy	none	calm
	30-Jun-21	23	24.6	88.5	7.36	1709.5	2646	5216	1.33	7.4	-30.8	moderate	none	calm
	5-Jul-21	24	19	93.3	8.63	8118.5	12489	11066	7.19	6.8	-16.2	heavy	drizzle	slight
	7-Jul-21	26	21.7	134.9	11.86	4036	6220	5830	3.4	7.3	-49.7	heavy	drizzle	slight
	8-Jul-21	23	22.3	146.1	12.7	3757	5789	5483	3.16	7.44	-59.5	none	none	slight
Daniel's Brook	9-Jun-21	28	23.3	81.4	6.94	66.95	103.3	99.6	0.05	7.07	17.5	heavy	drizzle	slight
	25-Jun-21	21	19.6	92.9	8.51	81.25	124.7	112	0.06	6.52	14.1	drizzle	drizzle	slight
	30-Jun-21	25	25.3	95	7.8	91	140.1	141.1	0.06	7.27	-26.6	moderate	none	slight
	5-Jul-21	21	17.4	98.4	9.43	86.45	133.5	114.1	0.06	6.85	-19.3	heavy	drizzle	slight
	7-Jul-21	26	20.2	115.4	10.45	99.45	151.9	137.8	0.07	6.89	-22.7	heavy	drizzle	calm
	8-Jul-21	23	21.8	115.6	10.14	80.6	123.4	116.2	0.06	6.98	-28.6	none	none	calm
Paradise Creek	11-Jun-21	20	21	101.5	9.05	66.95	103	95.2	0.05	6.44	18	heavy	none	moderate
	25-Jun-21	23	20.8	108.2	9.68	78.65	121	111.3	0.06	7.03	-16	drizzle	drizzle	moderate

Appendix B. Table of egg tow, flow, and volume data

Site	Date	Start Time	End Time	Duration (mins)	Start Flow	End Flow	distance (m)	volume (m3)	Eggs (Y/N)
Paradise Creek	11-Jun	16:04	16:21	15	133620	161083	738.01	144.87	N
	11-Jun	16:32	16:44	12	161083	177829	450.02	88.34	N
	25-Jun	15:13	15:25	12	233553	251100	471.54	92.56	N
	25-Jun	15:32	15:40	8	251100	261279	273.54	53.70	N
Daniel's Brook	9-Jun	15:18	15:33	15	76886	88014	299.04	58.70	N
	9-Jun	15:40	15:59	19	88014	98190	273.46	53.68	N
	25-Jun	13:45	13:58	13	205688	215347	259.57	50.95	N
	25-Jun	14:09	14:19	10	215347	233540	488.90	95.97	N
	30-Jun	13:00	13:08	8	307384	313457	163.20	32.04	N
	30-Jun	13:24	13:32	8	313457	322422	240.92	47.29	N
	5-Jul	13:02	13:16	14	322407	329677	195.37	NA	N
	5-Jul	13:24	13:37	21	332481	332759	7.47	NA	N
	7-Jul	11:40	11:55	15	378516	402538	645.54	126.72	N
	7-Jul	12:08	12:21	13	402538	435315	880.82	172.90	N
	8-Jul	12:42	12:53	11	451840	451857	0.46	NA	N
	8-Jul	13:02	13:19	12	451857	463179	304.26	59.73	N
Bloody Creek	11-Jun	13:43	13:56	13	98241	119525	571.97	112.28	N
	11-Jun	14:10	14:20	10	119525	133617	378.69	74.34	N
	24-Jun	14:06	14:16	10	733448	182179	NA	NA	N
	24-Jun	14:32	14:56	24	182179	205638	630.41	123.75	N
	30-Jun	11:25	11:36	11	849742	849226	NA	NA	N
	30-Jun	11:41	11:51	10	849226	307383	NA	NA	N
	5-Jul	14:43	15:00	17	332759	332903	3.87	NA	N
	5-Jul	15:10	15:42	32	332903	378518	1225.81	NA	N
	7-Jul	13:28	13:45	23	402538	451924	1327.15	NA	N
	7-Jul	13:50	14:07	17	451924	451818	NA	NA	N
	8-Jul	14:16	14:27	11	463179	463172	NA	NA	N
	8-Jul	14:35	14:53	26	463172	491744	767.82	150.72	N

Appendix C. Average, maximum and minimum total length of each species collected during the second seine of beach seine surveys, sorted by site.

Note: BR2 is omitted, because no fish were collected during the duplicate seine.

AC1

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	21	53.24	70	40
Mummichog	2	46.00	47	45
Smooth Flounder	9	61.33	80	40
Grand Total	**32**	**55.06**	**80**	**40**

AR1

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Banded Killifish	24	50.33	84	25
Clupeidae	1	50.00	50	50
Fourspine Stickleback	40	35.65	52	27
Mummichog	14	40.64	46	34
Three-spined Stickleback	3	36.00	37	35
White Perch	4	43.00	52	37
Grand Total	**86**	**41.08**	**84**	**25**

AR2

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	16	42.81	61	34
Atlantic Tomcod	1	79.00	79	79
Banded Killifish	20	47.60	83	27
Clupeidae	20	53.10	62	43
Fourspine Stickleback	40	33.18	48	24
Mummichog	7	48.29	70	34
Three-spined Stickleback	12	36.00	43	22
Uknown	3	76.33	83	72
Grand Total	**119**	**42.89**	**83**	**22**

AR3

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
American Eel	1	128.00	128	128
Atlantic Silverside	20	109.35	140	77
Clupeidae	19	51.89	67	32
Fourspine Stickleback	20	22.45	32	12
Northern Pipefish	5	135.60	150	113
Smallmouth Bass	5	166.00	180	145
Three-spined Stickleback	3	24.33	33	16

Uknown	13	39.00	48	30
Grand Total	**86**	**67.88**	**180**	**12**

AR4				
Species	**n**	**Average Total Length (mm)**	**Max Total Length (mm)**	**Min Total Length (mm)**
American Eel	4	96.50	120	70
Atlantic Silverside	40	85.08	130	48
Clupeidae	2	56.50	60	53
Fourspine Stickleback	1	38.00	38	38
Mummichog	5	35.80	40	31
Northern Pipefish	1	148.00	148	148
Grand Total	**53**	**80.51**	**148**	**31**

AR5				
Species	**n**	**Average Total Length (mm)**	**Max Total Length (mm)**	**Min Total Length (mm)**
American Eel	1	122.00	122	122
Atlantic Silverside	40	86.73	128	39
Fourspine Stickleback	6	35.00	42	20
Northern Pipefish	2	141.00	165	117
Grand Total	**49**	**83.33**	**165**	**20**

