Comparing body size of the sand tiger shark *Striatolamia macrota* from Eocene localities in the Eureka Sound Formation, Banks Island, northern Canada, and the Tuscahoma Formation, Meridian, Mississippi

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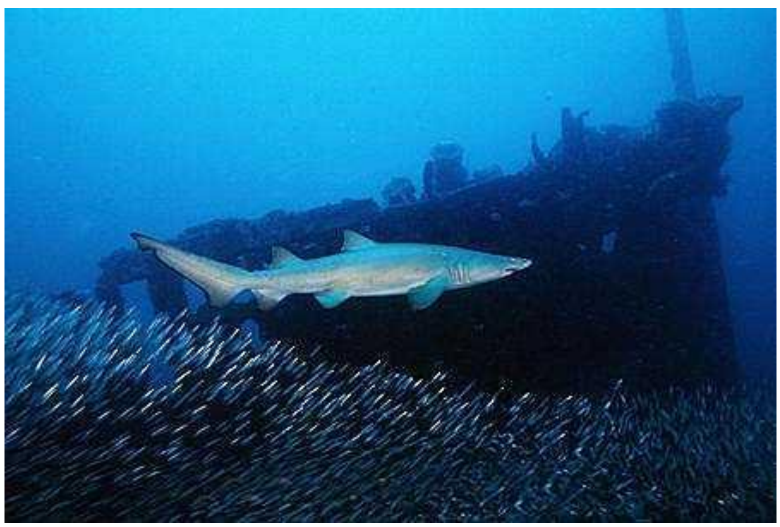

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INTRODUCTION

As the most abundant vertebrate fossil in the geologic record, shark teeth have the potential to provide remarkable insight into the past. Sharks are in the class Chondrichthyes and possess cartilaginous skeletons which have a low fossilization potential and decompose quickly (Hamm and Shimada, 2002; Cappetta, 2012). The teeth, on the other hand, are highly mineralized and have an added layer of enameloid that, in turn, make them exceptionally preservable (Cappetta, 2012). Analyzing a shark tooth can not only give insight into the fauna living in oceans, but give understanding of the paleoenvironment, such as salinity or temperature. Among the most abundant fossil shark teeth found during the early to middle Eocene Epoch (55-50 Ma) belong to *Striatolamia macrota.* In the order of Lamniformes (Berg, 1958), *Striatolamia* belongs to the family Odontaspididae (Müller and Henle, 1839). *Striatolamia macrota* became extinct during the Miocene Epoch (25-15 Ma), however their closest relatives today are that of the sand tiger shark *Carcharias* (Cappetta, 2012).

On northern Banks Island, in the Northwest Territories, Canada, an abundant amount of fossil shark teeth was found in the Cyclic Member of the Eureka Sound Formation, most of which belong to *Striatolamia macrota.* Placed during the early-middle Eocene (50-55 Ma), the sharks thrived in a brackish, warm-water environment that was adjacent to a lush rainforest inhabited by a variety of vertebrate animals. A coeval fossil locality in Meridian, Mississippi, known as the Red Hot Truck Stop, also contained a vast amount of shark teeth, most being *Striatolamia macrota*. Considered a hot, deltaic environment where many different fish and mammals prospered, this was a warmer environment in the early Eocene than today.

As is evident, these two localities are of comparable age and paleoenvironment. During the early-middle Eocene, the latitudinal temperature gradient was quite shallow (Fricke and Wing, 2004), so the paleotemperatures of Banks Island and Mississippi were not nearly as different as they are today. The fossil shark teeth found in both localities were discovered in fine-grained, unconsolidated sand in formations that consisted of cycles of sand, silt, and lignite indicating a nearshore, deltaic environment. If the environments are similar, then one would predict the same species in both localities will also be comparable in size. As stated by Cappetta (2012) and Shimada (2004), the largest tooth can be a proxy for the body size of the shark. Since the early Eocene localities on Banks Island and Mississippi both have a large amount of *Striatolamia macrota* teeth, I measured approximately 400 teeth from each locality and compared their sizes in order to determine if they had similar-sized sand tiger sharks during the early Eocene Epoch. Specifically, this paper will talk about whether latitude plays a role in the body size of these sharks because they inhabited a similar nearshore deltaic environment.

GEOLOGIC SETTING

Banks Island, NWT, Canada

Lithology

The fossil shark teeth from the Arctic were discovered as float on the unconsolidated Cyclic Member sands of the Eureka Sound Formation close to the Muskox and Eames rivers within Aulavik National Park on northern Banks Island, Northwest Territories (NWT), Canada (~74^{o} N; see Figure 1). The localities are within the boundaries of a national park, so the precise coordinates cannot be provided here. Researchers should request the exact coordinates from the Canadian Museum of Nature, Ottawa, Canada. Dr. Jaelyn Eberle and her team recovered the shark teeth in this study from localities at the Muskox and Eames Rivers in July 2004 (Fig. 1).

The Eureka Sound Formation on Banks Island is assigned a Late Cretaceous to Paleogene age, and contains two members (Miall, 1986). The complete thickness of the Cyclic Member, the unit that preserved the shark teeth included in my study, is unknown since most of the unit is exposed at the surface and an unknown thickness has been removed by erosion. The Shale Member, which consists mainly of soft, dark grey shale, has a gradational contact with the Cyclic Member. Silty shale predominates in the Shale Member but becomes coarser near the top of the base of the Cyclic Member. There is an abundance of coarsening-upward cycles that consist of shale, interbedded shale and silt, sand, then lignitic coal within the Cyclic Member (Padilla et al., 2014). The sand beds are fine-grained, light-tan, that contain large-scale trough and planar crossbedding as well as small-scale ripple marks. The unconsolidated sands that contained the shark teeth are dominated by fine to coarse-grained sand, but also include some pebble and conglomerate beds with clasts up to 12 cm (Miall, 1979).

While Miall (1979) initially used the designation 'Eureka Sound Formation' for the rocks on Banks Island, in 1986, Miall reassigned the Cyclic Member on Banks Island to the Margaret Formation of the Eureka Sound Group, in an attempt to correlate to the Margaret Formation in the eastern Arctic (and specifically Ellesmere Island). However, as noted by Eberle and Greenwood (2012), there are inconsistencies with taking this approach. The Margaret Formation in the eastern Arctic is predominantly non-marine, whereas the Cyclic Member on Banks Island is not. Given the enormous distance, about 40º of longitude (GEOMAR, 2011), from Ellesmere to Banks Island, researchers continue to utilize the Cyclic Member for the Eocene shark tooth-bearing sediments on Banks Island (Eberle and Greenwood 2012).

Throughout Banks Island fossils are generally sparse, although an abundance of shark teeth, bivalves, and the trace fossil known as *Ophiomorpha* (Miall, 1979; Padilla et al., 2014), interpreted by others as ancient shrimp burrows (Frey et al., 1978), have been recovered from the Cyclic Member. Foraminiferans and radiolarians (marine microfossils) have also been found, but are rare (Miall, 1979).

Age

The fossil shark teeth localities near the Muskox and Eames rivers are Eocene in age. This is based on pollen samples initially analyzed by Hopkins (1974, 1975), and then reported by Miall (1979). Recent reanalysis of five pollen samples by Arthur Sweet in 2012 also suggest that the shark teeth localities are late early to middle Eocene in age, spanning the Early Eocene Climatic Optimum (or EECO) approximately 51-53 Ma (Padilla et al., 2014). The Margaret Formation on

Ellesmere Island contains a diverse vertebrate fauna that includes fish, amphibians, alligators, turtles, and at least 25 mammalian genera, and based upon mammalian biostratigraphy, it is early Eocene in age, equivalent to the late Wasatchian North American Land Mammal Age (Eberle and Greenwood 2012, Dawson et at., 1993). A zircon retrieved from volcanic ash on the southern shore of Stenkul Fiord (southern Ellesmere Island) produced a date of 52.6 ± 1.9 Ma (Reinhardt et al., 2010), which is consistent with a late Wasatchian age based on the fossil mammals. As stated earlier, the Cyclic Member on Banks Island appears to be temporally correlative with the the Margaret Formation in the eastern Arctic.

Paleoclimate and environment

The trace fossil known as *Ophiomorpha* occurs in the Cyclic Member (Miall 1979; Eberle and Greenwood, 2012) and are inferred to be the burrows of a thalassinidean shrimp that suggests shallow-water, high-energy marine environments (Frey et al., 1978). Based on the lithology of the upward cycles of coal, shale, and sand in the Eureka Formation, it was concluded by Miall (1979) that the depositional environment was a proximal delta-front to delta-plain environment with various channels and coal swamps. The unconsolidated sand the shark teeth were found in is interpreted as a channel or mouth bar deposit in the delta front (Padilla et al., 2014). Including the shark teeth, a number of bony fish fossils, a single crocodyliform fossil, and rare turtle shell pieces, were found as float in the Cyclic Member on Banks Island (Eberle et al., 2014). The crocodyliform fossil suggests a mild temperature on Banks Island in the Eocene, if compared to the environment of recent crocodylians who prefer to exist in above-freezing temperatures (Markwick, 1998). This is strengthened by the presence of garfishes, which are associated with mild, temperate conditions, and are restricted to freshwater environments today

(Grande, 2010). From analysis of oxygen isotope ratios of biogenic phosphate of mammals, fish, and turtle fossils on Ellesmere Island, Eberle et al. (2012) estimated a mean annual temperature (MAT) of 8 ºC, and an annual range from 0-19 ºC.

