

Investigation into sturgeon feeding excavations using RPAS: Initial Site Assessments

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ABSTRACT

O’Laughlin, C., Law, B.A., Zions, V.S. 2019. Investigation of sturgeon feeding excavations using RPAS: initial site assessments. Can. Tech. Rep. Fish. Aquat. Sci. 3323: v + 68 p.

Atlantic Sturgeon (*Acipenser oxyrinchus*) use inner Bay of Fundy tidal flats and channels to feed on buried infauna, leaving feeding excavations in bottom sediments. As commercial development of tidal power resources continues, future outlook suggests that up to several hundred turbines may be proposed to occupy the area. The potential for interaction between sturgeon and tidal turbines has been described as concerning, as sturgeon are poor swimmers (Stokesbury *et al.* 2016). This work is intended to establish linkages between Atlantic Sturgeon feeding grounds in the inner Bay of Fundy, where feeding excavations are observable at low tide from the ground and air, and site-specific sediment characteristics (e.g. grain size). This includes RPAS (remotely piloted aircraft systems) surveys of intertidal areas, to construct surface models of sturgeon feeding grounds, coupled with traditional grain size methods. Surveys confirm springtime feeding in large numbers, in bottom material with a median grain size of approximately 30 µm. During summer months, a less-dense patchwork of feeding excavations were identified in coarser material, with median grain sizes of 60-80 µm, at several locations. These data will contribute to a more complete understanding of sturgeon habitat use through linkages with sediment characteristics.

RÉSUMÉ

O’Laughlin, C., Law, B.A., Zions, V.S. 2019. Investigation of sturgeon feeding excavations using RPAS: initial site assessments. Can. Tech. Rep. Fish. Aquat. Sci. 3323: v + 68 p.

L’esturgeon noir (*Acipenser oxyrinchus*) utilise les battures et les canaux de la baie de Fundy pour se nourrir de l’endofaune ensevelie, créant des fosses d’alimentation dans les sédiments marins. Puisque le développement commercial des ressources marémotrices se poursuit, on peut supposer qu’on pourrait proposer l’installation de plusieurs centaines de turbines dans la région. Les interactions possibles entre l’esturgeon et les turbines marémotrices sont jugées préoccupantes, puisque l’esturgeon est un piètre nageur (Stokesbury *et al.* 2016). Ces travaux visent à établir des liens entre les aires d’alimentation de l’esturgeon noir à l’intérieur de la baie de Fundy, où l’on peut observer, à marée basse, des fosses d’alimentation, depuis la surface et du haut des airs, et les caractéristiques propres au site (ex. taille des grains de sédiments). On procède entre autres à des relevés des zones intertidales au moyen de systèmes d’aéronef télépiloté (SATP) afin de produire des modèles de surface des aires d’alimentation de l’esturgeon, en plus des méthodes traditionnelles de granulométrie. Les relevés confirment une alimentation printanière intensive dans des sédiments marins dont la taille médiane des grains est d’environ 30 µm. Durant les mois d’été, à plusieurs endroits, des réseaux moins denses de fosses d’alimentation ont été observés dans les sédiments plus grossiers dont la taille médiane des grains est de 60 à 80 µm. Ces données permettront de mieux comprendre la façon dont l’esturgeon utilise son habitat, en établissant des liens avec les caractéristiques sédimentaires.

1.0 Introduction

1.1 Initiative

Extensive tidal flats in the macro-tidal inner Bay of Fundy (iBoF) are ubiquitous and provide important habitat for an abundance of shorebirds, fishes and intertidal fauna (Buzeta *et al.*, 2013). Atlantic Sturgeon *Acipenser oxyrinchus oxyrinchus*, Mitchill 1815, which are listed as threatened under COSEWIC, use iBoF tidal flats and channels throughout spring and summer months to feed on buried infauna (Beardsall *et al.*, 2016; Taylor *et al.*, 2016), primarily in areas composed of mud with a small sand fraction, <10% (Person *et al.*, 2007). Previous studies by Law *et al.* (2014) have documented these same compositions of mud and sand in the southern bight of Minas Basin, on the Kingsport tidal channel-flat complex. In 2016, the placement of one grid-connected tidal turbine occurred in the Minas Passage, where it remained until being removed for maintenance in 2017. In late 2018, a second test deployment occurred, with more turbines scheduled to be placed in the next 1 – 3 years. Future outlooks and potential extractable power calculations suggest commercial development could incorporate hundreds of turbines (Karsten, 2011; Mulligan *et al.*, 2013).

Large development projects such as Tidal In-Stream Energy Conversion (TISEC) devices could fundamentally change regional tidal flat morphodynamics. Seabed change occurs through either the deposition or the erosion of sediment. In areas that experience a decrease in tidal flow, mud can accumulate while in areas that experience accelerated flow, the erosion of mud could occur, both of which may cause an equilibrium shift in the seabed (c.f. van Proosdij *et al.*, 2009). However, a complete understanding of processes related to cohesive sediment dynamics in this area is lacking, including the formation and morphology of macro-tidal flats and channels. Therefore, understanding natural baseline conditions in a dynamic sediment environment such as the iBoF is necessary to fully gauge the possible impact of development projects. This project is intended to examine the prevalence of Atlantic Sturgeon in the iBoF, through observation of excavations left in the mud during feeding to establish linkages between preferred feeding grounds and sediment characteristics (i.e. grain size).

1.2 Background

When feeding, Atlantic Sturgeon produce distinct feeding excavations in intertidal sediment as they forage through mud and sand with their snouts. Previous work by Pearson *et al.* (2007) and Dadswell *et al.* (2016) suggests that this feeding practice is the primary erosional and depositional agent on the intertidal mudflats in Chignecto Bay during the summer months.

Additionally, a clockwise migratory pattern around the Minas Basin through the summer has been proposed (Dadswell *et al.*, 2016). However, the temporal and spatial distribution of sturgeon within the iBoF, as well as specific habitat utilization patterns, are not well understood. Recent estimates suggest that approximately 9,000-10,000 Atlantic Sturgeon enter the Minas Basin annually to feed on a variety of buried infauna, predominately tube-dwelling polychaetes and amphipods (McLean *et al.*, 2013b). The extreme tide range in the iBoF (>15 m) creates a highly dynamic environment, throughout which desirable sturgeon foraging areas are scattered, both spatially and temporally; it has been shown that foraging sturgeon move more frequently into feeding areas during flood tides than during ebb phases, presumably to increase their foraging time (McLean *et al.*, 2013b). In addition, the highly varied iBoF substrate means feeding areas are often discontinuous, with gravel lags and intertidal ledges mixed amongst feeding grounds. It is possible that the nature of sediments in which Atlantic Sturgeon feed is sufficiently unique. If so, the definition of appropriate feeding grounds based on sedimentary properties such as the dominant or median grain size of bottom sediments may provide insight to Atlantic Sturgeon population vulnerability. This includes the likelihood to which they may be impacted by changing coastal environments, e.g. in response to TISEC devices or sea level rise. Stokesbury *et al.* (2016) classify the potential for interaction between sturgeon and tidal turbines as 'concerning', and as sturgeon are poor swimmers, their ability to avoid turbines in fast moving water is low.

This research centers on spatial and temporal sampling of the iBoF intertidal mudflats using RPAS (Remotely Piloted Aircraft Systems) in conjunction with traditional grain size sampling of bottom sediments. RPAS, also known as drones, have recently gained popularity in several facets of geoscientific research, including their use to remotely collect imagery of dynamic areas of coastal change (Cunliffe *et al.*, 2019; Turner *et al.*, 2016; Long *et al.*, 2016), including mudflats (Jaud *et al.*, 2016). This includes the generation of high-resolution models, created using digital imagery and the long-standing principle of photogrammetry. Within this approach, a further specialized mapping method known as Structure from Motion (SfM) has been developed to produce a three-dimensional digital topography, constructed using overlapping aerial photographs at multiple viewpoints (Micheletti *et al.*, 2015; Fonstad *et al.*, 2015). This method has proven useful and sufficiently accurate in comparison with existing light detection and ranging (LiDAR) methods, especially in small and more concentrated areas of study. SfM only requires a series of overlapping images, with no special requirements of camera positions, orientations and lens parameters, making it possible to use images collected with consumer-grade RPAS to generate high-quality 3D digital topography (O'Donnell and Smith, 2015).

Grain size is a fundamental defining property of soft-sediment benthic ecosystems, which hold within them a record of the processes responsible for the formation of sedimentary deposits (Kranck 1973; Kranck 1985). Grain-size analysis is especially useful in description of tidal flats because they are generally composed of beds containing a mixture of particle sizes. Tidal flats can often experience abrupt transitions from sands in areas where tidal stress is large, to fine muds pushed into vegetated areas where shear stress is decreased. The processes of deposition, erosion, and transport of sand sized grains is well understood (Soulsby, 1997), but mud, or the <63um fraction, behaves in a different manner. The Kingsport tidal channel-flat complex (Southern Bight, Minas Basin), which is used as summer foraging grounds by Atlantic Sturgeon, will provide an understanding of the natural erosion and depositional conditions. Material from this location has been previously collected and analyzed for grain size during high-resolution sampling under the Strategic Program for Ecosystem-Based Research and Advice (SPERA) and also through Nova Scotia Offshore Energy Research (OEER/OERA) funding to the Particle Dynamics Lab, BIO. These grain-size analyses (e.g. Law *et al.*, 2014; Law *et al.*, 2018) have shown that the composition of mud and sand is similar to those studied by Pearson *et al.* (2007) at Mary's Point, New Brunswick, where feeding is well documented. Feeding excavations similar to those illustrated in Pearson *et al.* (2007) have been observed on the Kingsport flats during previous work at the site, but have not yet been properly documented.

The D-morphology module within DELFT-3D computes sediment transport and morphological change. A high resolution hydrodynamic model has already been established to drive sediment dynamics in the D-morphology module (Ashall *et al.*, 2016). Data collected in this project as well as from previous projects will be used to validate the morphological module. Once validated, the hydrodynamic-morphodynamic model will be used to predict morphology changes to the iBoF tidal flats under a variety of scenarios related to tidal power development in the Minas Passage, such as the implementation of different numbers of tidal turbine devices. Changes to hydrodynamics in the model will be implemented by varying drag, which causes acceleration of tidal flow in some areas and deceleration in others, allowing the model to predict areas of the tidal flats that may be at risk for change in morphology. Imagery collected with RPAS are used to construct accurate 3D models of intertidal areas, which is used in conjunction with bottom grain size samples to further assist with validation of the morphodynamic model.

We anticipate that this research, while focused on the southern Bight of the Minas Basin, will demonstrate the general usefulness of RPAS as platforms to locate and quantify inter-tidal Atlantic Sturgeon foraging habitat. A combination of commercial landings, RV trawl survey and

Fishery Observer records (Bradford *et al.* 2016) imply an association of Atlantic Sturgeon with areas of extensive inter-tidal habitat in the iBoF, including embayment areas with potential for tidal power generation with TISEC devices (e.g. Minas Basin) and the Musquash Estuary Marine Protected Area. Furthermore, the extensive intertidal flats of the Bay of Fundy region support numerous localized commercial, recreational, and food, social and ceremonial (FSC) fisheries for shellfish and marine worms. Several species harvested by these fisheries are known components of the Atlantic Sturgeon diet (MacLean *et al.* 2013a; Pearson *et al.* 2007), and were accordingly identified as threats to habitat (DFO, 2013). Through creation of 3D models characterizing the intertidal zone, RPAS and SfM offer the potential to help assess the effects of these fisheries on the food supply of an aquatic species of high regional and national conservation significance, using non-invasive, cost-effective and efficient methods.

1.3 Objectives

Overall, this work has three primary objectives: (1) to use RPAS to map the spatial and temporal morphodynamics (e.g. changing topography) of the Kingsport tidal channel-flat complex, and to relate RPAS imagery to grain-size conditions in the contexts of sediment dynamics and sturgeon habitat mapping; (2) To use DELFT-3D modelling systems (D-morphology module) to predict changing morphology (e.g. grain size) as compared to the observations in bottom sediment samples collected on the Kingsport tidal-channel-flat complex; and (3) to describe baseline conditions of grain size and morphology on the tidal flats of the iBoF, and provide advice on possible change to morphodynamics of tidal flats in Minas Basin (an Ecologically or Biologically Significant Marine Area, or EBSA) in response to change in tidal flow from TISEC development. This report is focussed on the first and third objectives, intended to develop baseline conditions for use in modelling. Advice in the form of risk maps will be provided for areas that support Atlantic Sturgeon foraging such as the Kingsport tidal flats. The use of aerial imagery and comparison to the seabed grain size on temporal and spatial scales will provide detailed information on natural baseline conditions.

2.0 Methodology

2.1 Overflights, image processing and feeding excavation identification

RPAS (DJI, model Phantom 3 Professional) (Figure 1) were used to map a section of the Kingsport tidal channel-mudflat complex, central areas of the extensive Mary's Point tidal flats, and other tidal flat locations in the iBoF (Minas Basin) area. Survey overflights typically began 1 hour prior to low tide, to capture as much of the exposed intertidal zone as possible while the tide

was lowest, and concluded within 1 hr after the predicted low tide time. The drone's 12.4 megapixel camera utilizes a 1/2.3" CMOS sensor to capture 4000x3000 geotagged images. Automated piloting software (DJI, Ground Station Pro v. 1.8.2.) was employed to fly the drone during image acquisition. Once on site at any given study area, a bounding box drawn around the intended target allowed the flight software to produce a flight plan. Images were collected using a 'capture by time' function, where the drone flies at a given speed (~2.5 m/s) and collects imagery at a constant rate – in this case, every 3 s. Front overlap was set at 80% and sidelap 70% to ensure adjacent images had sufficient coverage for model construction. Flight altitudes were 25 m. Due to the low flight altitude necessary for sufficient resolution on the ground, and the high amount of overlap required for modelling, survey overflights typically took 2-3 hours to complete, including time for battery changes.

High-resolution 3D models were constructed from RPAS images via photogrammetry and SfM, using customized processing techniques in Pix4Dmapper Pro (v. 4.2.26). The identification of feeding excavations and fecal piles was completed manually, with features identified, marked and subsequently counted using ImageJ (version 1.52o). Only two-featured excavations, left by mouth and barbels, were counted. The use of RPAS for this work is a novel approach with success in other applications such as changing morphodynamics on beaches and other coastal habitats (O'Donnell and Smith, 2015; Sherwood, 2016).

During the summer and fall of 2017, three field campaigns were conducted to test proposed methods, including the RPAS flights and RTK (real-time kinematic) surveying, in the mudflat and tidal channel setting at Kingsport (Figure 2). Test flights were completed at multiple altitudes, ranging from 10 to 40 m. In general, lower level flights require more imagery to cover a given area and thus take more time, while higher level flights are quicker, but give a higher ground sampling distance (GSD) and capture less detail. Given these limitations, and the scale of the sturgeon mud marks reported by Pearson *et al.* 2007 (10-30 cm), a flight altitude of 25 m was settled upon. This allowed for an area ~500 m² to be surveyed during low tide conditions. Flight planning software, image collection methods (e.g. nadir versus oblique) and image processing methods (e.g. with and without oblique) were also tested during these campaigns. Ground control points (GCPs) were utilized to aid in georeferencing and model reconstruction. Simple GCPs made from nylon (Figure 3) were placed at known locations around the target area and surveyed with an RTK GPS system (Hemisphere, model S321). The GCPs were captured in drone imagery and then used within the processing software to spatially orient the surveyed area by incorporating accurate geolocation data. The use of GCPs strongly increases the georeferencing quality of

final model outputs, but their use is made challenging by the time and effort required to deploy, survey, and collect – especially in the intertidal zone. Data collected during 2017 campaigns were predominately used for testing and refinement of methods ahead of the 2018 feeding season, and are thus not reported on further.

2.1 Grain size analysis

Bottom sediments were collected in the same areas of the RPAS over-flights and will be used to link bottom feeding habitat with grain size, and to validate model outputs. The disaggregated inorganic grain size (DIGS) of bottom sediments were determined using a Coulter Multisizer (Beckman-Coulter, model MS3). Organic matter was removed from bottom sediments with 35% hydrogen peroxide (H₂O₂). Tubes sized 30, 200 and 400 µm were used to produce DIGS, which are expressed as the log of equivalent volume versus log of particle diameter, normalized over the size range. For more information on grain size analysis and a complete description of protocols, see Milligan and Kranck (1991) and Law *et al.* (2008).

2.2 Modelling

The modelling component of this study is currently in progress and is being completed by Dr. Ryan Mulligan (Queens University). The D-morphology module of the DELFT 3-D modelling system will be used to validate morphological change and to make future predictions. The hydrodynamic model for the area is available and validated (Ashall *et al.*, 2016a; Ashall *et al.*, 2016b). This hydrodynamic model will be used to run the morphological module, which will be validated using grain size results and RPAS surface models. Once the morphodynamic model is validated, it will be used to predict change in iBoF tidal flat morphodynamics in response to tidal power development.

3.0 Results & discussion

A total of 7 sites around the iBoF were surveyed during the spring, summer and fall of 2018, including Mary's Point, NB; Five Islands, NS; Economy, NS; Portapique, NS; Walton, NS; Bramber, NS; and Kingsport, NS (Figure 4). Previous work by Pearson *et al.* (2007) documented a large concentration of feeding excavations at Mary's Point, New Brunswick, in late spring. Work for this project began in March 2018 at Mary's Point to capture and example of pre-fish conditions. Mary's Point was investigated again in early June 2018, when three adjacent patches of mudflat were surveyed with the RPAS. Many excavations and associated fecal piles were identified and photographed from the ground (Figure 5) and air (Figure 6). Feeding excavations and fecal piles

were manually identified and counted; incomplete traces and depressions that lacked the two-featured arrangement indicative of feeding excavations were excluded on the possibility that these were formed by other environmental processes, such as shellfish and crab burrowing, erosion or infauna activity. Due to the previous research on the site and the large numbers of fish that feed there (evidenced by multiple fully complete feeding excavations), the characteristics of Mary's Point bottom sediments (e.g. median grain size, particle size distribution) will be treated as an indicator of potential sturgeon feeding grounds. DIGS results show that the maximum grain size measured at Mary's Point was $<130\ \mu\text{m}$; d_5 , d_{50} and d_{95} values ranged from $1\text{-}8\ \mu\text{m}$, $20\text{-}50\ \mu\text{m}$ and $65\text{-}108\ \mu\text{m}$ respectively. A comparison of the average bottom sediment DIGS at all sites is presented in Figure 7. Bottom sediment material from Mary's Point, Kingsport and Portapique were most similar and tended to be silt-dominated; bottom sediment from remaining sites was generally coarser, including a stronger component of fine sand. If linkages between grain size results (e.g. DIGS analysis) and remotely-sampled sediment composition (e.g. RPAS imagery) can be sufficiently developed to predict grain size attributes from three-dimensional modelled surfaces, then this method could well be adapted to investigate changes in substrate texture (e.g. grain size) in response to any form of anticipated change, such as sea level rise or a reduction in tidal amplitude due to energy extraction by TISEC devices.

In the Minas Basin, site selection followed the clockwise progression of migratory feeding proposed by Dadswell *et al.* (2016), where sturgeon abundance shifts from the northern to southern shore through the spring to summer months. Study sites were generally near active fishing weirs, where sturgeon are regularly encountered by local fishers. Overflights (25 m altitude) were completed at each site, and bottom sediments for grain size analysis were collected from the flight area. Orthomosaics of each survey and location maps for each study site are shown in Figures 8-31. In situations with uneven lighting, or where changes in lighting conditions occur during image acquisition flights, some orthomosaics show inconsistent surface colors and suffer from a banding effect. No orthomosaic is presented for zone b at Bramber due to survey inconsistencies. In general, feeding excavations in the bottom sediments that can be attributed to feeding Atlantic Sturgeon were identified at 5 of the 7 sites visited in 2018 (Figure 32). These were seen in highest density in early June at Mary's Point, and in lower density in late June at Five Islands and Economy, and in mid to late July at Portapique and Bramber. Feeding excavations found at Portapique appeared to have been reworked by tides, and were thought to be old at the time of our survey (July 31, 2018); however marks thought to be reworked feeding

excavations were of high density and in high numbers, covering most of the surveyed surface (Figure 20).

The high density of feeding excavations observed at Mary's Point supports the findings of Pearson *et al.* (2007), which reported > 50 excavations per 100 m² in large areas of the expansive mudflat; at some locations, they counted over 400 feeding excavations (Pearson *et al.*, 2007, Figure 5). For direct comparison with the results of this study, individual feeding excavations in RPAS images (Figure 33) were counted (Figures 34-38), from the same area of the Mary's Point flat that Pearson *et al.* found > 50 excavations per 100 m². Discrete RPAS photos of this area show in excess of 70 individual excavations over an area of approximately 35 m²; this extrapolates to over 200 excavations per 100 m², which compares well with results described by Pearson *et al.* (2007). Other sites where feeding excavations were found showed more sparse distribution, and the excavations occurred in smaller, more discrete patches (e.g. Economy, Bramber).

The complete results of grain size analyses are shown, for each site, in Figures 39-47. Overall, median grain size (d50) from all sites ranged from approximately 30 to 80 µm. Bottom sediment samples were not collected at Bramber (zone A) or Walton (zone A) due to tidal restrictions. The coarsest material (medium sand, approximately 250 µm) that was encountered came from samples at Economy and Walton; evidence of feeding excavations were located in low density at Economy, suggesting that some individuals may feed in the fine to medium sands found there. It is notable that at sites other than Mary's Point, the feeding excavations were of comparably lower number and density. Portapique may be the only exception, as potential excavations were seen in high density; however, reworking by tides reduced confidence in the validity of excavations observed at this location. Overall, this may support a possible disparity between high-density feeding zones with smaller median grain sizes (e.g. 30 µm at Mary's Point), and relatively lower-density feeding zones with beds composed of slightly coarser material (e.g. 60 µm, very fine to medium sands and shells at Economy).

The clockwise migration around the Minas Basin proposed by Dadswell *et al.* (2016) is generally supported by the findings of this study, where excavation marks were detected in June on the northern shore of Minas Basin (e.g. Economy), and in July on the southern (e.g. Bramber). However, excavations encountered at these sites were of undetermined age, and showed various amounts of reworking by tides, making it difficult to determine exactly when the fish were feeding at each particular area. The 'freshest' excavations during 2018 surveys were seen at Mary's Point in June; this was also the only site where fecal piles were seen during 2018 surveys, which are

expected to be removed in a few tidal cycles. In addition, relatively fresh feeding excavations and moderately reworked fecal piles were documented at Kingsport in late June 2019, which does not fit the clockwise hypothesis. This will be reviewed in continuing work on this project.

A number of challenges arose during the RPAS survey and image processing workflow. This includes but is not limited to the use of GCPs in the field, manual selection of camera settings, environmental conditions, image quality and image processing protocols. The deployment of GCPs has proven to be very time consuming, especially in the intertidal zone where access is limited by tides and travelling through deep mud is difficult and disruptive to the study area substrate. GCPs must be secured to the ground and surveyed with the RTK system to get an accurate, stable position that can then be located and marked in RPAS imagery. Ideally, 6-12 GCPs would be available for georeferencing per survey, spread out in a semi-random pattern over the area of interest. Due to the time restrictions imposed when using GCPs, and the belief that a useful orthomosaic could still be assembled without GCPs, they were only employed at one of the sites surveyed in 2018 (Kingsport). Continuing survey work will incorporate GCPs at all sites, including Mary's Point work in June 2019.

The deployment of GCPs at Kingsport was a planned effort to investigate the reproducibility of RPAS surveys and resultant surface models. Overall, surveys without GCPs from other sites show that surface re-creation can introduce spatial distortion errors that eliminate the potential for change detection or fine-scale observations or measurements (e.g. measuring sturgeon excavations). There is a strong likelihood that these errors are artefacts of the relatively ambiguous topography being surveyed. In certain environments (e.g. highly-varied substrate, or high relief topography), the software can more accurately determine the spatial distribution of objects on the ground using automatic tie points – hard, static features that show up in multiple images. On the intertidal mudflats, which are flat and with sometimes very few distinctive features, the software struggles to pull together an accurate surface and errors are generated. This makes GCPs even more critical for surveys in the intertidal zone as compared with more terrestrial areas, as they allow for precise georeferencing and produce models that accurately show the spatial characteristics (shape, size) and overall distribution of objects on the ground. An example digital surface model (DSM) constructed for Kingsport using GCPs is shown in Figure 41, along with profiles of the tidal channels bordering the site.

Camera settings were also considered during testing, and the use of automatic mode was found to be effective when strong changes in illumination conditions are anticipated over the flight

duration, allowing the camera to make changes mid-flight. With strong sun, the mudflats are very reflective and throw off a large amount of glare; this tends to produce illumination banding that makes surface interpretation from orthomosaics difficult. Flying the drone to flight altitude and making manual adjustments to camera settings prior to image acquisition has become the adopted practice. Parameters such as ISO, shutter speed and white balance are manipulated to maximize image quality (e.g. brightness). In addition, the use of polarizing filters has been adopted to reduce glare. However, lighting conditions rarely stay constant, and in-flight adjustments are frequently necessary. The best image acquisition conditions have proven to be in low light, with a moderate amount of cloud cover to shield the direct sun from the surface. Overflights are also limited by weather conditions such as wind and rain. Flights with the RPAS units used here cannot occur in any type of precipitation, and while they can fly in a substantial amount of wind (up to 30 km/h), the quality of GPS and orientation data from the drone is reduced in these conditions.

Another challenge that has been identified is the overall quality of images collected with the RPAS, which has limited the quality of 3D models. The flat, uniform nature of tidal flats make them difficult subjects when acquiring nadir images, and some photos show a blurring effect of textural changes in the mud. This causes problems in processing as the software cannot find the desired number or density of automatic tie points needed to accurately reconstruct the surface. The camera on the Phantom 3 Pro RPAS uses an electronic rolling shutter, which are common on affordable consumer cameras. Rolling shutters expose the camera sensor in a series of progressive rows that rapidly scan across the scene, usually top to bottom. This creates a time lag between the beginning and end of sensor exposure, which can produce predictable distortions. To address this, orthomosaics and digital surface models presented here (captured with the Phantom 3 Pro) were processed using a linear rolling shutter model within Pix4D, which attempts to rectify and process out any distortion caused by the rolling shutter. Currently, a new drone has been acquired (Phantom 4 Professional V2) and will replace the Phantom 3 Pro. The new unit has a larger, 20 megapixel 1" CMOS sensor, as well as a hybrid electronic and mechanical shutter, which will eliminate rolling shutter distortion and provide better definition of subtle variations in sediment color and texture.

Finally, processing techniques in Pix4D have been refined through the 2018 season. Processing within Pix4D is broken down into three discrete steps. The adopted method has evolved to truncate processing following each step to perform quality control. This allows errors that may develop in the point cloud in step one to be rectified before moving forward. Other

lessons learned during image processing workflows, along with use of the linear rolling shutter model, include definition of the desired processing area, the incorporation of high altitude photos in addition to those captured at 25 m, and the use of scale and orientation constraints.

4.0 Preliminary conclusions & future work

Excavation marks that can be attributed to foraging Atlantic Sturgeon were identified at 5 of the 7 sites surveyed in 2018. Samples of bottom sediment from surveyed sites have been processed for grain size, and the characteristics (e.g. dominant grain size, particle size distribution) of material found alongside excavation marks will be treated as an indicator of potential sturgeon feeding grounds. The clockwise feeding migration around the Minas Basin proposed by Dadswell *et al.* (2016) is generally supported by findings presented here. Potential feeding excavations were detected in late June on the northern shore of Minas Basin (e.g. Five Islands, Economy), and in July on the southern (e.g. Bramber). In continuing work on this project, emphasis will be placed on sediment sampling in those areas where feeding excavations are found, specifically during the period when fish are actively feeding, to better characterize any variability in substrate at sturgeon feeding sites. In addition to surveys at these locations, continued exploration will also be undertaken to further identify locations where feeding excavations might occur in high density, using dominant grain size as a general guide. Work completed by Logan-Chesney *et al.* (2017) reported a high number of sturgeon surface breeches in the Minas Basin, which is proposed to be part of the fishes' effort to maintain buoyancy at a particular depth, for feeding in soft substrata through regulation of gas bladders. Breeching behaviour was found to occur most frequently during flood tides. It then should be possible to observe surface breeches (from shore or a small boat) during flood tides to identify current feeding locations, which then could be surveyed with the RPAS and sampled for bottom sediments at the following low tide phase.

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Figure 1: Phantom 3 Professional from DJI, an off-the-shelf RPAS with a 12.4 megapixel camera.



Figure 2: Kingsport tidal channel-flat complex on the Southern Bight of the Minas Basin.

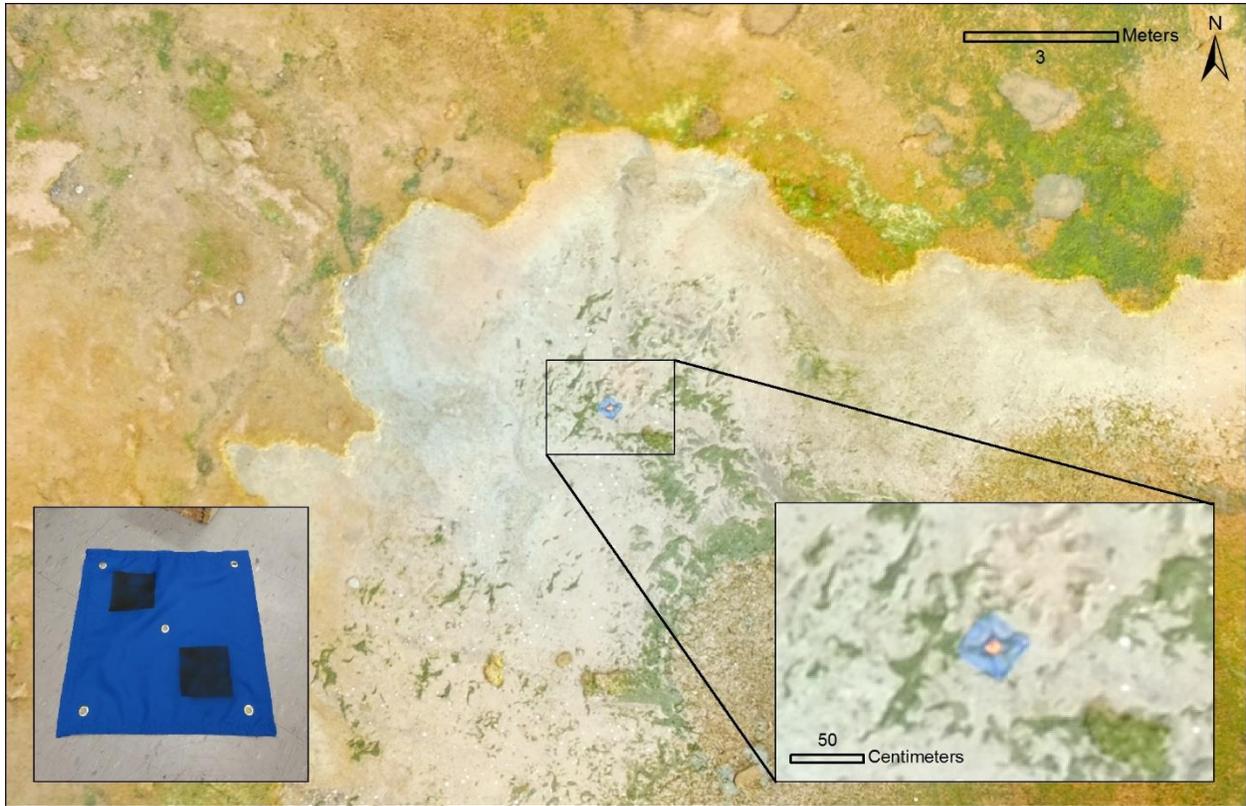


Figure 3: Ground control point (GCP) in place at Kingsport. Inset (left): Nylon GCPs were made in-house and measure 40 cm x 40 cm. Early designs featured two offset 10 cm x 10 cm black squares or a single 10 cm x 10 cm orange square in the center.

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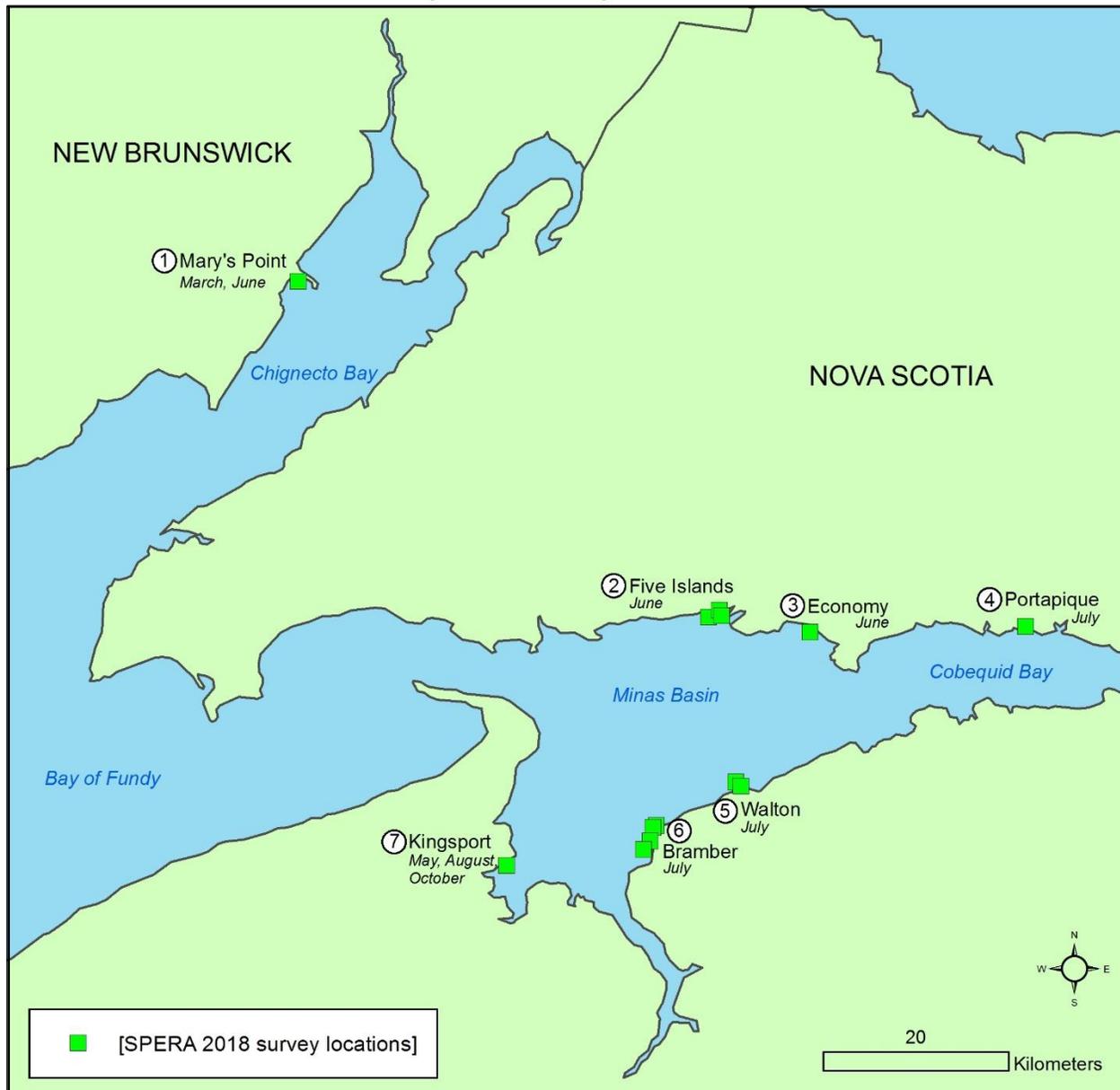


Figure 4: Inner Bay of Fundy RPAS survey sites (numbered 1-8) visited during the 2018 field season (March-November). Study sites were generally based on where Atlantic sturgeon have been caught in weirs, or where their feeding marks have been found.



