FINAL REPORT

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Project Title: Utilizing trace elements and stable isotope analysis to reconstruct distribution of scalloped and Carolina hammerheads

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Objectives:
The overall goal of the project is to determine if spatial segregation of juvenile and adult hammerheads occurs and give indicators of life-stage specific habitat use.

1. Obtain paired vertebrae and eye samples from young-of-year, juvenile and adult Carolina and scalloped hammerheads off the coast of the southeast U.S.
2. Genetically identify collected specimens to assure a sufficient sample size of both species and life stages for analyses.
3. Determine natal signatures of young-of-year hammerheads in multiple nurseries. For all objectives, LA-ICP-MS will be used to determine trace element (Li, Mn, Mg, Ca, Sr, Ba and S) concentrations in vertebrae and SIA will be used to examine isotopic signatures ($\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$) in eye lenses.
4. Determine signatures of juvenile and adult hammerheads across multiple years using LA-ICP-MS (vertebrae) and SIA (tissue run from multiple zones of eye lens corresponding with age/maturity).
5. Use established nursery signatures to assign juvenile and adult hammerheads to nurseries along the east coast of the U.S. (nursery contribution).
6. Analyze trace element concentrations and isotopic signatures to determine if ontogenetic shifts in habitat use occur in Carolina and scalloped hammerheads.
7. Determine the extent of spatial segregation and habitats used by the two species.

Executive Summary: The main objectives of this study were to determine if spatial segregation of juvenile and adult hammerheads occurs and if there are patterns in life-stage specific habitat use for Carolina and scalloped hammerheads. These objectives were investigated using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) of vertebrae as well as stable isotope analysis (SIA) of eye lenses. Trace element concentrations (Sr, Ba, Mg, Mn, Li and Ca) from the LA-ICP-MS were collected across the whole vertebrae (total transect) and integrated across vertebrae sections that were designated as life stages (in-utero, young-of-year (YOY) or nursery, early juvenile, late juvenile and adult) through measurements of the vertebrae

associated with age. Layers of eye lenses associated with general life stages were analyzed for $\delta^{15}N$, $\delta^{13}C$, and $\delta^{34}S$ stable isotope analysis. Analyzing life stage signatures from both techniques provided the ability to estimate natal origin of juvenile and adult species, ontogenetic shifts in habitat by maturity or life stage for each species, and the extent of spatial segregation throughout life stages between species. Nursery trace element signatures of scalloped hammerheads were different in Mg concentration between Bulls Bay and Cape Canaveral and between Tolomato River and Bulls Bay, while YOY Carolina hammerheads significantly differed between Bulls Bay and Cape Canaveral in Sr and Mn. A Random Forest Analysis conducted on Carolina and scalloped hammerheads was able to correctly predict natal origin 71.9% of the time. When the model was employed for juvenile and adult individuals, 95% of these older hammerheads were predicted to have originated from Bulls Bay nursery, while only 4.4% and 0.06% likely originated from Tolomato River and Cape Canaveral, respectively. In-utero and YOY trace element signatures differed slightly between species (in Mg, Mn and Li), but there was a more defined species difference in element concentrations (Sr, Mg, Mn and Li) in early juveniles. The overall transect concentrations were assessed by hammerhead maturity stage and generally reflected patterns between vertebrae life stages for both species. Sr:Ca and Sr:Ba ratio concentrations indicate that an ontogenetic habitat shift occurs between YOY and early juvenile sharks for both Carolina and scalloped hammerheads, and suggests Carolina hammerheads migrate to offshore waters at an earlier age and continually inhabit more offshore waters as late juveniles and adults than scalloped hammerheads. Species-specific distinctions in Mn and Li suggest possible dietary differences, which can allude to habitat differences, between species throughout their lifespan, though continued research will be needed to assess the extent of any differences. The results of eye lens stable isotope analysis generally confirm these results; that said, eye lens data may suggest scalloped hammerheads may have a more open ocean signal than Carolina hammerheads. Given the disparities, it may be more likely that dietary differences are leading to the observed differences in trace element and stable isotope eye lens data. Unfortunately Carolina hammerheads remain rare in catches, and equal sample sizes could not be run during this study. Despite the conclusion of this grant, we will continue to add samples to these analyses, giving us greater ability to tease apart the differences observed in these species. These results allowed the first insights into species-specific trophic ecology of Carolina and scalloped hammerheads, data that will be critical to effective management of hammerheads in the U.S.

Objective 1: Obtain paired vertebrae and eye samples from young-of-year, juvenile and adult Carolina and Scalloped hammerheads off the coast of the southeast U.S.

Accomplishments:

Sharks were collected by multiple fisheries surveys conducted from 2015–2020: the South Carolina Department of Natural Resources Turtle Trawl, Cooperative Atlantic States Shark Pupping and Nursery Survey (COASTSPAN) participants, Kennedy Space Center Ecological Monitoring Program (KSCEMP), Southeast Area Monitoring and Assessment Program (SEAMAP), and the Florida Fish and Wildlife Research Institute's Fisheries-Independent Monitoring (FIM) program. Additional samples were collected by commercial gillnet in coastal North Carolina waters.

Paired samples were obtained from 53 hammerheads (11 Carolina hammerheads, 32 scalloped hammerheads, and 1 hybrid hammerhead) from multiple states (Table 1). Genetic identification occurred after collection and therefore it was difficult to get an even sample number across species.