AR6				
Species	**n**	**Average Total Length (mm)**	**Max Total Length (mm)**	**Min Total Length (mm)**
Atlantic Silverside	20	51.45	69	40
Three-spined Stickleback	1	45.00	45	45
Grand Total	**21**	**51.14**	**69**	**40**

AR7				
Species	**n**	**Average Total Length (mm)**	**Max Total Length (mm)**	**Min Total Length (mm)**
American Eel	1	86.00	86	86
Atlantic Silverside	49	62.61	118	33
Grand Total	**50**	**63.08**	**118**	**33**

AR8				
Species	**n**	**Average Total Length (mm)**	**Max Total Length (mm)**	**Min Total Length (mm)**
Atlantic Silverside	48	71.56	159	41
Smooth Flounder	2	51.00	64	38
Winter Flounder	3	53.33	60	45
Grand Total	**53**	**69.75**	**159**	**38**

AR9

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	40	75.88	104	61
Winter Flounder	4	43.00	55	32
Grand Total	**44**	**72.89**	**104**	**32**

AR10

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	20	81.85	104	66
Mummichog	1	31.00	31	31
Sand lance	20	93.20	107	80
Smooth Flounder	1	38.00	38	38
Three-spined Stickleback	1	20.00	20	20
Grand Total	**43**	**83.49**	**107**	**20**

AR11

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	20	90.85	102	76
Grand Total	**20**	**90.85**	**102**	**76**

AR12

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	11	73.45	90	54
Grand Total	**11**	**73.45**	**90**	**54**

BR1

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	6	69.00	91	47
Grand Total	**6**	**69.00**	**91**	**47**

BR3

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	16	103.94	123	80
Grand Total	**16**	**103.94**	**123**	**80**

BR4

Species	n	Average Total Length (mm)	Max Total Length (mm)	Min Total Length (mm)
Atlantic Silverside	33	68.55	120	31
Banded Killifish	1	40.00	40	40
Mummichog	5	47.80	56	41
Rainbow Smelt	1	126.00	126	126
Grand Total	**40**	**66.68**	**126**	**31**

Appendix D. Count data collected from beach seine surveys, sorted by site.

AC1	*n*
Atlantic Rock Crab	1
Atlantic Silverside	369
European Green Crab	36
Hermit Crab	120
Mummichog	20
Sand Shrimp	675
Smooth Flounder	9
Winter Flounder	4
Grand Total	**1234**

AR1	*n*
Banded Killifish	132
Blacknose Dace	1
Clupeidae	3
Fourspine Stickleback	186
Mummichog	152
Sand Shrimp	4
Three-spined Stickleback	3
White Perch	4
Grand Total	**485**

AR2	*n*
American Eel	4
Atlantic Silverside	16
Atlantic Tomcod	5
Banded Killifish	1086
Clupeidae	59
European Green Crab	3
Fourspine Stickleback	724
Mummichog	387
Ninespine Stickleback	1
Sand Shrimp	101
Rainbow Smelt	1
Three-spined Stickleback	61
Uknown	3
White Perch	2
Grand Total	**2453**

AR3	*n*
American Eel	1
Atlantic Silverside	107
Banded Killifish	199
Clupeidae	19
European Green Crab	9
Flounder	2
Fourspine Stickleback	32
Mummichog	8
Northern Pipefish	10
Sand Shrimp	130
Smallmouth Bass	5
Three-spined Stickleback	6
Uknown	13
White Perch	1
Grand Total	**542**

AR4	*n*
American Eel	7
Atlantic Rock Crab	3
Atlantic Silverside	252
Clupeidae	6
European Green Crab	46
Fourspine Stickleback	2
Mummichog	5
Northern Pipefish	4
Sand Shrimp	799
Stickleback	6
Winter Flounder	2
Grand Total	**1132**

AR5	*n*
American Eel	1
Atlantic Silverside	907
Banded Killifish	1
Crab	1
European Green Crab	7
Fourspine Stickleback	15
Northern Pipefish	6
Sand Shrimp	2984
Stickleback	4
Winter Flounder	1
Grand Total	**3927**

AR6	*n*
Atlantic Rock Crab	1
Atlantic Silverside	881
Clupeidae	15
Fourspine Stickleback	3
Sand lance	3
Sand Shrimp	90
Three-spined Stickleback	1
Winter Flounder	5
Grand Total	**999**

AR8	*n*
Atlantic Rock Crab	9
Atlantic Silverside	945
Clupeidae	6
European Green Crab	70
Hermit Crab	3
Rainbow Smelt	1
Sand Shrimp	667
Smooth Flounder	5
Three-spined Stickleback	1
Winter Flounder	8
Grand Total	**1715**

AR10	*n*
Atlantic Silverside	27
European Green Crab	12
Mummichog	1
Sand lance	80
Sand Shrimp	41
Smooth Flounder	1
Three-spined Stickleback	1
Grand Total	**163**

AR12	*n*
Atlantic Silverside	13
European Green Crab	4
Grand Total	**17**

BR2	*n*
European Green Crab	14
Grand Total	**14**

AR7	*n*
American Eel	1
Atlantic Silverside	900
Clupeidae	2
European Green Crab	123
Fourspine Stickleback	1
Hermit Crab	1
Sand Shrimp	481
Three-spined Stickleback	2
Winter Flounder	5
Grand Total	**1516**

AR9	*n*
Atlantic Silverside	246
European Green Crab	95
Winter Flounder	4
Grand Total	**345**

AR11	*n*
Atlantic Silverside	114
European Green Crab	2
Grand Total	**116**

BR1	*n*
Atlantic Silverside	10
European Green Crab	16
Grand Total	**26**

BR3	*n*
Atlantic Rock Crab	1
Atlantic Silverside	127
European Green Crab	28
Flounder	1
Mummichog	1
Grand Total	**158**

BR4	*n*
Atlantic Silverside	430
Banded Killifish	1
European Green Crab	7
Mummichog	15
Rainbow Smelt	1
Grand Total	**454**

Appendix E. Estuary water quality monitoring data, collected using a YSI multiparameter sonde.