Figure 5: Fecal piles and feeding excavations at Mary's Point, New Brunswick, in early June 2018.

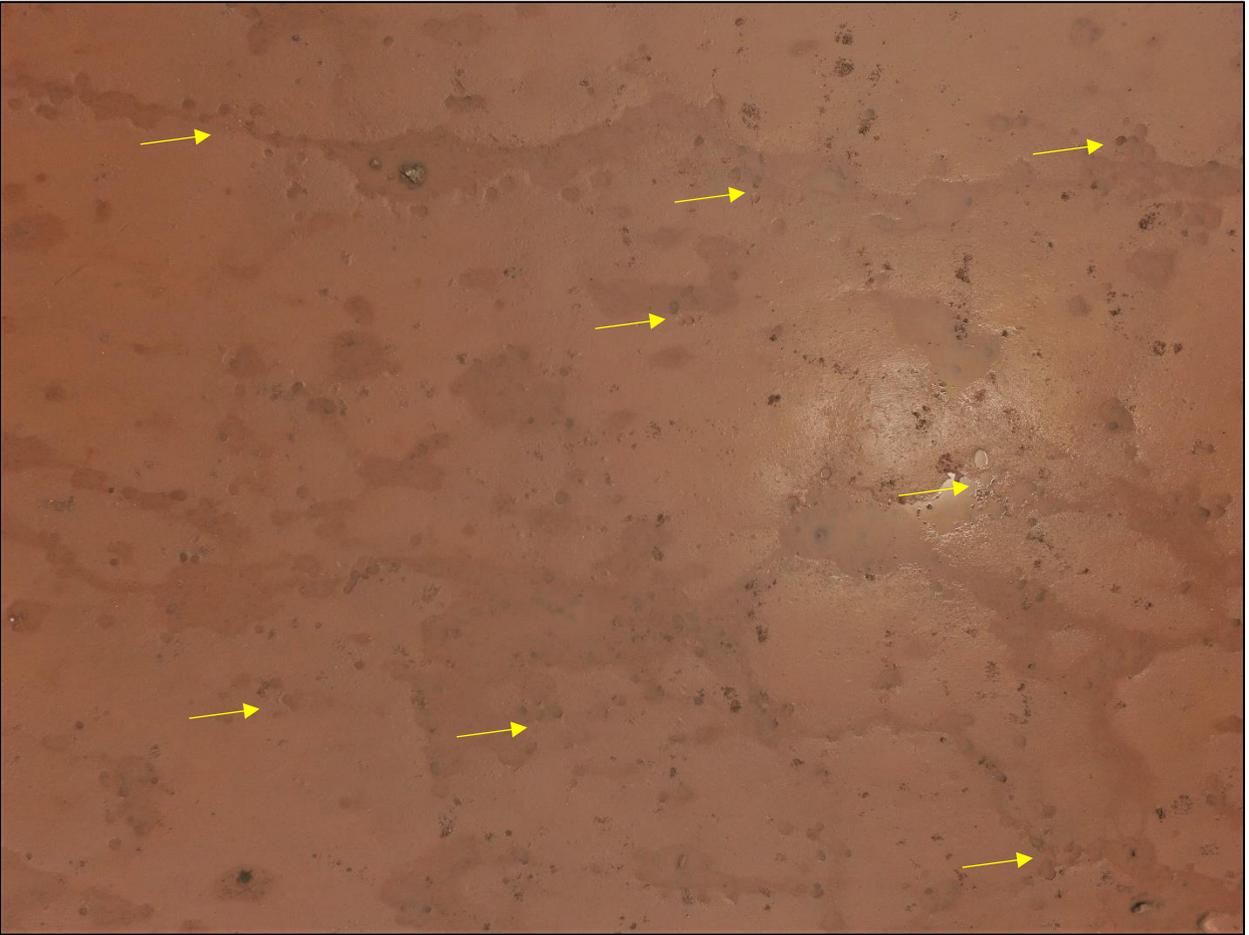


Figure 6: Fecal piles and feeding excavations visible in RPAS photo (altitude 5 m) at Mary's Point, New Brunswick, in early June 2018. Arrows indicate areas of well defined, two-feature excavations.

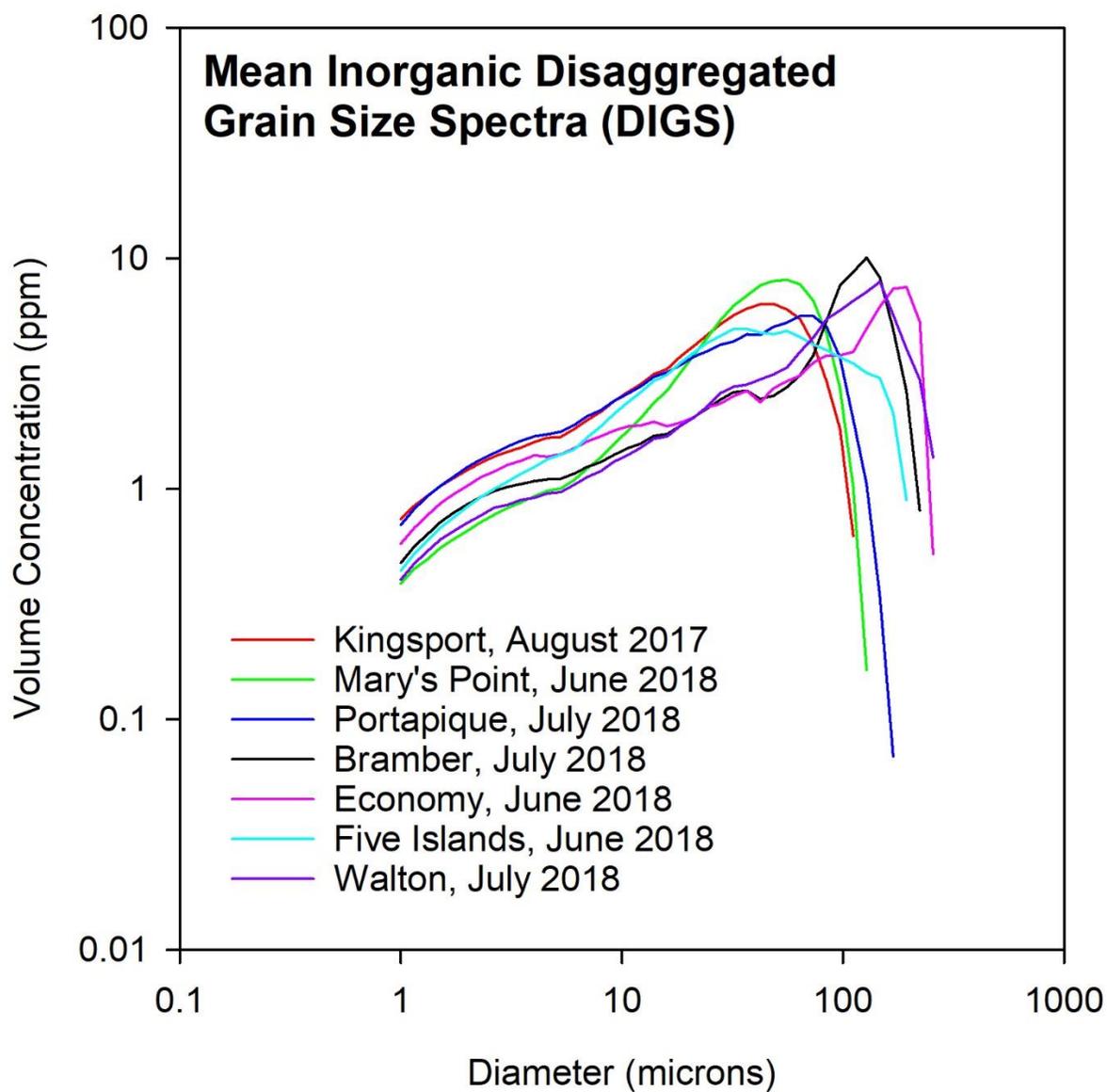


Figure 7: A preliminary comparison of average disaggregated inorganic grain size (DIGS) from all SPERA sites, including Mary's Point, NB (June 2018) and Kingsport, NS (August 2017).

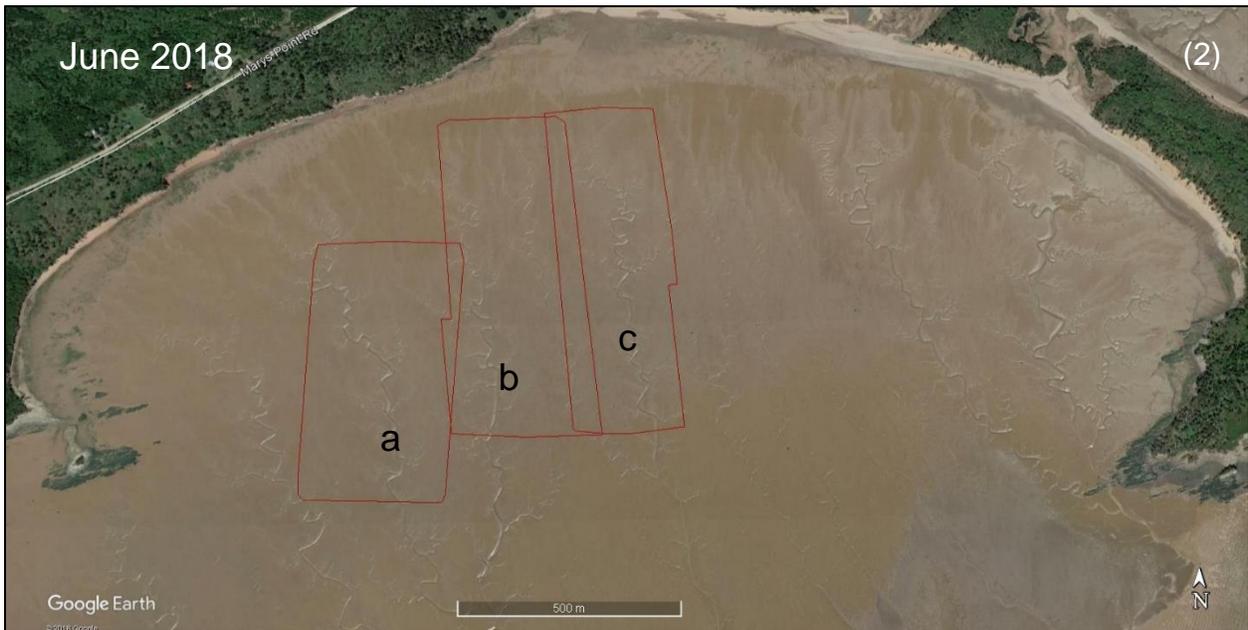


Figure 8: Location & extent (colored polygons) of RPAS surveys of the expansive mudflat at Mary's Point, NB, within the Shepody wilderness area on Chignecto Bay, in (1) March and (2) June 2018 (zones a-c).

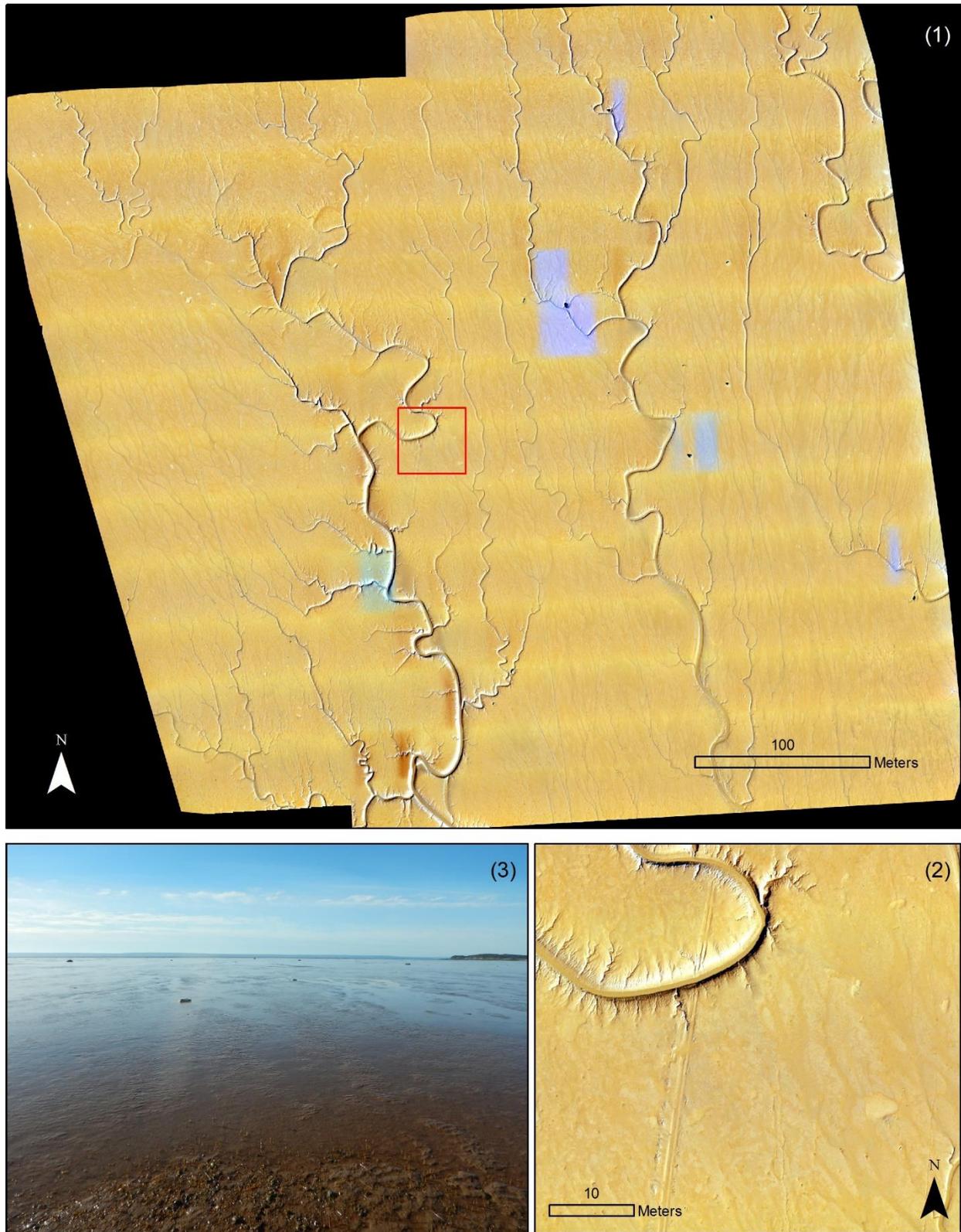


Figure 9: (1) Orthomosaic of surveyed area at Mary's Point, 21 March 2018; area in red square is shown in panel (2); (3) view from the ground.

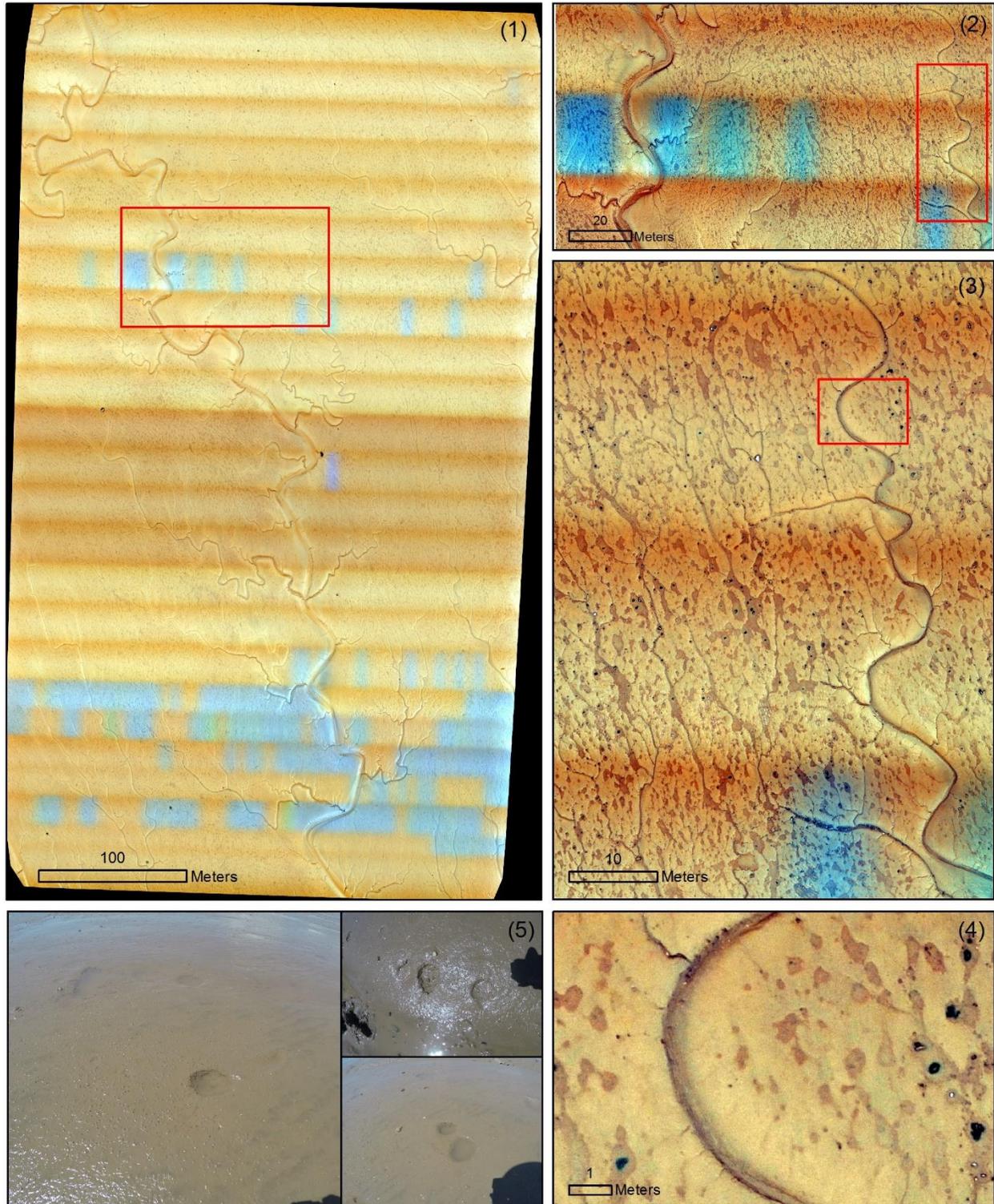


Figure 10: (1) Orthomosaic of surveyed area at Mary's Point, zone a, 6 June 2018; areas in red squares are shown in subsequent panels (2,3,4). Panel 5 shows ground-level photos of feeding excavations.

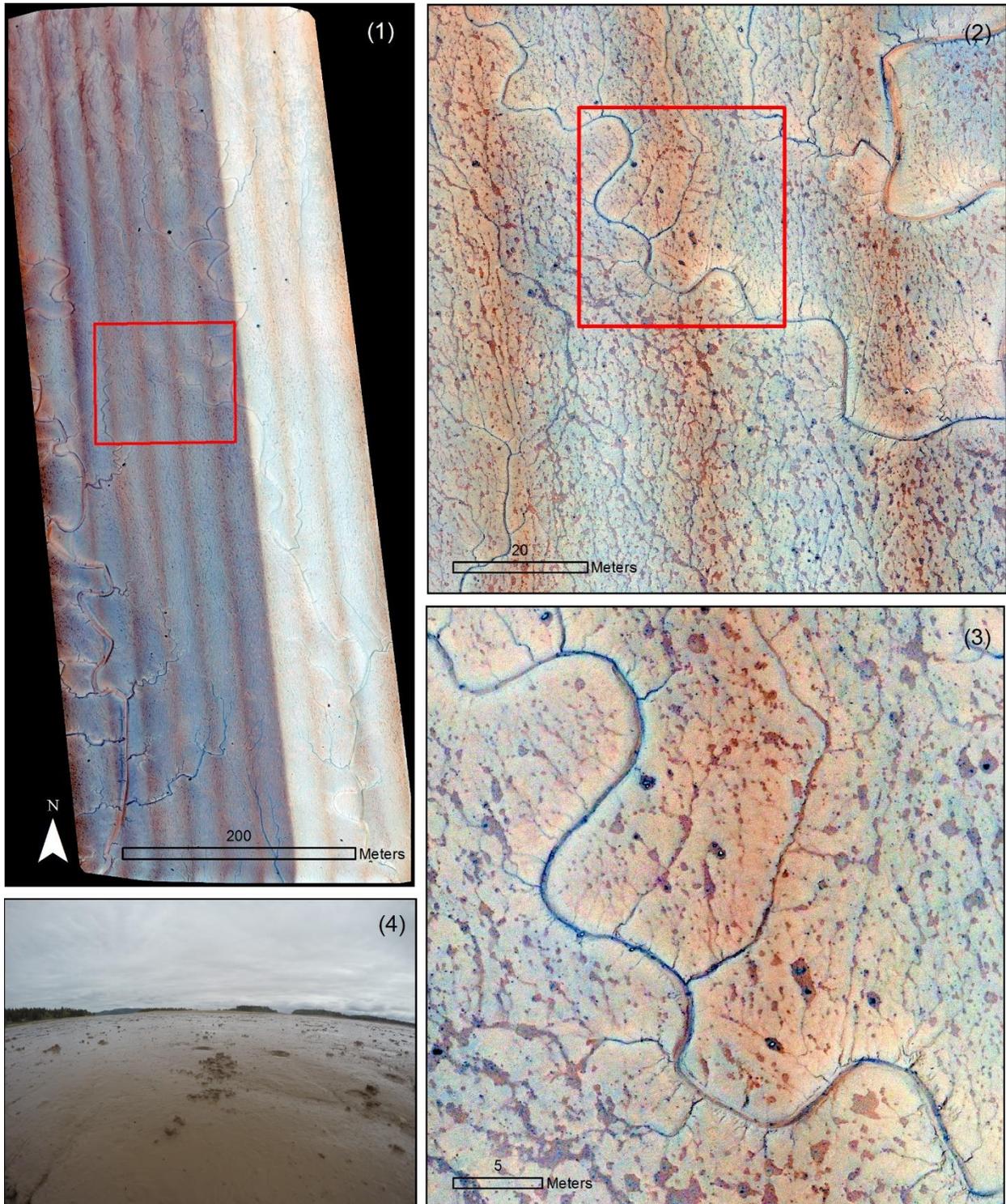


Figure 11: (1) Orthomosaic of surveyed area at Mary's Point, zone b, 5 June 2018; areas in red squares are shown in subsequent panels (2,3); (4) fish-eye photo from the ground showing feeding excavations and fecal piles.

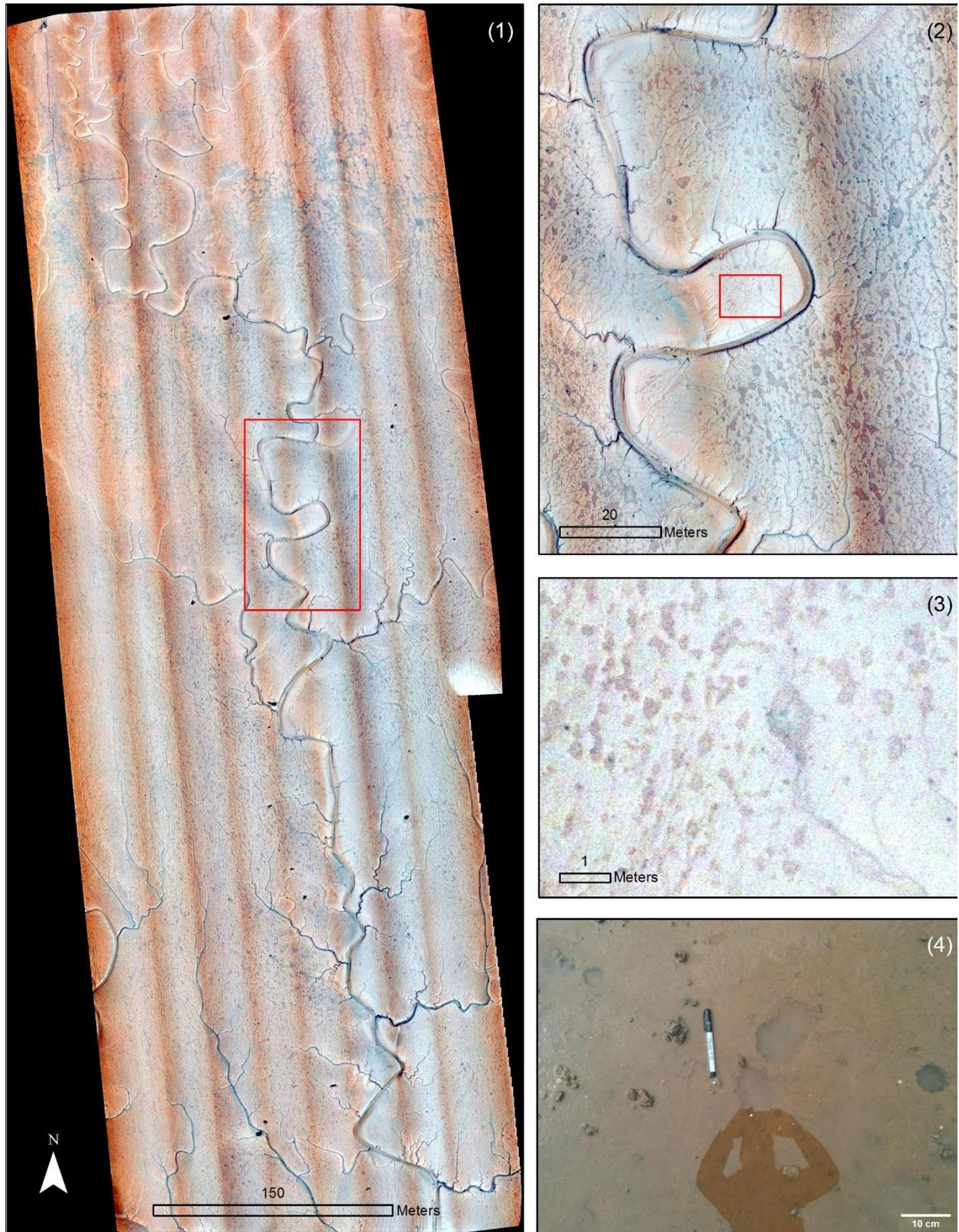


Figure 12: (1) Orthomosaic of surveyed area at Mary's Point, zone c, 6 June 2018; areas in red squares are shown in subsequent panels (2,3); (4) an individual feeding excavation.

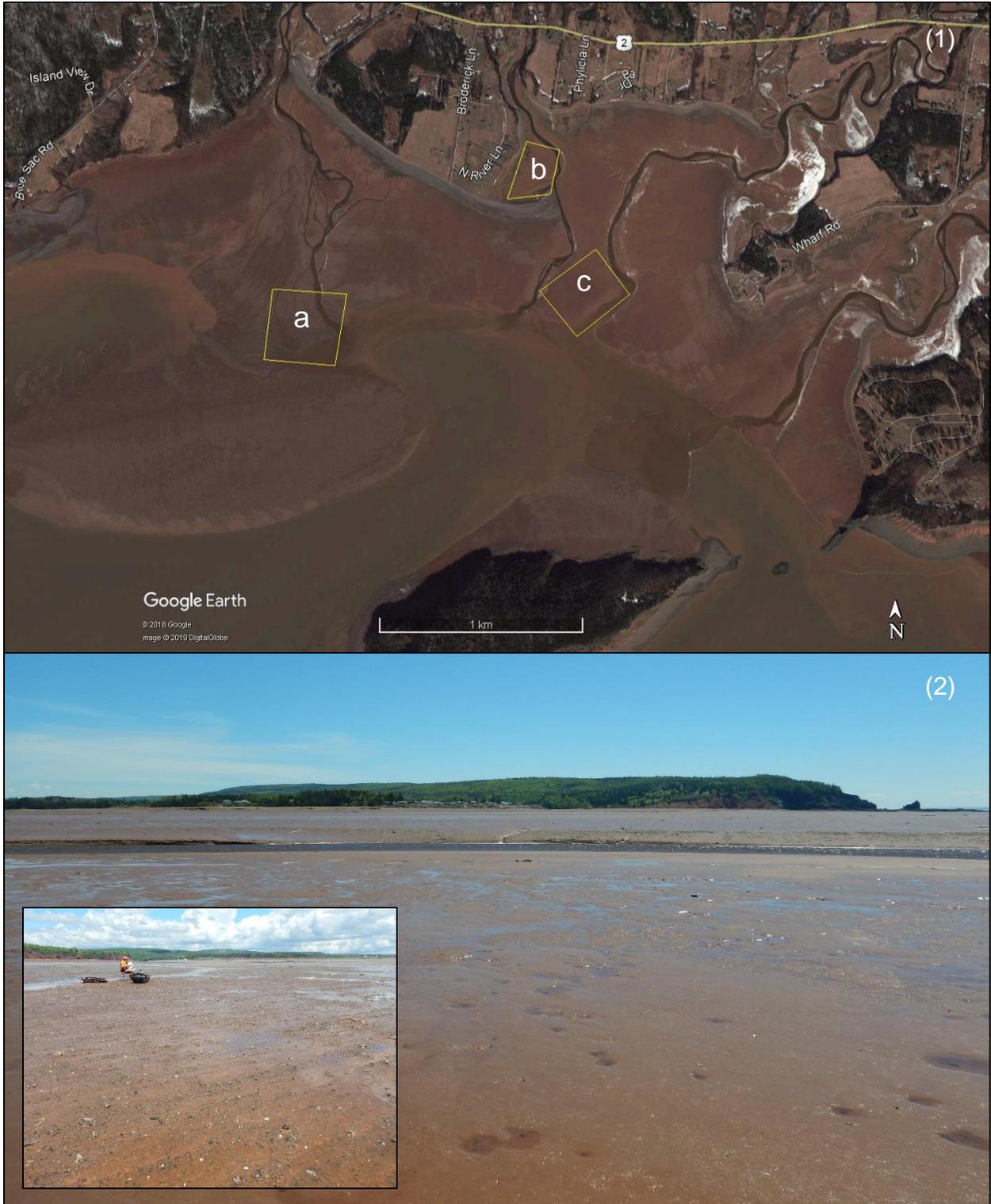


Figure 13: (1) Locations and extents (yellow polygons) of RPAS surveys at Five Islands, Nova Scotia. Three zones were surveyed in June 2018 (a-c). (2) Photo showing the view to the south east from the north shore, from ground level; inset: rocky substrate at survey zone a.

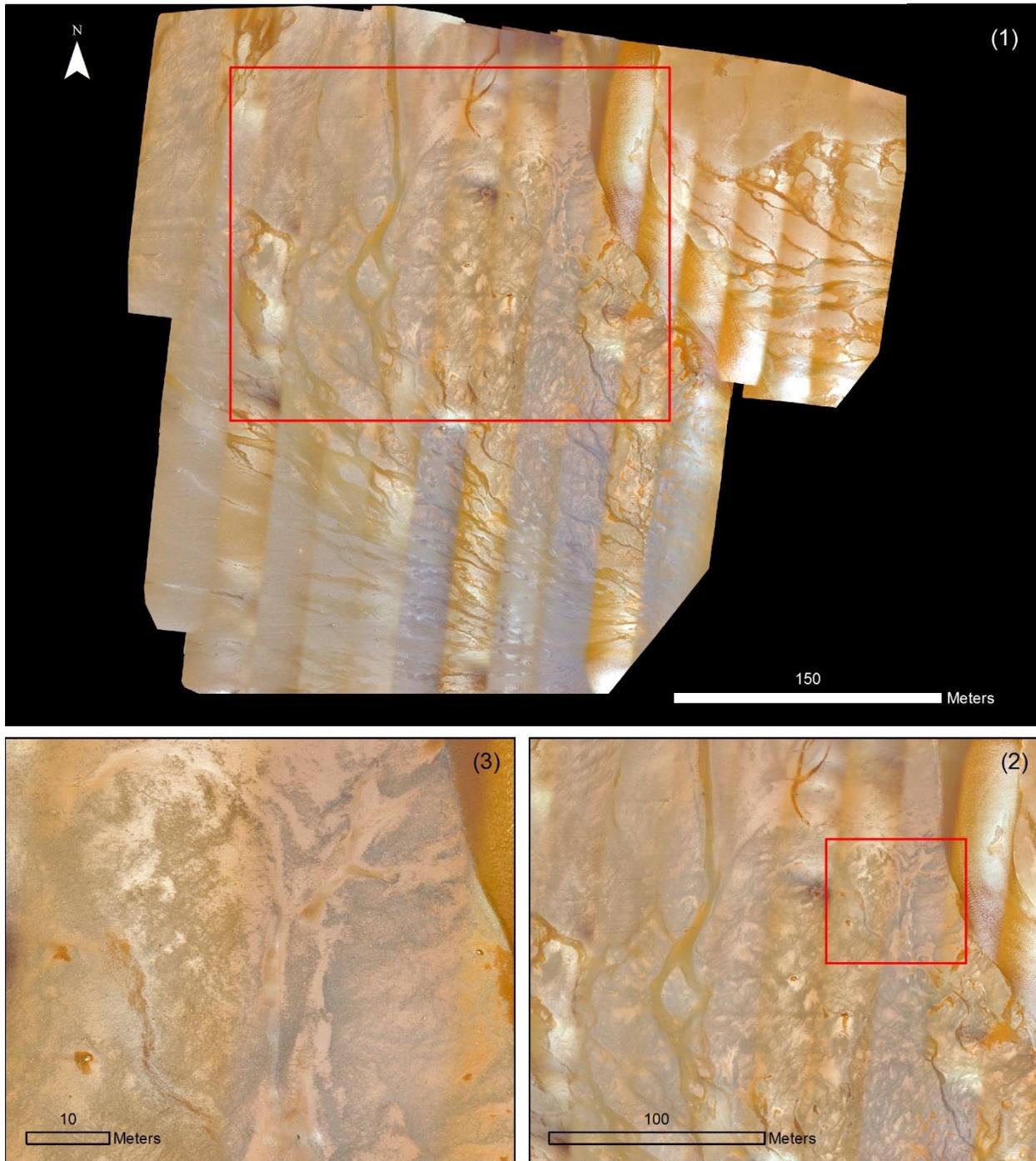


Figure 14: (1) Orthomosaic of surveyed area at Five Islands (zone a), 19 June 2018. Areas in red squares are shown in subsequent panels (2,3).