The paleo-precipitation has been estimated, based on isotope analysis of mummified fossil wood samples that were collected from the deltaic deposits in the Margaret Formation on Ellesmere Island as well as the Cyclic Member on northern Banks Island. The fossil wood was sampled for high-resolution carbon isotope analysis (Schubert et at., 2012). The high-resolution δ^{13}C measurements across the sampled tree rings were used to estimate annual precipitation. The δ^{13}C patterns differ between evergreen and deciduous trees, and from the samples, the measurements indicated evergreen trees in the Arctic (Schubert et al., 2012; Barbour et al., 2002). A model by Schubert and Jahren (2011) demonstrated the δ^{13}C trends of evergreen wood, that in turn can be used to estimate the ratio of summer to winter precipitation across the Eocene Arctic (see Schubert and Jahren., 2011; Equation 9). The results from the mummified wood from Ellesmere and Banks Islands revealed a climate of a wet summer that was two to four times greater than that in winter. The calculated mean summer precipitation was an estimated 1134 mm and the mean winter precipitation was estimated to be 366 mm (Schubert et al., 2012). The seasonal precipitation estimates are very similar to that of today's temperate forests in eastern Asia.

An ocean paleotemperature of 12-13 °C was estimated for the early-middle Eocene Arctic based on the TEX_{86} method (Sluijs et al., 2008). A riverine temperature on Ellesmere Island was estimated to be around 9 °C based on δ^{18}O from terrestrial vertebrate bioapatite (Eberle et al., 2010). Using the range of paleotemperatures from 9-13 °C incorporated along with δ^{18}O values measured from 30 teeth of the sand tiger shark *Striatolamia,* a paleosalinity model was modified by Kim et al. (2014). These authors estimated a mean paleosalinity of 12.7 PSU, which is similar to modern day Delaware Bay, between Delaware and New Jersey. This is much lower than today's Arctic surface waters which have a salinity of 25-33 PSU, and therefore implies a brackish water environment for the early Eocene Arctic Ocean (Kim et al., 2014).

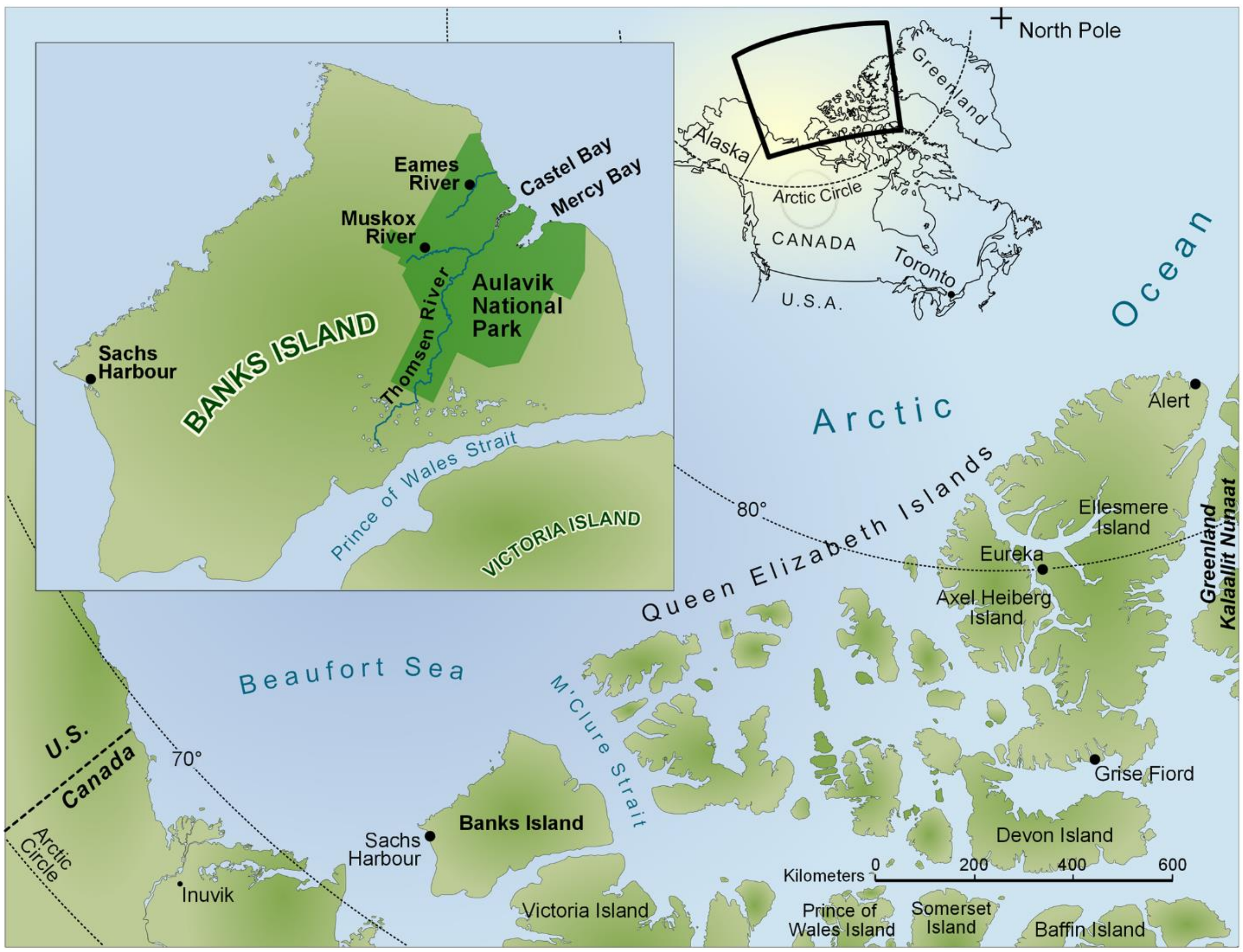

Figure 1. Map of Arctic Canada showing locations of Eocene shark localities within Aulavik National Park, northern Banks Island, NWT. Modified from Padilla et al., 2012.

Red Hot Truck Stop locality in Meridian, Mississippi

Lithology

The shark teeth found in eastern Mississippi were discovered in the unconsolidated sands of the T4 Channel Sand (or T4 Green Sand) at the top of Tuscahoma Formation at the Red Hot Truck Stop locality (Carnegie Museum or CM 517), near Interstate 20, in the NW corner, of the NW ¼, of the NE ¼, of Section 20, T6N, R16E, Lauderdale County, Mississippi (Ingram, 1991; Mississippi Geological Survey). The Tuscahoma Formation conformably overlies the Nanafalia Formation, which mainly consists of tan, coarse-grained sand (Mancini and Tew, 1995). The Tuscahoma Formation includes about 110 meters of interbedded clay, silt, sand, and lignite, but only the upper ten feet of the Tuscahoma Formation is exposed in the Red Hot Truck Stop locality (Mancini and Tew, 1995; Ingram, 1991). The exposure at the Red Hot Truck Stop is composed of glauconitic, micaceous, fine to very fine-grained quartz sands, with interbedded layers of silts and clays (Ingram, 1991). The fine-grained glauconite gives the sand a green to grey color. The sand and silt beds are laminar and cross-bedded, and range from 0.1 foot to 1.5 feet thick. At most of the bases of the sand beds, fossiliferous channel lag deposits appear and contain bioturbation, burrow casts, and concretions. Plant fragments as well as wood has been found that are carbonized or pyritized (Ingram, 1991). Lignite is present throughout the Tuscahoma and overlying formations that include the angiosperm pollen of the hazelnut, birch, ferns, and lily (Mancini and Tew, 1995). The Bashi Formation (also known as Hatchetigbee Formation) lowstand unit overlies the Tuscahoma Formation, and is comprised of interbedded sand and shale. The source area for the sediment was from the northwest, and the sediment influx was related to the Laramide Orogeny occurring in the Rocky Mountain region (Mancini and Tew, 1995; Galloway, 1990).

The T4 Channel Sand that the shark teeth were found in lies just below the base of the Bashi Formation. It is composed of fine-to very fine-grained quartz sand, glauconite, and mica. The glauconite and mica give the sand it's green color. The unconsolidated and friable sand contains cross beds with multiple cross-cutting scours. At the base of the T4 Sand is a lag deposit that preserved the vertebrate teeth and fossil fragments (Ingram, 1991). The fauna includes nine different orders of mammals (Beard and Tabrum, 1991; Beard and Dawson, 2009), sharks, rays, and numerous bony fishes including gar and catfish (Case, 1986). Crocodilian teeth, turtle shells, and snake vertebrae have also been found (Case, 1986).