Site	Date	Time	Depth_m	Secchi_m	Temp_C	DO_mg	DOSAT	SPC	Cond	TDS	Salinity	pH
AR-45	6/3/2021	8:30	1	1.3	17	7.95	NA	77.6	65.7	50.05	0.04	7.02
AR-49	6/3/2021	9:04	1	1.3	18.1	8.24	88	83.4	72.6	53.95	0.04	7.06
AR-49	6/3/2021	9:04	2	NA	18	8.09	85.7	83.3	72.1	53.95	0.04	6.98
AR-49	6/3/2021	9:04	3	NA	17.9	7.49	80.1	105.2	108	54.6	0.04	6.89
AR-49	6/3/2021	9:04	4	NA	17.9	7.94	87.9	89.8	77.6	58.5	0.04	6.65
AR-53	6/3/2021	9:48	1	1.1	18	8.31	88	1108	962	728	0.6	6.75
AR-53	6/3/2021	9:48	2	NA	17.9	8.19	86.5	1325	1167	885	0.68	6.74
AR-60	6/3/2021	10:00	1	1	17.1	7.93	83.3	2845	2394	1855	1.51	6.79
AR-60	6/3/2021	10:00	2	NA	17	8.01	83.8	3742	3130	4492	1.94	6.77
AR-60	6/3/2021	10:00	3	NA	16	7.68	79.4	3891	3240	8296	14	6.65
AR-60	6/3/2021	10:00	4	NA	12.9	6.82	71.9	3890	3311	8477	17.61	6.82
AR-64	6/3/2021	10:45	1	1.1	17.6	8.69	92.3	9008	8488	6180	2.67	7.07
AR-64	6/3/2021	10:45	2	NA	15	7.63	80.8	10724	8906	8892	11.77	6.99
AR-64	6/3/2021	10:45	3	NA	12.5	7.01	77	12444	9411	9041	20.62	7.11
AR-64	6/3/2021	10:45	4	NA	12.2	6.82	72.4	12986	10464	9800	21.56	7.22
AR-64	6/3/2021	10:45	5	NA	12.1	6.88	73.3	13929	19433	11412	21.85	7.3
AR-67	6/3/2021	11:25	1	1	17.6	8.65	91.7	13942	14454	18201	3.76	7.27
AR-67	6/3/2021	11:25	2	NA	14	7.66	83.4	14256	26131	18946	18.2	7.09
AR-67	6/3/2021	11:25	3	NA	12.3	7.7	82.6	16994	26495	19416	20.39	7.28
AR-67	6/3/2021	11:25	4	NA	12.1	7.6	81.7	17009	28291	12153	23.02	7.41
AR-71	6/3/2021	12:03	1	1.9	16.7	8.89	0.99	21664	19463	15532	12.4	7.35
AR-71	6/3/2021	12:03	2	NA	14	8.35	92	26133	19696	19642	20.37	7.38
AR-71	6/3/2021	12:03	3	NA	13	8.14	89	28989	26432	19941	22.26	7.44
AR-71	6/3/2021	12:03	4	NA	12	8.15	88.2	30111	27774	22326	23.81	7.4
AR-75	6/3/2021	12:30	1	1	16.4	9.13	104.7	39426	42944	34291	18.95	7.54
AR-75	6/3/2021	12:30	2	NA	13.3	8.95	99.2	42136	44116	34326	23.98	7.61
AR-75	6/3/2021	12:30	3	NA	12.2	8.92	98.4	43341	45499	36219	25.48	7.65
AR-75	6/3/2021	12:30	4	NA	12.1	9.09	99.1	43926	46533	37222	25.82	7.65
AR-75	6/3/2021	12:30	5	NA	11.9	9.18	100.3	45041	46667	37411	26.14	7.67
AR-75	6/3/2021	12:30	6	NA	11.9	8.96	95.5	45641	47920	38422	26.22	7.7
AR-75	6/3/2021	12:30	7	NA	11.8	8.94	97.6	46002	54613	39991	26.26	7.7
AR-75	6/3/2021	12:30	8	NA	11.8	8.76	95.5	46423	54612	41010	26.32	7.91
AR-75	6/3/2021	12:30	9	NA	11.8	7.96	88.1	46439	54660	41940	26.31	7.73
AR-75	6/3/2021	12:30	10	NA	11.8	6.82	75.2	46520	55006	41946	26.21	7.63

AR-81	6/3/2021	13:00	1	1	18	9.89	114.5	37981	32451	29642	15.1	7.85
AR-81	6/3/2021	13:00	2	NA	14.9	9.5	104.7	41195	34456	31212	23.9	7.72
AR-81	6/3/2021	13:00	3	NA	12.1	9.4	102.9	42499	37001	32435	26.08	7.9
AR-81	6/3/2021	13:00	4	NA	12.1	9.48	104.4	44472	37946	32669	26.47	7.96
AR-81	6/3/2021	13:00	5	NA	12	9.3	102.5	44911	38800	34101	26.58	7.96
AR-81	6/3/2021	13:00	6	NA	12	9.4	102.6	45812	39044	34878	26.66	7.96
AR-81	6/3/2021	13:00	7	NA	12	9.36	102.6	47006	41014	35140	26.74	7.97
AR-81	6/3/2021	13:00	8	NA	11.9	9.43	103.3	47077	41112	35201	26.85	7.98
AR-81	6/3/2021	13:00	9	NA	11.9	9.42	103.3	47921	41946	36149	26.9	7.98
AR-81	6/3/2021	13:00	10	NA	11.9	9.44	103.3	48014	42224	36294	26.95	7.82
AR-82	6/3/2021	14:05	1	1.3	17.9	10.07	117.2	28661	26666	16792	15.63	7.93
AR-82	6/3/2021	14:05	2	NA	12.6	9.95	110	29929	27721	16944	26.12	7.74
AR-82	6/3/2021	14:05	3	NA	12.3	9.63	107.4	37742	29004	17411	26.38	7.81
AR-82	6/3/2021	14:05	4	NA	12.3	9.71	107.4	37926	30010	17821	26.6	7.79
AR-82	6/3/2021	14:05	5	NA	12.2	9.75	107.4	39004	30943	17901	26.82	7.74
AR-82	6/3/2021	14:05	6	NA	12.1	9.83	108.8	40111	31310	18004	26.83	7.79
AR-82	6/3/2021	14:05	7	NA	12.1	9.83	108.2	41400	32000	18104	26.81	7.8
AR-82	6/3/2021	14:05	8	NA	12.1	9.3	108.2	41912	32091	18444	27.5	7.8
AR-82	6/3/2021	14:05	9	NA	12.2	9.5	109.5	41992	33001	18901	26.52	7.81
AR-83	6/3/2021	14:05	1	1.3	17.9	10.07	117.2	28661	26666	16792	15.63	7.93
AR-83	6/3/2021	14:05	2	NA	12.6	9.95	110	29929	27721	16944	26.12	7.79
AR-83	6/3/2021	14:05	3	NA	12.3	9.63	107.4	37742	29004	17411	26.38	7.81
AR-83	6/3/2021	14:05	4	NA	12.3	9.71	107.4	37926	30010	17821	26.6	7.79
AR-83	6/3/2021	14:05	5	NA	12.2	9.75	107.4	39004	30943	17901	26.82	7.79
AR-83	6/3/2021	14:05	6	NA	12.1	9.83	108.8	40111	31310	18004	26.83	7.79
AR-83	6/3/2021	14:05	7	NA	12.1	9.83	108.2	41400	32000	18104	26.81	7.8
AR-83	6/3/2021	14:05	8	NA	12.1	9.3	108.2	41912	32091	18444	27.5	7.8
AR-83	6/3/2021	14:05	9	NA	12.2	9.5	109.5	41992	33001	18901	26.52	7.81
AR-51	6/8/2021	7:15	1	NA	14.2	6.23	62.3	81.6	69	48.1	0.03	7.61
AR-51	6/8/2021	7:15	2	NA	13.5	5.9	60	73	71.4	48.6	0.09	7.53
AR-45	6/21/2021	9:38	1	1.6	21.6	8.22	92.2	132.1	123.5	85.8	0.06	7.03
AR-45	6/21/2021	9:38	2	1.6	21.6	7.61	87.6	132.1	123.6	85.8	0.06	7.62
AR-49	6/21/2021	10:11	1	1.2	20.8	7.53	84.7	1081	1006	715	0.56	6.39
AR-49	6/21/2021	10:11	2	NA	20.5	7.41	82.7	2114	1879	1391	1.06	6.23
AR-49	6/21/2021	10:11	3	NA	20.3	6.84	76.4	4115	3136	2645.5	2.13	6.13
AR-49	6/21/2021	10:11	4	NA	20.3	6.77	75.9	4168	3787	2710.5	2.22	6.2
AR-53	6/21/2021	10:48	1	1.3	21	7.39	83.8	4240	3919	2736.5	2.23	6.32