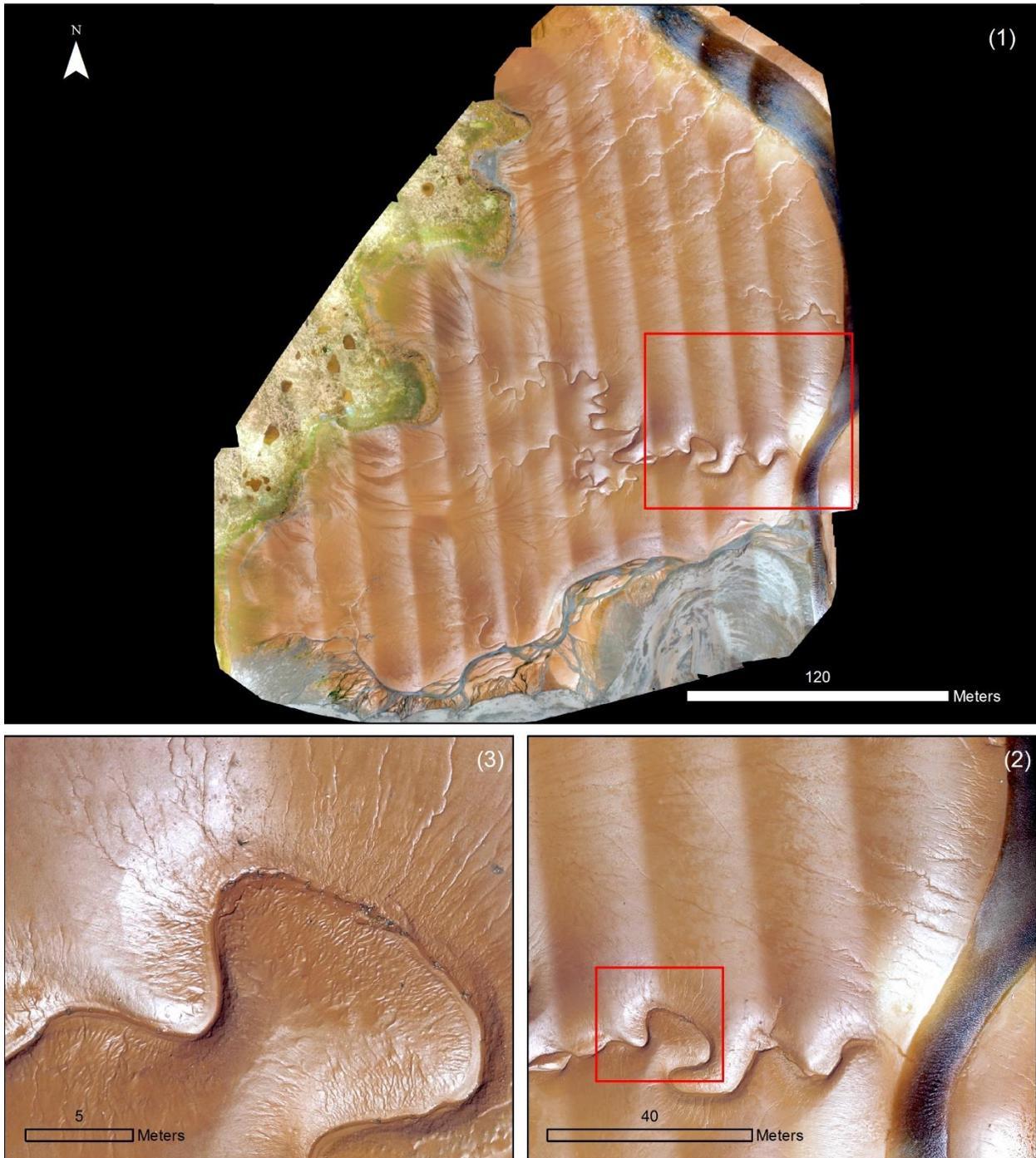


Figure 15: (1) Orthomosaic of surveyed area at Five Islands (zone b), 20 June 2018. Areas in red squares are shown in subsequent panels (2,3).

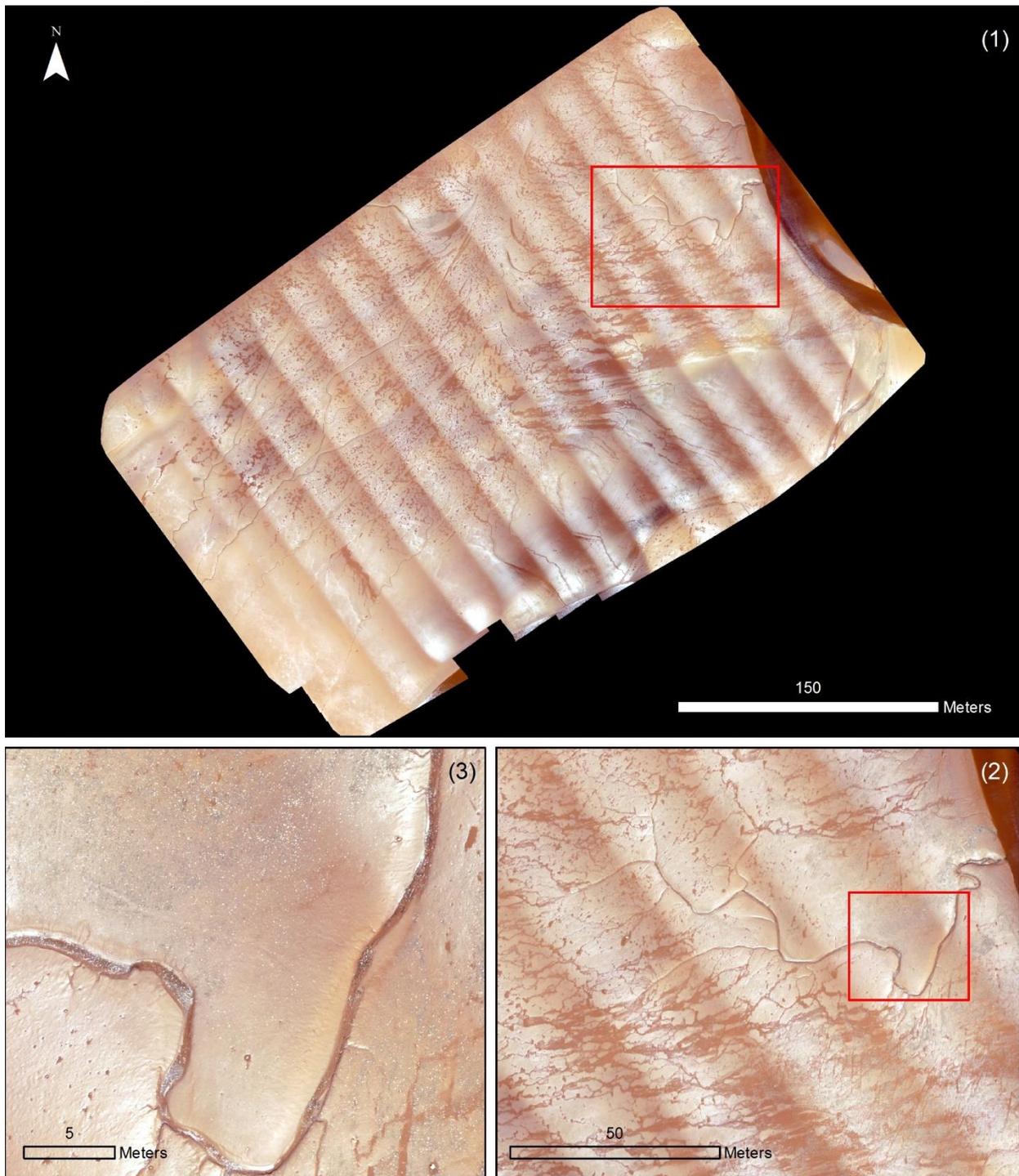


Figure 16: (1) Orthomosaic of surveyed area at Five Islands (zone c), 20 June 2018. Areas in red squares are shown in subsequent panels (2,3).

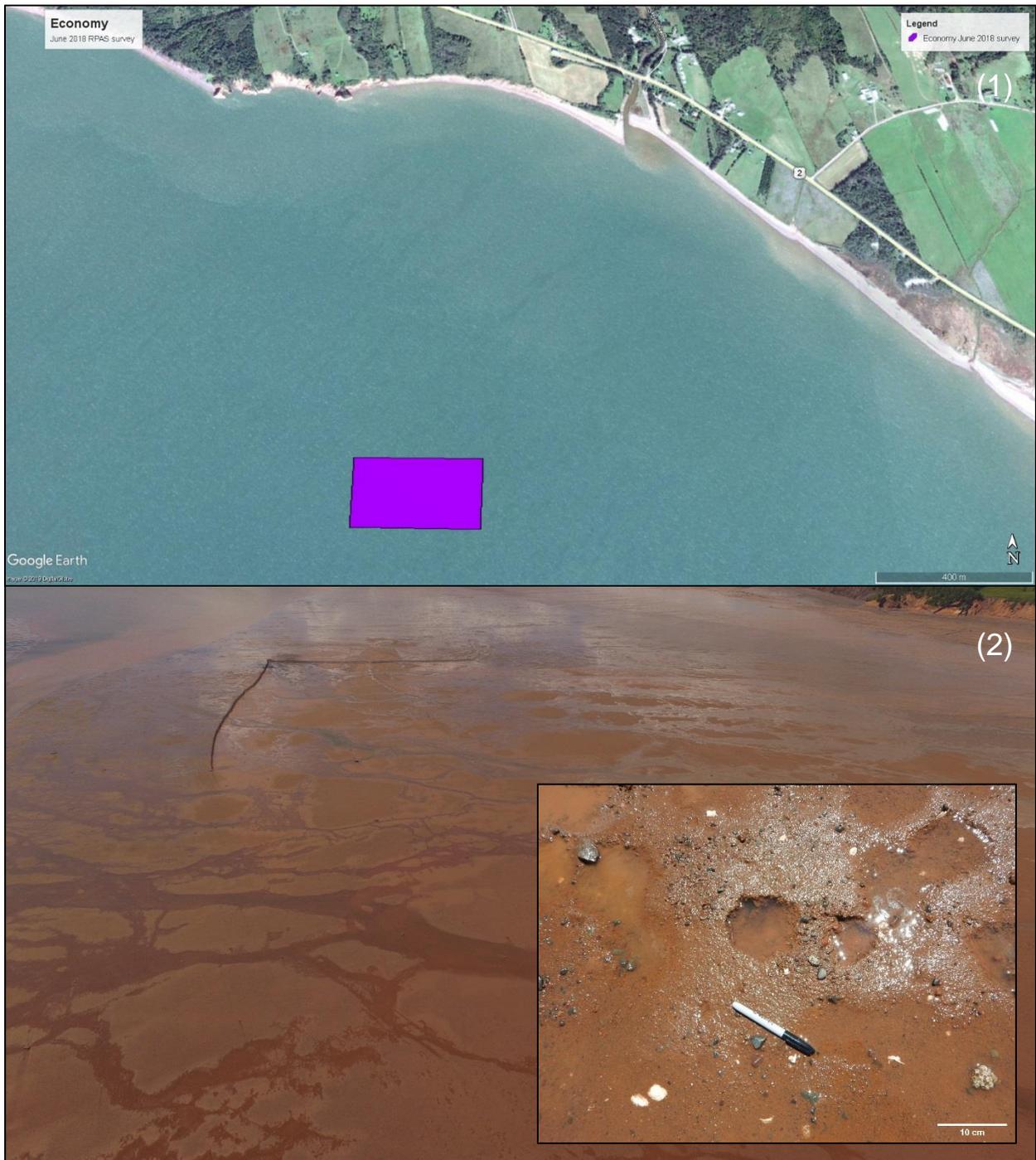


Figure 17: (1) Location (purple polygon) of RPAS survey at Economy, Nova Scotia, on the northern shore of the Minas Basin, 21 June 2018; (2) high-altitude RPAS image shows site view to the west, note the fishing weir where sturgeon have been caught. Inset: small feeding excavation.

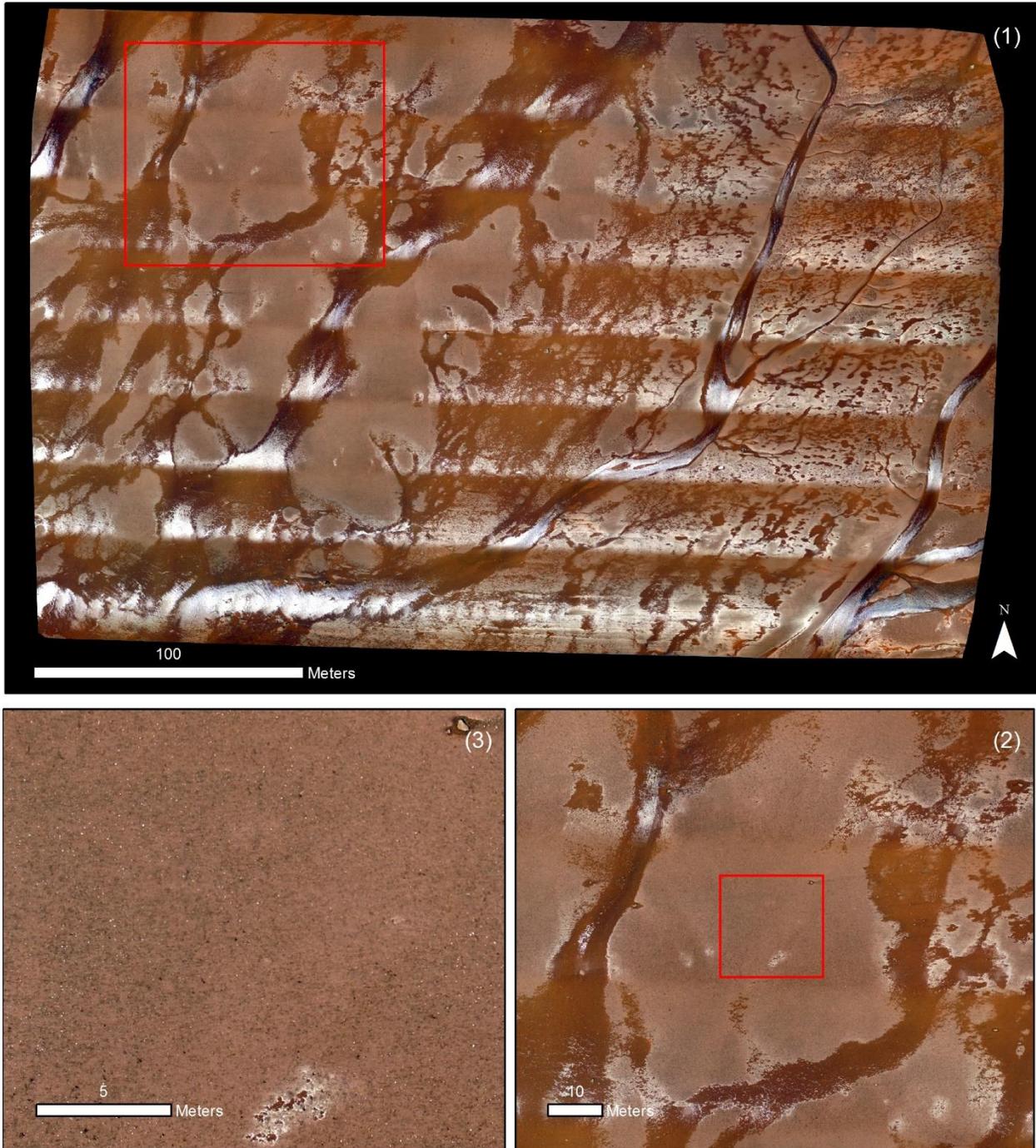


Figure 18: (1) Orthomosaic of surveyed area at Economy, Nova Scotia, 21 June 2018. Areas in red squares are shown in subsequent panels (2,3).

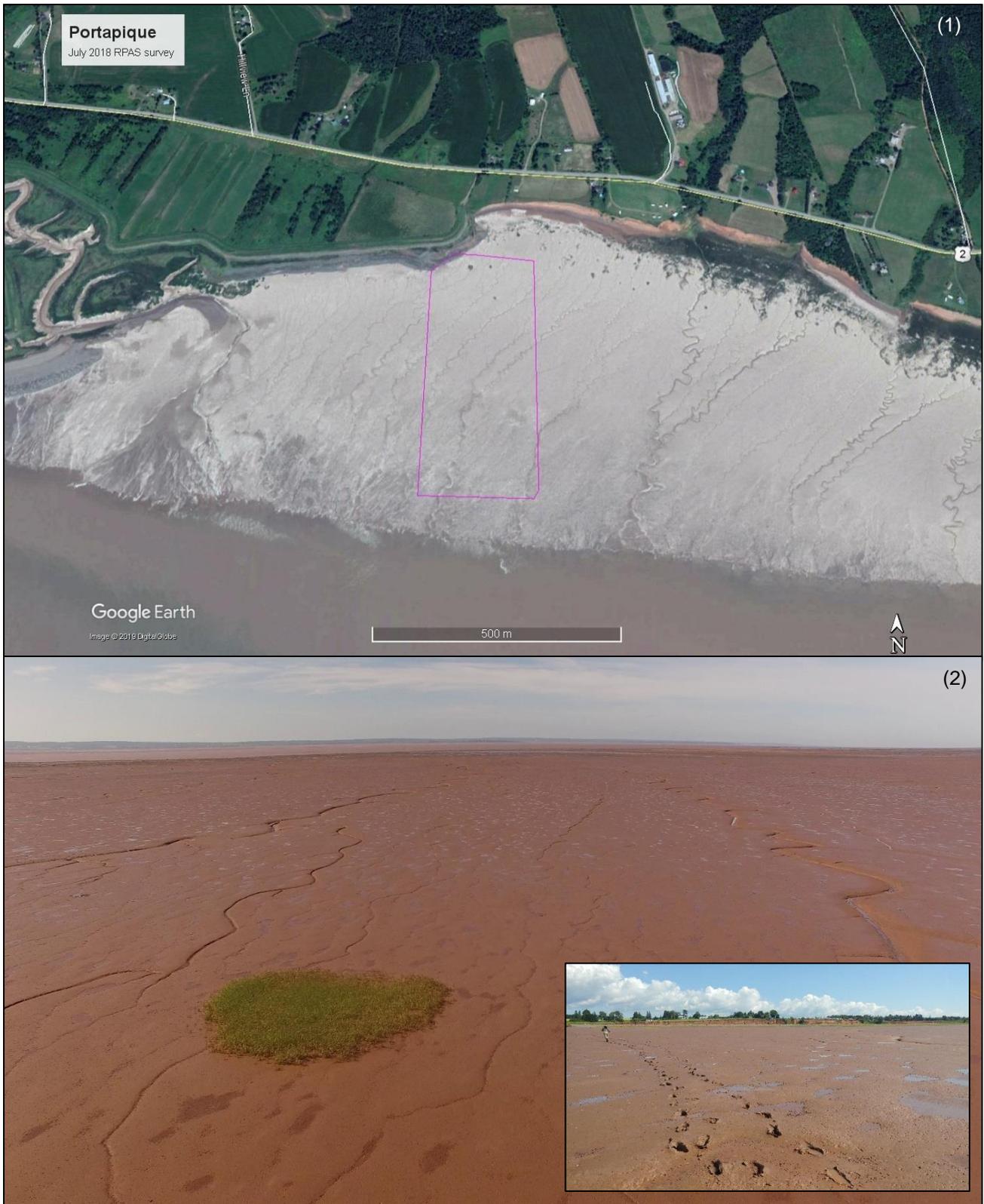


Figure 19: (1) Location (pink polygon) of RPAS survey at Portapique, Nova Scotia, on the northern shore of the Minas Basin, 31 July 2018. Low-altitude oblique RPAS image in panel (2) shows the extensive mudflat and view seaward; inset shows the view landward, from ground level.

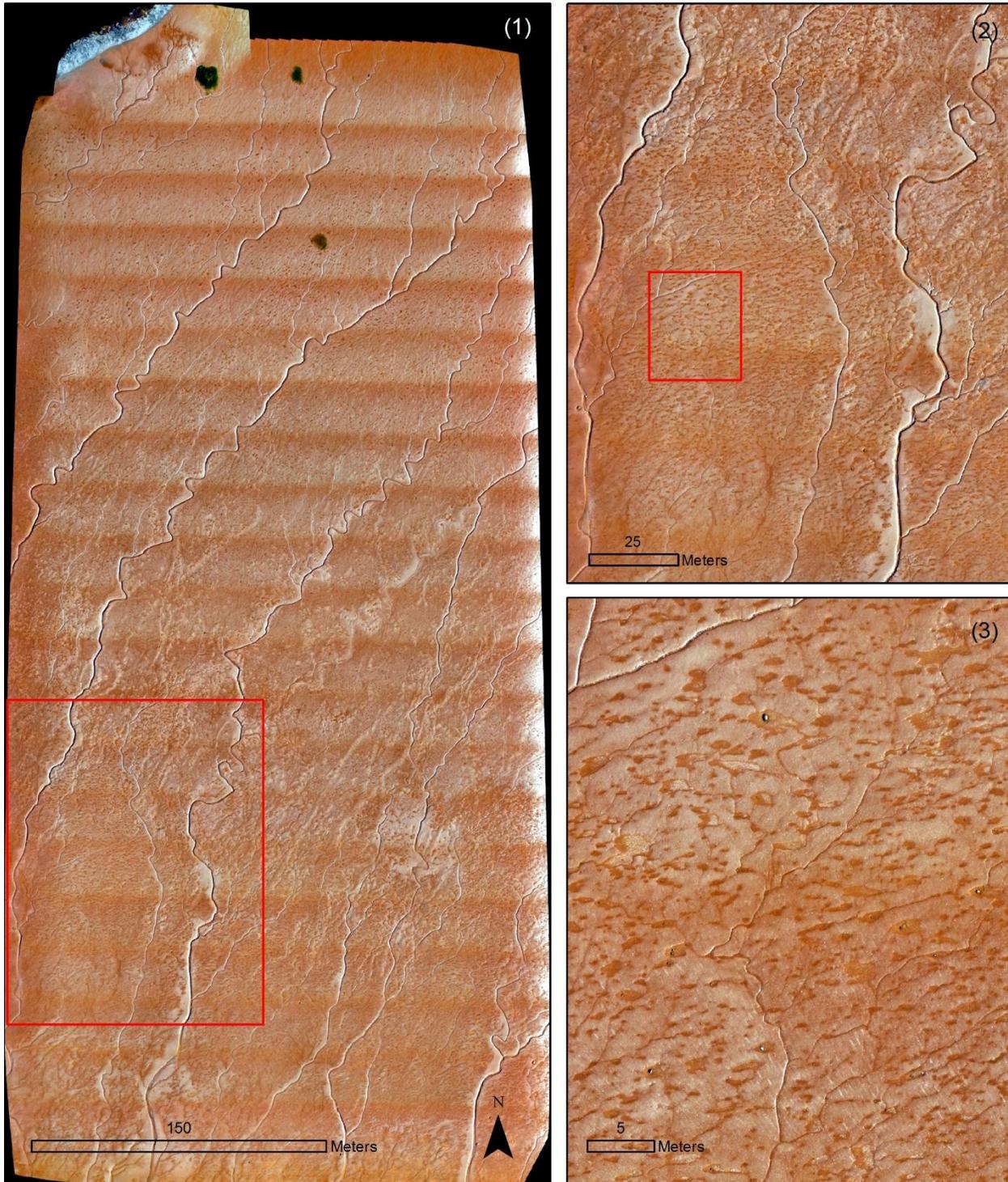


Figure 20: (1) Orthomosaic of surveyed area at Portapique, NS, July 31 2018. Areas in red squares are shown in subsequent panels.



Figure 21: (1) Locations (green polygons) of RPAS surveys at Walton, Nova Scotia, on the southern shore of Minas Basin. Two zones were surveyed, on 3 and 16 July, 2018 (a,b). High-altitude RPAS image in panel (2) shows the shoreline looking west. Inset: View to the west from ground level.

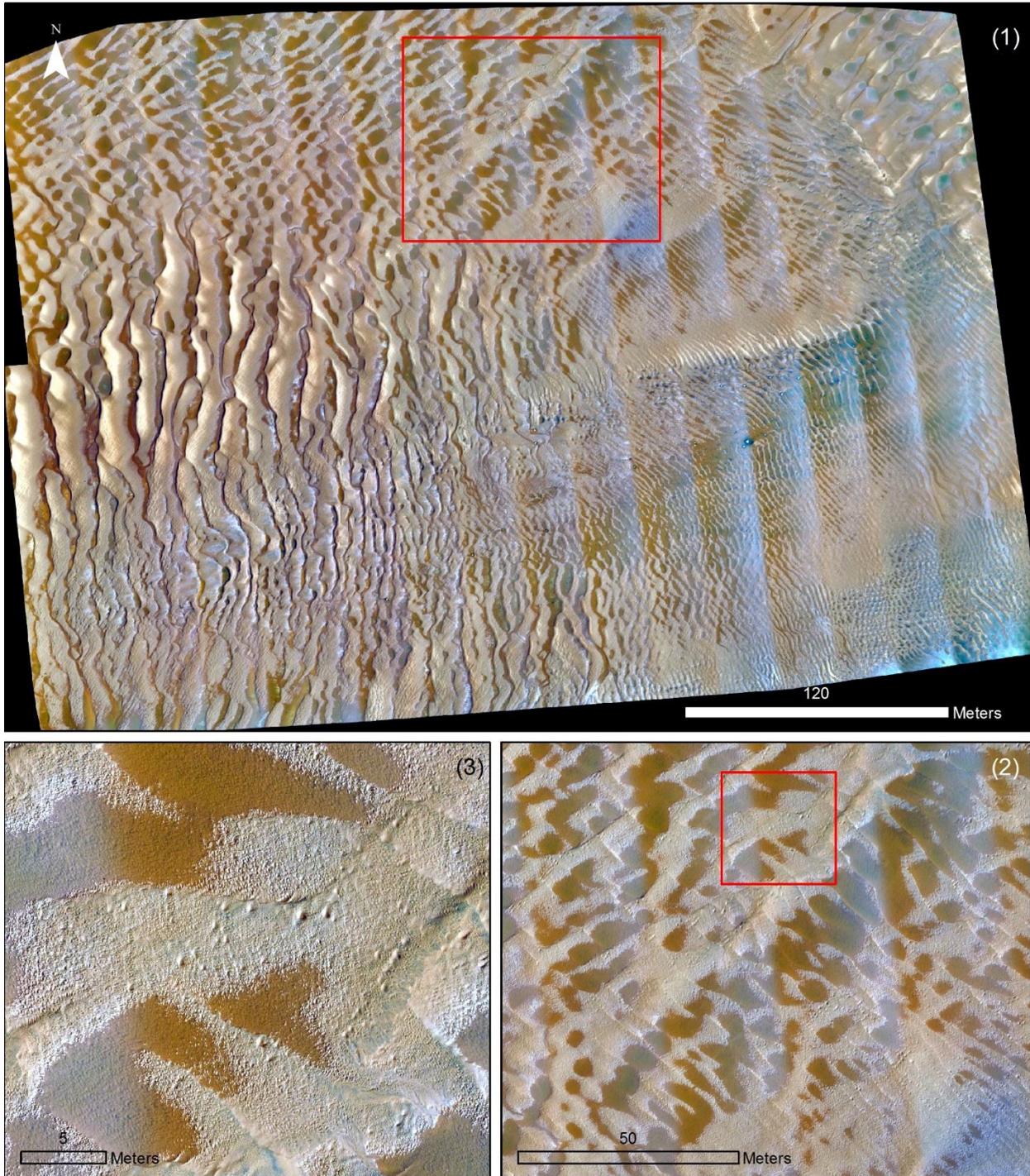


Figure 22: (1) Orthomosaic of surveyed area at Walton, NS (zone a), on the southern shore of the Minas Basin, 3 July 2018. Areas in red squares are shown in subsequent panels (2,3).

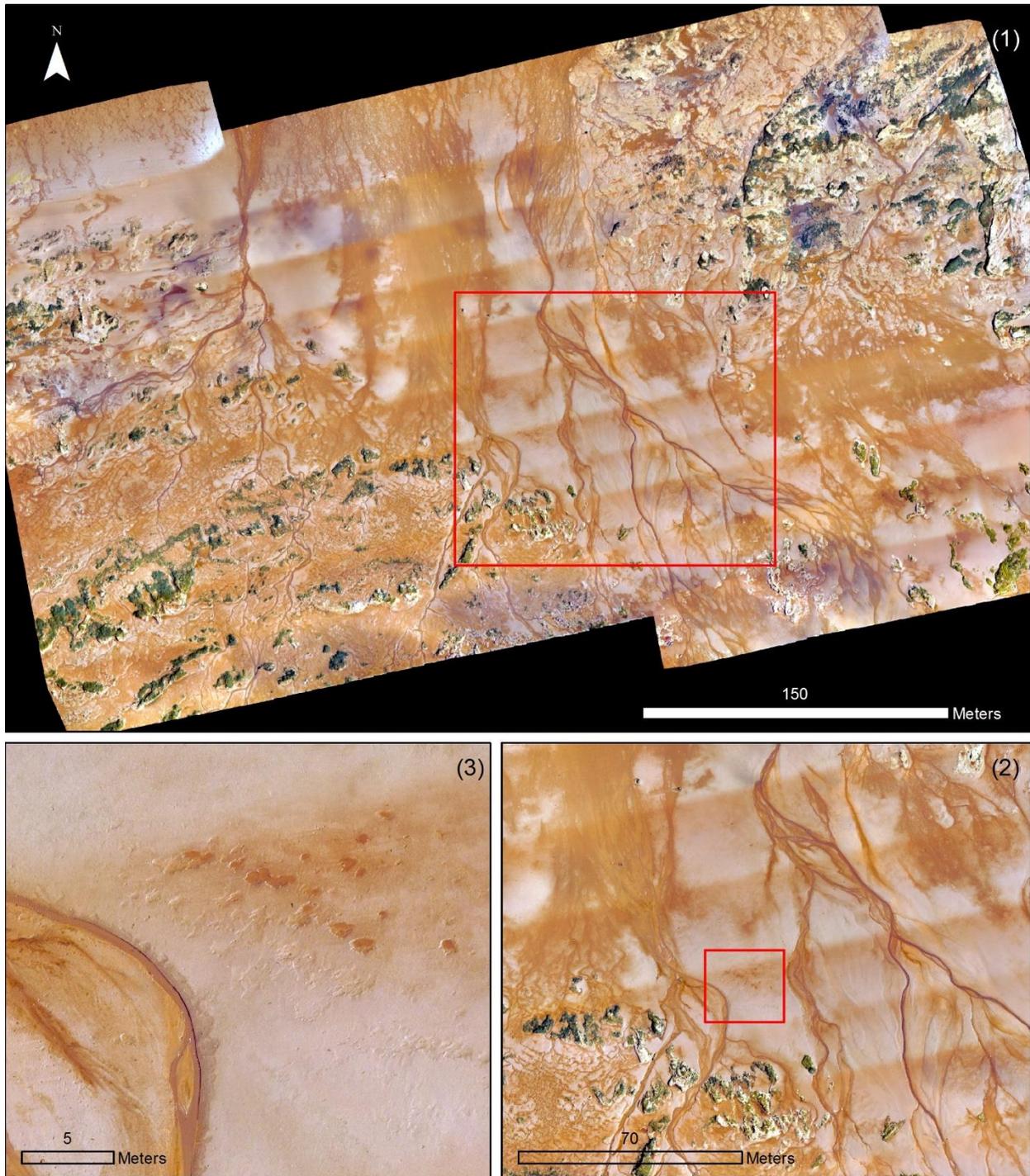


Figure 23: (1) Orthomosaic of surveyed area at Walton, NS (zone b), on the southern shore of the Minas Basin, 16 July 2018. Areas in red squares are shown in subsequent panels (2,3).

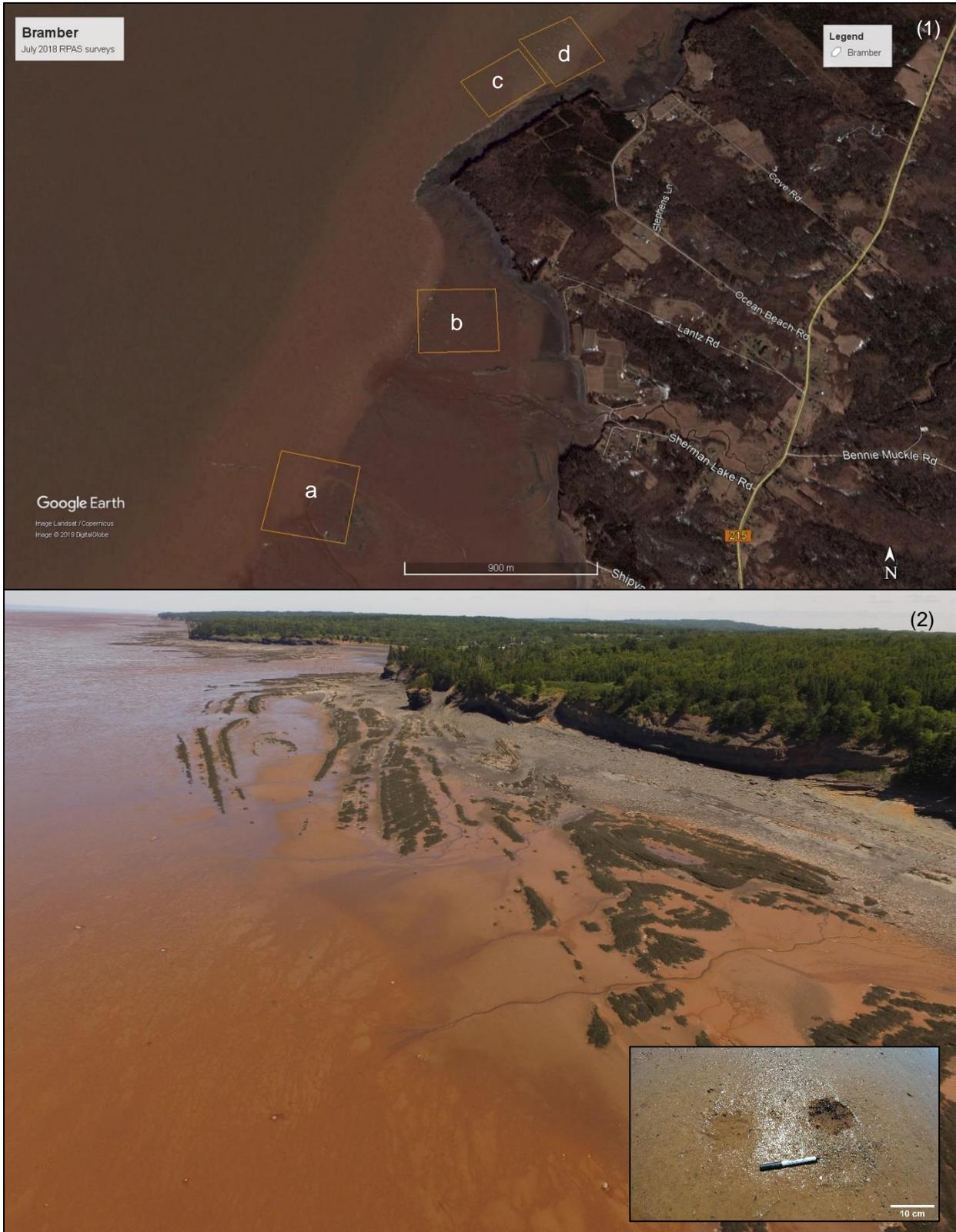


Figure 24: (1) Locations (orange polygons) of RPAS surveys at Bramber, Nova Scotia. Four zones were surveyed in July 2018 (a-d). High-altitude RPAS image (panel 2) shows extensive mudflats and view to the east. Inset: individual feeding excavation.