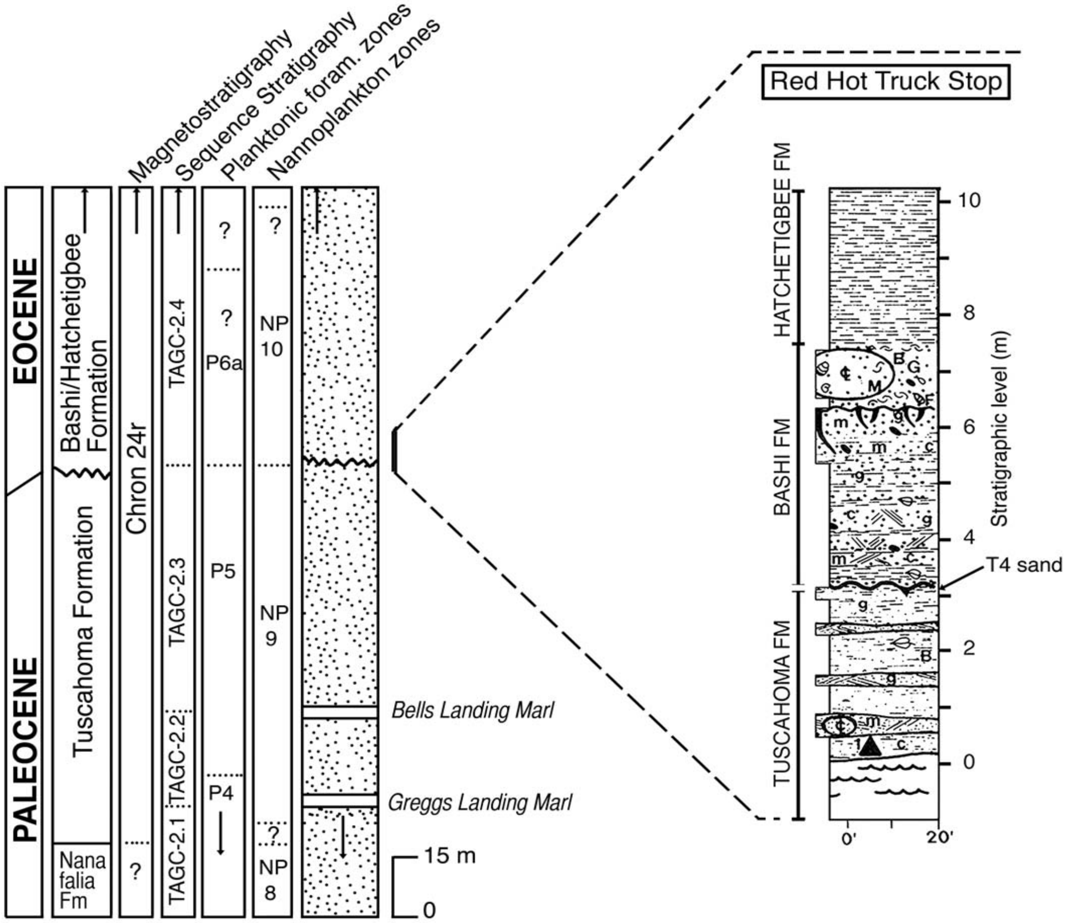

Figure 2. Schematic representation of the stratigraphic column at the Red Hot Truck Stop Locality, taken from Beard and Dawson, 2009. Fossil shark teeth were recovered by Beard and team from the T4 sand.

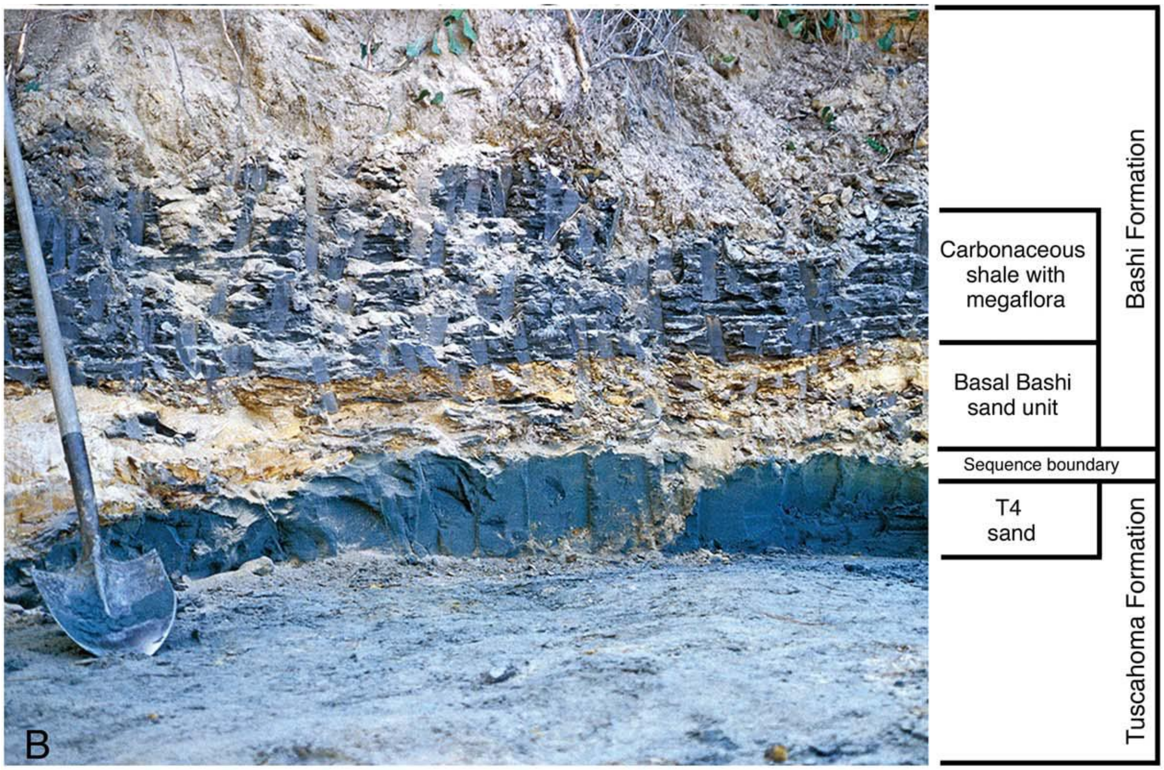

Figure 3.Photograph taken by Dr. David T. Dockery, III, of the Tuscahoma- Bashi contact of the Red Hot Truck Stop Locality, from Beard and Dawson (2012). The fossil shark teeth and other vertebrates were found by Beard and crew at the base of the T4 Sand.

Age

The preliminary report provided by Beard and Dawson (2001) concluded that the mammalian assemblages from the T4 Sand can be correlated with early Wasatchian (earliest Eocene) faunas from the Bighorn Basin in Wyoming. They also concluded that the fauna must be older than a well-known Dormaal assemblage from Belgium, which is regarded as the one of the oldest Eocene mammal faunas. Pollen samples taken by Frederiksen (1998) initially suggested that the uppermost Tuscahoma Formation strata are very latest Paleocene in age and contains the most complete sequence of uppermost Paleocene and lowermost Eocene strata in Mississippi. More recently, nine pollen samples were also analyzed by Harrington (2003) from the Red Hot Truck Stop locality and found the youngest age to be earliest Eocene, which in consistent with the early

Wasatchian age estimated from mammalian biostratigraphy (Beard and Dawson, 2001;2009). Six samples of the glauconitic sand from the Tuscahoma and Bashi Formations were analyzed by Mancini and Tew (1995) for Potassium-Argon (K-Ar) radiometric age determination. The upper Tuscahoma T4 sand was dated to be 55 ± 1.4 Ma (Macini and Tew, 1995), which fits with an early Eocene (early Wasatchian) age.

Paleoeclimate and environment

The lithology of the Tuscahoma Formation and T4 Sand is consistent with that of a large-scale, fluvial-dominated deltaic system (Beard and Dawson, 2009). The large-scale cross bedding and cross-cutting represents the cut-and-fill depositional characteristics that is associated with estuarine channel facies (Ingram, 1991). The sand of the T4 Green Sand represents that of a highstand system tract sequence, indicating levels of higher sea level. Eleven species of bony fish (teleosts) and over thirty species of sharks, skates, rays, and sawfishes have been recovered by Case (1986) in the Tuscahoma Formation. Case noted that the fossil fishes recovered from the T4 Sand are consistent with the deposition in an estuarine environment (Case, 1994a and 1994b). The pollen samples analyzed by Mancini and Tew (1995) from the lignite beds in the Tuscahoma Formation such as ferns and mosses, indicate a swamp and marsh environment (Mancini and Tew, 1995). Fossil pollen and spores from the T4 Sand were taken by Frederiksen (1998) and Harrington (2003). Palynofloras at the Red Hot Truck Stop locality contained 113 taxonomic groups that allowed an assessment of a paratropical vegetation habitat in the Gulf Coast (Harrington. 2003). Other flora included families from the fern, laurel, guava, legumes, and walnut (Danehy et al., 2007).

The Eocene has been known as one of the warmest periods in Earth's history and has been studied extensively as a potential analog for the global warming occurring today (Kobashi et al., 2001). Paleotemperature estimates made by various geologists throughout the years have indicated the early Eocene to be the warmest climatic conditions in the Cenozoic Era (i.e., the last 66 million years; Keating-Bitonti et al., 2011). The shells of bivalve mollusks were analyzed for stable carbon and oxygen isotope ratios in the Hatchetigbee Formation on the Gulf Coast (ca. 54-52 Ma) at a paleolatitude of around 30°N (Keating-Bitonti et al., 2011). Ten shells were analyzed and resulted in a MAT (Mean Annual Temperature) of 26.5 ± 1.0 °C. This is only 2-3 °C warmer than modern sea-surface MAT in the northern Gulf of Mexico (Keating-Bitonti et al., 2011; Levitus and Boyer, 1994). Another study was conducted by Kobashi et al. (2001) that also analyzed mollusk shells throughout the Gulf Coast from the Eocene to Oligocene. These authors found that the climate of the Mississippi Embayment (paleolatitude of 30°N) changed from a tropical environment of 26-27 °C in the Eocene, to paratropical, 22-23 °C in the Oligocene Epoch (Kobashi et al., 2001). Using modern regional salinity of 33 ppt, and the equation sought out by Grossman and Ku (1986), the estimated MAT of the Eocene Gulf Coast ocean water was about 23.3 °C, slightly cooler than the temperature of the continent (Kobashi et al., 2001). Even though the isotope analyses were not done on fossils found from the Red Hot Truck Stop locality, these temperatures suggest a warm climate for this region during the Eocene and is consistent with the fauna found at the locality.

Figure 4. Paleogeographic reconstruction of North America during the Eocene, modified from Eberle and Greenwood (2012) and Beard and Dawson (2009). Reconstruction by Ron Blakey, https://www2.nau.edu/rcb7/globaltext2.html

MATERIALS AND METHODS

In July 2004 and 2010, Dr. Jaelyn Eberle and crew collected thousands of shark teeth from various sites in the Cyclic Member on Banks Island near the Muskox and Eames Rivers in Aulavik National Park. Only one fossil shark tooth locality was found near the Muskox River, but dozens of localities were discovered near the Eames River on northern Banks Island. The teeth that I measured in my study are from the collections made in 2004. The teeth from Banks Island are curated and housed at the Canada Museum of Nature in Ottawa, Ontario and are on loan to the University of Colorado.