AR-53	6/21/2021	10:48	2	NA	20.2	6.76	76.3	9582	8185	5603.5	5.01	7.01
AR-53	6/21/2021	10:48	3	NA	18.7	5.75	65.3	16812	14563	10894	9.84	6.2
AR-53	6/21/2021	10:48	4	NA	18.4	5.25	59.8	18379	16507	11920	10.89	6.28
AR-60	6/21/2021	11:20	1	1.3	20.1	7.08	83	13187	12024	8294	6.97	6.37
AR-60	6/21/2021	11:20	2	NA	17.6	5.22	60.2	25960	22295	16880	15.92	6.3
AR-60	6/21/2021	11:20	3	NA	17.3	4.81	56.9	27007	23074	17589	16.66	6.36
AR-60	6/21/2021	11:20	4	NA	16.9	4.49	51.3	28924	24460	18876	18	6.39
AR-64	6/21/2021	11:38	1	1.1	20.4	6.71	78.1	14010	12766	9080	8.33	6.53
AR-64	6/21/2021	11:38	2	NA	18.1	5.86	68.6	26724	23010	17166	16.26	6.46
AR-64	6/21/2021	11:38	3	NA	16.4	5.17	60	34559	28906	22457	21.75	6.48
AR-64	6/21/2021	11:38	4	NA	16	4.71	55.9	36137	29945	23530	22.94	6.53
AR-64	6/21/2021	11:38	5	NA	15.9	4.9	56.6	36609	30242	23790	23.2	6.58
AR-64	6/21/2021	11:38	6	NA	15.9	4.9	57	36700	30300	23861	23.26	6.59
AR-67	6/21/2021	12:00	1	1.4	20.4	6.88	80.9	15787	14255	16200	9.1	6.65
AR-67	6/21/2021	12:00	2	NA	17	5.94	73	35599	30188	23224	22.51	6.6
AR-67	6/21/2021	12:00	3	NA	15.9	5.68	66.3	38622	31909	25129	24.69	6.68
AR-67	6/21/2021	12:00	4	NA	15.7	5.36	63.7	39117	32201	25421	24.95	6.74
AR-67	6/21/2021	12:00	5	NA	15.6	5.69	66.7	39499	32443	25694	25.25	6.74
AR-67	6/21/2021	12:00	6	NA	15.6	5.64	66.1	39690	32548	25798	25.36	6.74
AR-71	6/21/2021	12:37	1	1.2	20.5	7.72	93.4	23660	20489	14332	13.3	6.93
AR-71	6/21/2021	12:37	2	NA	18.2	7.49	90.4	34962	30354	22685	22	6.9
AR-71	6/21/2021	12:37	3	NA	16.5	6.53	77.8	38063	31997	24804	24.29	6.84
AR-71	6/21/2021	12:37	4	NA	15.7	6.52	77	40389	33302	26321	25.87	6.84
AR-71	6/21/2021	12:37	5	NA	15.4	6.5	76.6	41191	33669	26767	26.41	6.86
AR-71	6/21/2021	12:37	6	NA	15.4	6.51	77.3	41243	33705	26806	26.46	6.86
AR-75	6/21/2021	13:00	1	1.8	18.5	8.17	100.05	37580	32955	24453	24.06	7.09
AR-75	6/21/2021	13:00	2	NA	16.8	8.22	98.6	40195	34272	26513.5	26.08	7.1
AR-75	6/21/2021	13:00	3	NA	16.1	7.79	91.8	41439	34445	26975	26.64	7.9
AR-75	6/21/2021	13:00	4	NA	15.9	7.81	93.2	42475	34838	27605.5	27.34	7.1
AR-75	6/21/2021	13:00	5	NA	15.5	8	94.9	42514	34829	27638	27.36	7.12
AR-81	6/21/2021	13:34	1	2.1	17.1	8.79	108.2	28711	26955	18980	17.66	7.31
AR-81	6/21/2021	13:34	2	NA	17.1	8.66	104.8	41161	34880	26754	26.42	7.23
AR-81	6/21/2021	13:34	3	NA	16	8.86	105.6	42486	35460	27859	27.61	7.22
AR-81	6/21/2021	13:34	4	NA	15.9	8.65	105.4	42965	35499	27937	27.7	7.23
AR-81	6/21/2021	13:34	5	NA	15.8	8.78	105.3	43112	35545	28021.5	27.79	7.47
AR-81	6/21/2021	13:34	6	NA	15.8	8.78	104.9	43205	35588	28106	27.88	7.98
AR-81	6/21/2021	13:34	7	NA	15.8	8.6	104.5	43274	35363	28125.5	27.91	8.06