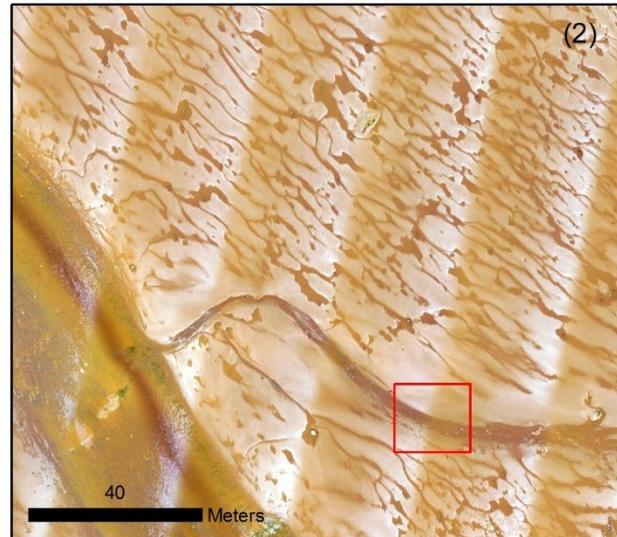
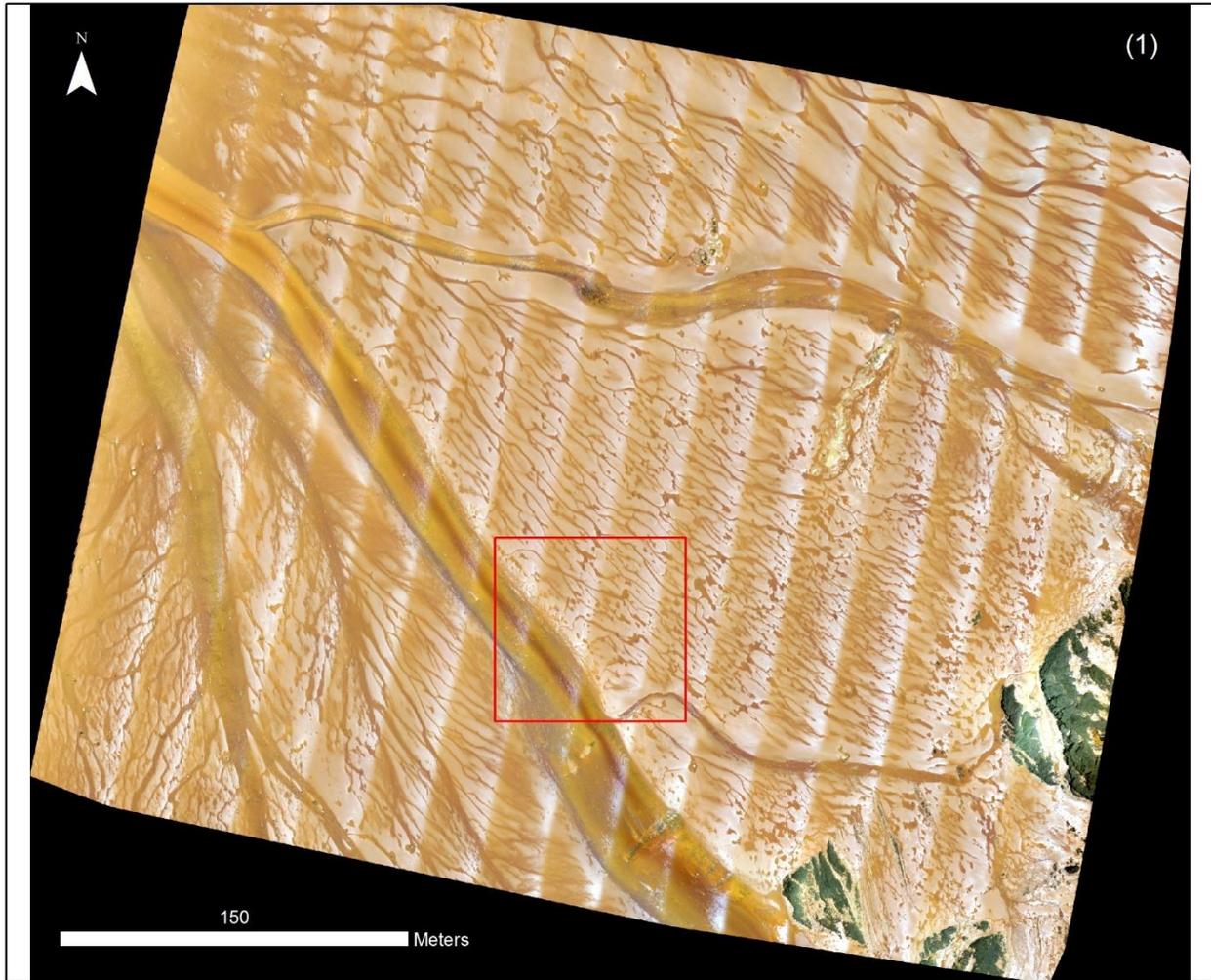


Figure 25: (1) Orthomosaic of surveyed area at Bramber (zone a), 4 July 2018. Areas in red squares are shown in subsequent panels (2,3).

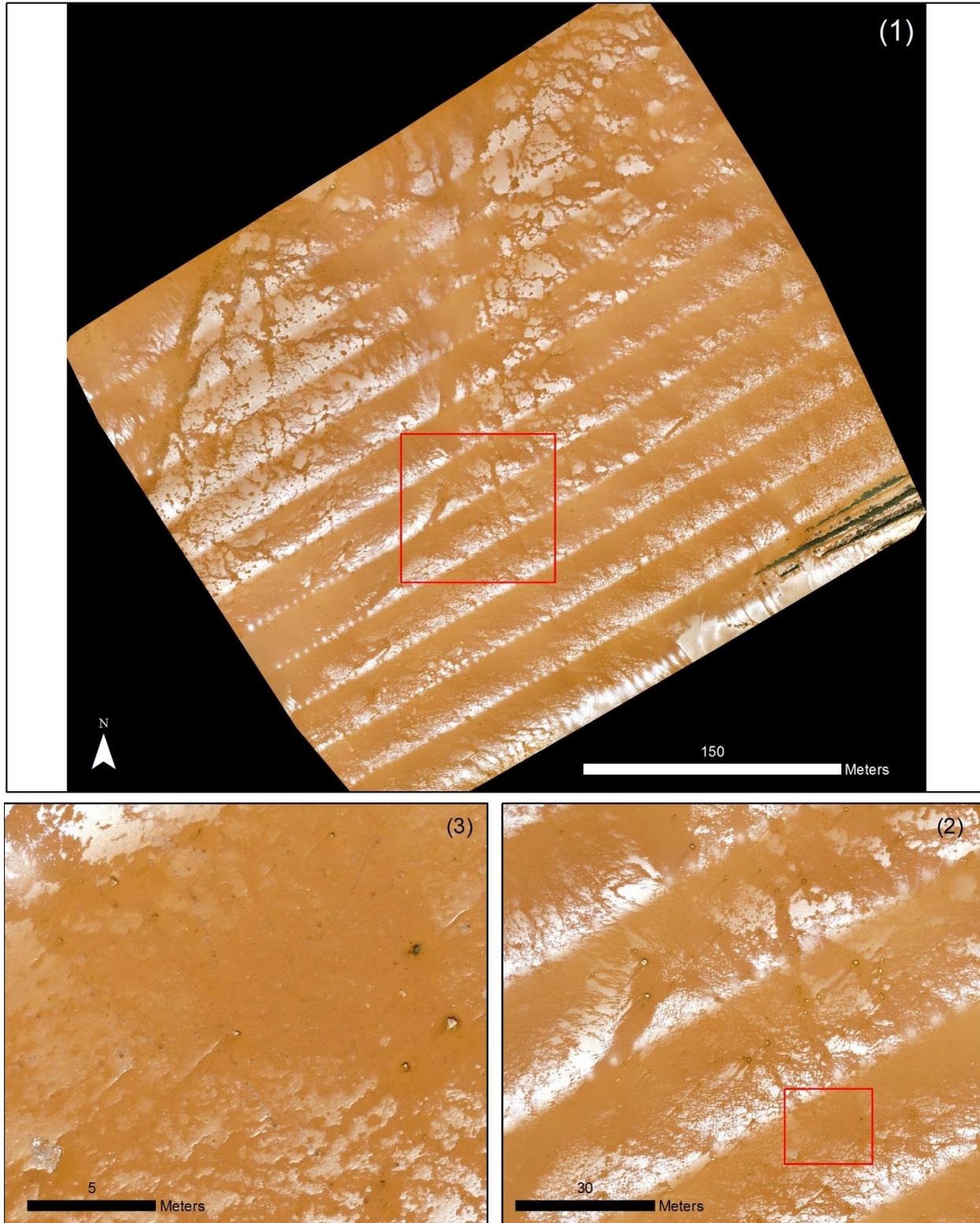


Figure 26: (1): Orthomosaic of surveyed area at Bramber (zone c), 20 July 2018. Areas in red squares are shown in subsequent panels (2,3).

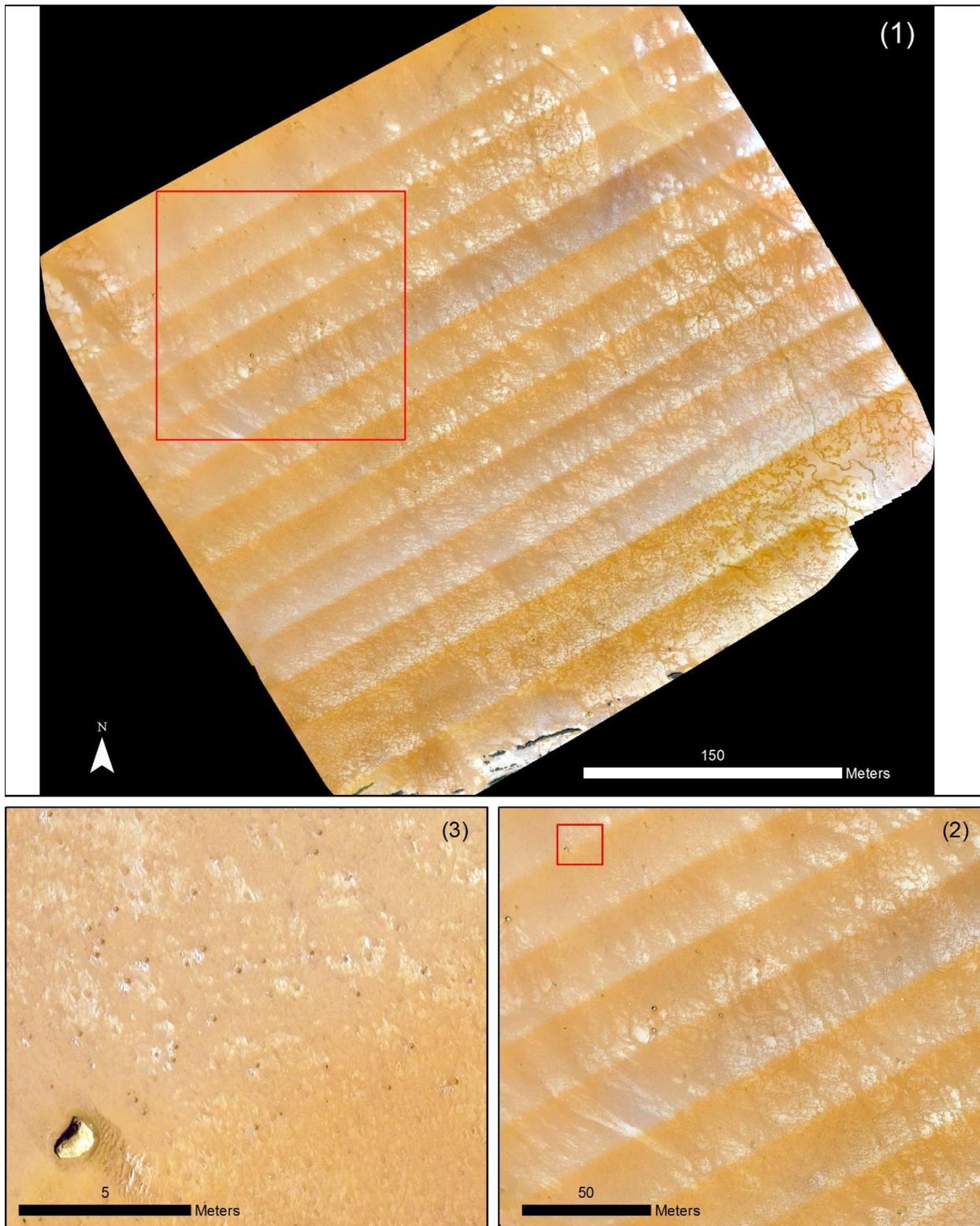


Figure 27: (1) Orthomosaic of surveyed area at Bramber (zone d), 31 July 2018. Areas in red squares are shown in subsequent panels (2,3).

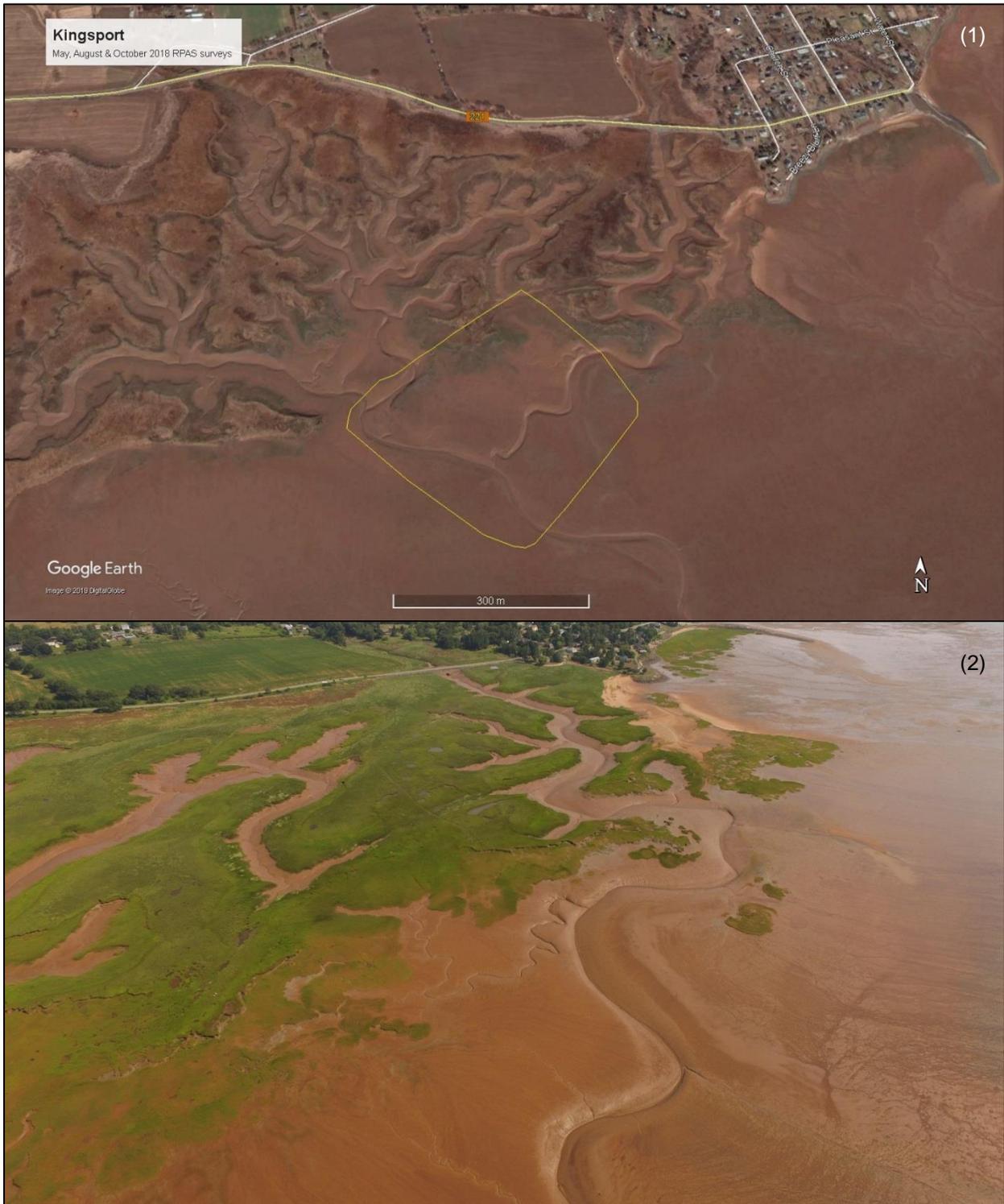


Figure 28: (1) Location (yellow polygon) of RPAS surveys at Kingsport NS, on the western shore of the Southern Bight of the Minas Basin, surveyed in May, August and October 2018. (2) RPAS image showing the eastern end of Kingsport marsh, with study area at bottom center.

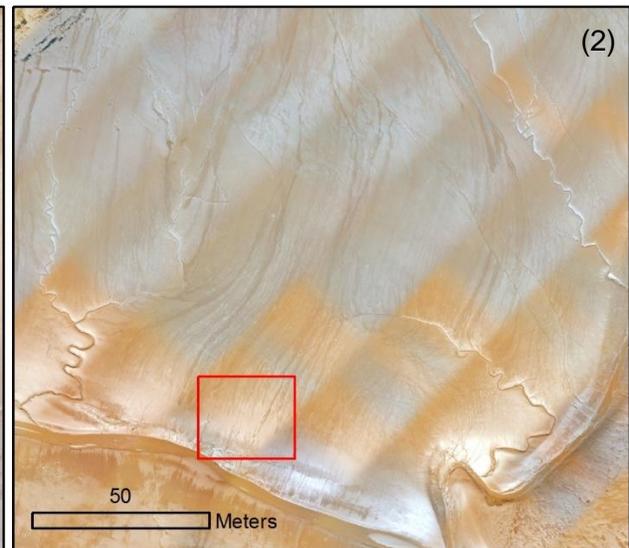
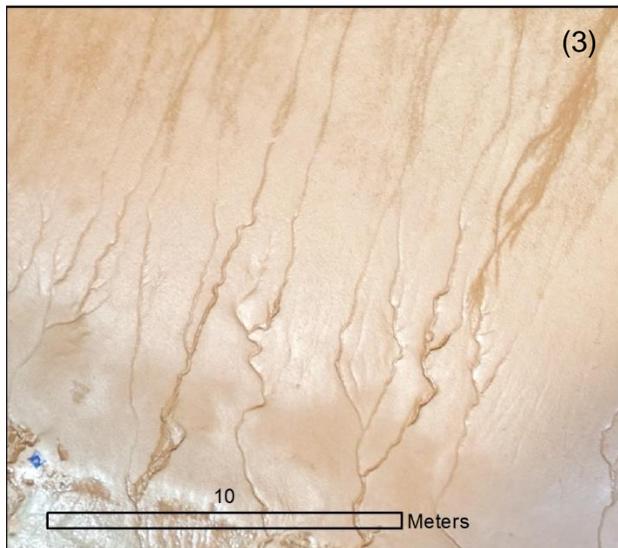
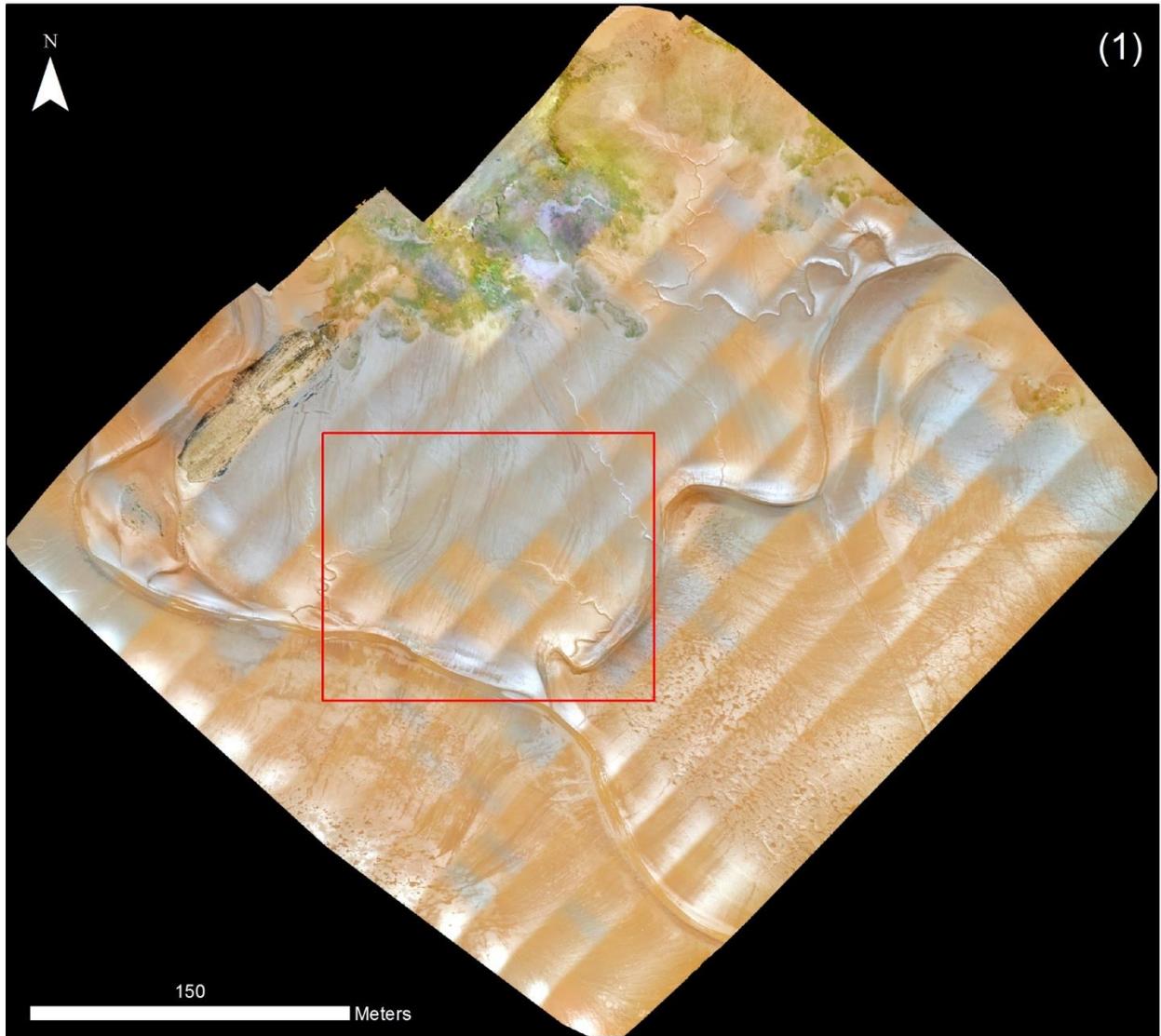


Figure 29: Orthomosaic of surveyed area at Kingsport, 9 May 2018. Areas in red squares are shown in subsequent panels (2,3).

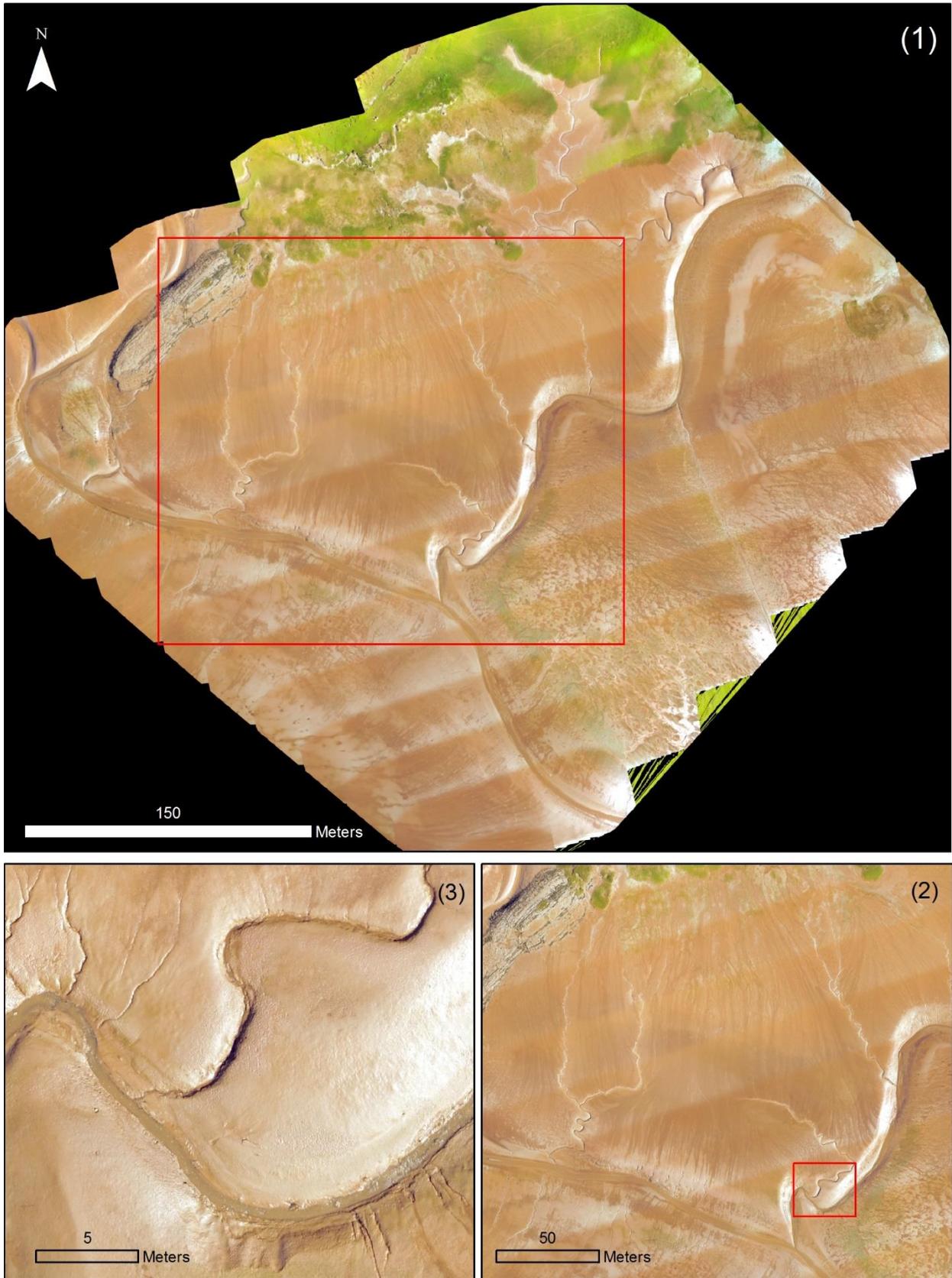


Figure 30: (1) Orthomosaic of surveyed area at Kingsport, 1 August 2018. Areas in red squares are shown in subsequent panels (2,3).

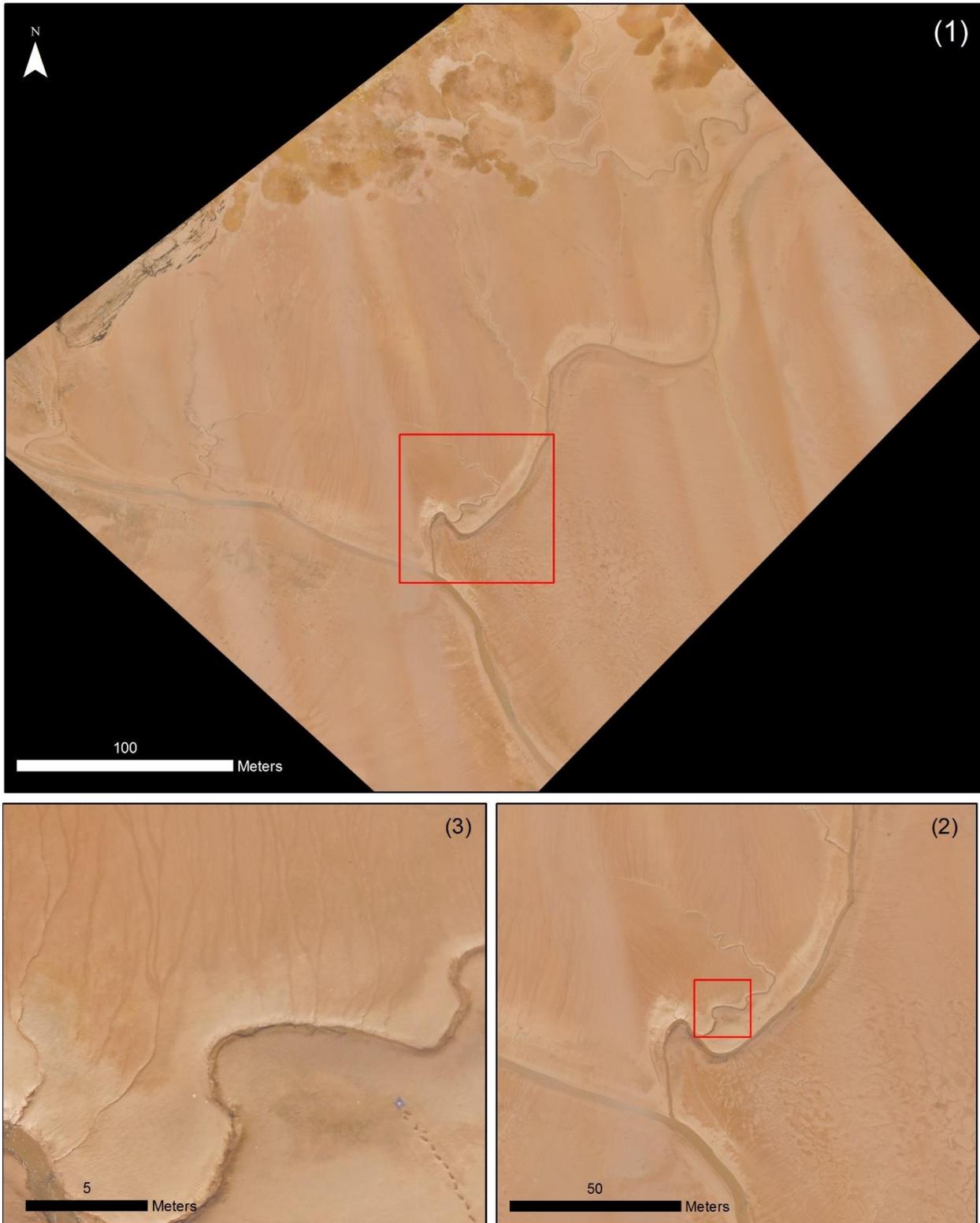


Figure 31: (1) Orthomosaic of surveyed area at Kingsport, 30 October 2018. Areas in red squares are shown in subsequent panels (2,3).

SPERA 2018: iBoF feeding excavations

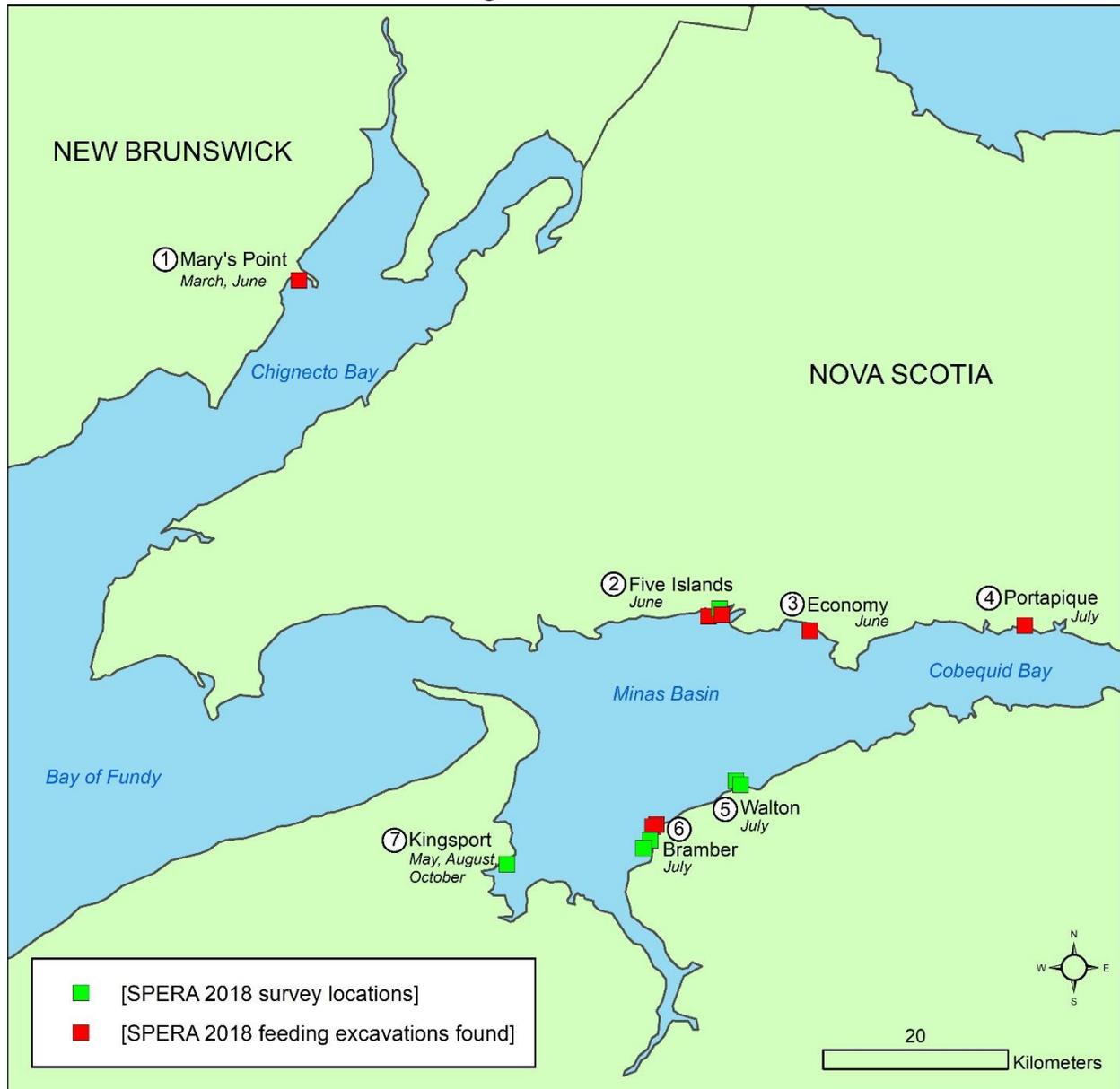


Figure 32: Inner Bay of Fundy 2018 RPAS survey sites (numbered 1-8); feeding excavations that can be attributed to Atlantic sturgeon were found during 2018 surveys marked in red.