Dr. K. Christopher Beard and crew collected the fossil shark teeth from the Red Hot Truck Stop (Carnegie Museum or CM locality 517) in 1999-2000. These teeth are now housed at the Carnegie Museum in Pittsburgh, PA and are on loan to the University of Colorado for my study.

Using shark teeth as a proxy for body size

Since sharks contain cartilaginous skeletons that erode over time, the teeth must be used as a proxy for body size. Unlike most marine vertebrates, sharks lose and replace thousands of teeth in their lifetime. Their teeth are different sizes and shapes at the front of the jaw and at the back, similar to mammals. Cappetta (2012) used the term 'monognathic heterodonty' to describe the different tooth shapes in a shark's jaw (Fig. 5). The largest teeth are located in the front of the jaw and are called anteriors, whereas the laterals make up the teeth in the middle of the jaw, and the posteriors are located in the back (Cappetta, 2012). Since there is a relationship between the length of the shark and the teeth size, the anterior teeth are usually chosen for measurements because they are the most accessible and the largest (Cappetta, 2012). The anteriors are also the easiest to sort out because their shape is more distinguishable. Even though sharks consist of dignathic heterodonty, meaning the teeth of the upper and lower jaw have different morphologies (Cappetta, 2012), it is challenging, if not impossible, to determine the jaw location for isolated teeth.

In 1999, Shimada presented an equation depicting the relationship between the crown height of the anterior tooth and the body length of the shark. This was found by taking the tallest tooth of modern *Mitsukurina owstoni,* a modern lamniform shark, and comparing it to the total body length of the shark. Since isolated anterior teeth are difficult to place in the jaw, the body length for *Striatolamia macrota* can be considered a minimum length in my study. This is because the anteriors range in size (Fig. 5; Shimada, 2002; Cappetta, 2012). In 2004, Shimada measured the teeth of the modern Odontaspidid *Carcharias taurus, Striatolamia's* closest living relative, and obtained a positive correlation between the tooth and body length. The length of the body when compared to the largest anterior is represented by the equation:

$$TL = -26.665 + CH(12.499)$$

where *TL* is the total body length in centimeters, and *CH* is crown height of the anterior tooth in millimeters (Shimada, 2004). In the Results section below, I estimate the body size range of the Eocene sharks from Banks Island and the Red Hot Truck Stop locality, utilizing the above equation.

Sorting and Identification of shark teeth

Species of sharks in the fossil record are largely identified by their tooth morphology (Cappetta, 2012). In order to identify *Striatolamia macrota* from other species, I compared its description according to Padilla et al. (2014), Cunningham (2000), and Cappetta (2012) to my samples. *Striatolamia macrota* teeth were identified by their strong striations on the lingual side of the tooth and a smooth labial side (Fig. 5; Cappetta, 2012). The anteriors ($A_{1\text{-}3}$) were recognized by their long and narrow shape, compared to the laterals (lat) and posteriors (pot) that have a short, blade-like appearance (Cunningham, 2000). The anterior teeth have an acute angle between the two roots and have two small lateral cusplets (Fig. 6; Padilla et al., 2014; Cappetta, 2012).

In the Banks Island collection, approximately 8,000 shark teeth were collected in 2004. For Aspen Padilla's Masters thesis in 2008, she was able to identify the thousands of teeth into their specific family and genus. The three sand tiger shark species found in the Banks Island localities were *Striatolamia macrota*, *Carcharias* sp. A, and *Carcharias* sp. B. Most teeth were sorted into labelled boxes; however, many boxes were labelled "miscellaneous" and were not sorted based on heterodonty. To collect only anterior teeth, I had to inspect hundreds of *Striatolamia macrota* teeth, confirming they were anterior teeth. From the Banks Island localities, I identified and subsequently measured 397 anterior teeth.

From the Red Hot Truck Stop locality, Amy Henrici, the paleontology collection manager at the Carnegie Museum sent boxes to the Paleontology Department that contained unidentified shark teeth, as well as ray teeth, fish tooth plates, and other miscellaneous fossils. In total, I had to sort through thousands of specimens. Over 30 Chondrichthyians (sharks, skates, and rays) species were found in the T4 Green Sand in the Red Hot Truck Stop (Case, 1994a), However, I did not have a chance to sort out each species from Beard and crew's collection. From the collection taken from the Carnegie Museum, I was able to sort out over 500 *Striatolamia macrota* teeth, and I obtained 373 anterior teeth for measuring.

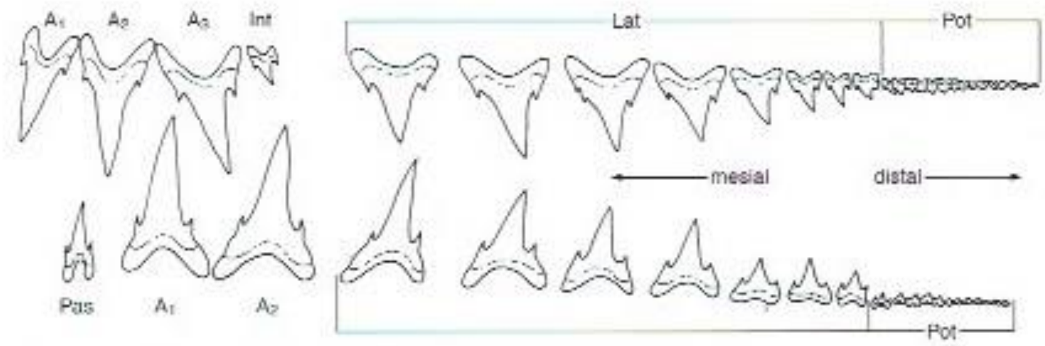

Figure 5. Monognathic heterodonty, as seen in lamniform sand tiger sharks. Figure modified from Cappetta, 2012

Methods of measuring shark teeth

To interpret the range of *Striatolamia macrota* sizes in each locality, I measured the length of each anterior tooth. Measuring from the exact same location on each tooth can be problematic due to the fact that some of the tooth might be eroded or worn. To resolve this, I measured the length from the bottom of where I assumed the enameloid would have been to the tip of the blade with digital calipers to the tenth millimeter. I also measured the labial and lingual sides of the tooth, as well as the maximum width in order to be consistent with measurements taken from Sora Kim at the University of Chicago for *Striatolamia macrota* teeth from the Red Hot Truck Stop Locality. Kim's measurements were not included in my dataset. The labial side of the tooth is adjacent to the cheek of the shark, and the lingual is that side adjacent to the tongue (Fig. 6; Cappetta, 2012). As I measured the teeth from each locality, I also cataloged and gave them a CMN number (for Banks Island teeth) and CM number (for the Mississippi teeth) for the Canadian Museum of Nature and the Carnegie Museum, respectively.

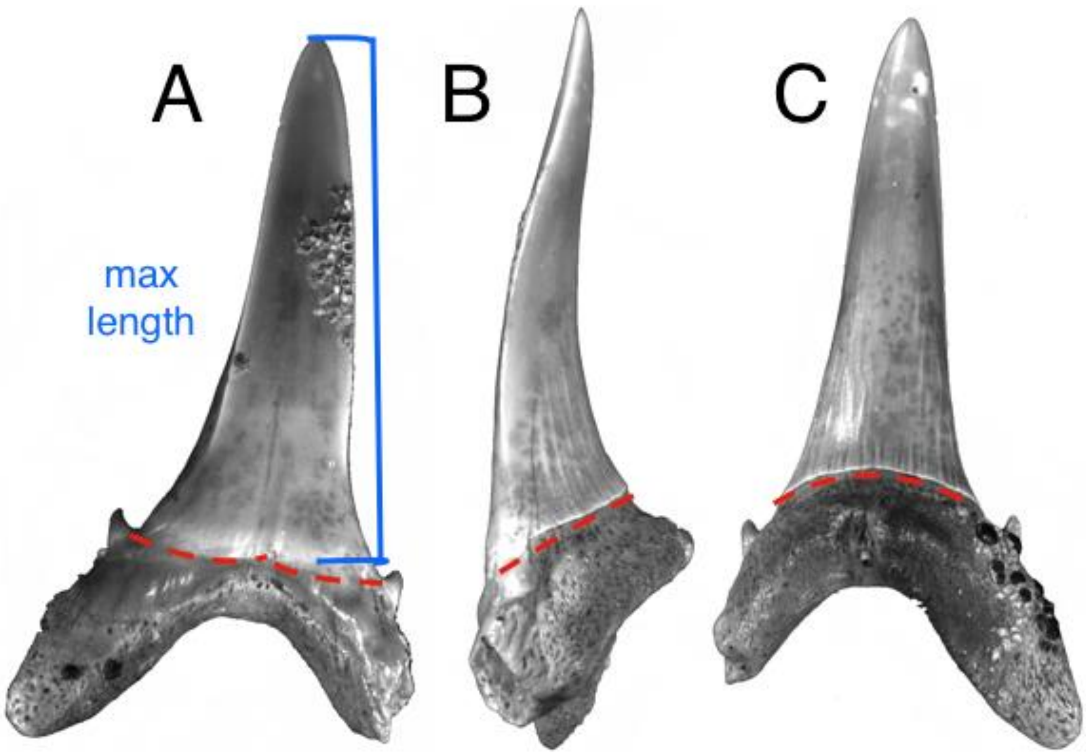

Figure 6. Image of labial (A), lateral (B), and lingual (C) sides of Striatolamia macrota anterior tooth (CMN 52970), modified from Padilla et al. (2014). Note the striations along the length of the tooth crown on its lingual side (especially at the base), and the tiny lateral cusplets, which are diagnostic of S. macrota teeth. Maximum length measured from the center of the bottom of the enameloid (the dashed red line) to the tip of the tooth.