AR-81	6/21/2021	13:34	8	NA	15.7	8.62	102.5	43279	35629	28132	27.91	8.06
AR-81	6/21/2021	13:34	9	NA	15.7	8.7	104.4	43327	35661	28158	27.95	7.27
AR-81	6/21/2021	13:34	10	NA	15.7	8.51	102.1	43460	35725	28249	28.04	8.05
AR-82	6/21/2021	14:05	1	2.3	20.8	8.31	106.3	35193	32026	22340	21.53	7.27
AR-82	6/21/2021	14:05	2	NA	17.4	8.93	111.1	41467	35344	26968	26.68	7.25
AR-82	6/21/2021	14:05	3	NA	16.5	9.05	110.5	42248	35612	27657	27.37	7.25
AR-82	6/21/2021	14:05	4	NA	16.4	9.12	110.4	42958	35887	27950	27.73	7.24
AR-82	6/21/2021	14:05	5	NA	16	9.05	108.8	43409	35949	28216	28.01	7.22
AR-82	6/21/2021	14:05	6	NA	16	8.83	106	43551	36023	28307	28.1	7.22
AR-82	6/21/2021	14:05	7	NA	16	8.86	105.9	43561	36027	28314	28.14	7.22
AR-82	6/21/2021	14:05	8	NA	15.9	8.84	105.8	43574	36016	28333	28.14	7.22
AR-82	6/21/2021	14:05	9	NA	15.9	8.74	104.6	43574	35973	28320	28.13	7.22
AR-82	6/21/2021	14:05	10	NA	15.8	8.61	102.7	43554	35852	28288	28.09	7.19
AR-83	6/21/2021	14:36	1	3	18.2	8.91	110	41293	35326	26825.5	26.62	7.25
AR-83	6/21/2021	14:36	2	NA	17.1	9.04	110.5	41821	35463	27228.5	26.8	7.28
AR-83	6/21/2021	14:36	3	NA	16.7	9.29	112.6	42384	35658	27566.5	27.23	7.28
AR-83	6/21/2021	14:36	4	NA	16.3	9.25	111.5	43506	35917	27982.5	27.72	7.27
AR-83	6/21/2021	14:36	5	NA	16.1	9.25	111.2	43460	36101	28255.5	28.03	7.26
AR-83	6/21/2021	14:36	6	NA	16.1	9.06	109.1	43517	36118	28288	28.09	7.27
AR-83	6/21/2021	14:36	7	NA	16	8.93	107.5	43612	36160	28353	28.16	7.26
AR-83	6/21/2021	14:36	8	NA	16	8.78	107.3	43680	36182	28392	28.2	7.27
AR-83	6/21/2021	14:36	9	NA	16	8.79	105.9	43770	36227	28457	28.27	7.27
AR-83	6/21/2021	14:36	10	NA	15.9	8.77	105.1	43867	36278	28515.5	28.33	7.27
AR-51	6/22/2021	7:15	1	NA	21.9	7.2	80	110	105.2	70.6	0.05	7.66
AR-51	6/22/2021	7:15	2	NA	19.2	5.49	74.6	96	89.1	66.4	0.06	7.49
AR-51	7/6/2021	14:00	1	NA	20	9.09	101.8	4944	4220	4076	2.45	6.76
AR-51	7/6/2021	14:00	2	NA	19.5	8	90.7	7400	6224	4745	3.88	6.73
AR-51	7/6/2021	14:00	3	NA	19	5.03	56.7	21283	18995	13962	15.02	6.63
AR-45	7/19/2021	10:16	1	NA	22.2	3.63	45.5	14495	1516	624	14.95	7.38
AR-45	7/19/2021	10:16	2	NA	21.8	3.75	47.1	24291	22851	15717	15.22	7.02
AR-45	7/19/2021	10:16	2.5	NA	21.8	3.74	46.7	24028	22575	15606	14.57	7.1
AR-49	7/19/2021	10:53	1	2	20.5	4.46	55.8	31295	29289	18934	19.2	7.08
AR-49	7/19/2021	10:53	2	NA	19.4	4.5	56.2	37448	33410	24297	23.71	7.26
AR-49	7/19/2021	10:53	3	NA	19.3	4.4	55.5	37752	33623	24524	23.99	7.32
AR-53	7/19/2021	11:25	1	1.7	21.5	5.05	65.2	32743	30178	23159	22.09	7.29
AR-53	7/19/2021	11:25	2	NA	18.8	5.45	67.9	40164	35389	26104	25.7	7.49
AR-53	7/19/2021	11:25	3	NA	18.8	5.43	67.4	40158	35393	26104	25.71	7.53

AR-53	7/19/2021	11:25	4	NA	18.8	5.32	66.5	40134	35378	26084	25.69	7.55
AR-60	7/19/2021	11:45	1	2	18.8	6.35	79.3	41464	36398	26903	26.78	7.63
AR-60	7/19/2021	11:45	2	NA	18.4	6.46	80.7	41783	36514	27157	26.87	7.7
AR-60	7/19/2021	11:45	3	NA	18.4	6.38	79.5	4180	36530	27170	26.87	7.71
AR-60	7/19/2021	11:45	4	NA	18.4	6.3	78.7	41802	36528	27170	26.87	7.71
AR-64	7/19/2021	14:19	1	2	19.6	6.45	83.2	38465	33596	23946	22.85	7.61
AR-64	7/19/2021	14:19	2	NA	18.2	6.97	87.7	42678	37134	27742	27.5	7.72
AR-64	7/19/2021	14:19	3	NA	18.1	6.98	87.4	42907	37195	27891	27.66	7.77
AR-64	7/19/2021	14:19	4	NA	18	6.66	84	42981	37223	27937	27.72	7.79
AR-64	7/19/2021	14:19	5	NA	17.9	6.77	84.2	43089	37277	28015	27.8	7.81
AR-67	7/19/2021	14:40	1	1.2	20.2	7.03	90.1	38471	34962	25044	24.3	7.69
AR-67	7/19/2021	14:40	2	NA	18	7.7	85.7	43193	37457	28086	27.93	7.81
AR-67	7/19/2021	14:40	3	NA	17.8	7.56	92.9	43622	37616	28359	28.18	7.85
AR-67	7/19/2021	14:40	4	NA	17.7	7.58	94.3	43804	37694	28476	28.31	7.87
AR-67	7/19/2021	14:40	5	NA	17.7	7.44	92.8	43870	37725	28515	28.35	7.87
AR-71	7/19/2021	15:00	1	1	21	7.88	99	38576	35450	25597	23.3	7.81
AR-71	7/19/2021	15:00	2	NA	18	8.2	102.5	43608	37712	28281	28.41	7.86
AR-71	7/19/2021	15:00	3	NA	17.6	7.95	98.5	44228	37981	28704	28.58	7.9
AR-71	7/19/2021	15:00	4	NA	17.5	7.96	99.4	44440	38097	28886	28.76	7.9
AR-75	7/19/2021	15:25	1	0.8	23.5	9.59	127	30990	30049	20150	19.3	8.15
AR-75	7/19/2021	15:25	2	NA	20.7	8.25	107	40085	36696	26071	25.65	8.07
AR-75	7/19/2021	15:25	3	NA	18.1	8.63	108.7	43817	38049	28470	28.29	7.99
AR-75	7/19/2021	15:25	4	NA	17.4	7.82	98.1	44823	38295	29146	29.06	7.95
AR-75	7/19/2021	15:25	5	NA	17.3	7.57	93.6	44884	38252	29178	29.08	7.94
AR-75	7/19/2021	15:25	6	NA	17.3	7.5	92.5	44894	38247	29178	29.08	7.93
AR-51	7/20/2021	12:00	1	NA	23.1	78.1	6.36	10345	9946	6701	5.83	7.25
AR-51	7/20/2021	12:00	2	NA	22.1	64	5.25	18990	17929	12343	11.28	7.08
AR-51	7/20/2021	12:00	3	NA	20.9	55.8	4.45	29051	26745	18869	18	7.04
AR-81	7/27/2021	14:20	1	1.7	23	7.77	101.5	35297	34051	22964	22.25	6.66
AR-81	7/27/2021	14:20	2	NA	22.7	7.48	98.8	35833	34309	23383	22.6	6.84
AR-81	7/27/2021	14:20	3	NA	22.4	7.53	98.9	36963	35401	24479	23.7	6.9
AR-81	7/27/2021	14:20	4	NA	20.8	7.97	10.4	40518	37295	26637	26.23	6.88
AR-81	7/27/2021	14:20	5	NA	18.6	8.08	102.4	43926	38480	28515	28.38	6.85
AR-81	7/27/2021	14:20	6	NA	18.4	7.95	100.3	44044	38436	28587	28.4	6.83
AR-81	7/27/2021	14:20	7	NA	17.7	7.71	95.4	44725	38456	29074	28.17	6.8
AR-81	7/27/2021	14:20	8	NA	17.7	7.59	94.9	44718	38460	29061	28.95	6.79
AR-81	7/27/2021	14:20	9	NA	17.7	7.57	94.7	44710	38468	29068	28.96	6.79