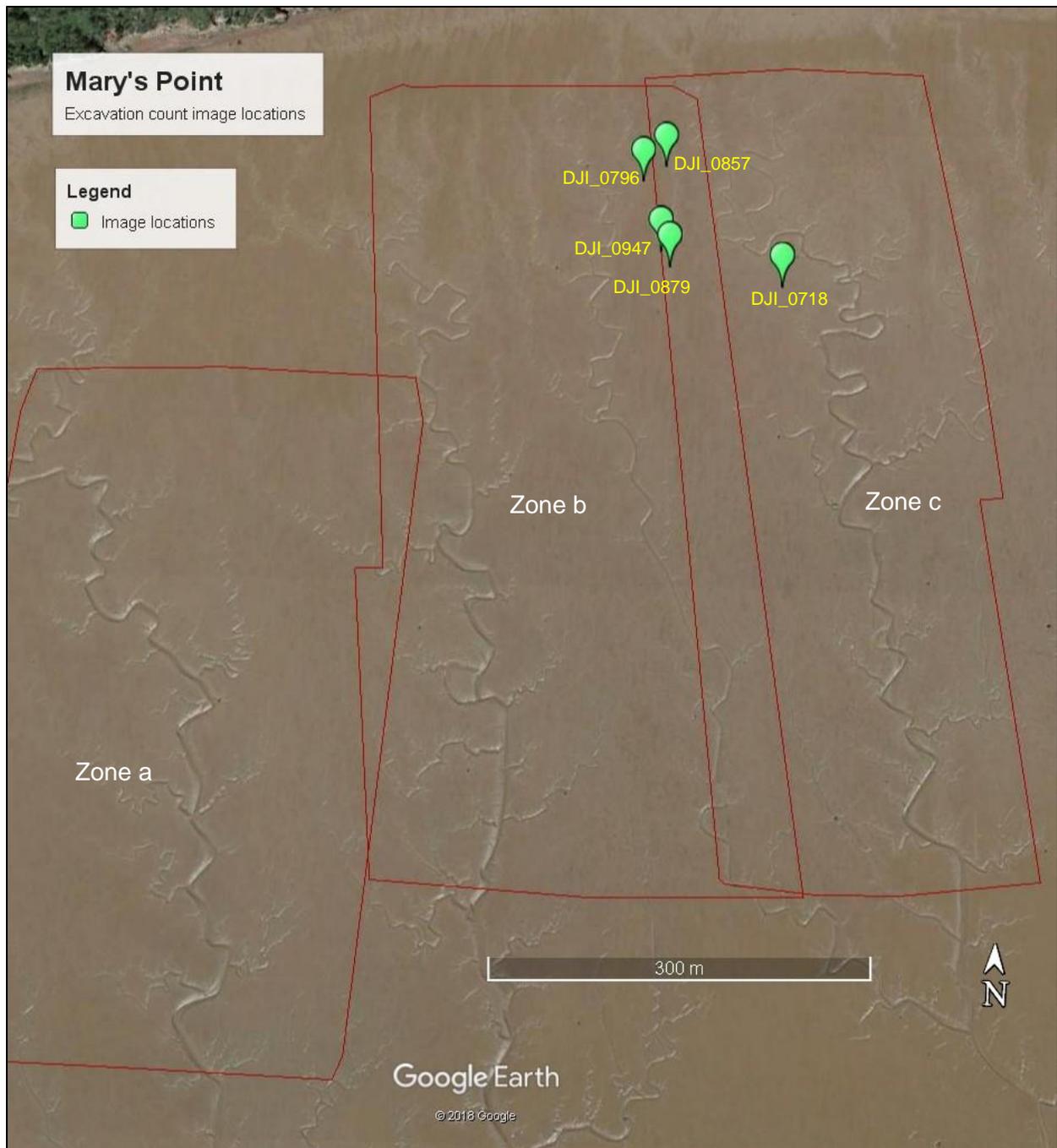


Figure 33: Locations of low-altitude RPAS images collected at Mary's Point, New Brunswick (June, 2018) in the northern sections of zones b and c, which were used to count feeding excavations.

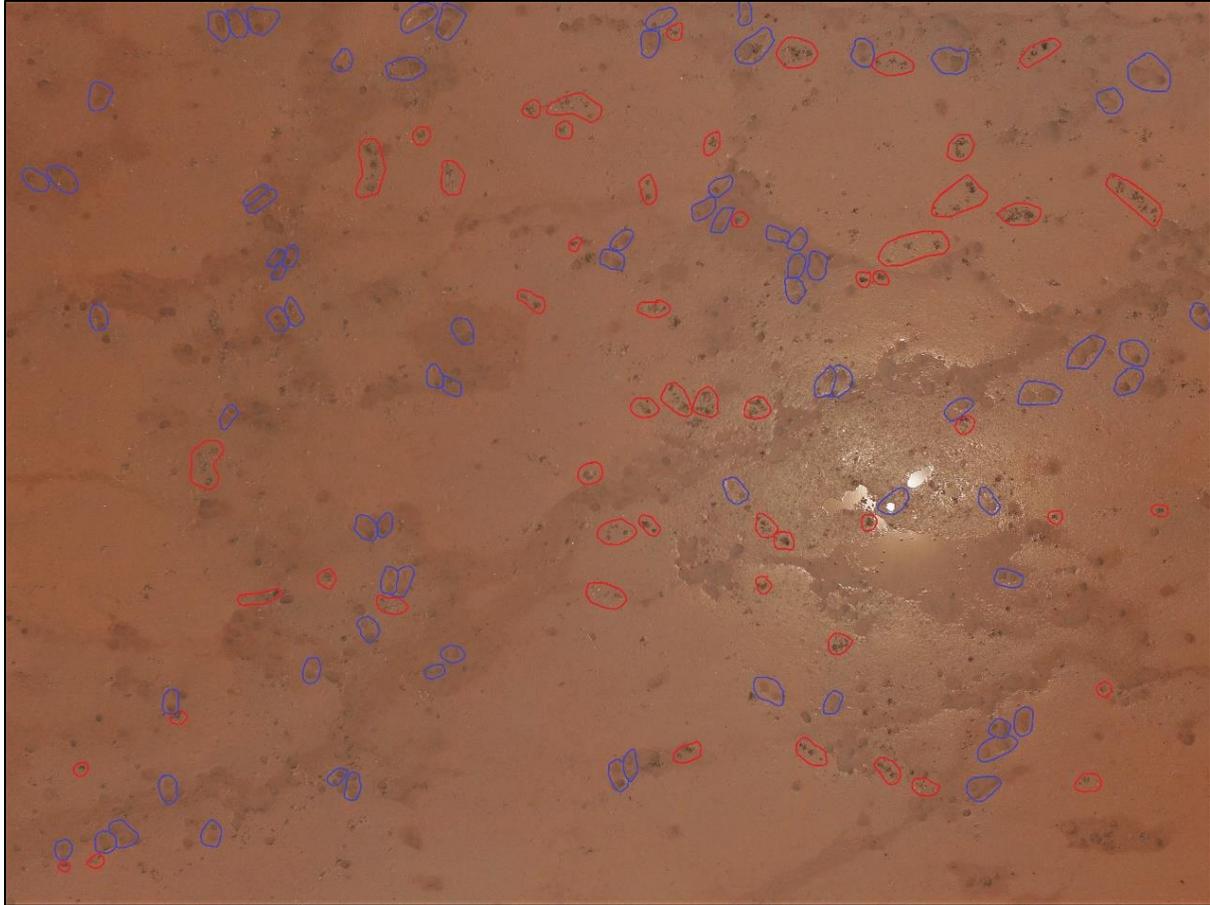


Figure 34: Low-altitude (5 m) RPAS image (DJI_0857) showing examples of feeding excavations (blue circles) and fecal piles (red circles). Image covers approximately 35 m²; >70 conclusive feeding excavations were counted in this image. Additional marks that may or may not be associated with feeding excavations are also visible.

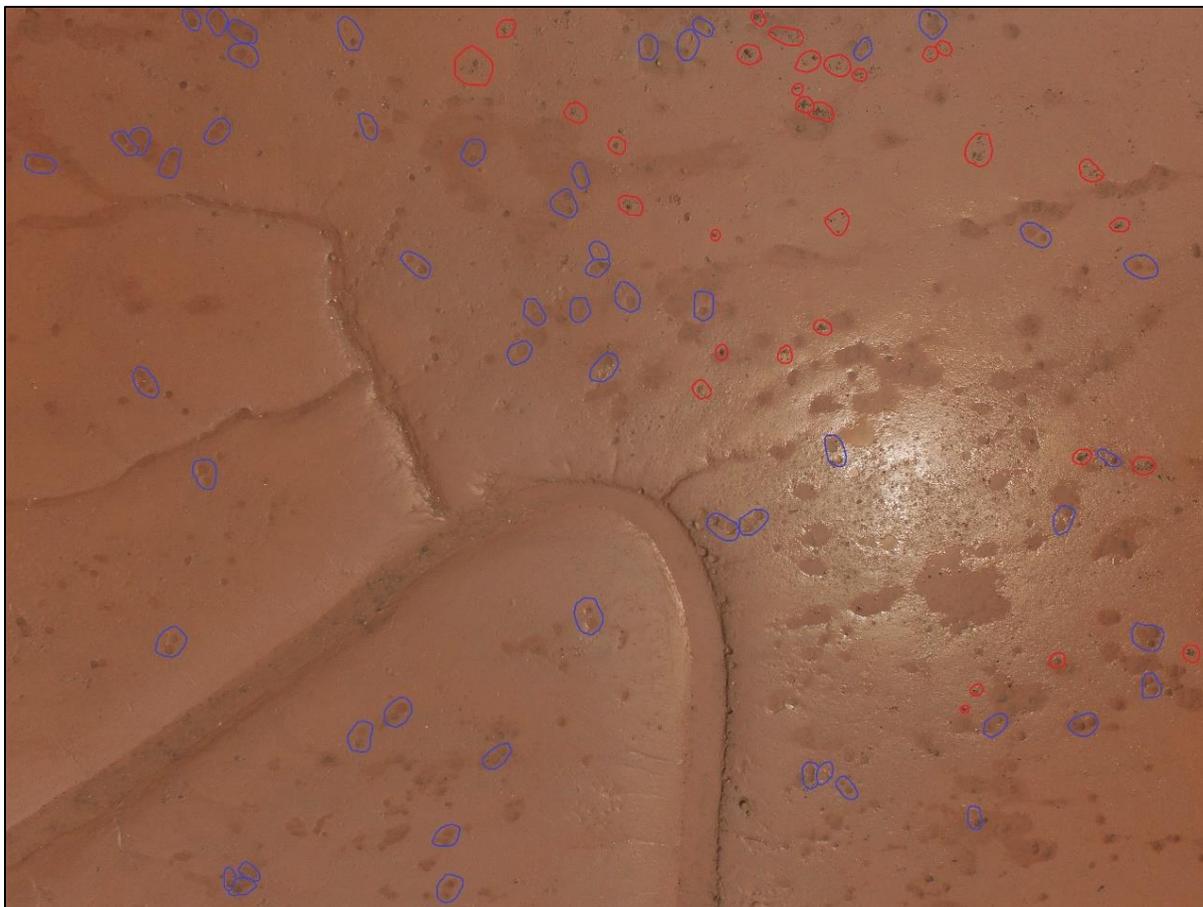


Figure 35: Low-altitude (5 m) RPAS image (DJI_0796) showing examples of feeding excavations (blue circles) and fecal piles (red circles). Image covers approximately 35 m²; >50 conclusive feeding excavations were counted. Additional marks that may or may not be associated with feeding excavations are also visible.

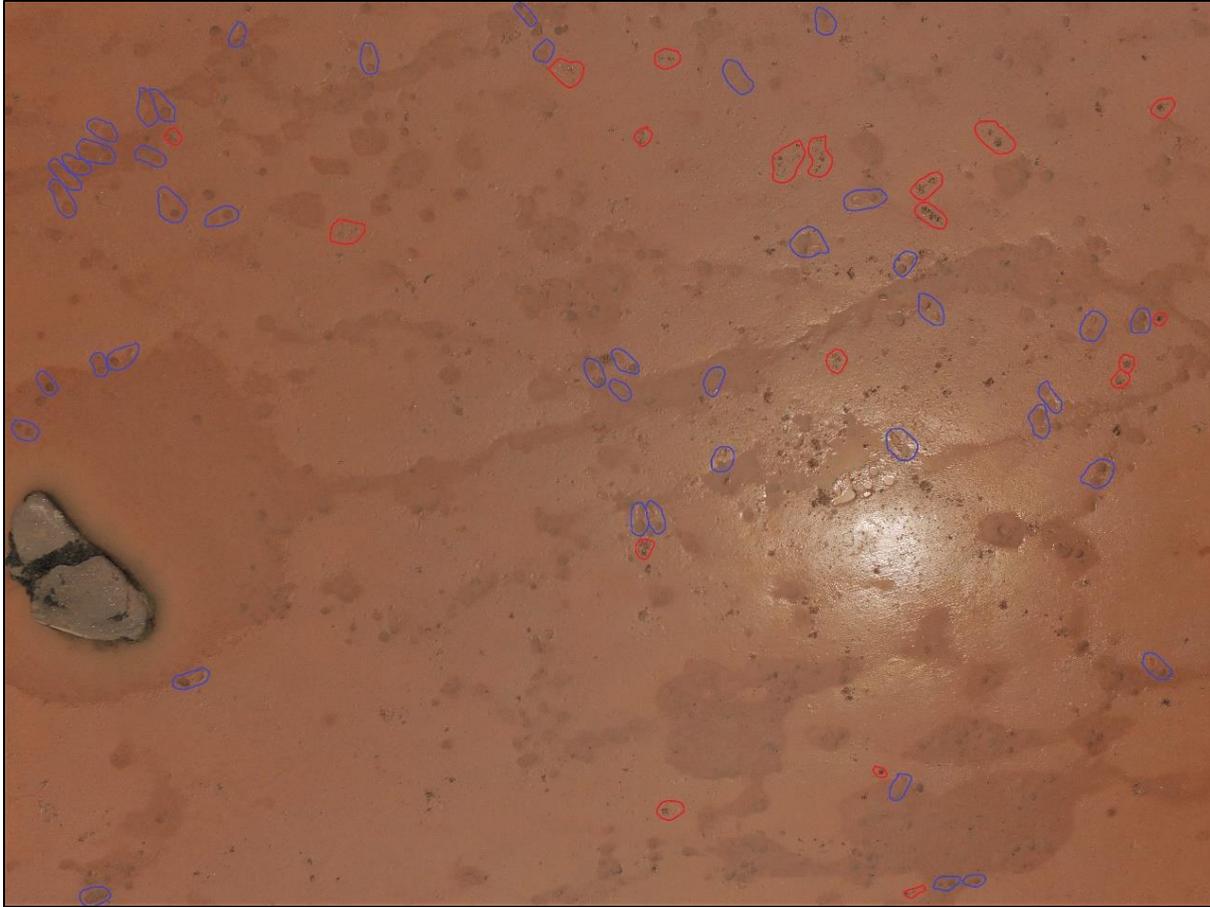


Figure 36: Low-altitude (5 m) RPAS image (DJI_0947) showing examples of feeding excavations (blue circles) and fecal piles (red circles). Image covers approximately 35 m²; >40 conclusive feeding excavations were counted in this image. Additional marks that may or may not be associated with feeding excavations are also visible.

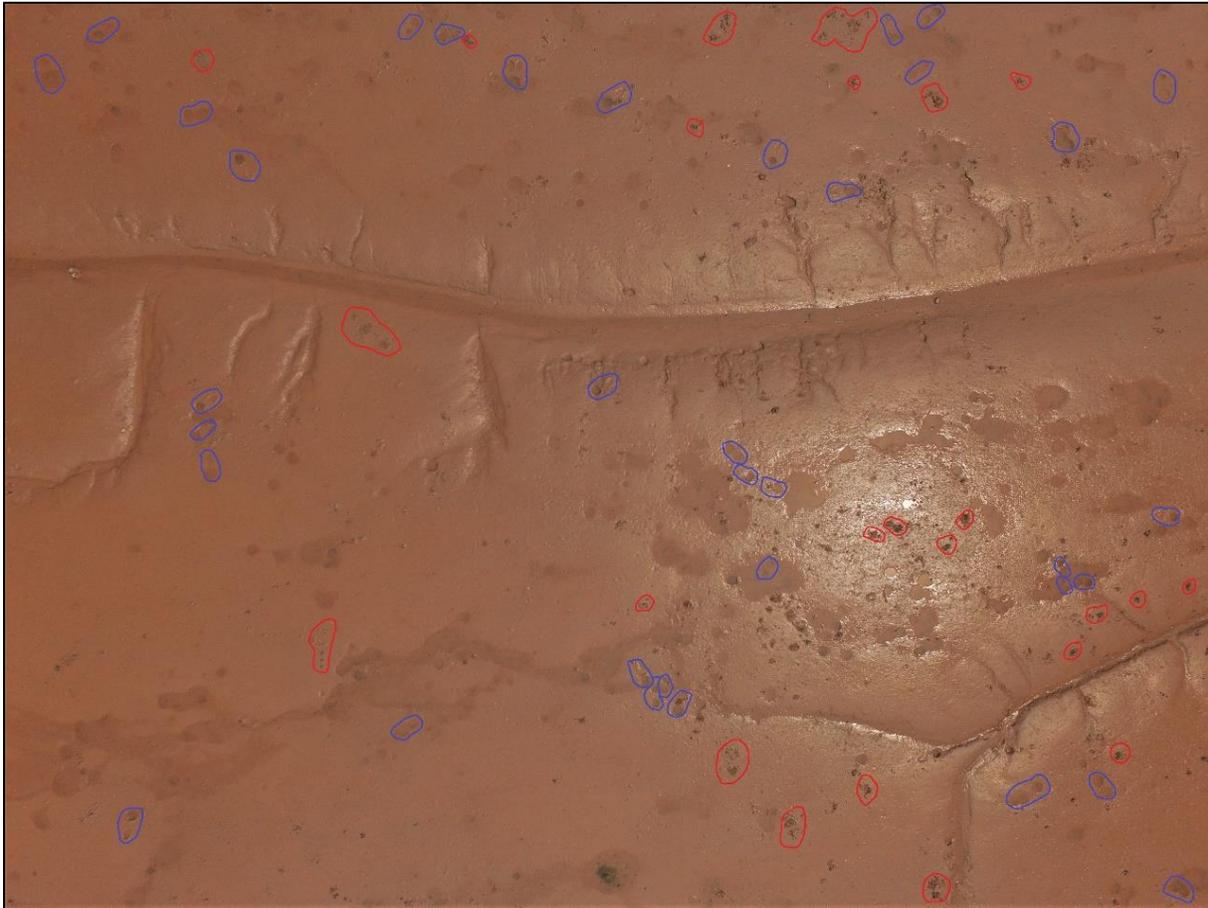


Figure 37: Low-altitude (5 m) RPAS image (DJI_0879) showing examples of feeding excavations (blue circles) and fecal piles (red circles). Image covers approximately 35 m²; >30 conclusive feeding excavations were counted. Additional marks that may or may not be associated with feeding excavations are also visible.

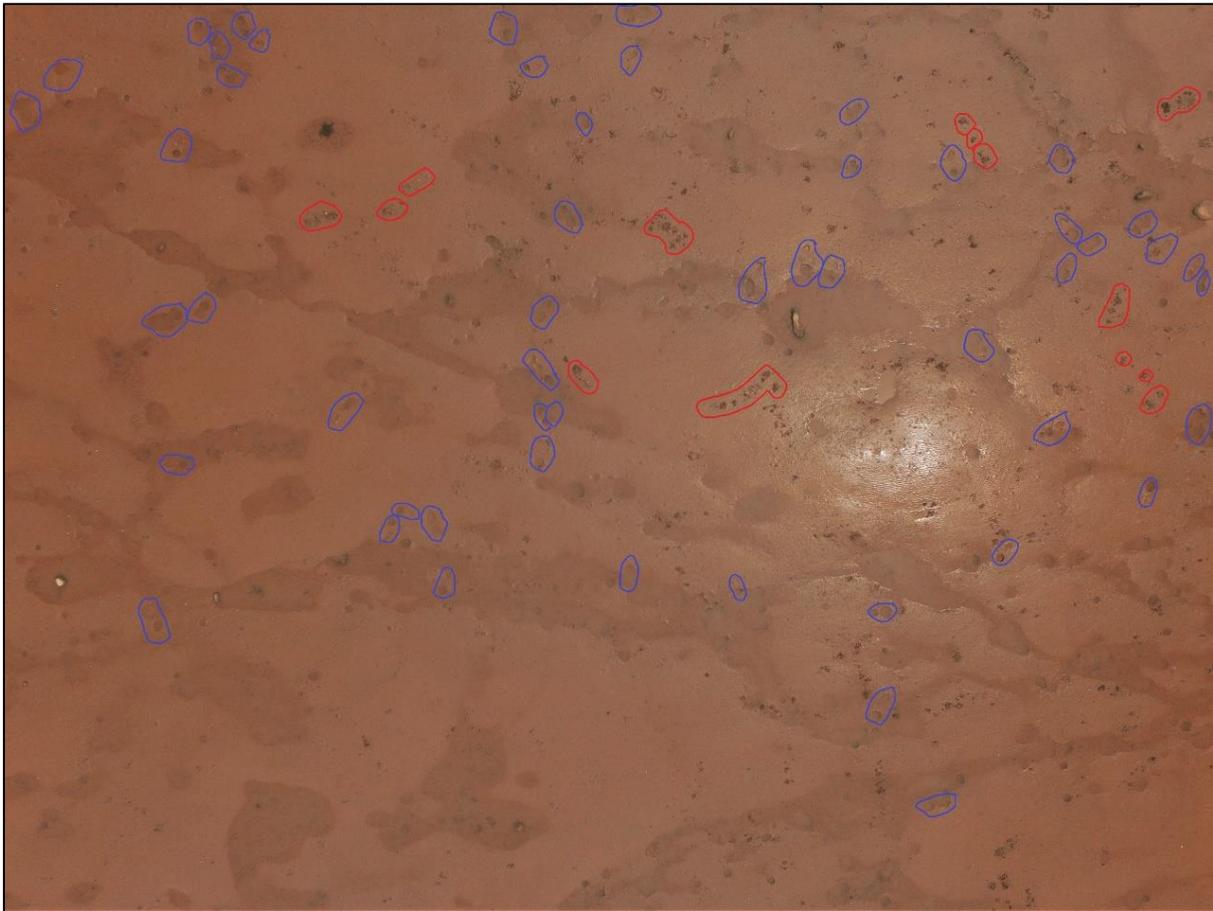


Figure 38: Low-altitude (5 m) RPAS image (DJI_0947) showing examples of feeding excavations (blue circles) and fecal piles (red circles). Image covers approximately 35 m²; >50 conclusive feeding excavations were counted in this image. Additional marks that may or may not be associated with feeding excavations are also visible.

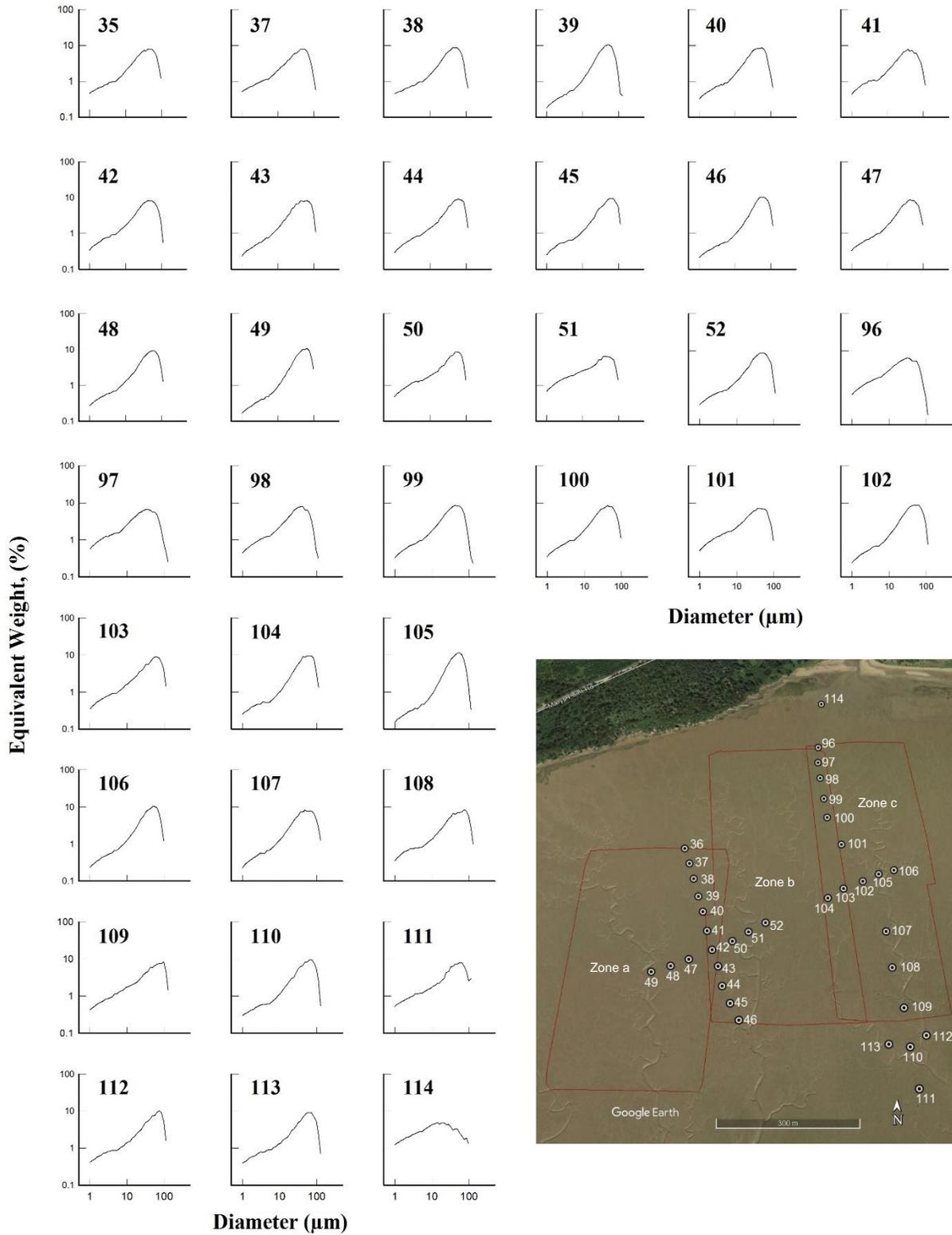


Figure 39: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Mary's Point, New Brunswick (survey zones a,b & c) in June 2018. Sample IDs correspond with numbered stations on location map (inset).

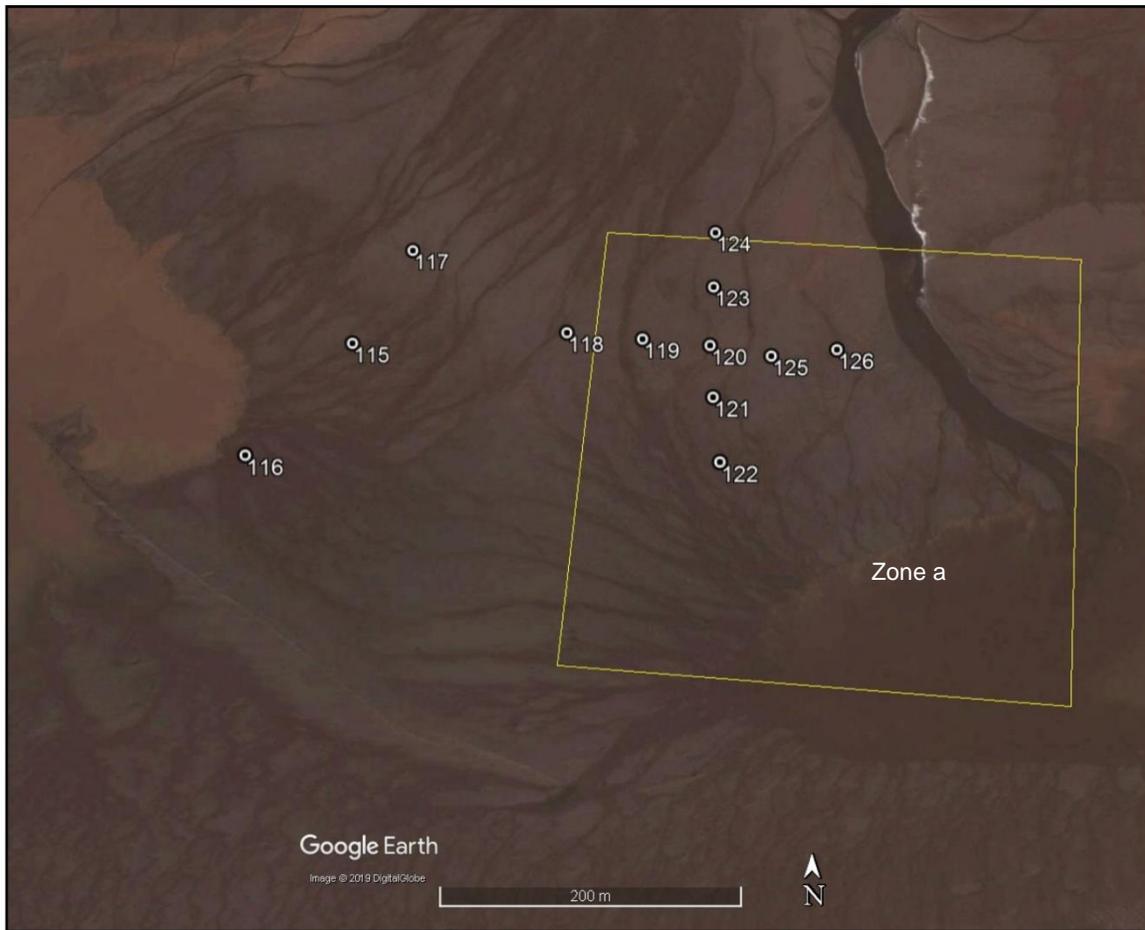
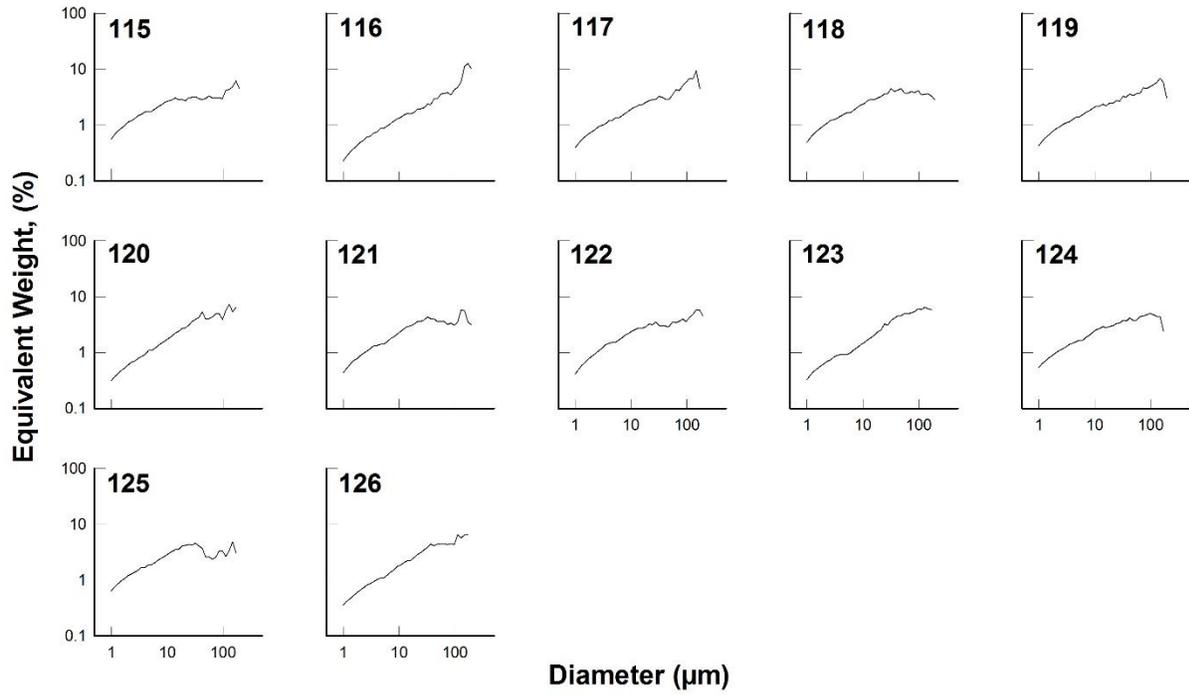


Figure 40: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Five Islands, Nova Scotia (survey zone a) in June 2018. Sample IDs correspond with numbered stations on location map.

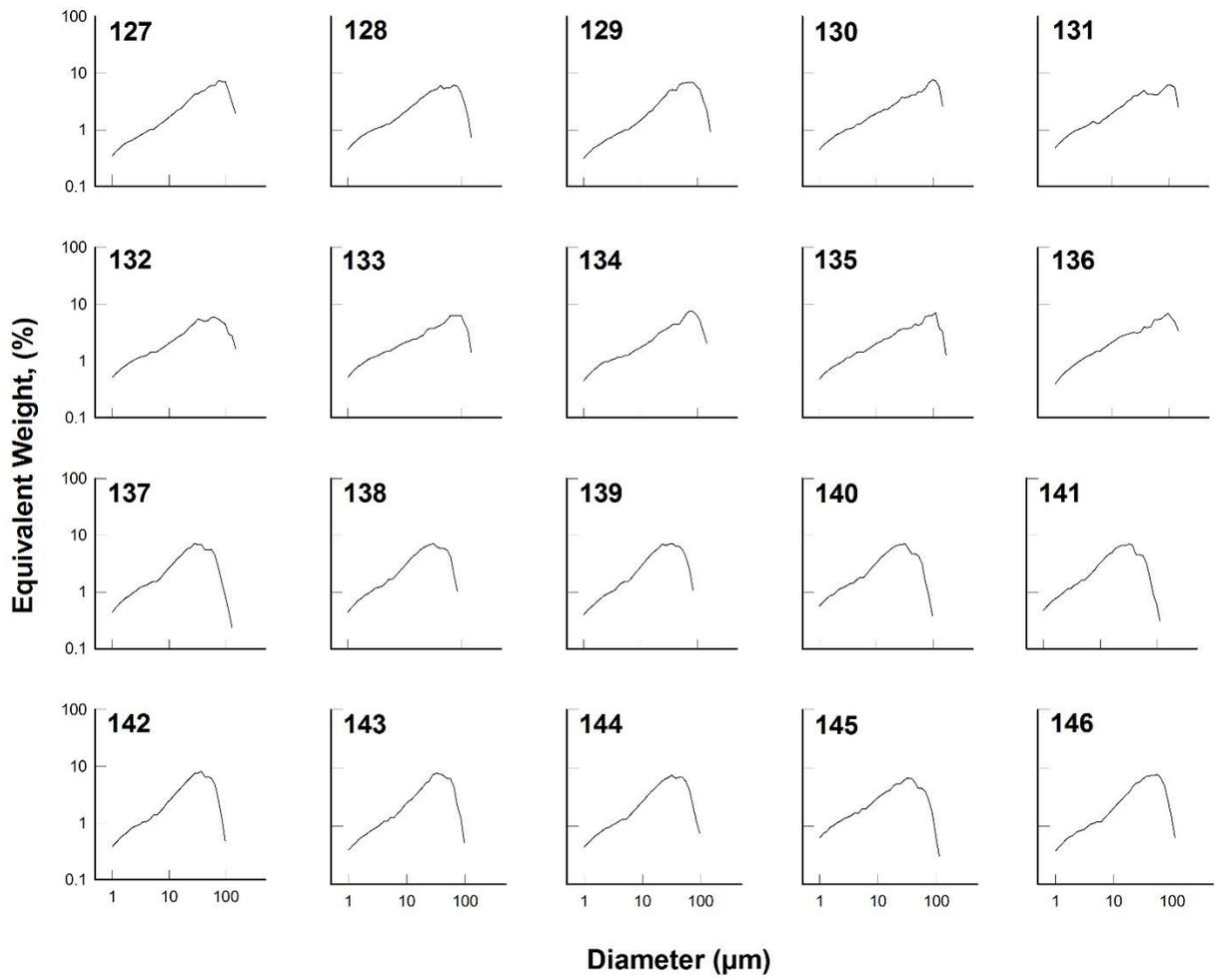


Figure 41: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Five Islands, Nova Scotia (survey zones b & c) in June 2018. Sample IDs correspond with numbered stations on location map.