RESULTS AND DISCUSSION

The body lengths from the Banks Island and the Red Hot Truck Stop range from 40.83-230.06 cm, and 10.93-235.56 cm respectively. This was found by utilizing Shimada's (2004) equation and the measurements taken from the labial side of the tooth (measurements of each tooth can be found in the Appendix). The two localities provide a similar size range. However, taking a closer look at the data portray how the distributions are actually very different. From hence on, I will talk about the size of the anterior teeth, in order to associate with my data, and it has been well established that the teeth are a proxy for body size.

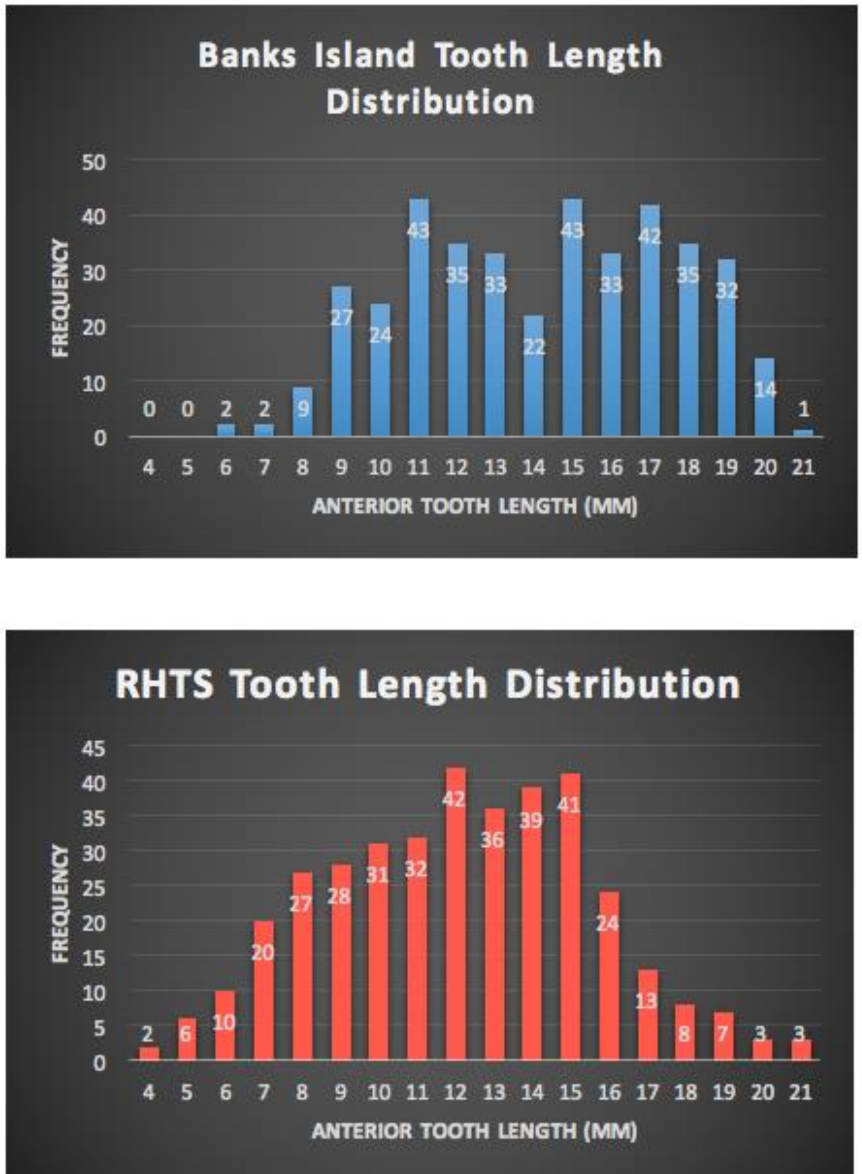

Figure 7. Histograms of the anterior tooth length and the frequency. For Banks Island n=397, and for the Red Hot Truck Stop, n=373

The mean length of the anterior teeth from the Banks Island was found to be 13.70 mm, whereas the mean length from the Red Hot Truck Stop was 11.60 mm. This difference can also be shown in the median length, which was found to be 14.1 mm from Banks Island and 11.76 mm from the Red Hot Truck Stop. The Banks Island teeth have a higher density of teeth larger than 16 mm, whereas the teeth from the Red Hot Truck Stop have a much higher density of teeth smaller than 14 cm (Fig. 7). This incongruity can be seen more clearly in Figure 8 in the probably density function. The probably density function represents the likelihood a length will be in the range. The Mississippi locality is more likely to have smaller teeth than the Arctic, even thought the majority of teeth are within the same range.

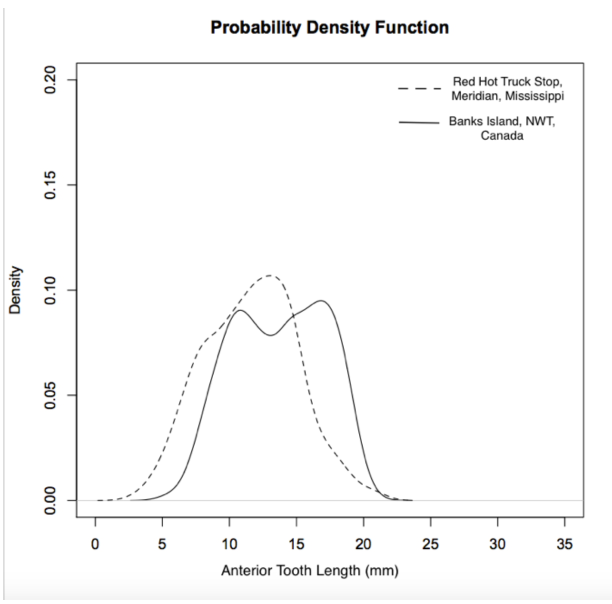

Figure 8. Probability density function found by taking the integral of the length's density over the range. In other words, it describes the likelihood for the length to be a certain size in the range. Code for graph provided by Dr. Sora Kim, University of Chicago.

Both localities have two relative maxima that can be clearly seen in Figure 8. Perhaps this was collecting bias, but an argument can be made that the two maxima may represent teeth from the upper and lower jaws, respectively. That is, the anterior teeth of the lower jaw tend to be a bit larger than teeth from the upper jaw (Cappetta, 2012). However, it is near impossible to tell the difference between an upper and lower anterior tooth without it being found within the jaw or with the teeth belonging to the same shark. Alternatively, the two maxima may also be capturing male and female sand tiger sharks, as females tend to be larger than males (Compagno, 2001).

The outcome of these distributions may have with various explanations. Like with any type of fossil collection, there may be a sampling bias. Dr. Eberle and her crew did not dry screen the fossil localities until 2010, which could explain why the fossil shark teeth collected in 2004 from Banks Island are larger than those from Mississippi. However, this seems unlikely because there are smaller posterior teeth in the Banks Island collection that were found that are smaller than the minimum anterior tooth length.

Compared to modern times, the salinity differed between the two localities in the Eocene. The Gulf Coast had about a 50% increase in salinity than the coast of Banks Island (Kobashi et al., 2001; Kim et al., 2014). The diversity of shark species was also much higher in the Red Hot Truck Stop locality, suggesting a typical ocean salinity. In contrast, the shark fauna from Banks Island had very low diversity (seven shark species), and salinity estimates suggest brackish water during the early Eocene (Kim et al., 2014). This paleosalinity difference may have a relationship to the shark size. Where the salinity is lower, the sharks also tend to be larger. The reason why salinity might correlate with length of the Eocene sand tiger sharks is unknown; however, there does seem to be a correlation.

The most compelling argument to explain the shark size distribution is most likely a latitudinal one. According to Bergmann's rule, within species of mammals, individuals are larger at colder temperatures (Bergmann, 1848). Bergmann (1848) proposed that it was an advantage for mammals in colder climates to have a lower surface area to volume ratio in order to retain heat more efficiently. Therefore, the body size of individuals increases with latitude. Many researchers have studied this pattern, including Ashton et al. (2000) and have concluded that most mammal species do in fact follow the rule. However, an explanation for this occurrence is not widely accepted. McNab (1971) suggested that the correlation between body size and latitude is associated with factors such as competition and food sources, not necessarily with temperature. However, it should be noted that the latitudinal temperature gradient during the early Eocene was fairly shallow (Fricke and Wing, 2004), so size difference due to temperature would not be predicted.

No matter the cause of Bergmann's rule, most studies have only been done on mammals and birds (Ashton et al., 2000; James 1970), although some reptiles have been studied (Ashton and Feldman, 2003). No shark species have been studied rendering Bergmann's rule. However, my data from the Arctic and Mississippi seem to suggest it. The Eocene localities on northern Banks Island are at about 74 ºN, and using anterior tooth size as a proxy for body size, *Striatolamia macrota* had a median and mean body size that was about 24% larger than the *Striatolamia macrota* teeth from the Red Hot Truck Stop locality located at 36 ºN in Mississippi.

Implications

Even though Bergmann's rule has been studied in some marine animals such as Bivalves (Berke et al., 2012), I have not found any published studies in any shark species. Bergmann's rule has been accepted for various mammals and reptiles; however, it is interesting that some marine vertebrates may in fact follow the rule as well.

While *Striatolamia macrota* was present in the brackish Eocene Arctic Ocean, today's lamniform sharks such as the thresher, mako, white, and sand tigers, are largely intolerant to low salinities (Compagno, 2001). The Eocene sand tiger sharks lived in typical saline waters near Mississippi and in the brackish waters of the Arctic Ocean, which could be good news for the physiology and behavior of sharks with a changing ocean due to global warming (Kim et al., 2014). As global warming is predicted to cause rapid changes in ocean acidification and temperature, it is difficult to determine how it will affect marine life (Kroeker et al., 2013). However, since it is evident that the sand tiger sharks' tolerance for salinity can evolve, they may be able to adapt to future salinity changes in the ocean.