AR-81	7/27/2021	14:20	10	NA	17.6	7.59	94.6	44722	38457	29074	28.97	6.8
AR-82	7/27/2021	14:45	1	1.5	20.4	8.31	107.9	42505	38741	27631	27.36	6.94
AR-82	7/27/2021	14:45	2	NA	19.5	8.54	110	43181	38667	28245	27.84	6.92
AR-82	7/27/2021	14:45	3	NA	18.1	8.73	109.4	44440	38527	28899	28.79	6.89
AR-82	7/27/2021	14:45	4	NA	17.7	8.42	104.7	44627	38401	29003	28.89	6.86
AR-82	7/27/2021	14:45	5	NA	17.6	8.25	102.8	44707	38364	29074	28.97	6.99
AR-83	7/27/2021	15:00	1	1.6	17.8	8.35	104.9	44901	38711	29185	29.09	6.85
AR-83	7/27/2021	15:00	2	NA	17.7	8.39	10.8	44905	38675	29191	29.1	6.8
AR-83	7/27/2021	15:00	3	NA	17.7	8.47	103.6	44926	38647	29191	29.1	6.84
AR-83	7/27/2021	15:00	4	NA	17.6	8.27	103	44966	38629	28224	29.14	6.84
AR-83	7/27/2021	15:00	5	NA	17.5	8.43	104.8	45066	38608	29289	27.21	6.84
AR-83	7/27/2021	15:00	6	NA	17.3	8.31	103.5	45097	38617	29315	29.23	6.83
AR-83	7/27/2021	15:00	7	NA	17.4	8.54	105.4	43211	38629	29406	29.31	6.83
AR-83	7/27/2021	15:00	8	NA	17.3	8.61	106.7	45266	38633	29419	29.35	6.88
AR-83	7/27/2021	15:00	9	NA	17.3	8.37	104.2	45336	38656	29464	29.4	6.7
AR-83	7/27/2021	15:00	10	NA	17.3	8.46	104.3	45321	38641	29451	29.39	6.88
AR-49	8/4/2021	8:45	0	1	18.7	6.23	66.1	131.3	115.5	85.15	0.06	8.18
AR-49	8/4/2021	8:45	1	NA	18.7	6.22	66.5	129.7	114.9	83.85	0.06	7.93
AR-51	8/4/2021	9:25	0	1.5	20.2	6.84	75.4	590	536	377	0.27	7.16
AR-51	8/4/2021	9:25	1	NA	20.1	6.55	71.8	1046	964	669	1.8	7.43
AR-51	8/4/2021	9:25	2	NA	20.1	5.2	58.6	7910	7024	4959	4.2	6.98
AR-51	8/4/2021	9:25	2.5	NA	20.1	3.18	35.4	18654	16892	12064	11.08	6.85
AR-53	8/4/2021	10:20	0	1.5	19.5	8.14	88	2268	2033	1501	1.21	2-Jun
AR-53	8/4/2021	10:20	1	NA	19.4	6.73	73.6	2778	2480	1807	1.45	6.05
AR-53	8/4/2021	10:20	2	NA	19.4	6.11	64.6	4771	4207	2983	2.5	6.48
AR-53	8/4/2021	10:20	3	NA	19.9	1.99	20	28590	25814	18590	17.67	5.31
AR-53	8/4/2021	10:20	4	NA	19.9	1.14	13.8	3.0071	27137	19552	18.69	5.32
AR-60	8/4/2021	10:45	0	1.3	20.6	11.04	119.4	5860	5369	3809	3.19	7.55
AR-60	8/4/2021	10:45	1	NA	20.3	8.12	91.4	6253	5697	4069	3.42	7.5
AR-60	8/4/2021	10:45	2	NA	20.1	4.5	54	25110	22908	16276	15.4	7.13
AR-60	8/4/2021	10:45	3	NA	19.7	3.38	41.6	34203	30738	2217	21.52	7.07
AR-60	8/4/2021	10:45	4	NA	19.5	2.56	32.1	36387	32589	23467	23.03	7.13
AR-64	8/4/2021	11:10	0	0.8	21.2	9.01	103.3	10120	9396	6574	5.73	7.59
AR-64	8/4/2021	11:10	1	NA	20.6	7.42	84.6	11512	10564	7507	6.6	7.52
AR-64	8/4/2021	11:10	2	NA	19.9	6.4	79.3	33387	30270	21879	21.05	7.25
AR-64	8/4/2021	11:10	3	NA	19.4	5.4	67.2	38281	34188	24908	24.41	7.34
AR-64	8/4/2021	11:10	4	NA	19.3	5.1	62.5	39150	34898	25447	24.99	7.38