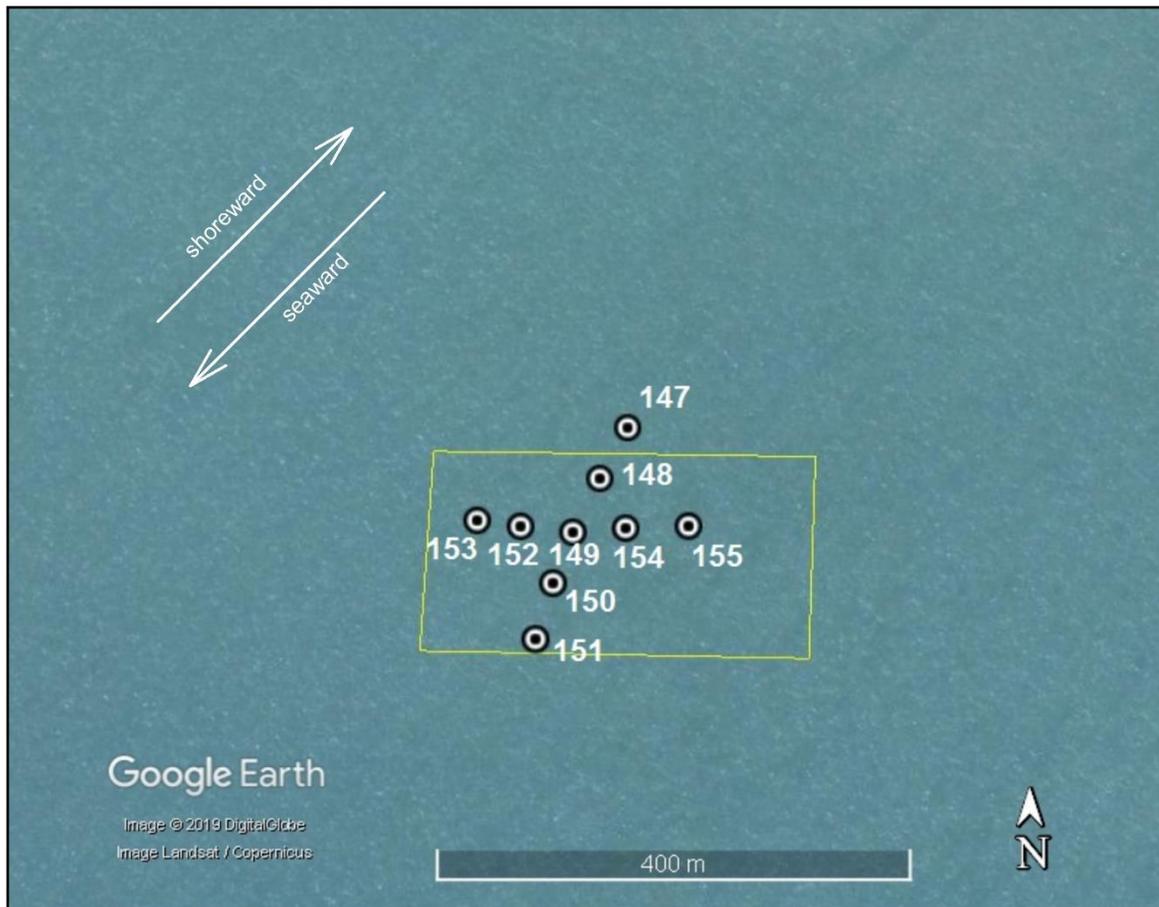
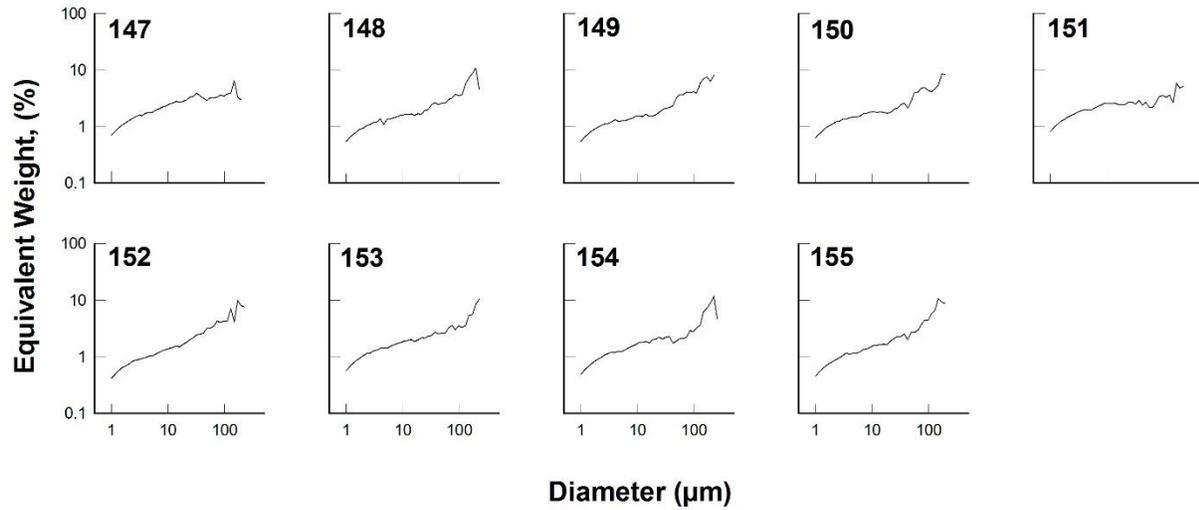


Figure 42: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Economy, NS in June 2018. Sample IDs correspond with numbered stations on location map. There are no low tide Google Earth data available for Economy; seaward and shoreward directions are shown with white arrows.

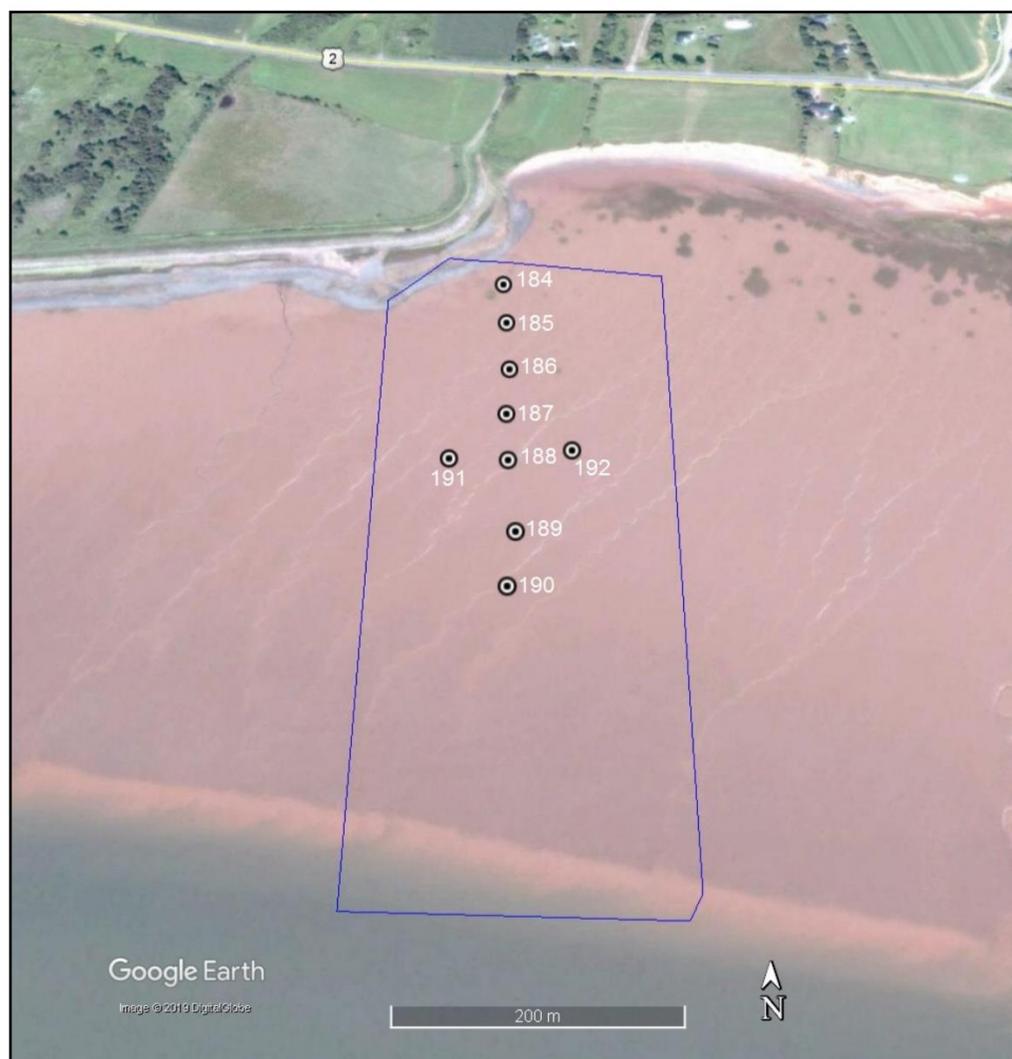
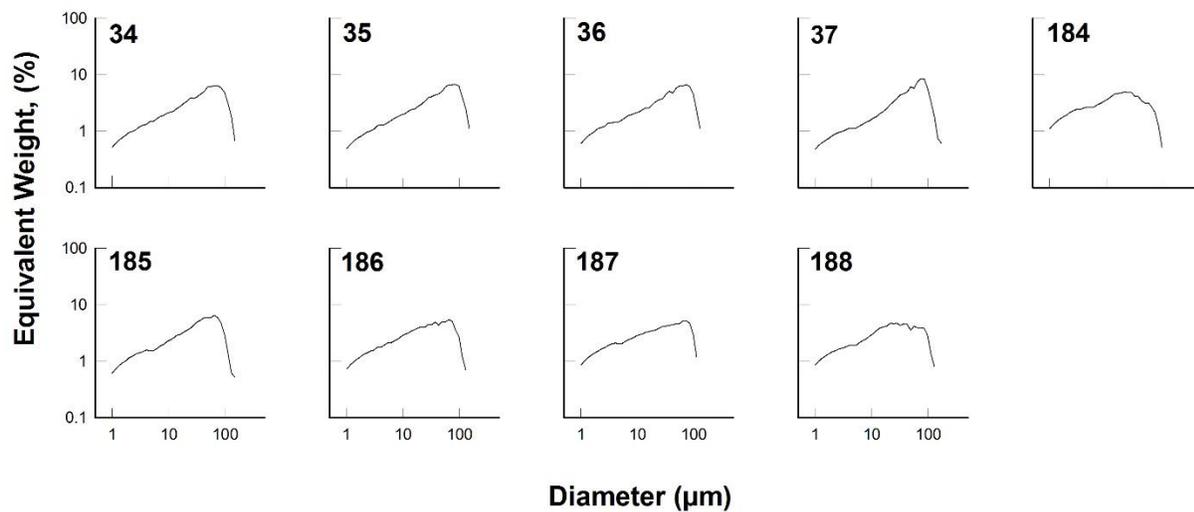


Figure 43: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Portapique, NS in July 2018. Sample IDs correspond with numbered stations on location map.

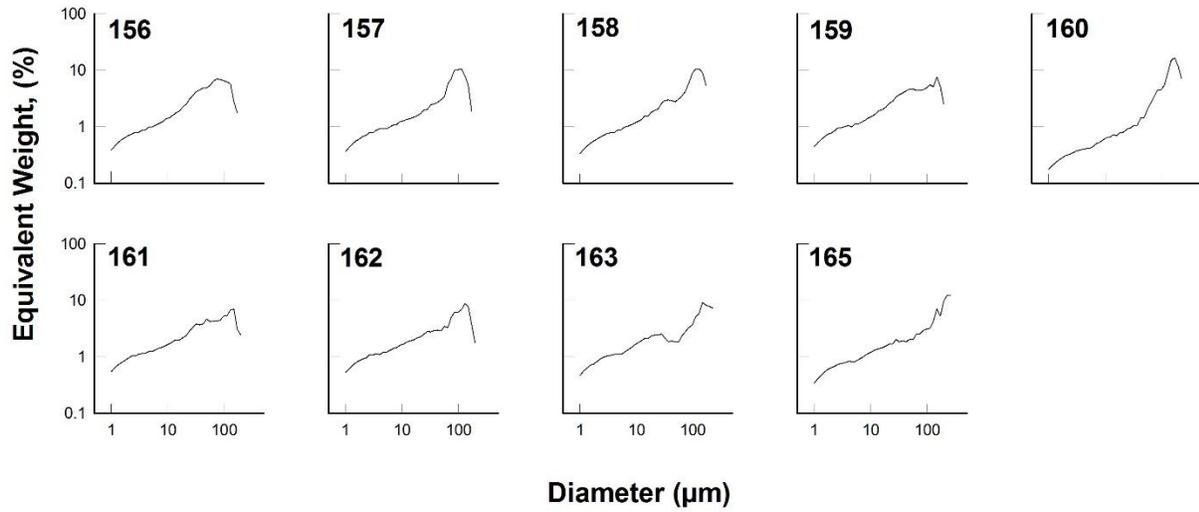


Figure 44: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Walton, NS (survey zone b) in July 2018. Sample IDs correspond with numbered stations on location map. Sediment samples were not collected in survey zone a.

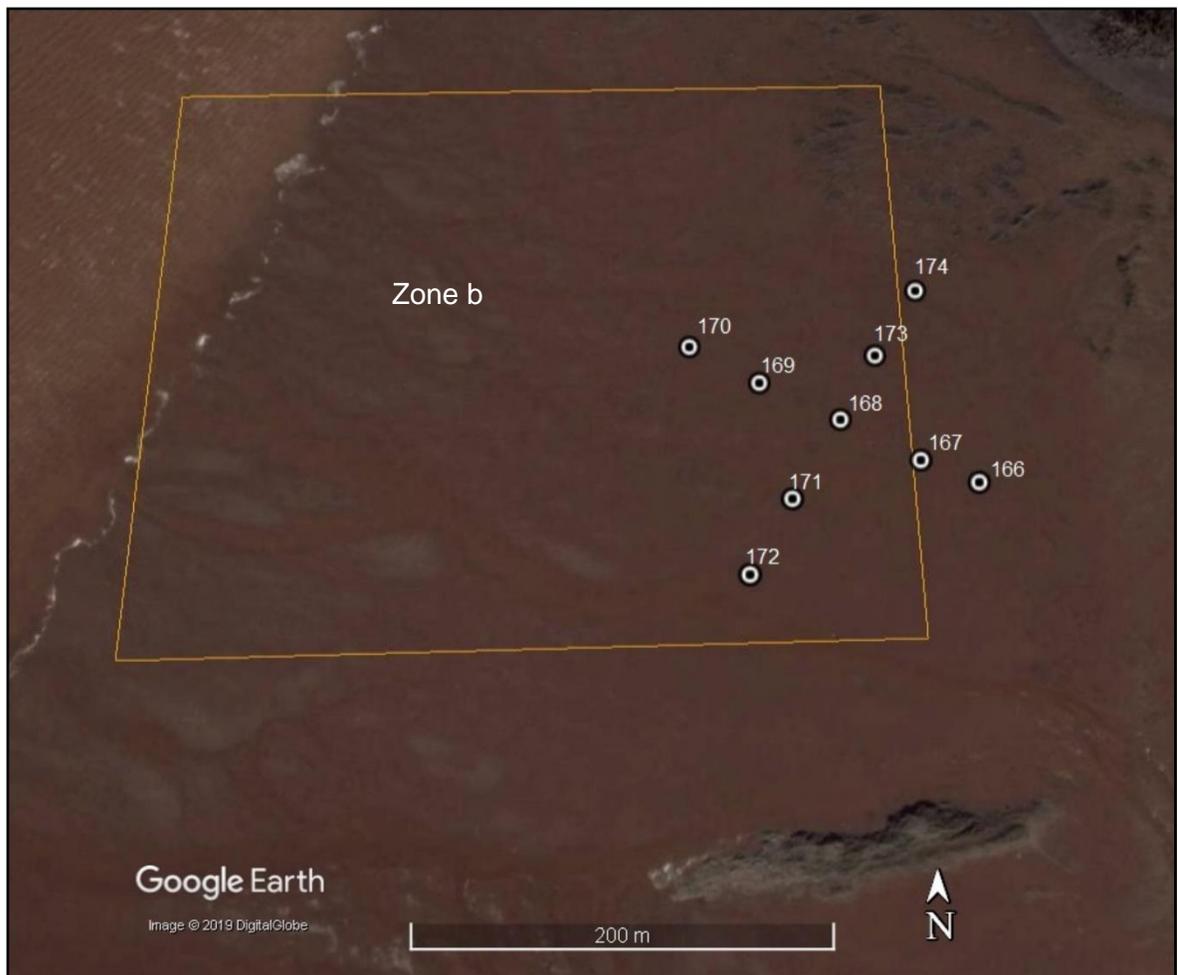
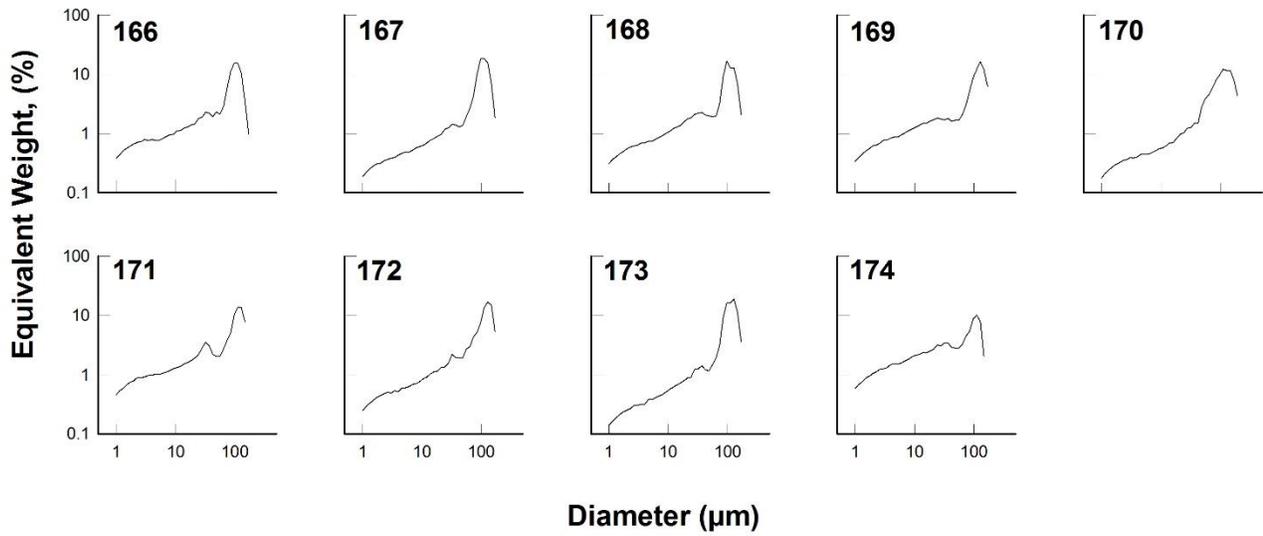


Figure 45: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Bamber, NS (survey zone b) in July 2018. Sample IDs correspond with numbered stations on location map.

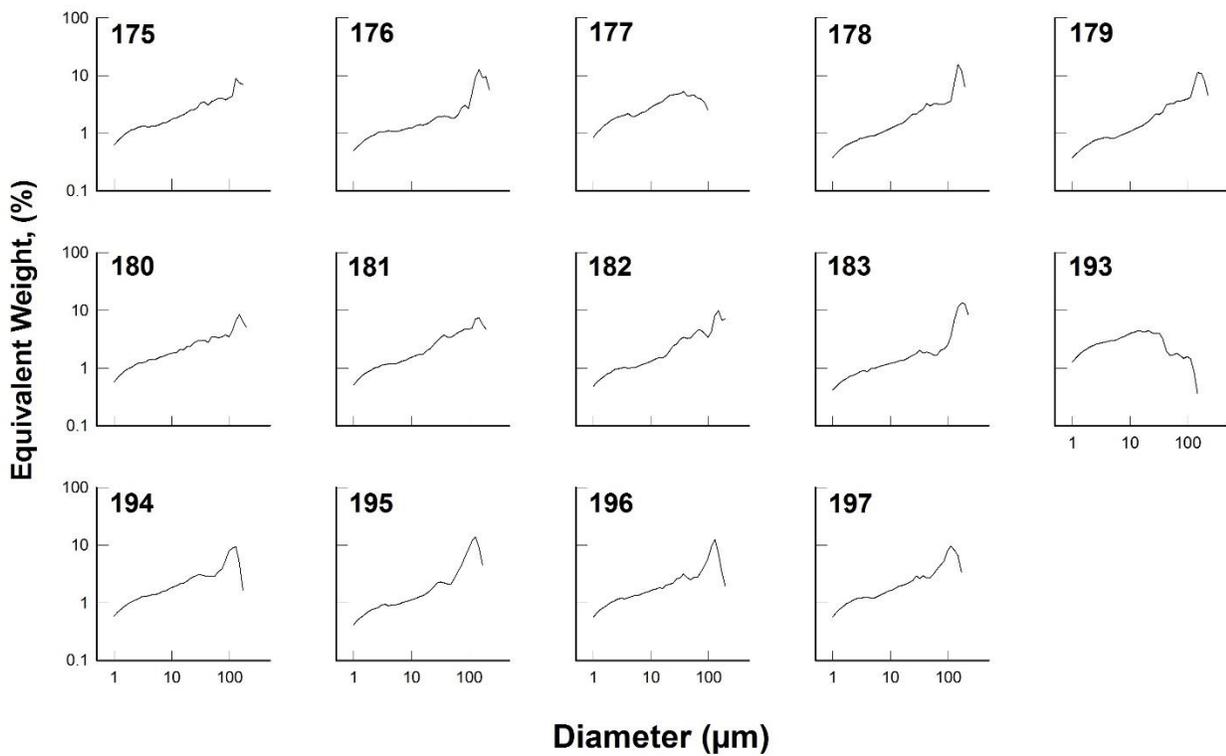


Figure 46: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Bramber, NS (survey zones c & d) in July 2018. Sample IDs correspond with numbered stations on location map.

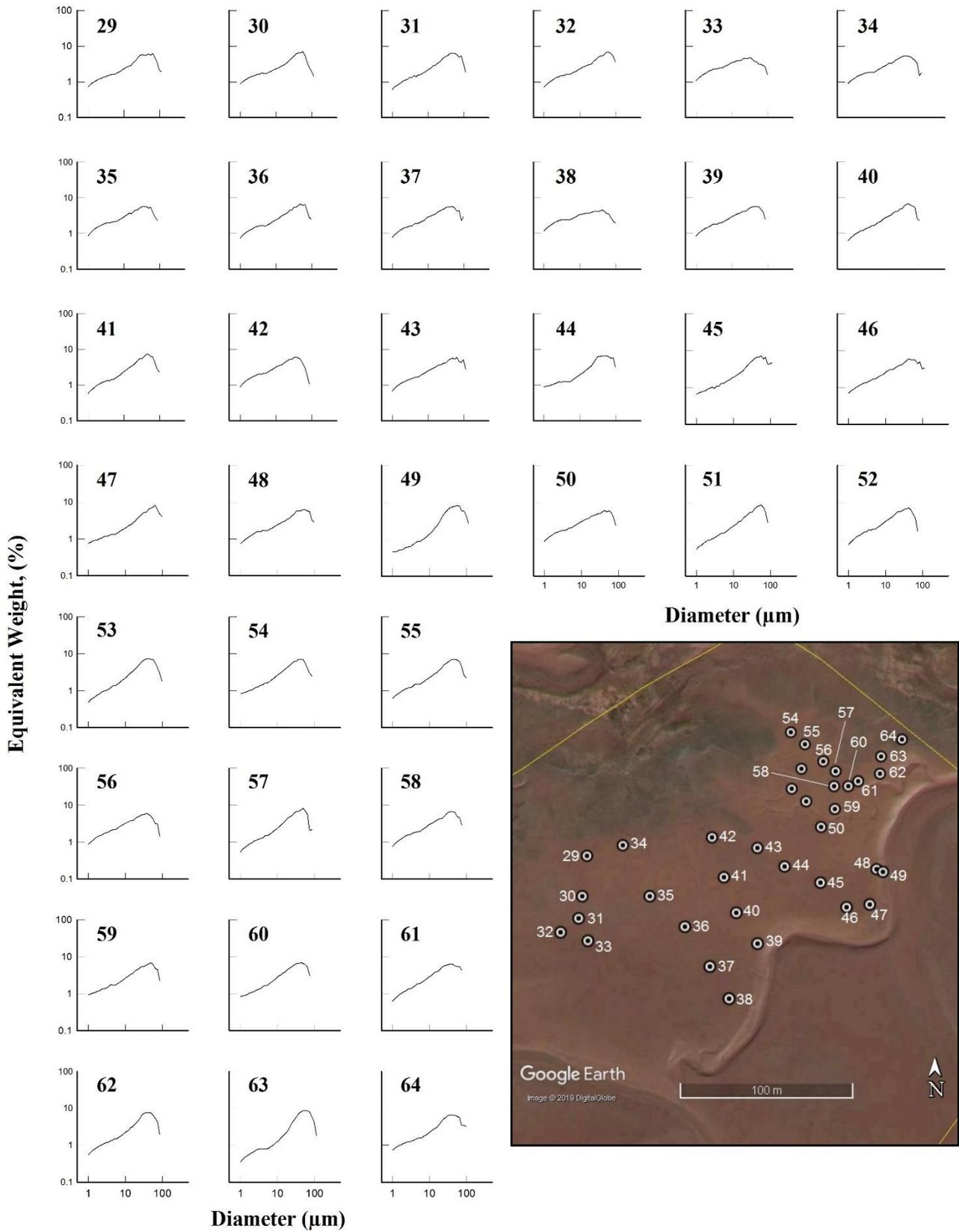


Figure 47: Disaggregated inorganic grain size (DIGS) results for bottom sediment collected at Kingsport, NS in August 2017. Sample IDs correspond with numbered stations on location map. Samples collected in 2018 are currently being analyzed.

Appendix: Grain size analysis results tables

The following tables (1-10) contain raw grain size data for all SPERA samples.

Sample ID	35	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	96	97	98	99	100	101	102	
Zone	a	a	a	a	a	b	b	b	b	b	b	a	a	a	b	b	b	c	c	c	c	c	c	c	
Latitude	45.719617	45.71923	45.71885	45.71842	45.71805	45.7176	45.71717	45.7168	45.71637	45.716	45.71565	45.71695	45.7168	45.71667	45.71737	45.71758	45.7178	45.72247	45.72202	45.72157	45.72098	45.72047	45.71975	45.71882	
Longitude	-64.67475	-64.6746	-64.6744	-64.6742	-64.674	-64.6738	-64.6736	-64.6734	-64.6732	-64.673	-64.6727	-64.6743	-64.6748	-64.6753	-64.673	-64.6726	-64.6721	-64.6706	-64.6706	-64.6705	-64.6703	-64.6702	-64.6698	-64.6691	
Date	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	
1	0.4591908	0.522308	0.454445	0.185781	0.319905	0.432595	0.34185	0.238626	0.289286	0.252202	0.212426	0.33538	0.274014	0.172082	0.488753	0.694194	0.352559	0.654621	0.561891	0.444087	0.330503	0.355724	0.516034	0.243915	
1.1486984	0.5198882	0.574581	0.482782	0.21651	0.371525	0.519022	0.40991	0.285642	0.346752	0.303858	0.246337	0.389374	0.312869	0.195406	0.582858	0.814924	0.404113	0.760965	0.668878	0.520286	0.386895	0.422287	0.60466	0.284402	
1.3195079	0.5463659	0.611101	0.515398	0.244957	0.424498	0.582041	0.4601	0.32463	0.392574	0.346423	0.27141	0.435651	0.348539	0.219379	0.639939	0.889253	0.441123	0.869428	0.743132	0.586272	0.44062	0.467961	0.686901	0.318292	
1.5157166	0.6029151	0.679409	0.52933	0.273115	0.467831	0.667057	0.49742	0.35408	0.441239	0.382737	0.304797	0.475787	0.392233	0.244085	0.738933	1.022431	0.499902	0.963947	0.8605	0.64833	0.489925	0.526525	0.781934	0.363056	
1.7411011	0.6524217	0.719275	0.571453	0.299819	0.512569	0.719774	0.555885	0.383412	0.500327	0.418591	0.329766	0.521789	0.424465	0.555885	0.260734	0.804064	1.143921	0.552843	1.060534	0.944347	0.733335	0.542025	0.58708	0.868253	0.407363
2	0.6878563	0.745832	0.637935	0.331889	0.55199	0.8264	0.597037	0.418358	0.539029	0.482331	0.347446	0.558244	0.467856	0.287615	0.874755	1.250844	0.594667	1.170362	1.034286	0.786943	0.594643	0.629456	0.94117	0.436453	
2.2973967	0.7128535	0.824138	0.658688	0.360295	0.604411	0.879453	0.687344	0.473029	0.600568	0.534961	0.371898	0.631411	0.496355	0.325838	0.967375	1.373914	0.646581	1.284331	1.13687	0.878366	0.664856	0.693417	1.05205	0.478581	
2.6390158	0.80666	0.890142	0.703095	0.376401	0.665201	0.899234	0.738682	0.504877	0.638859	0.542814	0.422427	0.672725	0.533757	0.348699	1.060957	1.465266	0.691749	1.407565	1.244489	0.945143	0.711431	0.741847	1.147403	0.511398	
3.0314331	0.8128093	0.935148	0.751006	0.430985	0.730785	1.058694	0.774847	0.555515	0.704644	0.551057	0.447196	0.690646	0.587539	0.380116	1.169192	1.59316	0.731121	1.463415	1.225118	1.041754	0.748322	0.790085	1.240927	0.552283	
3.4822023	0.930099	1.007447	0.759094	0.42743	0.735385	1.029755	0.783337	0.574428	0.765542	0.597711	0.465644	0.771831	0.604698	0.416136	1.246107	1.655163	0.777021	1.583515	1.338576	1.103088	0.792562	0.878885	1.287198	0.6315	
4	0.9574774	1.073467	0.837321	0.507805	0.814434	1.090248	0.905266	0.654862	0.828635	0.647673	0.511713	0.81114	0.635517	0.412622	1.328348	1.759362	0.77898	1.713358	1.397277	1.196181	0.860932	0.96288	1.423783	0.676277	
4.5947934	0.9922319	1.133817	0.948088	0.546047	0.810328	1.056665	0.936938	0.7388	0.873553	0.664345	0.539086	0.697036	0.482192	1.260996	1.85842	0.852151	1.786536	1.496757	1.231493	0.956947	0.977692	1.502206	0.679614		
5.2780316	0.9922319	1.133817	0.980107	0.546047	0.917446	1.056665	0.936938	0.7388	0.873553	0.664345	0.575065	0.996311	0.697036	0.482192	1.386794	1.85842	0.852151	1.918955	1.543113	1.231493	0.956947	0.977692	1.59972	0.679614	
6.0628663	1.1336107	1.285925	0.980107	0.628484	0.917446	1.182971	1.063838	0.844086	0.9859	0.73701	0.575065	0.996311	0.804109	0.559531	1.386794	2.014672	0.959856	1.918955	1.543113	1.392824	1.096068	1.11015	1.708151	0.776898	
6.9644045	1.2978209	1.447201	1.11314	0.722337	1.067915	1.407031	1.205889	0.978774	1.100548	0.820882	0.657626	1.16865	0.923091	0.63027	1.542336	2.220493	1.096634	2.206161	1.755524	1.579519	1.235017	1.255451	1.708151	0.866219	
8	1.476533	1.653358	1.23751	0.833868	1.227568	1.519377	1.382067	1.127737	1.216468	0.909902	0.749523	1.327297	1.028637	0.726849	1.635513	2.360001	1.220874	2.46335	2.011214	1.771588	1.395164	1.422003	1.853571	1.009333	
9.1895868	1.7564046	1.948517	1.458594	0.979528	1.456343	1.801713	1.52837	1.286106	1.350423	1.068565	0.866429	1.535363	1.201006	0.848962	1.808296	2.537076	1.421004	2.800582	2.370756	2.046706	1.630109	1.692136	2.043234	1.192583	
10.556063	2.0851791	2.150048	1.678061	1.191716	1.69111	2.099467	1.751557	1.486422	1.493395	1.2348	0.98969	1.815289	1.379777	1.046695	1.95466	2.640688	1.612719	3.105329	2.697935	2.366138	1.927725	1.975982	2.342483	1.447905	
12.125733	2.4007408	2.519683	1.969196	1.488995	2.034457	2.42085	2.047311	1.754252	1.650775	1.370229	1.177401	2.017349	1.571748	1.228122	2.127788	2.779709	1.828278	3.51096	3.180161	2.751882	2.209125	2.271033	2.587833	1.697413	
13.928809	2.8260359	2.811311	2.302016	1.781962	2.430611	2.798951	2.3845	2.234471	1.878097	1.68115	1.406446	2.510814	1.868769	1.587097	2.339269	2.919924	2.240024	4.077153	3.679106	3.185073	2.560976	2.734865	2.97052	2.001429	
16	3.3612295	3.108516	2.696136	2.295742	2.857721	3.45313	2.802986	2.436201	2.045644	1.990477	1.635799	2.943049	2.161332	1.904133	2.473249	3.037959	2.676358	4.332388	4.094716	3.681962	3.085664	3.202946	3.297606	2.455415	
18.379174	3.9042992	3.784433	3.284456	2.820093	3.383478	3.873135	3.306335	3.122813	2.61462	2.39103	2.135266	3.587032	2.464827	2.507687	3.09679	3.317844	3.156538	4.921672	4.678099	4.374087	3.742264	3.945663	4.014469	3.126994	
21.112127	4.907789	4.154742	4.087628	3.635387	4.322154	4.737259	4.225354	3.545823	3.060056	2.775376	2.584055	4.425718	3.208181	2.984038	3.50203	3.648506	3.594697	5.39413	5.348421	5.06439	4.568293	4.798611	4.618163	3.885854	
24.251465	5.4381998	5.040376	4.974001	4.859154	5.075363	5.511636	4.98454	4.933933	3.669723	3.932759	3.144293	5.465561	3.977997	3.941712	3.704021	4.0982	4.706586	5.813004	5.757299	6.255161	5.397512	5.611103	5.166391	4.696862	
27.857618	6.3706113	5.881467	6.076467	6.151337	6.139312	6.620774	5.95984	5.322668	4.258131	4.871073	4.199479	6.320898	4.883527	5.071308	4.739896	5.257501	5.965248	6.200096	6.244347	6.941121	6.340351	6.709883	6.012505	5.687408	
32	7.2500243	6.156672	6.910599	7.228591	7.420593	7.013377	7.048811	6.78088	5.727802	5.349143	5.276433	6.746206	6.16957	6.564524	5.684696	5.090442	6.840508	6.425301	6.617637	7.619553	7.183274	7.063795	6.250712	6.921617	
36.758347	7.0998273	6.896783	7.507328	8.365485	7.961628	7.878721	7.572155	6.771575	6.075813	5.961607	6.942341	8.174147	7.01349	7.551763	6.783863	6.383157	7.762162	6.149036	6.678412	7.879891	7.974547	7.602664	7.116497	7.966479	
42.224253	8.0067203	7.872176	8.994814	9.913876	8.348471	6.916463	8.306588	8.104738	7.54057	7.099798	8.622536	8.785697	8.196385	8.91989	6.997383	6.547765	8.700487	5.333522	6.307146	8.136987	8.648216	8.500558	7.196501	8.446349	
48.50293	7.8215439	7.889987	8.644188	10.23553	8.348471	7.342304	8.022926	7.954708	8.483983	8.452497	10.22579	8.182223	8.884611	10.14002	8.581994	6.320116	8.567986	5.333522	5.724105	6.477698	8.11169	7.923584	6.900888	8.642688	
55.715236	7.8215439	7.889987	8.644188	10.23553	8.65225	6.070283	8.022926	7.954708	8.928731	9.608693	10.22579	8.182223	9.434195	10.14002	8.581994	6.320116	8.567986	5.2581	5.724105	6.477698	8.11169	7.923584	6.900888	8.642688	
64	6.5463125	7.005312	7.522022	9.264498	7.804469	6.070283	7.144943	8.167512	8.928731	7.522022	10.06166	6.933882	9.434195	10.84055	8.3										