Further Research

In order to fully understand the distribution of the various sizes of *Striatolamia macrota,* it is important to obtain an absolute salinity of the Red Hot Truck Stop locality. The salinity was based upon an average temperature of the Gulf Coast in the Eocene, however not of the specific locality where the shark teeth were collected. Given more time, I could analyze the anterior teeth's isotope ratios measured from the Red Hot Truck Stop to potentially estimate the salinity of this specific locality.

Teeth from the sharks *Carcharias* and *Physogaleus* were also found at the Banks Island and Red Hot Truck Stop localities. If given more time, I would perform the same study with their anterior teeth and determine if the various species show the same interesting pattern as *Striatolamia macrota.* By comparing more species, it could give more evidence of the size distribution from mid latitudes to the Arctic and help confirm whether Bergmann's rule occurs in Eocene sharks.

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APPENDIX

Table A1. Measurements of *S. macrota* anterior teeth found from the Red Hot Truck Stop, Meridian, Mississippi

CM #	Labial Height (mm)	Lingual Height (mm)	Max Width (mm)
091100	13.59	11.74	5.32
091101	15.23	13.7	7.04
091102	13.71	12.43	6.13
091103	12.22	10.42	4.19
091104	14	12.58	4.02
091105	10.7	8.27	3.77
091106	13.21	10.73	3.45
091107	10.79	8.5	3.37
091108	10.34	8.71	3.58
091109	11.96	10.5	4.54
091110	13.5	11.56	3.97
091111	11.72	9.89	4.02
091112	12.18	10.49	4.45
091113	9.87	7.75	3.13
091114	8.59	6.64	2.92
091115	16.51	13.99	6.76
091116	12.87	11.52	4.49
091117	14.97	13.08	4.56
091118	14.74	13.22	5.24
091119	11.72	10.36	4.2
091120	14.44	12.71	4.8
091121	7.21	6.46	3.47
091122	15.15	13.75	6.98
091123	10.25	9.65	4.15
091124	11.33	10.04	4.81
091125	9.61	7.5	3.2
091126	10.65	8.75	4.85
091127	9.04	7.98	3.89
091128	18.23	16.88	6.58
091129	12.03	10.59	6.14

Table A2. Measurements of *S. macrota* anterior teeth found from Banks Island, NWT, Canada

CMN #	Labial Height (mm)	Lingual Height (mm)	Max Width (mm)
56072	16.88	13.85	6.55
56073	10.38	7.94	4.08
56074	13.8	12.48	5.42
56075	19.55	15.68	8.05
56076	17.9	15.03	7.03
56077	16.43	14.44	6.09
56078	15.67	12.33	5.35
56079	17.6	15.49	5.24
56080	17.94	15.5	5.57
56081	10.18	8.83	3.35
56082	18.06	15.63	6.63
56083	9.4	7.7	3.91
56084	8.99	7.3	3.72
56085	16.89	14.05	7.18
56086	19.77	16.58	8.56
56087	11.26	9.07	3.91
56088	8.61	7	2.77
56089	10.45	8.08	3.36
56090	18.93	15.54	6.54
56091	9.74	7.71	3.55
56092	10.78	9.38	4.31
56093	18.28	15.63	6.19
56094	16.13	13.11	6.1
56095	19.12	15.18	6.73
56096	17.51	14.61	5.9
56097	9.91	7.89	4.48
56098	11.8	9.6	4.37
56099	18.24	14.78	7.19
57285	9.82	8.51	4.27
57286	10.07	8.25	4.39

091130	9.85	9.24	3.89
091131	12.46	10.07	3.8
091132	12.75	11.25	4.81
091133	13.65	11.75	4.46
091134	15.18	13.59	6.04
091135	9.79	8.67	4.62
091136	10.85	9.15	4.5
091137	11.52	10.04	4.85
091138	15.14	12.65	5.08
091139	10.34	8.03	4.18
091140	12.79	11	3.82
091141	9.5	7.46	3.57
091142	12.82	11.49	3.99
091143	10.33	8.23	3.29
091144	11.76	10.56	5.51
091145	6.34	5.04	3.25
091146	10.3	8	4.23
091147	8.8	7.38	2.98
091148	10.56	8.74	3.36
091149	9.84	7.69	4.55
091150	7.54	6.45	3.41
091151	14.17	12.54	4.77
091152	9.62	8.71	3.94
091153	14.6	12.48	4.38
091154	8.82	7.76	3.48
091155	11.26	9.82	3.96
091156	14.07	12.29	4.35
091157	14.59	13.27	4.95
091158	12.08	9.95	4.62
091159	11.69	9.65	3.87
091160	11.85	10.04	5.07
091161	7.68	6.32	2.64
091162	11.91	10.61	5.73
091163	8.83	7.78	3.5
091164	8.18	6.35	2.51
091165	6.63	5.37	1.75
091166	17.71	15.5	5.52
091167	15.63	14.03	6.91
091168	14.13	12.78	4.79

57287	8.38	7.18	3.37
57288	7	5.44	3.34
57289	9.02	7.7	4.76
57290	11.26	9.89	4.78
57291	11.04	9.81	5.15
57292	11.27	9.57	3.96
57293	15.12	13.37	6.94
57294	16.79	14.87	7.17
57295	11.06	9.43	4.21
57296	12.62	11.18	5.57
57297	18.88	15.23	6.38
57298	17.36	14.69	5.84
57299	14.57	13.01	6.09
57300	14.14	12.85	6.46
57301	15.78	13.9	6.52
57302	12.61	11.28	7.01
57303	15.61	13.61	7.08
57304	17.83	14.88	5.9
57305	15.48	13.51	5.2
57306	16.04	14.11	6.87
57307	17.26	14.46	7.62
57308	18.34	15.56	7.05
57309	11.36	8.82	4.34
57310	10.62	8.46	4.24
57311	11.45	8.74	3.29
57312	12.58	11.22	5.12
57313	17.61	15.8	6.72
57314	11.8	10.36	5.01
57315	12.06	10.63	5.03
57316	11.6	9.44	4.5
57317	15.56	12.98	5.61
57318	18.05	15.27	6.93
57319	15.91	13.88	6.61
57320	15.8	13.37	6.62
57321	10.81	9	4.01
57322	15.64	13.33	5.8
57323	14.48	12.89	7.49
57324	14.48	12.48	4.9
57325	18.96	15.52	6.75

091169	12.06	10.27	5.16
091170	15.08	13.94	5.62
091171	13.75	12.09	4.3
091172	15.78	13.68	4.64
091173	16.48	14.13	4.91
091174	16.27	14.41	4.67
091175	11.8	9.87	3.82
091176	9.53	8.01	3.27
091177	13.05	11.88	5.57
091178	7.93	6.3	2.98
091179	10.87	8.72	3.57
091180	14.53	12.68	5.84
091181	15.08	13.23	5.35
091182	12.46	10.42	4.32
091183	14.2	12.2	4.68
091184	7.74	5.67	2.56
091185	11.06	9.35	3.32
091186	10.19	8.8	3.17
091187	6.4	4.79	2.24
091188	14.31	13.18	6.64
091189	13.14	11.29	4.39
091190	15.03	13.02	5.05
091191	16.58	14.07	4.81
091192	13.51	11.45	4.83
091193	9.72	7.98	3.58
091194	15.16	13.38	6.71
091195	9.77	8.39	3.35
091196	13.29	11.28	3.48
091197	7.34	5.84	2.78
091198	8.99	6.99	4.33
091199	16.75	14.59	5.63
091300	6.37	5.22	2.44
091301	8.43	7.37	3.46
091302	14.1	12.13	4.62
091303	9.15	7.33	3.77
091304	10.22	8.11	4.01
091305	15.37	12.91	5.19
091306	15.19	13.12	5.38
091307	10.82	8.86	3.91

57326	10.02	8.35	5.11
57327	10.64	8.28	4.31
57328	18.94	16.07	7.88
57329	11.84	9.33	4.73
57330	16.21	13.36	5.25
57331	18.14	15.09	6.37
57332	18.27	14.95	6.77
57333	18.16	15.3	6.94
57334	11.14	9.37	3.91
57335	16.62	14.22	6.09
57336	14.6	13.5	5.18
57337	10.77	9.21	4.36
57338	11.48	9.48	3.95
57339	13.74	11.52	4.86
57340	13.74	12.05	6.16
57341	14.17	12.55	6.49
57342	16.91	14.58	6.16
57343	18.35	15.53	6.75
57344	14.53	13.13	6.42
57345	17.12	14.49	5.99
57346	18.09	15.21	6.62
57347	16.5	14.4	5.22
57348	17.99	15.73	8.2
57349	12.86	10.07	4.93
57350	12.45	10.83	5.89
57351	18.49	15.19	6.97
57352	16.37	14.47	6.72
57353	15.22	13.36	7.01
57354	14.31	13.19	6.92
57355	15.6	13.85	7.09
57356	13.79	11.92	6.3
57357	12.46	11.04	6.69
57358	11.09	10.12	4.49
57359	9.7	7.81	3.79
57360	14.15	12.11	6.3
57361	16.93	14.79	7.17
57362	12.09	10.99	6.27
57363	15.45	12.57	5.23
57364	15.31	12.89	5.27