AR-64	8/4/2021	11:10	5	NA	19.3	4.85	60.7	39621	35277	25753	25.32	7.49
AR-64	8/4/2021	11:10	5.5	NA	19.2	4.85	61	39653	35298	2577	25.35	7.5
AR-67	8/4/2021	11:50	0	1.2	21.6	8.13	95.4	11931	11164	7754	6.82	7.76
AR-67	8/4/2021	11:50	1	NA	20.7	8.23	100.6	24198	22164	15463	14.47	7.74
AR-67	8/4/2021	11:50	2	NA	19.3	7	87	39838	35551	25915	25.49	7.65
AR-67	8/4/2021	11:50	3	NA	19	6.77	85	41767	36937	27163	26.87	6.12
AR-67	8/4/2021	11:50	4	NA	18.9	6.45	81.8	42074	37137	27352	27.07	7.01
AR-67	8/4/2021	11:50	5	NA	18.8	6.44	81.3	42488	37409	27618	27.36	6.02
AR-71	8/4/2021	12:58	0	1	21.7	8.66	103.2	14372	13466	9340	8.35	7.99
AR-71	8/4/2021	12:58	1	NA	20.9	9.12	110.9	21602	19975	14404	15.5	8.09
AR-71	8/4/2021	12:58	2	NA	19.6	8.36	105	39737	35555	25883	25.5	7.93
AR-71	8/4/2021	12:58	3	NA	18.9	7.83	98.2	42394	37432	27560	27.29	7.93
AR-71	8/4/2021	12:58	4	NA	18.6	7.55	95	43195	37895	28086	27.9	7.93
AR-71	8/4/2021	12:58	5	NA	18.4	7.31	91.7	43509	38052	28288	28.1	7.94
AR-75	8/4/2021	13:30	0	0.9	22.2	9.25	112.6	18047	17119	11745	10.69	8.26
AR-75	8/4/2021	13:30	1	NA	19.7	7.95	100.5	38295	34572	24999	24.99	8.05
AR-75	8/4/2021	13:30	2	NA	19	8.16	103.4	41779	36943	27196	26.9	8.08
AR-75	8/4/2021	13:30	3	NA	18.5	8.32	104.2	43347	37936	28177	27.99	8.08
AR-75	8/4/2021	13:30	4	NA	18.3	8.12	100.6	43830	38219	28489	28.33	8.07
AR-75	8/4/2021	13:30	5	NA	18.2	7.95	99.5	43992	38295	28593	28.44	8.06
AR-75	8/4/2021	13:30	6	NA	18.1	7.85	98	44266	38407	28769	28.63	8.06
AR-75	8/4/2021	13:30	7	NA	18	7.57	95	44361	38421	28834	28.7	8.05
AR-81	8/4/2021	14:15	0	NA	21.6	7.95	100.8	30516	28549	19831	18.97	8.13
AR-81	8/4/2021	14:15	1	NA	21.1	8.06	101.4	31932	29556	27187	20.12	8.12
AR-81	8/4/2021	14:15	2	NA	18.6	8.68	109.7	42349	37256	27709	27.53	8.12
AR-81	8/4/2021	14:15	3	NA	18.2	8.94	111.6	43688	37983	28411	28.24	8.15
AR-81	8/4/2021	14:15	4	NA	18	8.87	11.1	44100	38174	28678	28.54	8.16
AR-81	8/4/2021	14:15	5	NA	17.8	8.78	108.8	44591	38414	28983	28.88	8.16
AR-81	8/4/2021	14:15	6	NA	17.5	8.37	104.2	44882	38457	29172	29.08	8.14
AR-81	8/4/2021	14:15	7	NA	17.4	8.43	104.1	45023	38461	29269	29.18	8.15
AR-81	8/4/2021	14:15	8	NA	17.4	8.36	103.6	45020	38459	29256	29.17	8.15
AR-81	8/4/2021	14:15	9	NA	17.4	8.49	105.4	45044	38459	29282	29.2	8.16
AR-81	8/4/2021	14:15	10	NA	17.2	8.52	105.1	45259	38460	29412	29.34	8.16
AR-82	8/4/2021	NA	0	1	20.6	8.55	110.8	40021	36673	26093	25.6	8.19
AR-82	8/4/2021	NA	1	NA	20.5	8.38	108.1	40281	36970	26213	25.95	8.19
AR-82	8/4/2021	NA	2	NA	18.5	8.75	110.1	43270	37887	28125	27.92	8.19
AR-82	8/4/2021	NA	3	NA	18	9.07	113.8	44264	38308	28769	28.6	8.2

AR-83	8/4/2021	14:58	0	1.5	19.6	8.76	111.8	41968	37648	27287	26.99	8.22
AR-83	8/4/2021	14:58	1	NA	19.6	8.64	110.3	41986	37639	27300	27.02	8.22
AR-83	8/4/2021	14:58	2	NA	18.5	9.17	115.4	43687	38078	28372	28.13	8.22
AR-83	8/4/2021	14:58	3	NA	17.7	9.16	113.3	44383	38150	28853	28.7	8.23
AR-83	8/4/2021	14:58	4	NA	17.5	9.08	111.3	44446	38060	28899	28.77	8.22
AR-83	8/4/2021	14:58	5	NA	17	8.6	105.9	45009	38093	29263	29.19	8.21
AR-83	8/4/2021	14:58	6	NA	16.9	8.77	107.4	45138	38156	29334	29.25	8.2
AR-83	8/4/2021	14:58	7	NA	16.9	8.64	106.6	45171	38189	29360	29.28	8.2
AR-83	8/4/2021	14:58	8	NA	16.9	8.5	104.9	45249	38255	29412	29.35	8.19
AR-83	8/4/2021	14:58	9	NA	16.9	8.54	105.1	45310	38273	29451	29.38	8.19
AR-83	8/4/2021	14:58	10	NA	16.8	8.58	106.5	45430	38272	29529	29.49	8.19
AR-45	11/12/2021	9:47	1	1.23	5	11.64	91.3	89	55	57.85	0.04	6.39
AR-45	11/12/2021	9:47	2	NA	5	11.62	90.9	89.9	54.9	57.85	0.04	6.37
AR-49	11/12/2021	10:03	1	1.12	5.4	11.3	89.5	374.7	235.5	232.05	0.17	6.67
AR-49	11/12/2021	10:03	2	NA	5.6	11.03	85.4	1888	1194	1222	0.96	6.35
AR-49	11/12/2021	10:03	3	NA	8.6	7.79	73	21558	14783	14001	12.88	5.92
AR-51	11/12/2021	10:13	1	1.61	5.5	11.33	90.2	1120	720	754	0.58	6.9
AR-51	11/12/2021	10:13	2	NA	5.8	10.88	87.8	2703	1682	1547	1.32	6.72
AR-51	11/12/2021	10:13	3	NA	8.9	7.36	70.1	24145	16818	15886	14.83	6.12
AR-53	11/12/2021	10:33	1	1.54	5.9	10.99	88.7	2169	1398	143.5	1.12	6.75
AR-53	11/12/2021	10:33	2	NA	8.2	8.59	78.7	18573	12430	11862.5	9.54	6.28
AR-53	11/12/2021	10:33	3	NA	10	6.57	66	31044	22143	20169.5	19.25	6.28
AR-60	11/12/2021	10:49	1	1.76	6.1	10.59	87	5530	3521	3529.5	2.96	7.01
AR-60	11/12/2021	10:49	2	NA	10.5	6.75	69.4	35139	25391	22847.5	22.07	6.57
AR-60	11/12/2021	10:49	3	NA	10.7	6.41	66.9	36345	26435	23621	22.91	6.74
AR-64	11/12/2021	11:07	1	1.35	7.2	9.73	84.6	12973	8551	8443	7.45	7.11
AR-64	11/12/2021	11:07	2	NA	11	6.85	72.7	38486	28232	25007	24.47	6.82
AR-64	11/12/2021	11:07	3	NA	11.2	6.33	67.5	39748	29312	25893	25.34	7
AR-64	11/12/2021	11:07	4	NA	11.3	6.56	70	39949	29465	25961	25.43	7.12
AR-64	11/12/2021	11:07	5	NA	11.3	6.61	71.1	40066	29566	26032.5	25.51	7.21
AR-67	11/12/2021	11:25	1	1.68	8.8	8.88	81.5	19544	13745	12844	12.02	7.28
AR-67	11/12/2021	11:25	2	NA	11	6.89	73.6	39166	28750	25486.5	24.91	7.14
AR-67	11/12/2021	11:25	3	NA	11.4	6.8	73.4	40800	30189	26533	26.06	7.22
AR-67	11/12/2021	11:25	4	NA	11.4	6.67	71.9	41153	30481	26754	26.29	7.28
AR-67	11/12/2021	11:25	5	NA	11.5	6.55	71.3	41468	30747	26962	26.52	7.34
AR-71	11/12/2021	11:58	1	1.24	8.2	8.6	80.2	23207	15960	14985	13.13	7.47