Sample ID	103	104	105	106	107	108	109	110	111	112	113
Zone	c	c	c	c	c	c	c	c	n/a	n/a	n/a
Latitude	45.71863	45.7184	45.719	45.7191	45.71762	45.7168	45.71593	45.71513	45.71432	45.71537	45.71518
Longitude	-64.6697	-64.6702	-64.6686	-64.6681	-64.6684	-64.6683	-64.668	-64.6678	-64.6676	-64.6674	-64.6684
Date	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018	6/7/2018
1	0.351232	0.249813	0.151277	0.232667	0.225162	0.356304	0.425978	0.298869	0.524439	0.41434	0.396174
1.1486984	0.415271	0.286236	0.179999	0.270281	0.278036	0.419522	0.476077	0.333877	0.601565	0.463698	0.427413
1.3195079	0.460872	0.312061	0.196958	0.30387	0.309731	0.471899	0.525928	0.352427	0.64259	0.497421	0.471309
1.5157166	0.536893	0.3415	0.215797	0.347719	0.349988	0.541219	0.587739	0.388413	0.712957	0.559103	0.538241
1.7411011	0.570915	0.396419	0.239994	0.368774	0.38661	0.612359	0.649786	0.415721	0.755571	0.609534	0.577655
2	0.63358	0.41243	0.260005	0.420801	0.427572	0.642281	0.692996	0.438261	0.823024	0.64939	0.602674
2.2973967	0.683674	0.451153	0.293919	0.45061	0.458432	0.684061	0.749657	0.497167	0.871608	0.722316	0.650413
2.6390158	0.744636	0.474396	0.313691	0.477462	0.515476	0.760993	0.821601	0.528707	0.948758	0.737026	0.717827
3.0314331	0.799434	0.469366	0.324872	0.519683	0.570788	0.757906	0.841582	0.5691	1.000086	0.812945	0.784058
3.4822023	0.846699	0.538337	0.36724	0.552986	0.553732	0.770541	0.900677	0.592807	1.137741	0.831854	0.772897
4	0.917433	0.535825	0.348766	0.580597	0.558672	0.774549	0.958559	0.588627	1.141018	0.88036	0.794592
4.5947934	0.934122	0.525713	0.40176	0.678415	0.676255	0.804234	1.145988	0.61425	1.183108	0.866968	0.885353
5.2780316	0.934122	0.525713	0.467933	0.678415	0.676255	0.804234	1.145988	0.61425	1.183108	0.866968	0.914621
6.0628663	1.053226	0.593794	0.467933	0.753499	0.763839	0.903131	1.28651	0.693518	1.288275	0.949135	0.914621
6.9644045	1.180802	0.679055	0.547892	0.878371	0.855708	1.008478	1.400526	0.777292	1.413962	1.067096	1.036716
8	1.331407	0.775551	0.635943	0.986726	0.996211	1.144005	1.462733	0.875031	1.523259	1.144301	1.110985
9.1895868	1.565651	0.929983	0.781524	1.153879	1.149867	1.282868	1.70005	1.039074	1.61075	1.331609	1.276678
10.556063	1.666795	1.055055	0.94752	1.365375	1.3488	1.405474	1.786229	1.199071	1.823838	1.453851	1.347399
12.125733	1.963136	1.264482	1.185037	1.610681	1.56703	1.697367	1.899295	1.435555	1.959046	1.533982	1.630411
13.928809	2.169156	1.622469	1.567068	1.963029	1.953598	1.929545	2.056582	1.75457	2.199413	1.872505	1.808225
16	2.420187	1.91502	1.99347	2.310948	2.311236	2.299019	2.169734	2.051027	2.237743	2.069971	1.919835
18.379174	2.784064	2.356845	2.667458	2.941973	2.871233	2.630758	2.351494	2.531058	2.703697	2.505127	2.340205
21.112127	3.470416	3.053983	3.423587	3.746726	3.502403	3.209523	2.701597	3.000362	2.976082	2.820148	2.989389
24.251465	3.775442	3.717633	4.678731	4.845363	4.245027	3.860055	3.176851	3.175376	4.343235	3.19194	3.281274
27.857618	4.436545	4.782264	5.846251	5.721726	5.243083	4.792805	3.79482	4.365075	4.550093	4.1076	3.947097
32	5.544231	5.782962	7.519214	7.383063	5.844255	5.381586	4.243603	5.500089	6.12628	4.990394	4.969906
36.758347	5.498372	6.883138	8.649932	8.205363	7.440478	6.702333	4.591589	6.243712	6.366546	5.375077	5.443994
42.224253	6.567669	9.105969	10.02763	9.02464	7.296326	6.279501	6.019862	6.688032	7.416501	6.156401	6.836315
48.50293	7.956238	8.824273	11.33378	10.28752	8.281747	7.022127	5.964245	8.334109	7.416501	7.543314	7.998672
55.715236	8.858802	9.564528	11.33378	10.28752	7.577594	7.022127	6.61142	8.334109	7.989902	7.543314	9.147898
64	8.858802	9.564528	10.05496	9.474149	7.773005	7.390897	7.26014	9.531452	7.946274	9.229807	9.147898
73.516695	8.250693	9.360399	7.07913	6.576614	7.773005	8.405015	7.594527	9.560501	6.369581	10.28619	8.919272
84.448506	6.284857	7.740798	3.810984	3.384716	6.563737	7.776873	7.594527	7.884671	4.695588	9.108838	6.896794
97.00586	4.093684	3.564196	1.345951	1.215845	4.664229	5.634384	8.398442	5.694439	2.594112	5.201487	5.460828
111.43047	1.44094	1.344116	0.340013	0	2.730223	2.795746	4.562202	2.555719	2.92375	1.605996	2.325462
128	0	0	0	0	1.260657	1.026284	1.450465	0.543684	0	0	0.716896
147.03339	0	0	0	0	0	0	0	0	0	0	0
168.89701	0	0	0	0	0	0	0	0	0	0	0
194.01172	0	0	0	0	0	0	0	0	0	0	0
222.86094	0	0	0	0	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	0	0	0	0
294.06678	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2: DIGS (disaggregated inorganic grain size) results for Mary's Point, NB sediments, samples 103-113 (June 2018). Diameter (microns) is shown at left; sample IDs are shown at the top of each column. Data are normalized over the size range. Coordinates are relative to WGS84, UTM Zone 20 N.

Sample ID	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	
Zone	n/a	n/a	n/a	a	a	a	a	a	a	a	a	a	c	c	c	c	c	c	c	c	c	c	b	b	
Latitude	45.398617	45.397767	45.399367	45.3987	45.39865	45.3986	45.3982	45.397717	45.399067	45.399517	45.398517	45.398567	45.4007	45.4005	45.400167	45.3998	45.399433	45.399083	45.399833	45.399533	45.400417	45.400783	45.40383	45.40405	
Longitude	-64.10182	-64.10275	-64.10128	-64.0997	-64.09895	-64.09828	-64.09827	-64.09822	-64.09823	-64.09823	-64.0982	-64.09768	-64.09703	-64.07995	-64.07973	-64.07933	-64.07895	-64.07858	-64.07822	-64.07978	-64.0802	-64.07877	-64.07835	-64.08305	-64.08318
Date	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/19/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	
1	0.5650929	0.2290057	0.3936311	0.4954687	0.4303638	0.3163146	0.434591	0.4115625	0.328382	0.5451506	0.6436324	0.3577705	0.3477577	0.4554841	0.3178738	0.4462259	0.4821449	0.5172012	0.5197389	0.4450365	0.478579	0.3970778	0.442819	0.4461832	
1.1486984	0.6838821	0.2780109	0.4730438	0.5951157	0.5183108	0.3725048	0.5217293	0.5016051	0.3949856	0.6364333	0.7649844	0.4181355	0.4127746	0.5380445	0.3728471	0.5273306	0.5647688	0.6011344	0.6201378	0.5364904	0.565322	0.4728283	0.529337	0.5373382	
1.3195079	0.7868191	0.3258304	0.5524202	0.6863961	0.596222	0.4220585	0.6113066	0.5905416	0.4601889	0.7110725	0.8599434	0.461629	0.4687682	0.6107147	0.4219498	0.5911184	0.6407017	0.6702693	0.7087257	0.612064	0.6413545	0.5554581	0.616516	0.6138633	
1.5157166	0.8879452	0.3743965	0.625824	0.788828	0.6744493	0.4808002	0.7128021	0.6741499	0.5117892	0.8091759	0.9804681	0.5242008	0.5360635	0.6966491	0.4863378	0.6638018	0.7286041	0.7644067	0.8054728	0.6987757	0.7161991	0.6424216	0.699068	0.7156041	
1.7411011	0.984927	0.4269419	0.7021019	0.8808868	0.7654035	0.5299337	0.7744996	0.7842882	0.5734339	0.8939234	1.0730592	0.5971524	0.5893052	0.7845325	0.5242095	0.7354062	0.816035	0.8382753	0.8819893	0.7847055	0.79444	0.7115674	0.794458	0.7866377	
2	1.1350593	0.4916469	0.7660065	0.9780992	0.8497262	0.6062871	0.8757392	0.864667	0.6263578	0.9871494	1.2057808	0.6588786	0.6273649	0.8417858	0.572284	0.8282546	0.8973959	0.9341463	0.975604	0.8843358	0.8525107	0.8017182	0.85606	0.884937	
2.2973967	1.1971511	0.5267966	0.8367453	1.0828535	0.9218401	0.6759705	0.9732321	0.9568269	0.7006613	1.0858653	1.2981554	0.7267917	0.6685217	0.9305633	0.6314154	0.8705323	0.9813622	1.0116996	1.075389	0.9627006	0.9247085	0.8856926	0.963028	0.9486528	
2.6390158	1.3233441	0.6204419	0.9471705	1.2109547	1.0137078	0.7098288	1.0612632	1.0821233	0.7391629	1.1660081	1.4008232	0.8167431	0.7285283	0.9790998	0.7006518	0.9472479	1.0303177	1.0872941	1.1431396	0.9718999	1.0082411	0.9925256	1.058822	1.0561537	
3.0314331	1.4758942	0.6279374	0.9943358	1.2526741	1.0967102	0.7884958	1.1699268	1.1933356	0.8323349	1.2549518	1.5132988	0.8612038	0.7874454	1.0449098	0.7287684	1.0420834	1.0992054	1.1554654	1.1951668	1.0436988	1.1325111	1.0687397	1.19239	1.1626036	
3.4822023	1.5682494	0.7243312	1.0538068	1.3257188	1.1331982	0.8499025	1.3251765	1.3813961	0.8919104	1.3995308	1.7054047	0.9381914	0.8615572	1.103382	0.8051462	1.0561929	1.159257	1.2153616	1.2688849	1.0803274	1.1590641	1.1906593	1.270682	1.2145659	
4	1.728057	0.7492229	1.1871095	1.4581023	1.2613678	0.9266749	1.3445832	1.4612661	0.9249729	1.4693298	1.688335	1.0178985	0.9263018	1.1415637	0.873166	1.1039364	1.2566255	1.2551464	1.3745624	1.1701513	1.2906917	1.2513736	1.335568	1.2703607	
4.5947934	1.765226	0.8654384	1.2084633	1.5680203	1.3854522	1.0902052	1.4060993	1.5381009	0.932867	1.5664642	1.8917811	1.0908017	1.0186997	1.2478716	0.9234516	1.2792243	1.4166347	1.4036007	1.4618006	1.1692947	1.4254094	1.351119	1.439801	1.4445217	
5.2780316	1.765226	0.8654384	1.3636307	1.6871453	1.3854522	1.0902052	1.4060993	1.5381009	0.932867	1.6725612	1.8917811	1.0908017	1.0186997	1.2478716	1.0062294	1.2792243	1.3271184	1.4521422	1.4618006	1.2589432	1.4372133	1.4695804	1.534165	1.6931705	
6.0628663	1.961612	0.9592754	1.3626307	1.6871453	1.536968	1.2078588	1.5699066	1.6829768	0.9972518	1.6725612	2.0776662	1.2230133	1.1348796	1.4020859	1.0062294	1.4190445	1.3271184	1.4521422	1.593	1.2589432	1.4372133	1.4695804	1.534165	1.6931705	
6.9644045	2.1599041	1.0638253	1.4979478	1.8709434	1.6960943	1.3578369	1.779118	1.8626727	1.1335106	1.8759987	2.3013509	1.3824937	1.2758209	1.5530946	1.1341634	1.5784046	1.5159779	1.5930829	1.7440852	1.4066267	1.5904607	1.6524458	1.753432	1.9698363	
8	2.3390231	1.1720578	1.6402136	2.073442	1.8107593	1.4814292	1.9196222	2.0836543	1.2400544	2.0418866	2.5046056	1.5084863	1.3935301	1.7094809	1.2341754	1.7385517	1.6356266	1.7518982	1.8997783	1.5416096	1.7283215	1.818342	2.066066	2.2912	
9.1895868	2.5927287	1.2958922	1.8118615	2.2878154	1.9938419	1.6444241	2.1379313	2.2350997	1.38316	2.3049984	2.7340985	1.7478084	1.5612532	1.9576621	1.378561	1.8480936	1.8554156	1.9366916	2.0343035	1.6465856	1.9187736	2.037375	2.457657	2.6686971	
10.556603	2.7118591	1.3690593	2.003549	2.4406612	2.1831491	1.8055686	2.3909628	2.4534942	1.5154703	2.5657272	2.9966923	1.8670504	1.761863	2.1472789	1.5699571	2.0241617	2.0509599	2.1401884	2.1613799	1.7956874	2.1106814	2.219769	2.824141	3.1301728	
12.125733	2.830592	1.5075941	2.1310206	2.7247609	2.1847681	1.9817702	2.6565779	2.6287617	1.680057	2.6980317	3.2382381	2.0472896	1.9461877	2.4306142	1.7556138	2.1001182	2.300739	2.3450469	2.2466561	1.9354101	2.1871091	2.4164789	3.289227	3.6662448	
13.928809	3.0788301	1.6222623	2.2953862	2.8995599	2.3712477	2.2686794	2.9430684	2.781564	1.849772	2.9196572	3.5216021	2.2249898	2.2363572	2.7280752	2.065288	2.3278076	2.4792247	2.618915	2.4318957	2.1380592	2.4555005	2.6931596	3.879403	4.3073184	
16	2.83235	1.596895	2.282856	2.8570535	2.213091	2.407961	3.0163894	2.7441553	2.0557725	2.8080678	3.5294936	2.2555654	2.393315	2.9877875	2.1938162	2.323821	2.7159584	2.8155716	2.4376527	2.3114006	2.4846212	2.8273171	4.362554	4.6999755	
18.379174	2.9029127	1.6760926	2.5431145	3.0568118	2.4576075	2.7124243	3.2315743	2.894897	2.3526909	2.9521093	4.1089722	2.514202	2.7363724	3.4673314	2.6091971	2.5789177	3.1318623	3.1039312	2.6832442	2.6542053	2.6894971	2.9625171	5.044655	5.4916707	
21.112127	2.721989	1.9346599	2.7523831	3.2507552	2.4474143	2.7803103	3.5984841	3.2464351	2.5145833	3.0262732	4.1915572	2.8749801	3.1842249	3.8034636	2.9976618	2.8411605	3.4323547	3.5906031	2.8480407	3.117804	2.9878856	3.1014804	5.821119	6.0195126	
24.251465	3.07084	1.9509156	2.8520705	3.5868677	2.7438062	3.1250396	3.6517605	3.1528972	3.2801726	3.3164538	4.3655867	3.0975307	3.6707697	4.2864268	3.5754835	3.1406632	3.9684481	4.1410861	3.5433073	3.3583587	3.406436	3.2118185	6.128613	6.5242463	
27.857618	3.1650757	2.0443699	2.8919431	3.67214	2.6874766	3.611128	3.8650823	3.5372018	3.0956565	3.371435	4.2348749	3.4849841	4.2738584	4.7596752	4.0299358	3.746351	4.0628367	4.6393095	3.7732781	3.6242221	3.6530326	3.1291949	7.238074	6.9166125	
32	3.2369714	2.3655142	3.2818466	4.4671956	3.2655893	3.9380381	4.3736528	3.0831119	3.7916266	3.8221504	4.5899641	3.8423239	4.3415437	5.0328832	4.9731969	3.6813006	4.4617242	5.4963968	3.7481456	3.9577666	3.71845	3.2734286	6.843896	7.2082526	
36.758347	2.9689594	2.3588481	3.1498474	4.0100112	3.2078246	4.2450653	4.0670049	3.0591132	4.1306787	3.6889482	4.1134433	4.4109815	4.7436768	5.2784918	5.1313796	3.8082192	4.942883	5.2816702	4.0108988	4.3926023	3.7436977	3.9598438	6.995533	6.2656491	
42.224253	2.8602337	3.0032899	2.8958723	4.2513069	3.6074037	5.4218092	4.0068774	2.9868625	4.573207	4.1887463	3.7137806	4.1263908	4.9942998	6.1034404	4.9289021	4.1652734	4.2709793	4.9818492	4.2787466	4.4469077	3.9076348	3.8941553	5.578161	5.8883876	
48.50293	3.0058105	3.0032899	2.8958723	4.5307802	3.3678488	4.0594574	3.5816841	2.9868625	4.573207	3.8151961	2.629624	4.4071363	5.6774572	5.3173396	6.259952	4.1020907	4.2887561	5.1940896	4.620824	4.4469077					

Sample ID	147	148	149	150	151	152	153	154	155
Zone	n/a								
Latitude	45.385817	45.38538	45.38493	45.38452	45.384067	45.38498	45.385033	45.38497	45.384983
Longitude	-63.95638	-63.95668	-63.95697	-63.95717	-63.95733	-63.95757	-63.95807	-63.95637	-63.95565
Date	6/21/2018	6/21/2018	6/21/2018	6/21/2018	6/21/2018	6/21/2018	6/21/2018	6/21/2018	6/21/2018
1	0.7090128	0.546177	0.551315	0.635578	0.8181653	0.420513	0.5697405	0.491132	0.4519365
1.1486984	0.8164916	0.639853	0.654673	0.739126	0.959804	0.489285	0.6696645	0.585302	0.5346771
1.3195079	0.9403884	0.725917	0.731116	0.828246	1.0923125	0.560229	0.7664932	0.658089	0.6121832
1.5157166	1.0543426	0.81257	0.830199	0.954477	1.235923	0.637928	0.8608585	0.748203	0.6889908
1.7411011	1.1530973	0.90288	0.908463	1.040676	1.3352413	0.681156	0.9450367	0.838531	0.7617277
2	1.2622774	0.942169	0.979761	1.112827	1.4657398	0.732242	1.0504324	0.911782	0.8206996
2.2973967	1.3783929	1.042724	1.055778	1.218579	1.5771475	0.825247	1.1404264	0.97878	0.889946
2.6390158	1.4956386	1.100374	1.118378	1.245354	1.671713	0.866159	1.1675383	1.081345	0.9636688
3.0314331	1.5941365	1.192463	1.14291	1.356353	1.7961025	0.892942	1.2740957	1.14162	1.0636132
3.4822023	1.55982	1.225085	1.219128	1.355937	1.9187213	0.931692	1.3161116	1.216504	1.1612321
4	1.7360387	1.378933	1.336636	1.446633	2.0023931	0.967606	1.4124016	1.200992	1.1060803
4.5947934	1.7937381	1.088193	1.235656	1.486994	1.9655629	1.032797	1.4155293	1.234099	1.1555108
5.2780316	1.7937381	1.369043	1.268112	1.486994	1.9655629	1.032797	1.4155293	1.234099	1.1555108
6.0628663	1.9655734	1.369043	1.268112	1.54671	2.1456891	1.120571	1.5332686	1.332446	1.2251405
6.9644045	2.0880852	1.445922	1.353214	1.679194	2.3006274	1.206201	1.6276886	1.451985	1.3467546
8	2.2348829	1.502361	1.404849	1.714211	2.4355899	1.286226	1.7181691	1.533316	1.3757821
9.1895868	2.3271911	1.599861	1.532098	1.812475	2.6080544	1.338307	1.7849285	1.644065	1.4739934
10.556063	2.5167772	1.631923	1.540457	1.842085	2.5837898	1.407751	1.9037727	1.78952	1.5790736
12.125733	2.6281888	1.644127	1.515583	1.779873	2.5805167	1.466238	1.9383304	1.799659	1.6064942
13.928809	2.7974127	1.682443	1.665223	1.823232	2.5978249	1.539739	2.0152335	1.859845	1.6422711
16	2.7003502	1.591153	1.521906	1.782126	2.4514266	1.497657	1.8643218	1.767703	1.6770054
18.379174	2.8026767	1.701135	1.543267	1.724627	2.4445986	1.660816	1.9735967	1.996116	1.638053
21.112127	2.9549422	1.660482	1.634331	1.774284	2.4671323	1.797305	2.1624287	2.041919	1.8942457
24.251465	3.3449676	1.929356	1.800739	2.015745	2.7240733	2.024409	2.1380076	2.219129	2.095893
27.857618	3.4373036	1.996436	2.001095	2.154473	2.7066204	2.171893	2.303124	2.050957	2.2851557
32	3.9074835	2.429349	2.132811	2.457712	2.4936579	2.459411	2.3831991	2.238242	2.2822489
36.758347	3.4971764	2.648603	2.193063	2.604187	2.9262028	2.509355	2.7473484	2.295962	2.5367778
42.224253	3.1633378	2.447885	2.339155	2.117377	2.4024509	2.638245	2.5447898	1.740014	1.994484
48.50293	2.9157102	2.621945	3.209607	2.773507	2.6890595	3.199066	2.6104148	1.889458	2.6802498
55.715236	3.2408862	2.621945	3.676924	4.08374	2.2077531	3.199066	2.6104148	2.088247	2.6925865
64	3.2408862	3.00774	3.676924	4.08374	2.2077531	3.491915	3.2169786	2.088247	2.9355986
73.516695	3.3234796	3.176405	4.116959	4.796279	2.6546289	4.27808	3.5947358	2.230442	3.6898586
84.448506	3.6367954	3.741862	3.978431	4.912027	3.428616	4.115073	3.0210063	2.889742	4.4413252
97.00586	3.4638422	3.554204	4.130256	4.392692	3.564754	4.284195	3.5160096	2.806621	4.4413252
111.43047	3.7824043	3.667858	3.881385	4.175404	3.320012	4.297252	3.2843201	3.254987	5.7701058
128	3.9361259	5.733166	5.883079	4.618261	3.6508097	7.092387	3.5692026	3.614744	6.5593837
147.03339	6.4848382	7.373209	7.04737	5.444425	2.6920181	4.168386	5.4098995	6.367402	10.678623
168.89701	3.3419201	8.780904	7.629868	8.645167	5.8938192	9.975934	5.6104403	7.294494	9.2091429
194.01172	2.9796492	10.88948	6.27799	8.33867	4.8102705	8.064368	8.5038373	8.845108	8.8826503
222.86094	0	4.584823	8.013181	0	5.2078619	7.63956	10.410675	11.85975	0
256	0	0	0	0	0	0	0	4.689398	0
294.06678	0	0	0	0	0	0	0	0	0

Appendix Table 4: DIGS (disaggregated inorganic grain size) results for Five Islands, NS sediments, samples 139-146 (June 2018). Diameter (microns) is shown at left; sample IDs are shown at the top of each column. Data normalized over the size range. Coordinates are relative to WGS84, UTM Zone 20 N.

Sample ID	139	140	141	142	143	144	145	146
Zone	b	b	b	b	b	b	b	b
Latitude	45.40425	45.40445	45.404383	45.404517	45.404733	45.405	45.40462	45.404433
Longitude	-64.08328	-64.08338	-64.08308	-64.08277	-64.08247	-64.08253	-64.08213	-64.0817
Date	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018	6/20/2018
1	0.3955335	0.573167	0.4787656	0.3865949	0.3867433	0.4346118	0.635072	0.3761549
1.14869835	0.471425	0.66085	0.5605793	0.4497032	0.4507712	0.5105363	0.740617	0.4413024
1.31950791	0.5324254	0.749683	0.6421795	0.5184364	0.5143769	0.5769448	0.812854	0.5022985
1.51571657	0.6045094	0.850101	0.7326615	0.5992578	0.5926865	0.6659105	0.956618	0.5908608
1.74110113	0.6903876	0.892953	0.7994662	0.6594724	0.6665632	0.7390342	1.030869	0.6576704
2	0.7745529	1.011979	0.8941294	0.7563254	0.7150202	0.8146293	1.143891	0.6888259
2.29739671	0.8733286	1.147531	0.9966276	0.8365952	0.8075441	0.9142612	1.223814	0.7879413
2.63901582	0.9359953	1.19983	1.1330973	0.8975957	0.8741219	0.9471656	1.357319	0.8387584
3.03143313	1.0133597	1.299854	1.1591946	0.9457139	0.9500961	1.0402669	1.431219	0.866661
3.48220225	1.0682671	1.41633	1.3161078	1.0535675	1.0558743	1.1138442	1.519007	0.967925
4	1.2663517	1.446173	1.416601	1.0672814	1.1956583	1.2226919	1.691498	1.0778693
4.59479342	1.4407937	1.675878	1.6103742	1.1676603	1.2019261	1.3058518	1.656346	1.1277374
5.27803164	1.5360873	1.829811	1.6103742	1.3780802	1.3995439	1.3058518	1.968182	1.1899966
6.06286627	1.5360873	1.829811	1.867933	1.3780802	1.3995439	1.5275906	1.968182	1.1899966
6.96440451	1.7857259	2.164393	2.1478971	1.5994687	1.6501051	1.7941497	2.231228	1.3912887
8	2.1397919	2.53612	2.4966423	1.8608274	1.8768206	2.0777584	2.510953	1.5937179
9.18958684	2.5023611	2.972396	2.9999223	2.2740256	2.2852312	2.4395213	2.915946	1.8729981
10.5560633	3.0030284	3.451194	3.4577869	2.6058151	2.6326029	2.826261	3.228161	2.1917412
12.1257325	3.5280247	4.049076	4.0225345	3.0528298	2.8948329	3.3201874	3.547012	2.5495209
13.928809	4.1460838	4.585723	4.5924208	3.5950925	3.3748278	3.8516948	3.943254	2.9277409
16	4.8145318	5.143011	4.9845767	4.1632934	3.8987998	4.3801273	4.145065	3.3900401
18.3791737	5.3543413	5.762612	5.8768884	4.8273965	4.5326676	5.033976	4.946404	3.8946435
21.1121266	6.0332124	6.3801	6.3090923	5.6467457	5.5403836	5.8090788	5.383341	4.8108558
24.2514651	7.0513454	6.790223	6.7475802	6.5418838	5.9540216	6.385126	5.305615	5.47577
27.857618	6.630882	6.82798	6.666904	7.4860404	7.6239146	6.8669133	6.144304	5.7486949
32	7.0245694	7.148343	7.0543034	7.6097733	8.0932602	7.5031536	6.693735	6.5462842
36.7583474	7.1746126	5.848908	6.7132682	8.2387567	7.9044972	6.6539812	6.642778	7.2645495
42.2242531	6.3808049	4.737842	4.5823047	6.5872196	7.4635596	6.8884963	5.74223	7.3750962
48.5029301	6.3808049	4.737842	4.5823047	6.5872196	6.5990406	6.8884963	4.471024	7.3750962
55.7152361	5.480512	4.341815	4.3913097	6.1653586	6.5990406	5.8560065	4.471024	7.7539738
64	3.9091307	3.182539	3.3469148	4.7312077	4.7413382	4.1309493	3.976113	6.7205843
73.5166947	2.447338	1.519981	1.9177318	2.6224143	2.2220566	2.2438948	2.830037	4.9276163
84.4485063	1.0737942	0.847948	0.9564906	1.2268015	1.3855729	1.1881602	1.722482	2.8243625
97.0058603	0	0.388	0.6213294	0.4834657	0.5169565	0.742877	0.707441	1.4269777
111.430472	0	0	0.3139198	0	0	0	0.306366	0.6344488
128	0	0	0	0	0	0	0	0
147.033389	0	0	0	0	0	0	0	0
168.897013	0	0	0	0	0	0	0	0
194.011721	0	0	0	0	0	0	0	0
222.860944	0	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	0
294.066779	0	0	0	0	0	0	0	0

Appendix Table 5: DIGS (disaggregated inorganic grain size) results for Economy, NS sediments (June 2018). Diameter (microns) is shown at left; sample IDs are shown at the top of each column. Data are normalized over the size range. Coordinates are relative to WGS84, UTM Zone 20 N.

Sample ID	34	35	36	37	184	185	186	187	188
Zone	n/a								
Latitude	45.3944	45.394017	45.393567	45.39315	45.39273	45.392117	45.39167	45.39275	45.392817
Longitude	-63.66003	-63.65998	-63.65993	-63.65995	-63.65992	-63.65982	-63.65988	-63.66053	-63.65925
Date	7/30/2018	7/30/2018	7/30/2018	7/30/2018	7/30/2018	7/30/2018	7/30/2018	7/30/2018	7/30/2018
1	0.525589	0.4934383	0.6080393	0.478441	1.11255	0.6218497	0.729344	0.8609331	0.8613816
1.1486984	0.6119047	0.5766725	0.714187	0.563619	1.295563	0.7353683	0.854704	1.012664	1.0066794
1.3195079	0.6984822	0.6638949	0.8175902	0.622919	1.473963	0.837905	0.974111	1.1521089	1.1296042
1.5157166	0.7741895	0.7432573	0.9030838	0.690696	1.645809	0.9417063	1.085428	1.279966	1.2429646
1.7411011	0.8549248	0.8067868	1.0003719	0.756348	1.80264	1.0194776	1.197116	1.4079448	1.3563169
2	0.9605299	0.8818966	1.1196585	0.832974	1.934924	1.1574415	1.322937	1.5166295	1.4769929
2.2973967	0.9984015	0.9703509	1.1691644	0.901905	2.179775	1.2345293	1.418383	1.6524908	1.5482952
2.6390158	1.0722536	1.0117375	1.2274981	0.957414	2.33008	1.3589625	1.508252	1.7532518	1.6587592
3.0314331	1.1974591	1.0840601	1.4001669	0.997678	2.446495	1.4106318	1.577443	1.9130613	1.7091666
3.4822023	1.2770131	1.2536079	1.410025	1.062589	2.439777	1.4799545	1.778809	2.0304612	1.807171
4	1.31916	1.3071342	1.4661326	1.145528	2.584549	1.5844063	1.769651	2.0982283	1.9215845
4.5947934	1.4789157	1.3071342	1.4661326	1.145833	2.683391	1.5372355	1.942002	2.061233	1.926384
5.2780316	1.4789157	1.4186089	1.5770672	1.145833	2.692084	1.5372355	2.113377	2.061233	1.926384
6.0628663	1.6561726	1.5484268	1.7393886	1.241593	2.692084	1.6636606	2.113377	2.251876	2.1282053
6.9644045	1.8252134	1.6954404	1.910673	1.345523	2.960019	1.8466511	2.303075	2.4369078	2.3357301
8	1.8988774	1.8157642	1.977871	1.456984	3.110224	1.975527	2.447911	2.5481069	2.5039354
9.1895868	2.0774864	1.9540024	2.1186936	1.548688	3.414394	2.2119285	2.75262	2.7613058	2.8061176
10.556063	2.1792449	2.0300653	2.2085193	1.703478	3.696147	2.3921784	2.999747	2.9421498	3.1029361
12.125733	2.2656085	2.2382777	2.4053059	1.826692	4.0753	2.5921905	3.146602	3.0201441	3.4884287
13.928809	2.5388966	2.4191469	2.5826808	2.064865	4.529965	2.8819566	3.427904	3.2629904	3.8959804
16	2.7890545	2.4833627	2.5968378	2.251953	4.670028	2.9955879	3.648557	3.3526008	4.0613416
18.379174	3.1010398	2.759621	2.963054	2.525092	4.748358	3.2867018	3.918377	3.483016	4.1997199
21.112127	3.4357864	3.0210608	3.3683626	2.958499	4.997911	3.5719076	4.037242	3.6002764	4.6947418
24.251465	3.9245494	3.4212381	3.6114692	3.329127	4.902125	3.8613406	4.012533	3.8540322	4.6578593
27.857618	3.8083449	3.9364456	3.7883575	3.802793	4.91386	4.451081	4.503504	4.138906	4.6966274
32	4.1195984	4.1193111	4.5291432	4.433812	4.144462	4.9809836	4.442927	4.198816	4.3237316
36.758347	4.5802849	4.3817952	5.1242254	4.635101	4.142366	5.3740362	4.94216	4.348128	4.5995903
42.224253	5.0438761	4.5620936	4.7431288	4.958295	3.449809	5.9030255	4.371468	4.401288	4.5342099
48.50293	6.1418392	5.081604	5.7963239	6.084952	3.189649	5.9732066	4.985512	4.666317	3.5356032
55.715236	6.1844917	6.0448205	6.4018985	5.781621	3.189649	5.9732066	4.985512	4.666317	4.1547089
64	6.413746	6.650009	6.4018985	7.511399	2.671087	6.5064851	5.449548	5.2109003	3.9244424
73.516695	6.413746	6.650009	6.6892814	8.459801	2.130089	5.9183748	5.123273	5.2158241	3.9244424
84.448506	5.8487894	6.7913625	6.1623596	8.459801	1.231682	4.704849	3.558555	4.6869573	3.8471097
97.00586	4.8431988	6.2740457	4.5551658	5.746059	0.519192	2.9339867	2.664125	2.9529085	2.8570185
111.43047	3.1304158	3.9726565	2.3363172	3.373106	0	1.4000105	1.191558	1.2000259	1.3488226
128	1.8590827	2.4959259	1.1099267	1.83948	0	0.6241233	0.702358	0	0.8070129
147.03339	0.6729176	1.1349349	0	0.738035	0	0.5202967	0	0	0
168.89701	0	0	0	0.621473	0	0	0	0	0
194.01172	0	0	0	0	0	0	0	0	0
222.86094	0	0	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	0	0
294.06678	0	0	0	0	0	0	0	0	0

Appendix Table 6: DIGS (disaggregated inorganic grain size) results for Portapique, NS sediments (July 2018). Diameter (microns) is shown at left; sample IDs are shown at the top of each column. Data are normalized over the size range. Coordinates are relative to WGS84, UTM Zone 20 N.