091308	12.16	10.94	5.86
091309	11.04	9.28	3.63
091310	8.39	6.33	3.1
091311	18.32	16.05	5.64
091312	10.8	8.79	3.54
091313	7.98	6.25	2.76
091314	12.03	10.07	4.18
091315	14.33	12.23	3.72
091316	13.49	11.56	4.43
091317	17.5	15.98	5.95
091318	18.25	16.06	5.71
091319	16.05	13.75	5.96
091320	14.02	11.68	4.74
091321	8.17	6.35	3.52
091322	7.06	6.06	3.27
091323	13.15	11.83	5.29
091324	10.46	8.58	3.87
091325	12.77	10.92	4.15
091326	8.46	6.74	3.95
091327	8.66	7.1	2.81
091328	13.11	10.94	4.16
091329	11.43	10.07	4.81
091330	14.07	11.71	5.02
091331	12.48	9.9	3.67
091332	10.32	8.23	4.77
091333	11.78	9.54	3.65
091334	4.97	3.96	1.8
091335	3.02	2.49	0.7
091336	11.29	10.22	5
091337	12.56	11.44	6.42
091338	11.81	9.82	3.72
091339	4.59	3.66	2.08
091340	12.51	10.27	3.54
091341	11.91	10.41	5.04
091342	9.43	7.72	2.75
091343	18.35	16.3	5.58
091344	15.17	12.98	4.47
091345	9.75	8.48	3.46
091346	5.53	4.18	1.92

57365	16.47	13.75	5.72
57366	15.45	13.04	5.68
57367	12.64	10.99	5.99
57368	16.49	14.26	5.49
57369	15.73	13.23	5.82
57370	15.6	13.39	7.03
57371	18.36	14.96	7.38
57372	14.85	12.54	6.5
57373	11.71	9.95	4.72
57374	10.83	9.48	4.78
57375	17.37	16.22	6.07
57376	14.37	12.5	6.19
57377	16.47	14.24	6.97
57378	15.94	13.67	5.32
57379	15.13	12.91	5.15
57380	12.71	11.09	6.22
57381	15.76	14.11	7.06
57382	13.26	11.73	6.26
57383	16.28	13.66	5.44
57384	15.83	13.7	5.52
57385	11.54	10.59	4.82
57400	8.64	7.45	4.64
57401	11.8	9.96	3.92
57402	9.35	8	4.2
57403	11.09	8.8	3.57
57404	19.32	16.44	7.5
57405	10.51	8.35	4.97
57406	10.2	8.73	5.59
57407	12.17	10.23	4.82
57408	14.97	12.35	4.36
57409	10.82	9.15	4.22
57410	12.75	10.89	5.03
57411	14.19	12.73	7.4
57412	12.3	10.36	4.41
57413	12.55	10.12	4.55
57414	8.68	7.39	2.99
57415	16.4	13.91	6.23
57416	17.56	14.86	6.95
57417	18.37	15.29	5.91

091347	8.55	6.47	2.68
091348	14.19	12.12	5.97
091349	6.37	5.1	2.94
091350	13.38	11.9	4.6
091351	14.05	11.71	4.01
091352	8.31	6.68	2.56
091353	11.01	9.26	3.55
091354	11.04	8.92	3.7
091355	11.67	9.65	3.5
091356	10.18	8.29	3.38
091357	7.83	7.01	3.59
091358	9.95	8.66	4.27
091359	11.45	10.33	4.85
091360	9.83	8.46	3.73
091361	9.26	7.83	3.63
091362	8.28	7	3.3
091363	10.8	8.61	4.3
091364	11.48	10.37	4.08
091365	9.54	7.88	3.12
091366	7.29	6.39	2.91
091367	20.68	18.16	6.15
091368	13.81	11.98	4.79
091369	13.18	11.06	5
091370	8.2	7.42	3.59
091371	6.55	5.01	2.01
091372	9.54	8.45	4.25
091373	9.46	7.49	3.7
091374	5.31	3.92	1.7
091375	11.97	10.27	4.21
091376	8.28	6.84	2.81
091377	11.1	9.21	3.72
091378	8.26	6.61	2.64
091379	10.03	8.41	2.99
091380	14.07	12.11	4.26
091381	14.26	12.37	4.94
091382	13.26	11.67	5.3
091383	9.65	8.46	3.6
091384	11.35	9.66	4.48
091385	7.78	6.11	3.14

57418	8.15	6.22	2.83
57419	10.31	8.67	4.08
57420	17.33	14.93	6.15
57421	19.51	16.51	7.22
57422	10.73	9.53	3.53
57423	10.13	8.57	5.21
57424	10.05	8.61	4.07
57425	10.93	8.89	5.25
57426	8.87	7.25	2.96
57427	13.03	11.5	6.13
57428	9.7	8.76	4.35
57429	8.85	7.61	4.99
57430	16.32	14.35	7.56
57431	9.39	8.09	4.65
57432	13.51	10.98	5.94
57433	10.57	9.24	3.81
57434	6.83	5.27	3.97
57435	12.75	11.7	5.86
57436	17.31	14.61	6.7
57437	12.96	11.74	6.02
57438	10.63	8.76	5.71
57439	14.96	13.65	6.24
57440	16.05	14.21	7.22
57441	10.98	9.34	4.13
57442	12.88	11.54	6.94
57443	14.25	12.45	6.55
57444	14.2	12.18	6.83
57445	13.64	13	6.02
57446	12.79	10.78	6.37
57447	8.69	7.11	3.96
57448	11	9.1	4.43
57449	16.97	14.22	5.9
57450	14.43	12.03	4.9
57451	12.46	10.91	5.69
57452	14.11	11.93	5.79
57453	12.8	11.32	6.31
57454	11.59	9.9	5.83
57455	16.36	13.82	5.98
57456	18.58	15.99	6.26

091386	13.05	10.83	4.85
091387	14.07	12.68	5.45
091388	7.74	5.96	2.98
091389	15.3	13.2	4.87
091390	10.84	8.99	3.36
091391	6.54	5.03	2.11
091392	12.85	11.8	4.21
091393	6.89	5.3	2.36
091394	13.65	10.78	3.87
091395	5.48	4.59	1.72
091396	7.79	6.45	3.25
091397	5.3	3.98	1.94
091398	4.85	4.07	1.73
091399	6.68	5.27	2.42
091400	10.34	8.65	3.31
091401	14.29	13.02	4.79
091402	11.41	9.25	3.43
091403	9.23	8.22	2.94
091404	7.06	6.08	3.19
091405	8.37	6.68	3.64
091406	6.89	5.41	2.2
091407	9.78	8.53	2.95
091408	4.2	3.05	1.33
091409	3.69	2.75	1.16
091410	4.56	3.5	2.11
091411	12.15	10.9	3.59
091412	8.66	7.14	2.92
091413	7.95	6.65	3.15
091414	7.86	6.32	2.49
091415	10.93	8.93	3.5
091416	5.78	4.3	2
091417	7.61	6.7	3.02
091418	5.34	4.3	2.12
091419	8.15	7.06	3.35
091420	7.88	6.63	3.49
091421	8.56	6.57	2.93
091422	8.09	6.79	2.24
091423	9.14	7.84	3.63
091424	14.78	12.23	3.78

57457	14.52	13.38	6.34
57458	12.24	11.29	6.2
57459	11.44	10.01	4.38
57460	9.77	7.91	4.33
57461	14.87	12.68	5.96
57462	16.59	13.64	5.32
57463	16.91	14.13	6.28
57464	17.09	14.86	6.82
57465	15.46	12.68	5.26
57466	17.94	15.65	7.06
57467	18.6	16.47	6.97
57468	14.28	12.67	6.73
57469	16.81	14.29	5.42
57470	13.13	11.35	6.04
57471	10.21	8.47	4.09
57472	15.06	13.07	5.29
57473	11.88	9.86	4.82
57474	10.36	8.74	4.67
57475	9.6	8.3	4.14
57476	17.95	14.94	6.15
57477	15.7	12.76	7.12
57478	12.75	11.36	6.31
57479	10.15	8.14	4.31
57480	16.3	14.29	6.15
57481	17.36	15.43	7.31
57482	17.9	15.12	7.07
57483	14.1	13.2	7.33
57484	8.86	7.67	4.04
57485	9.02	8.35	5.22
57486	16.19	12.92	5.89
57487	10.78	9.89	5.92
57488	18.05	15.26	6.28
57489	12.26	10.19	4.58
57490	18.44	14.74	6.42
57491	9.74	8.42	4.77
57492	5.4	4.47	2.65
57493	13.4	11.26	5.87
57494	9.2	7.62	3.64
57495	20.54	18.67	8.75

091425	10.83	8.55	3.41
091426	14.11	12.23	4.82
091427	5.91	4.39	1.93
091428	12.95	11.09	4.48
091429	13.13	12.03	4.73
091430	11.87	10.02	4.76
091431	11.02	9.26	3.08
091432	14.7	13.34	4.75
091433	12.31	10.4	3.34
091434	11.03	8.76	3.12
091435	6.22	5.14	2
091436	16.85	14.27	4.82
091437	17.47	15.74	5.41
091438	6.53	5.37	1.62
091439	12.49	10.28	4.29
091440	16.89	15.05	5.51
091441	12.34	10.09	3.74
091442	10.51	8.22	2.89
091443	20.98	17.65	6.1
091444	14.91	13.23	5.09
091445	19.27	17.38	7.1
091446	12.31	10.69	4.49
091447	10.51	8.75	3.49
091448	13.83	12.01	5.11
091449	13.58	12.23	4.36
091450	10.2	8.66	3.14
091451	15.36	13.66	4.45
091452	14.38	13.02	4.87
091453	14.82	12.59	4.32
091454	13.41	11.13	4.44
091455	14.23	12.21	4.42
091456	13.97	13.36	5.33
091457	11.96	9.9	3.29
091458	16.14	14.12	4.98
091459	17.36	15.69	5.87
091460	8.54	6.71	2.97
091461	10.34	8.27	3.09
091462	19.65	17.21	6.25
091463	15.54	13.46	4.97