AR-71	11/12/2021	11:58	2	NA	11	6.97	74.6	39544	28913	25655.5	25.06	7.31
AR-71	11/12/2021	11:58	3	NA	11.4	7.02	76.1	41622	30824	27053	26.62	7.37
AR-71	11/12/2021	11:58	4	NA	11.5	6.9	75	41974	31133	27287	26.88	7.42
AR-71	11/12/2021	11:58	5	NA	11.5	6.74	73.5	42111	31248	27378	26.97	7.46
AR-75	11/12/2021	12:18	1	1.78	10.5	7.61	79.8	39042	28311	2389.5	24.84	7.46
AR-75	11/12/2021	12:18	2	NA	11.3	7.52	81.2	42147	31123	27397.5	26.99	7.47
AR-75	11/12/2021	12:18	3	NA	11.4	7.42	80.8	42580	71483	27670.5	27.29	7.5
AR-75	11/12/2021	12:18	4	NA	11.4	7.47	81.1	42695	31598	22761.5	27.39	7.54
AR-75	11/12/2021	12:18	5	NA	11.4	7.51	81.1	42805	31684	27826.5	27.46	7.56
AR-75	11/12/2021	12:18	6	NA	11.4	7.38	80.6	42818	31691	27833	27.47	7.58
AR-81	11/12/2021	12:42	1	2	9.8	8.7	88.8	37764	26960	24368.5	23.7	7.64
AR-81	11/12/2021	12:42	2	NA	10.8	8.17	87.2	42317	30808	27508	27.08	7.62
AR-81	11/12/2021	12:42	3	NA	10.8	8.34	89.5	42590	31035	27683.5	27.28	7.64
AR-81	11/12/2021	12:42	4	NA	10.7	8.48	90.9	43041	31316	27956.5	27.58	7.66
AR-81	11/12/2021	12:42	5	NA	10.7	8.54	91.6	43159	31371	28060.5	27.69	7.67
AR-81	11/12/2021	12:42	6	NA	10.6	8.61	92.3	43228	31367	28099.5	27.72	7.69
AR-81	11/12/2021	12:42	7	NA	10.6	8.62	92.2	43266	31373	28119	27.75	7.7
AR-81	11/12/2021	12:42	8	NA	10.6	8.65	92.8	43291	31362	28138.5	27.76	7.71
AR-81	11/12/2021	12:42	9	NA	10.6	8.66	93	43304	31369	28145	27.77	7.71
AR-81	11/12/2021	12:42	10	NA	10.5	8.71	93.2	43355	31357	28190.5	27.82	7.72
AR-82	11/12/2021	13:03	1	2.16	9.9	8.93	92.6	38663	27579	24960	24.06	7.68
AR-82	11/12/2021	13:03	2	NA	10.6	8.61	91.8	42219	30556	27404	26.99	7.65
AR-82	11/12/2021	13:03	3	NA	10.6	8.7	93	42681	30934	27768	27.39	7.67
AR-82	11/12/2021	13:03	4	NA	10.7	8.64	92.8	42980	31242	27904.5	27.54	7.68
AR-82	11/12/2021	13:03	5	NA	10.6	8.66	92.9	43138	31295	28041	27.66	7.69
AR-82	11/12/2021	13:03	6	NA	10.3	8.72	93	43326	31139	28164.5	27.78	7.72
AR-82	11/12/2021	13:03	7	NA	10.1	8.95	94.9	43600	31222	28340	27.96	7.74
AR-82	11/12/2021	13:03	8	NA	10.2	9.08	95.8	43683	31299	28392	28.2	7.75
AR-82	11/12/2021	13:03	9	NA	10.1	8.86	94.2	43699	31306	28405	28.03	7.76
AR-82	11/12/2021	13:03	10	NA	10.2	8.91	95.4	43720	31352	28418	28.05	7.77
AR-83	11/12/2021	13:22	1	1.51	8.7	9.4	93.6	37915	26086	24609	23.8	7.78
AR-83	11/12/2021	13:22	2	NA	9	9.2	93.4	39423	27375	25876	25.43	7.77
AR-83	11/12/2021	13:22	3	NA	9.6	8.93	92.8	41852	29526	27222	26.7	7.76
AR-83	11/12/2021	13:22	4	NA	10	8.8	93	42377	30272	27579.5	27.12	7.76
AR-83	11/12/2021	13:22	5	NA	9.9	8.8	92.9	43132	30674	28034.5	27.62	7.77
AR-83	11/12/2021	13:22	6	NA	10	9.8	93	43568	31117	28320	27.93	7.77