Sample ID	156	157	158	159	160	161	162	163	164
Zone	b	b	b	b	b	b	b	b	b
Latitude	45.233067	45.233433	45.2338	45.23415	45.23453	45.23367	45.23355	45.233967	45.23412
Longitude	-64.04868	-64.04893	-64.04925	-64.0496	-64.0499	-64.0499	-64.05045	-64.04868	-64.04805
Date	7/16/2018	7/16/2018	7/16/2018	7/16/2018	7/16/2018	7/16/2018	7/16/2018	7/16/2018	7/16/2018
1	0.3898557	0.3674413	0.340366	0.452867	0.177574	0.551638	0.535585	0.4731101	0.344149
1.1486984	0.4563778	0.4330829	0.395035	0.526464	0.20527	0.645192	0.622072	0.5604077	0.411932
1.3195079	0.528003	0.492987	0.454201	0.591269	0.232456	0.72419	0.704799	0.6284697	0.467373
1.5157166	0.592669	0.5648838	0.509481	0.668449	0.259583	0.796665	0.78786	0.7158078	0.538242
1.7411011	0.6447303	0.6066103	0.561378	0.745708	0.286295	0.868589	0.861412	0.7504049	0.602835
2	0.6985341	0.6790336	0.60736	0.780237	0.310292	0.952112	0.913616	0.8302982	0.645861
2.2973967	0.7427625	0.7099137	0.664209	0.855735	0.3246	1.04712	0.956346	0.9270713	0.679612
2.6390158	0.7987007	0.7927817	0.710177	0.968153	0.344352	1.031587	1.087585	0.9896824	0.743326
3.0314331	0.8024623	0.7849109	0.768807	0.968435	0.373607	1.113026	1.077583	1.0393281	0.757962
3.4822023	0.8693507	0.8742403	0.782264	1.01346	0.384623	1.150955	1.144225	1.0703354	0.788849
4	0.8840822	0.9273559	0.788228	1.053532	0.401967	1.156379	1.097224	1.1014636	0.836307
4.5947934	0.991102	0.9246143	0.879971	1.00104	0.413478	1.24804	1.213035	1.1035721	0.827081
5.2780316	0.991102	0.9246143	0.879971	1.132114	0.413478	1.24804	1.213035	1.1035721	0.827081
6.0628663	1.0668735	1.0012064	0.984207	1.132114	0.449764	1.328741	1.304627	1.2081027	0.895416
6.9644045	1.148799	1.0830909	1.025034	1.219142	0.50519	1.438084	1.412879	1.3311364	0.972018
8	1.2181279	1.1069506	1.093377	1.311709	0.532449	1.478772	1.463456	1.4581789	1.066096
9.1895868	1.3877167	1.2370566	1.158846	1.45707	0.586463	1.58591	1.621747	1.6308464	1.159382
10.556063	1.4436905	1.2798927	1.24718	1.556478	0.648231	1.704549	1.689195	1.7809943	1.242062
12.125733	1.581394	1.3541543	1.343466	1.685927	0.654722	1.833509	1.843192	1.9245663	1.342207
13.928809	1.7650232	1.4088301	1.557037	1.944567	0.725249	2.012101	1.930775	2.130204	1.409393
16	1.9164981	1.4787235	1.55482	2.013315	0.701295	1.977435	2.00005	2.1106231	1.453399
18.379174	2.2501199	1.5713156	1.818762	2.216319	0.795914	2.179578	2.173766	2.346159	1.556582
21.112127	2.5179719	1.7076545	1.95419	2.599669	0.80637	2.392019	2.258451	2.4311852	1.686569
24.251465	3.0992296	2.0192326	2.087595	2.836932	0.91186	2.87195	2.527967	2.4278165	1.68936
27.857618	3.6562014	2.0317291	2.636021	3.383753	0.962744	3.383792	2.816158	2.5535447	2.029954
32	4.2206416	2.4651956	2.942853	3.718021	1.055743	3.843372	2.768056	2.1398561	1.851498
36.758347	4.5002398	2.5427557	2.999904	4.009422	1.055634	3.678193	2.940833	1.860976	1.939079
42.224253	4.9361035	2.7322472	2.912126	4.321527	1.434958	3.857366	2.971646	1.9073387	1.847785
48.50293	4.9361035	3.01685	2.787763	4.65679	1.434958	4.659068	2.882671	1.8323143	2.048848
55.715236	5.4012207	3.4503021	3.090844	4.692655	2.020735	4.223249	3.481795	1.8323143	2.022831
64	6.4826171	5.7967538	3.558109	4.40872	2.634217	4.302478	3.311319	2.368153	2.547835
73.516695	7.043162	7.0671896	4.224584	4.40872	3.402086	4.302478	5.019021	2.8023936	2.547835
84.448506	6.9420613	10.277592	5.994552	4.529308	4.512023	4.446753	6.181024	3.3077323	2.943827
97.00586	6.5763734	10.277592	8.87954	4.934946	4.53216	5.348197	6.181024	3.698546	3.118608
111.43047	6.2125629	10.639672	10.64189	5.549662	5.429761	5.332612	6.902191	5.1076411	3.199765
128	5.7623263	8.0293409	10.64189	5.16589	9.040507	6.75041	8.83371	5.9164488	4.298808
147.03339	2.769334	5.4662786	9.111657	7.691441	15.02588	7.000643	7.814292	9.1584607	7.184058
168.89701	1.7758762	1.8759235	5.412297	5.251371	16.6157	3.060862	3.671025	8.2422182	5.317882
194.01172	0	0	0	2.547069	12.15813	2.474347	1.784754	7.8902316	9.595716
222.86094	0	0	0	0	7.239681	0	0	7.3084945	12.21728
256	0	0	0	0	0	0	0	0	12.34529
294.06678	0	0	0	0	0	0	0	0	0

Appendix Table 7: DIGS (disaggregated inorganic grain size) results for Walton, NS sediments (July 2018). Diameter (microns) is shown at left; sample IDs are shown at the top of each column. Data are normalized over the size range. Coordinates are relative to WGS84, UTM Zone 20 N.

Sample ID	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	193	194	195	196	197
Zone	b	b	b	b	b	b	b	b	b	c	c	c	c	c	c	c	c	c	d	d	d	d	d
Latitude	45.178167	45.178283	45.1785	45.1787	45.1789	45.17808	45.1777	45.17885	45.17922	45.190917	45.19135	45.19163	45.192117	45.192617	45.191533	45.1918	45.192017	45.192217	45.193183	45.19342	45.19382	45.19358	45.193233
Longitude	-64.16997	-64.17035	-64.17088	-64.17143	-64.17192	-64.17122	-64.1715	-64.17063	-64.17033	-64.1701	-64.17023	-64.17042	-64.17065	-64.17077	-64.17107	-64.16993	-64.16938	-64.16873	-64.16383	-64.16407	-64.16428	-64.16443	-64.16458
Date	7/17/2018	7/17/2018	7/17/2018	7/17/2018	7/17/2018	7/17/2018	7/17/2018	7/17/2018	7/17/2018	7/20/2018	7/20/2018	7/20/2018	7/20/2018	7/20/2018	7/20/2018	7/20/2018	7/20/2018	7/20/2018	7/31/2018	7/31/2018	7/31/2018	7/31/2018	7/31/2018
1	0.3802004	0.1880586	0.31121	0.339191	0.1770083	0.459161	0.2460082	0.1393296	0.589025	0.6256739	0.49951	0.846618	0.3818488	0.3746887	0.5722062	0.509148	0.481505	0.4150617	1.2705224	0.593981	0.418359	0.568455	0.568536
1.1486984	0.4400253	0.2211848	0.36601	0.3966499	0.2122948	0.542484	0.2940516	0.1662427	0.686251	0.7411518	0.585028	1.024352	0.4468494	0.4349067	0.6830499	0.6077388	0.5672531	0.4812918	1.4922823	0.690926	0.496206	0.665593	0.6803752
1.3195079	0.5142251	0.2524047	0.405042	0.4529424	0.2409521	0.593747	0.3307918	0.1868184	0.765192	0.8409399	0.651453	1.161039	0.5088577	0.4881804	0.7774482	0.6987611	0.6381272	0.5449149	1.7124036	0.776944	0.552418	0.759021	0.7747478
1.5157166	0.5680608	0.2836867	0.456866	0.5081767	0.2717483	0.686979	0.3714997	0.2141153	0.886247	0.956375	0.751835	1.350963	0.5762115	0.5572267	0.8914668	0.7916397	0.7119509	0.6121767	1.9462359	0.872942	0.614642	0.834129	0.8700865
1.7411011	0.6223753	0.3098272	0.496761	0.5625886	0.3014247	0.757765	0.4189361	0.2363465	0.95626	1.0517936	0.820182	1.481028	0.630463	0.6164938	0.9799441	0.8583119	0.7927815	0.6578415	2.1115875	0.966878	0.689738	0.917611	0.9709804
2	0.6743953	0.3144661	0.549075	0.6264793	0.3212825	0.795697	0.4465706	0.2504918	1.052407	1.1469845	0.88924	1.666853	0.6698908	0.6632139	1.0233031	0.9244543	0.8312314	0.7219245	2.3073132	1.040903	0.752344	1.013898	1.0363637
2.2973967	0.7141552	0.3487955	0.596361	0.6425605	0.35123	0.912279	0.4791083	0.2708031	1.13102	1.1854993	0.93729	1.803819	0.7213204	0.7324351	1.1338827	1.0025522	0.939611	0.755452	2.4647378	1.112117	0.788015	1.073984	1.127916
2.6390158	0.7409951	0.3657664	0.622339	0.6947405	0.3624361	0.889993	0.5067088	0.3024839	1.248172	1.283327	1.039005	1.918989	0.7521402	0.775003	1.2284342	1.0425234	0.9637171	0.8054711	2.6223242	1.183042	0.8228	1.166611	1.1914885
3.0314331	0.7939428	0.3861127	0.638886	0.7800742	0.390592	0.921335	0.4918248	0.3081364	1.262768	1.3217619	1.065516	1.997463	0.8221921	0.7995291	1.2278723	1.1194048	0.9908509	0.8769261	2.6912906	1.283172	0.915777	1.205837	1.1931585
3.4822023	0.7657951	0.3933368	0.691693	0.783615	0.3876644	0.979335	0.5408137	0.3151287	1.332206	1.3105504	1.065706	2.06918	0.834163	0.8320775	1.2779597	1.1491289	1.0370506	0.8938915	2.8084444	1.293851	0.946268	1.176691	1.249631
4	0.7967368	0.4363006	0.699337	0.8425974	0.4031549	0.998026	0.5189596	0.3199664	1.50061	1.2897505	1.109703	2.210054	0.8710782	0.857928	1.4003285	1.1832499	0.9835265	0.8741558	2.887753	1.321598	0.886807	1.231992	1.2469491
4.5947934	0.769326	0.4668862	0.743984	0.881717	0.4471014	1.014381	0.6024608	0.3796745	1.511047	1.3425191	1.080856	1.983542	0.9003715	0.8185775	1.1792416	1.0180714	0.9866103	2.9936178	1.396058	0.920673	1.285549	1.2104027	
5.2780316	0.769326	0.4876885	0.743984	0.881717	0.4481645	1.014381	0.6024608	0.3796745	1.511047	1.3425191	1.080856	1.983542	0.9003715	0.8185775	1.1792416	1.0180714	0.9866103	2.9936178	1.396058	0.920673	1.347267	1.2104027	
6.0628663	0.8265884	0.4876885	0.799501	0.9607368	0.4481645	1.058375	0.6333966	0.4083841	1.597789	1.4023845	1.090195	2.130419	0.9714712	0.8665053	1.5297316	1.2456319	1.083501	1.0443224	3.1484787	1.477787	0.952333	1.347267	1.3086568
6.9644045	0.8990696	0.5272222	0.860207	1.0428547	0.4736693	1.109924	0.6890017	0.4420707	1.730228	1.5227316	1.15147	2.302322	1.0261771	0.9310587	1.5992741	1.3295831	1.1482017	1.0942348	3.3830792	1.580905	1.012648	1.43022	1.3943572
8	0.9513752	0.578211	0.926119	1.1301823	0.5062433	1.182537	0.7086582	0.466769	1.83832	1.5385579	1.196094	2.363866	1.0966775	0.9736909	1.6831407	1.371195	1.1966089	1.1365346	3.5494223	1.631833	1.047123	1.511581	1.4861128
9.1895868	0.9758075	0.6027626	1.013209	1.2036634	0.5507334	1.269081	0.7688537	0.5130862	2.034516	1.6780553	1.244875	2.665203	1.1617398	1.0393778	1.774118	1.4784244	1.2738694	1.1796653	3.8189807	1.774582	1.098638	1.576202	1.6052885
10.556063	1.1137879	0.6394637	1.100152	1.292704	0.5743222	1.332784	0.8639611	0.5704962	2.150587	1.8088243	1.265983	2.946369	1.2513417	1.1030732	1.8397703	1.5672759	1.3471893	1.2283761	4.1188995	1.886654	1.14782	1.681866	1.6646484
12.125733	1.1244688	0.697401	1.212741	1.3847433	0.6185826	1.390169	0.9136837	0.6213106	2.222962	1.8474687	1.35137	3.144373	1.3283348	1.1875765	1.8767452	1.6555789	1.4459983	1.253276	4.2162114	1.977862	1.204837	1.72671	1.7929878
13.928809	1.2483767	0.7790533	1.301232	1.502183	0.692308	1.533124	1.0404288	0.6740097	2.389793	2.0024964	1.40907	3.391573	1.4250887	1.2681454	2.1153941	1.754702	1.5236545	1.3445168	4.4752881	2.143334	1.29191	1.833268	1.9355959
16	1.2950836	0.8340363	1.367411	1.5018622	0.7073384	1.622232	1.1297875	0.7268532	2.349945	2.1190997	1.385921	3.563126	1.4935414	1.3336971	2.0798877	1.7549482	1.5158489	1.3500746	4.3286428	2.205442	1.343693	1.780642	2.0100083
18.379174	1.4092128	0.9069254	1.565569	1.6274885	0.8276049	1.747465	1.1545981	0.7880896	2.514701	2.3142903	1.45099	4.083809	1.6530685	1.4730733	2.3790113	2.0053132	1.6459937	1.4180031	4.3078632	2.389258	1.458862	2.043106	2.0988692
21.112127	1.4500774	0.9735528	1.768665	1.7204428	0.9750221	1.91981	1.3420278	0.8769379	2.727146	2.5251495	1.577489	4.543743	1.9186272	1.6173302	2.4163294	2.1695734	1.9893349	1.5473012	4.4363678	2.674075	1.62955	2.08134	2.2675633
24.251465	1.8038972	1.1882414	1.847834	1.8359384	1.0353642	2.192381	1.3598147	0.9083829	3.198762	2.5635418	1.756597	4.677467	2.1555771	1.8833227	2.7652736	2.5581285	2.4370459	1.6787571	4.0751821	2.862664	1.868962	2.215956	2.4346709
27.857618	1.8995473	1.2565376	2.113897	1.7510331	1.2339718	2.856941	1.5811129	1.2568178	3.068873	2.827373	1.928786	4.781436	2.12664	2.1945448	2.9760048	2.9559174	2.6238849	1.7935895	3.9947547	3.06473	2.23222	2.613857	2.9665878
32	2.2902531	1.4474617	2.214253	1.7179872	1.2667561	3.545362	2.2167801	1.2592842	3.481023	3.4547185	1.920912	4.873185	2.4235966	2.1176647	3.0071865	3.3738539	3.1376442	2.03893	4.0538906	3.073345	2.29101	2.704345	2.6450037
36.758347	2.2315979	1.4048925	2.278202	1.8027565	1.4987172	3.093384	1.9589249	1.4166689	3.440358	3.4659809	1.992119	5.303033	2.6204197	2.3245885	3.0487568	3.7666208	3.4216905	1.8244766	3.2215667	2.93816	2.219195	3.176741	2.9596413
42.224253	1.9292606	1.2980704	2.05502	1.6192402	1.4987172	2.224124	1.9270142	1.2211565	2.876218	3.0802572	1.97428	4.521316	3.2850981	3.1267412	2.7680554	3.4379794	3.2765515	1.9000294	1.9770122	2.89877	2.108829	2.749232	2.7166078
48.50293	2.3165838	1.3706227	1.991448	1.6873376	2.8118352	2.050019	1.9270142	1.167699	2.835468	3.5517227	1.848277	4.521316	2.9819403	3.2538158	3.4674277	3.4379794	3.320342	1.824891	1.6968643	2.945507	2.108829	2.519068	2.7166078
55.715236	2.1297955	1.9434448	1.934917	1.6873376	3.8682926	2.050019	2.7270804	1.4874698	2.835468	3.7770664	1.848277	4.649313	3.2405943	3.2538158	3.4674277	3.748514	3.9143201	1.6855419	1.6968643	2.945507	2.687546	2.783356	3.1673904
64	2.8791753	2.6917709	1.994294	2.1216772	4.5585262	2.74271	3.0041145	1.9691923	3.280525	4.079858	1.211639	4.073434	3.2405943	3.5802995	3.3500847	4.1859382	4.4986483	1.6855419	1.8132206	3.489105	3.541279	2.783356	3.8530028
73.516695	5.6864422	4.2339225	3.200596	3.0039634	5.7638906	3.788814	4.3479703	3.1145087	4.488989	4.079858	2.762829	3.95147	3.1751424	3.6087683	3.4783562	4.4037735	4.4986483	2.0360619	1.657147	3.855483	4.445538	3.423289	4.4966597
84.448506	11.224789	10.034521	9.432881	5.1766184	7.9687888	5.064802	5.1892052	9.4414247	5.435408	3.8176169	3.06346	3.462569	3.1906846	3.763106	3.7893953	4.7960195	4.01749	2.142574	1.4686277	5.39562	6.363833	4.402974	5.3167817
97.00586	15.494528	18.392872	16.74859	8.8771852	9.7513891	10.33648	7.6294033</																

Sample ID	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Zone	n/a																							
Latitude	45.153867	45.15362	45.15348	45.1534	45.15335	45.15393	45.153617	45.15343	45.1532	45.153017	45.15333	45.153517	45.15373	45.153983	45.153917	45.1538	45.1537	45.15355	45.153567	45.15378	45.153767	45.15405	45.154217	45.1543
Longitude	-64.37098	-64.371	-64.37102	-64.37115	-64.37093	-64.3707	-64.37047	-64.37018	-64.36998	-64.36983	-64.36962	-64.36978	-64.36988	-64.36998	-64.36962	-64.3694	-64.36912	-64.36892	-64.36873	-64.36867	-64.36862	-64.3691	-64.36922	-64.36933
Date	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017
1	0.7368608	0.874629	0.619059	0.7201225	1.083479	0.915922	0.8615746	0.744616	0.778701	1.178245	0.865446	0.6336201	0.57891	0.8906489	0.67931	0.883664	0.6620004	0.6996351	0.7689103	0.740687	0.4471567	0.8695	0.5228529	0.705914
1.148698	0.8497983	1.012375	0.724955	0.8409769	1.267941	1.056068	1.0233984	0.882784	0.911204	1.3917274	1.00957	0.7457666	0.689056	1.0598839	0.8058958	0.933123	0.7019046	0.7911784	0.8154349	0.8487874	0.4536816	0.998484	0.6234406	0.831502
1.319508	0.9448856	1.117891	0.787546	0.9467795	1.417388	1.165692	1.1695964	0.998334	1.022647	1.551337	1.121822	0.8333625	0.769808	1.2164287	0.956475	0.7496109	0.8719099	0.8773271	0.961406	0.4642193	1.129247	0.6711851	0.947513	
1.515717	1.0234823	1.205166	0.86859	1.0547319	1.594456	1.288626	1.3487675	1.10828	1.158483	1.7272938	1.265649	0.9536567	0.868767	1.3699649	1.0203885	0.988757	0.781045	0.9705179	0.9274812	1.069673	0.5047799	1.232305	0.7540219	1.07726
1.741101	1.104668	1.31931	0.954421	1.1424725	1.700862	1.400828	1.4676346	1.209794	1.281109	1.8719367	1.376824	1.0149328	0.984618	1.4916501	1.1207311	1.045699	0.8125654	1.0512045	0.9414932	1.153425	0.5059135	1.360459	0.840553	1.194355
2	1.2050686	1.403741	1.049739	1.2763863	1.845901	1.528142	1.5727323	1.293324	1.385457	2.0815313	1.444344	1.1040958	1.050707	1.6102677	1.1971358	1.105861	0.9019896	1.1377517	1.0175299	1.272955	0.5418531	1.494858	0.9319335	1.268025
2.297397	1.2475749	1.467843	1.13961	1.3526367	2.050728	1.586101	1.7012937	1.397112	1.488292	2.1723459	1.559263	1.2262376	1.146252	1.7604	1.2771252	1.16271	0.9549227	1.2296386	1.0666936	1.406613	0.59934	1.55146	0.939748	1.386538
2.639016	1.3570866	1.55244	1.171616	1.4116812	2.122419	1.701574	1.8159465	1.542274	1.511305	2.3433894	1.694054	1.2283058	1.224695	1.833358	1.3798589	1.242386	1.0164378	1.3223326	1.1613583	1.53524	0.6108951	1.636794	1.0148891	1.544513
3.031433	1.3858426	1.636864	1.335	1.5402291	2.31001	1.785223	1.9480721	1.592922	1.642135	2.4171077	1.842338	1.3586341	1.262892	1.9969459	1.4438247	1.202359	0.9492561	1.3522499	1.1625092	1.60836	0.6236928	1.707626	1.071455	1.550272
3.482202	1.4964544	1.65753	1.332004	1.4874892	2.289325	1.813121	1.9778827	1.650973	1.620995	2.4500375	1.844039	1.4298777	1.360785	2.0512661	1.5249735	1.255795	1.0848906	1.4596179	1.2238338	1.571614	0.693943	1.716776	1.1945066	1.792238
4	1.5613014	1.80033	1.51586	1.6116224	2.358671	1.885792	2.0006416	1.682202	1.83348	2.4803186	1.869763	1.5001042	1.315591	2.0161441	1.5961811	1.259281	1.0611642	1.5429487	1.3147614	1.729593	0.7809927	1.776553	1.3024613	1.738028
4.594793	1.611407	1.714813	1.394622	1.6347962	2.466459	1.868003	2.0761028	1.650998	1.948795	2.4387575	2.016335	1.6843658	1.469451	2.1866818	1.6858425	1.231428	1.2740746	1.7015681	1.335114	1.672246	0.8424769	2.002183	1.4210563	1.861682
5.278032	1.611407	1.714813	1.591725	1.6347962	2.466459	1.868003	2.160199	1.650998	1.948795	2.4387575	2.016335	1.6843658	1.469451	2.1866818	1.6858425	1.231428	1.2740746	1.7015681	1.335114	1.672246	0.8424769	2.002183	1.4210563	1.861682
6.062866	1.7084449	1.84109	1.591725	1.7664637	2.677486	2.03756	2.160199	1.791954	2.091902	2.6142991	2.209053	1.8488341	1.602927	2.348514	1.832685	1.371973	1.392161	1.8510219	1.4602264	1.832136	0.9236377	2.181939	1.5589751	2.061539
6.964405	1.8609438	1.963216	1.739409	1.906376	2.888332	2.231892	2.3401941	1.93901	2.241492	2.7978743	2.393299	2.074261	1.782089	2.5753656	2.0267681	1.512944	1.5336291	2.0306566	1.5938149	1.94283	1.0250541	2.397169	1.7223769	2.260069
8	1.9879309	2.105748	1.87151	2.0183943	3.042478	2.393944	2.5460747	2.132372	2.396387	2.9856137	2.56691	2.1532773	1.957201	2.799357	2.1684955	1.668872	1.6180671	2.1644451	1.7457621	2.103491	1.1058871	2.637998	1.9369027	2.522762
9.189587	2.2103177	2.252841	2.052779	2.2323088	3.366243	2.616025	2.7301367	2.328167	2.785038	3.3252226	2.825398	2.454799	2.236796	3.0415867	2.3914353	1.850952	1.8440483	2.3691759	1.8807132	2.329594	1.2879302	2.852317	2.1289723	2.840926
10.55606	2.4110956	2.389222	2.307912	2.3874588	3.537271	2.801014	3.0487888	2.483014	2.953441	3.463127	3.054791	2.7259434	2.474311	3.1110844	2.5967731	2.032728	1.9193066	2.6898674	2.0677019	2.523653	1.4332147	3.063075	2.3762572	3.151544
12.12573	2.6608715	2.531512	2.43817	2.6455991	3.709076	3.0328	3.3108875	2.690713	3.123625	3.5204597	3.263445	2.9129682	2.740125	3.5345083	2.7856078	2.210931	2.1433514	2.9089849	2.2719152	2.709398	1.6548451	3.324045	2.5895955	3.419345
13.92881	2.777828	2.769459	2.892862	2.7395435	3.991222	3.415181	3.7170093	3.069095	3.56345	3.6835333	3.555458	3.1246273	3.049435	3.6536789	3.0056438	2.513041	2.3625137	3.1339583	2.4573515	2.924583	2.0427755	3.576098	3.0039637	3.804876
16	2.9260904	2.936439	2.91174	2.949535	3.988247	3.293414	3.6108664	3.334994	3.480514	3.6835333	3.668389	3.3572251	3.360232	4.0359359	3.1520015	2.802819	2.5508856	3.1339583	2.6960546	3.0777	2.2917264	3.609472	3.0396011	4.16576
18.37917	3.5283267	3.210303	3.357227	3.0851575	4.066407	3.624648	4.1001415	3.565005	3.947082	3.7380794	3.940263	3.852405	3.66938	4.4483054	3.5218642	3.129235	2.8862338	3.3910201	3.0857453	3.449552	2.9127874	4.189791	3.7667525	4.828937
21.11213	3.9011566	3.623139	3.60391	3.1988793	4.570267	4.122318	4.5069434	3.869259	4.254254	3.9362584	4.227599	4.1648613	4.189909	4.8783249	3.7127917	3.498596	3.4403425	3.7378961	3.6263997	3.669414	3.7856635	4.324009	4.1026838	5.505554
24.25147	4.793093	4.196819	4.299602	3.8986153	4.462172	4.365123	4.6591251	4.476648	4.610576	4.1607315	4.227599	4.1648613	4.918739	5.2975581	3.8055688	4.376553	3.9936878	3.9931699	4.1146995	4.252249	4.7142431	4.551845	4.6269162	5.505554
27.85762	5.4962113	4.655009	4.897261	4.1981471	4.559588	4.8352	5.193297	4.604331	4.849551	4.121009	4.722998	4.8616424	5.53767	5.2975581	4.2240477	5.33131	4.6880166	4.1272609	4.6775386	4.654236	5.5710338	4.876202	5.3916452	5.854142
32	5.919654	5.396395	5.256656	4.8468035	4.818532	5.079105	5.6768461	5.509627	5.428094	4.1139973	5.301082	4.9520926	5.53767	5.9284859	4.2240477	6.338149	5.2233161	4.717656	5.2960122	5.688558	6.4822298	4.876202	5.3916452	6.411119
36.75835	5.5907785	6.242178	5.669254	5.3486804	4.393757	5.429594	5.7053527	5.509627	5.618284	4.3288836	5.606351	5.9888049	6.261439	6.0105383	4.8959982	6.404559	6.0653423	5.2523952	5.2960122	5.896669	7.2167568	5.540916	6.6165099	6.54171
42.22425	5.5907785	6.47357	6.436442	5.3486804	3.748832	5.429594	5.7053527	6.214068	5.618284	4.597416	5.67771	6.6264515	7.203096	5.7902354	5.4156802	6.483473	6.5298489	5.9778403	6.4442392	5.839284	7.4856637	5.941388	7.3796489	7.120439
48.50293	6.1121575	6.47357	6.436442	5.9747516	3.743545	5.253467	5.1437403	6.691159	5.728067	4.1945586	5.722856	6.8793304	7.435943	5.2383336	5.6794888	6.483473	6.5298489	5.6735297	6.8392373	6.201511	7.7904865	5.428525	8.0305839	6.186394
55.71524	5.6601718	7.102362	6.388768	6.7840223	3.141049	5.057	5.4418191	6.10452	5.122454	3.6659675	5.739339	6.256269	6.306271	4.0610273	5.3803095	6.575491	7.2364597	5.5511459	7.3308967	6.201511	7.7904865			

Sample ID	53	54	55	56	57	58	59	60	61	62	63	64
Zone	n/a											
Latitude	45.15443	45.15468	45.1546	45.15448	45.15442	45.15432	45.15417	45.154317	45.15435	45.1544	45.154517	45.154633
Longitude	-64.36925	-64.36933	-64.36922	-64.36907	-64.36897	-64.36898	-64.36898	-64.36887	-64.36878	-64.3686	-64.36858	-64.3684
Date	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017	6/14/2017
1	0.486528	0.824563	0.613245	0.875469	0.543087	0.763101	0.932734	0.8407284	0.631418	0.5551963	0.3565128	0.7254701
1.1486984	0.568656	0.859877	0.71289	1.00964	0.646572	0.901557	0.983167	0.8694069	0.729128	0.6318762	0.4188219	0.8272261
1.3195079	0.623798	0.901164	0.78774	1.119405	0.718268	1.010932	1.027868	0.9091566	0.825065	0.7354242	0.4772563	0.9018154
1.5157166	0.686312	0.953554	0.866969	1.282655	0.805482	1.124413	1.079632	0.9467169	0.93508	0.8026232	0.5164501	0.9863708
1.7411011	0.766589	1.01513	0.958352	1.393219	0.884246	1.22904	1.153844	1.0282317	1.028562	0.8754215	0.5710381	1.0369672
2	0.818169	1.03426	1.048026	1.495805	0.94855	1.378357	1.205433	1.0834819	1.123283	0.9730062	0.6228196	1.1179637
2.2973967	0.918946	1.141212	1.115766	1.567948	1.068813	1.477786	1.334487	1.1366458	1.195122	1.0229931	0.6700026	1.1750294
2.6390158	0.975472	1.230956	1.186987	1.711595	1.11763	1.586726	1.358519	1.2404062	1.346218	1.1075483	0.7403516	1.2405948
3.0314331	1.01223	1.293284	1.223908	1.798142	1.19298	1.618282	1.419348	1.3215317	1.350087	1.1794149	0.7838355	1.2540052
3.4822023	1.081736	1.40018	1.29469	1.880935	1.252874	1.751295	1.550342	1.3680893	1.461924	1.2135202	0.8103163	1.3183294
4	1.210107	1.446498	1.503546	2.062805	1.305772	1.833851	1.769357	1.5807462	1.627927	1.3222996	0.8099065	1.4163475
4.5947934	1.3515	1.633779	1.482898	2.146209	1.502582	1.891726	1.694289	1.675406	1.829814	1.3961099	0.8071508	1.5143628
5.2780316	1.3515	1.633779	1.482898	2.146209	1.502582	1.891726	1.694289	1.675406	1.829814	1.5254145	0.8071508	1.5519661
6.0628663	1.489651	1.769166	1.606507	2.375778	1.612114	2.081757	1.865567	1.8764257	2.013737	1.5254145	0.8589535	1.5519661
6.9644045	1.672916	1.975419	1.764148	2.649112	1.801773	2.330809	2.025903	2.0987247	2.231801	1.7098557	0.9501741	1.7496564
8	1.875102	2.167576	1.952334	2.835484	2.031078	2.531674	2.215845	2.3103007	2.45618	1.8429971	1.0438603	1.8684169
9.1895868	2.070937	2.487453	2.133491	3.103717	2.242681	2.886465	2.487438	2.5983786	2.750959	2.0835935	1.2034509	2.0859377
10.556063	2.331867	2.757365	2.376799	3.348437	2.537065	3.103163	2.769403	3.0324323	3.020346	2.3383593	1.3160395	2.3209192
12.125733	2.685514	3.002548	2.605388	3.556709	2.841924	3.320848	3.017493	3.2007808	3.33885	2.5217741	1.5695838	2.6257963
13.928809	3.069892	3.438215	2.910577	3.811377	3.244706	3.664327	3.362253	3.6128017	3.818081	3.0048665	1.7754291	2.8449697
16	3.332695	3.79256	3.118063	3.875891	3.663335	3.966893	3.525624	3.8370356	3.938989	3.2486309	2.0457094	3.0843347
18.379174	3.855091	4.331073	3.649055	4.348435	4.428478	4.294307	4.170808	4.5096229	4.372411	3.8009853	2.3772743	3.6532934
21.112127	4.456984	4.775348	4.039608	4.796338	4.792306	4.294307	4.491473	4.9261373	5.117163	4.3607626	3.0188144	4.4945406
24.251465	5.250302	5.458786	4.970742	5.0151	5.172809	4.850737	4.931912	5.385618	5.564016	5.1686663	4.0311382	5.2318348
27.857618	6.104743	6.192388	5.438621	5.521708	6.031163	5.728309	5.473046	5.8887821	5.85806	6.6309786	4.7673273	5.6300453
32	6.845377	6.250655	6.024999	5.521708	6.793414	6.472099	5.473046	6.5044936	6.12844	7.3348188	5.8068739	6.5000254
36.758347	7.191399	7.037993	6.705855	5.983347	6.793414	6.649898	5.959473	6.5044936	6.376592	7.6921125	7.1176724	6.522264
42.224253	7.402322	7.066147	7.094652	5.693663	7.374491	6.597749	6.395274	6.9973197	6.226559	7.6921125	7.935782	6.522264
48.50293	7.027801	7.066147	7.094652	5.031812	8.236155	6.385042	6.87302	6.5358816	5.634447	7.5533172	8.6799508	6.434056
55.715236	7.027801	5.58797	6.755004	4.260782	7.028624	4.816862	6.184123	6.2141049	5.444393	6.5081754	8.6799508	6.0506383
64	5.561051	4.017716	6.152386	3.164488	5.644713	4.621732	4.781052	5.1871772	5.444393	5.4003007	8.5448428	5.6644738
73.516695	4.15513	2.962566	4.453862	3.132386	2.048568	2.944229	4.481524	3.1035357	4.351137	4.2563691	7.853168	3.4342947
84.448506	2.969057	2.494672	2.637028	1.483691	2.191799	0	2.312415	0	0	1.9850613	5.9204283	3.4702782
97.00586	1.772825	0	2.238313	0	0	0	0	0	0	0	4.2506958	3.1935461
111.43047	0	0	0	0	0	0	0	0	0	0	1.8612678	0
128	0	0	0	0	0	0	0	0	0	0	0	0
147.03339	0	0	0	0	0	0	0	0	0	0	0	0
168.89701	0	0	0	0	0	0	0	0	0	0	0	0
194.01172	0	0	0	0	0	0	0	0	0	0	0	0
222.86094	0	0	0	0	0	0	0	0	0	0	0	0
256	0	0	0	0	0	0	0	0	0	0	0	0
294.06678	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 10: DIGS (disaggregated inorganic grain size) results for Kingsport, NS sediments, samples 53-64 (June 2017). Diameter (microns) is shown at left; sample IDs are shown at the top of each column. Data are normalized over the size range. Coordinates are relative to WGS84, UTM Zone 20 N.