57496	17.65	15.05	5.97
57497	14.86	12.64	5.11
57498	11.52	10.1	4.71
57499	12.36	10.19	3.96
57500	13.98	12.22	5.26
57536	17.95	15.19	7.9
57537	17.87	15.03	6.68
57538	8.72	7.8	3.31
57539	14.8	11.9	5.67
57540	9.46	8.02	5.04
57541	17.31	14.39	5.36
57542	14.64	12.85	5.27
57543	16.98	14.06	5.87
57544	8.21	7.43	4.39
57545	19.26	15.45	6.46
57546	18.89	14.96	8.47
57547	18.36	16.29	7.52
57548	16.88	14.03	6.51
57549	18.12	15.11	6.4
57550	19.04	16.17	6.99
57551	8.51	6.88	3.42
57552	8.62	7.47	5.09
57553	11.65	10.62	5.19
57554	10.11	8.06	3.69
57555	15.08	13.01	7.05
57556	13.8	12.67	6.25
57557	7.74	5.87	2.83
57558	11.23	9.35	4.16
57559	19.35	15.56	6.89
57560	14.02	12.15	5.57
57561	19.04	15.47	6.49
57562	14.47	12.6	6.05
57563	19.79	16.69	6.45
57564	16.51	14.18	5.36
57565	18.24	15.66	7.54
57566	18.82	16.54	7.74
57567	19.08	16.71	7.81
57568	13.24	11.3	6.02
57569	10.3	8.78	5.51

091464	13.55	11.23	4.2
091465	11.63	9.78	4.68
091466	6.39	5.53	1.84
091467	10.02	8.84	3.54
091468	12.97	11.21	4.1
091469	8.55	6.69	2.73
091470	13.28	12.04	4.42
091471	16.51	14.77	6.2
091472	13.45	12.15	4.53
091473	8.29	6.82	3.09
091474	13.31	11.39	4.43
091475	13.37	11.91	4.32
091476	17.34	15.33	5.8
091477	16.23	14.27	5.19
091478	14.84	13.47	5.82
091479	13.38	11.53	4.69
091480	9.65	7.67	3.63
091481	13.61	11.43	4.52
091482	7.31	5.41	2.23
091483	14.62	12.65	4.24
091484	14.46	11.7	4.17
091485	17.66	15.4	5.11
091486	20.75	17.89	5.92
091487	15.92	13.57	4.54
091488	9.5	7.79	3
091489	12.82	10.94	4.31
091490	17.98	15.53	5.04
091491	11.66	9.7	3.93
091492	9.38	7.69	3.19
091493	12.56	10.4	3.79
091494	12.77	10.11	3.94
091495	5.73	4.57	1.91
091496	12.29	10.53	4.01
091497	11.89	10.07	3.66
091498	19.37	17.09	6.19
091499	16.44	14.16	5.15
091500	13.14	11	3.89
091501	13.81	12.27	4.86
091502	18.42	16.99	6.83

57570	16.81	13.46	6
57571	8.13	7.18	3.93
57572	16.45	14.15	5.8
57573	16.6	14.56	6.54
57574	19.02	16.52	6.08
57575	11.1	8.72	4.23
57576	7.47	5.72	3.57
57577	16.2	13.13	6.07
57578	7.39	6.25	4.37
57579	8.78	7.32	3.6
57580	18.03	16.14	7.52
57581	17.72	15.49	7.76
57582	11.13	9.49	5.09
57583	12.58	11.08	4.34
57584	10.3	8.88	4.19
57585	7.59	6.56	3.82
57586	9.85	7.98	4.05
57587	16.71	14.9	6.64
57588	19.12	15.64	6.48
57589	16.83	14.32	5.97
57590	14.99	13.03	6.52
57591	14.73	13.89	6.6
57592	15.19	13.49	5.68
57593	17.23	14.54	5.69
57594	17.2	15.15	7.35
57595	18.64	16.01	6.61
57596	17.91	14.9	6.39
57597	10.66	8.99	3.75
57598	11.51	9.77	5.29
57599	11.28	9.7	4.2
57600	9.81	8.26	3.76
57601	14.26	11.94	6.76
57602	14.21	12.4	4.7
57603	19.75	17.95	7.53
57604	11.21	9.59	4.73
57605	9.73	8.56	4.56
57606	11.67	10.28	5.69
57607	14.23	12.25	5.29
57608	10.3	8.86	4.73

091503	15.25	13.02	4.55
091504	13.3	11.84	5.06
091505	14.47	12.61	4.78
091506	11.74	10.31	3.97
091507	11.46	9.56	3.14
091508	9.94	8.45	3.14
091509	12.22	10.68	4.1
091510	16.7	14.83	6.11
091511	18.19	16.64	6.49
091512	12.81	11.19	3.77
091513	14.48	12.58	4.98
091514	18.73	16.18	5.37
091515	11.36	9.04	3.56
091516	12.38	10.25	3.58
091517	14.5	12.26	4.41
091518	15.65	13.6	5.35
091519	13.64	11.82	4.34
091520	17.19	14.19	5.69
091521	9.29	7.83	3.1
091522	14.73	12.27	4.9
091523	11.17	8.86	3.82
091524	15.19	12.9	4.47
091525	14.25	12.28	5.15
091526	14.39	12.66	5.82
091527	14.82	12.9	5.35
091528	15.71	13.6	4.57
091529	10.02	8.23	3.37
091530	7.8	6.15	2.32
091531	5.77	4.63	1.77
091532	6.03	4.13	1.92
091533	12	9.73	3.86
091534	13.2	10.96	4.13
091535	12.63	11.32	5.5
091536	6.96	5.42	2.7
091537	6.19	5.23	2.11
091538	6.69	5.21	2.47
091539	11.77	9.97	3.95
091540	12.37	10.84	4.08
091541	12.2	10.67	4.03

57609	11.35	9.15	4.19
57610	8.04	6.77	4.72
57611	9.99	8.68	3.98
57612	14.81	13.54	5.67
57613	10.15	8.14	3.28
57614	10.06	8.46	3.93
57615	14.16	12.89	6.04
57616	12.59	11.09	5.46
57617	9.5	8.65	4.44
57618	8.25	6.24	3.03
57619	7.69	5.11	2.65
57620	8.36	7.36	4.8
57621	9.36	7.85	3.35
57622	15.1	13.06	4.89
57623	8.86	7.13	3.54
57624	16.94	14.21	6.13
57625	12.92	11.53	5.86
57626	13.33	11.2	6.22
57627	10.02	8.92	3.38
57628	10.53	8.18	3.36
57629	7.57	6.48	3.63
57630	17.25	14.86	5.73
57631	8.55	7.18	4.2
57632	18.76	15.92	6.49
57633	14.75	13.03	7.04
57634	10.08	8.27	3.68
57635	7.6	5.55	2.77
57636	8.62	7.35	4.63
57637	5.78	4.61	3.26
57638	8.69	7.08	3.73
57639	16.81	14.43	5.74
57640	8.7	7.09	2.93
57641	17.53	14.88	6.05
57642	11.85	9.81	4.1
57643	11.69	9.56	4.36
57644	12.35	11	5.7
57645	12.84	10.73	5.66
57646	17.02	14.03	7.45
57647	14.71	12.9	5.77

091542	8.02	6.77	3.25
091543	8.56	7.26	2.95
091544	15.15	13.43	5.39
091545	7.12	5.74	2.32
091546	10.49	9.12	3.96
091547	14.65	12.77	5.41
091548	13.02	10.98	3.69
091549	4.26	3.68	1.17
091550	6	5.02	2.15
091551	7.98	6.7	2.25
091552	8.28	6.95	2.91
091553	7.14	5.22	2.14
091554	11.38	10.29	4.99
091555	6.97	5.76	2.21
091556	6.93	5.23	2.04
091557	10.13	8.24	3.29
091558	6.88	5.1	2.69
091559	7.64	6.25	1.85
091560	9.68	8.07	3.05
091561	11.09	9.38	3.29
091562	9.23	8.1	3.39
091563	7.66	6.83	3.1
091564	7.72	6.27	2.71
091565	7.58	5.95	2.49
091566	12.89	11.39	4.53
091567	13.6	12.5	5
091568	14.35	12.35	4.5
091569	15.49	13.52	5.66
091570	15.09	13.5	5.05
091571	14.54	12.76	4.28

57648	10.27	8.79	4.56
57649	12.21	10.86	5.69
57650	15.56	12.93	5.3
57651	16.03	13.38	5.96
57652	10.1	8.76	4.67
57653	17.97	15.17	6.75
57654	9.51	7.8	3.21
57655	15.9	13.78	4.94
57656	15.82	13.03	5.37
57657	16.38	13.57	5.42
57658	13.21	10.34	4.72
57659	16.98	15.39	7.07
57660	18.46	15.67	6.11
57661	9.37	8.07	3.71
57662	13.88	12.24	4.65
57663	14.51	12.4	6.01
57664	14.23	12.76	6.81
57665	12.37	11.86	6.59
57666	17.1	13.55	5.76
57667	16	13.34	4.88
57668	10.69	9.33	4.42
57669	8.82	7.08	3.82
57670	14.34	12.72	5.13
57671	13.12	11.75	6.55
57672	18.53	15.4	6.05
57673	9.63	8.09	5.52
57674	8.24	6.92	4.79
57675	14.55	12.93	7.67
57676	10.48	8.71	5.6
57677	8.3	6.09	2.52
57678	11.64	9.75	4.33
57679	7.29	5.61	3.38
57680	7.34	5.82	3.75
57681	16.72	13.54	5.91
57682	13.43	12.33	5.9
57683	14.5	12.77	6.89
57684	15.29	13.23	5.97
57685	17.45	14.69	7.35
57686	13.28	11.13	5.66

57687	17.38	15.23	6.66
57688	10.83	9.76	5.56
57689	16.75	13.42	5.63
57690	14.61	13.56	6.89
57691	12.89	11.23	5.08
57692	18.13	15.15	6.7
57693	13.1	11.12	4.51
57694	15.28	12.26	5.81
57695	13.73	11.6	5.19
57696	15.74	13.39	7.18
57697	10.95	9.83	5.76
57698	14.14	12.38	5.13
57699	11.9	10.41	5.17
57700	13.06	10.22	4.83
57701	12.32	11.27	6.27
57702	17.81	15.09	6.24