A total of 185 hammerheads were run for LA-ICP-MS, and 181 of these were genetically identified (47 Carolina hammerheads, 133 scalloped hammerheads and 1 hybrid hammerhead), Non-identified hammerheads were excluded from all analyses. The sample size across analyses differed as certain individuals were included based on life history and other parameters (i.e. due to life stage, species, location caught, etc). Out of the 181 hammerheads that were processed with LA-ICP-MS, 119 vertebrae were used for total transect element concentration analyses (Table 2) and 118 were used to assess the difference between element concentrations across hammerhead life stages (vertebrae sections associated with life stages or maturity status of hammerheads) and species. Some groups of samples were not included in analyses for the report due to small sample sizes and may be included in future analyses as more samples are acquired that fall into those specific categories.

A subset of 136 Carolina, scalloped, or hybrid hammerhead individuals was selected for eye lens stable isotope ratio analysis to examine ontogenetic trophic or habitat shifts among species (Table 3). Samples were stratified by species, life stage (early YOY, late YOY, early juvenile, mid juvenile, late juvenile, late juvenile-mature, and mature), and sex, although samples were not available for all species-sex-life stage combinations (Table 3). Frozen eye lens samples were shipped to the Marine Fisheries Laboratory at the University of Florida for extraction of eye lens layers. Eye lenses do not have opaque zones that indicate chronology, as do otoliths. Therefore, sequential layers of eye lens protein represent relative, not absolute, time (Wallace et al. 2014).

Eye lens samples were thawed, wicked nearly dry with Kimwipe tissues, and then dried at air temperature. Tweezers were utilized to extract successive eye lens layers following the methods of Wallace et al. (2014). Early YOY lens samples were analyzed whole, while the external capsule on late YOY lens was removed to reveal similar-sized core (zero layer) samples as early YOY lenses. For all other samples, the outer lens layer was extracted at the smallest practicable size and then subsequent lens layers were extracted until only the YOY core remained.

There was a significant relationship between the number of extracted lens layers and shark age (Figure 1). However, the relationship was non-linear, with divergence in number of extracted layers and age occurring at approximately age-10 among all species. That is not to say that a given layer earlier than layer-10, such as layer-8, exactly corresponds to age-8 in the shark’s life. Eye lens diameter was highly correlated (Pearson’s $r = 0.97$) with fish length (Figure 2), thus different eye lens layers track the ontogenetic trends in individual sharks. Somatic, hence eye lens, growth slows as sharks age, thus any ontogenetic shifts that occur later in a shark’s life would be difficult to resolve with eye lens sub-sampling.

Each lens layer sample was placed in an aluminum tray that was closed and then freeze dried for 18 hours. Each sample was pulverized and homogenized in a stainless-steel bead mill. All tools or containers that came in contact with samples had been combusted at 500 °C for 24 hours or rinsed with 1% ultrapure HNO_3 followed by 18.3 MΩ cm^{-1} double-deionized water to remove any organic residues.

Preliminary eye lens tissue samples were shipped to Dr. Stefania Mambelli at the University of California-Berkeley’s Center for Stable Isotope Biogeochemistry (USB-CSIB) to test for appropriate sample aliquot size for CNS stable isotope analysis. Results indicated 1.0 mg sample sizes were sufficient to produce accurate, precise measurements of $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$.

Therefore, approximately 1 mg of each pulverized and homogenized hammerhead shark eye lens layer sample was weighed and packed in aluminum trays. Trays were closed, placed in 96-well plates, and shipped to the UCB-CSIB for analysis, with the standard for $\delta^{13}C$ being Vienna Pee Dee Belemnite, the standard for $\delta^{15}N$ being air, and the standard for $\delta^{34}S$ being Canyon Diablo Troilite. All samples were successfully analyzed with analytical precision meeting or exceeding long-term CNS precision on USB-CSIB's stable isotope mass spectrometers of ±0.12‰ for $\delta^{13}C$, ±0.13‰ for $\delta^{15}N$, and ±0.4‰ for $\delta^{34}S$ (Mambelli et al. 2016).

Significant deviations: Not applicable. Goals of this objective were met.

Objective 2: Genetically identify collected specimens to assure a sufficient sample size of both species and life stages for analyses.

Accomplishments: Fin clips were taken from every hammerhead, stored in salt-saturated 20% dimethyl sulfoxide (DMSO) buffer (Seutin et al. 1991), and genetically identified by using double-digest restriction associated DNA sequencing (ddRAD) to characterize diagnostic single-nucleotide polymorphisms (SNPs) that are fixed between hammerhead species (Barker et al. 2019). Samples were then retrospectively assigned as either Carolina hammerhead, scalloped hammerhead, or hybrid (mixed parentage). The single hybrid hammerhead was not used in any analyses.

A total of 181 hammerheads were genetically identified (47 Carolina hammerheads, 133 scalloped hammerheads and 1 hybrid hammerhead). The majority of samples were from YOY (48%) and early juvenile sharks (34%), with a higher number of scalloped hammerheads collected across all life stages (Table 4). Both species were sampled across all life stages for trace elements, though a lower number of samples were collected from older Carolina hammerheads than scalloped (Table 5). Individuals were caught in multiple states, with the majority sampled in North Carolina, followed by South Carolina (Table 6).

Significant deviations: Not applicable. Goals of this objective were met.

Objective 3: Determine natal signatures of young-of-year hammerheads in multiple nurseries. For all objectives, LA-ICP-MS will be used to determine trace element (Li, Mn, Mg, Ca, Sr, Ba and S) concentrations in vertebrae.

Accomplishments: Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) was used to analyze the elemental composition of distinct life stages of 165 scalloped and Carolina hammerheads collected off the southeastern Atlantic coast of the U.S. Young-of-year hammerheads were collected from three main nursery areas along the southeast US coast: Bulls Bay, SC and Cape Canaveral and Tolomato River, FL. All hammerhead vertebrae were sectioned and aged. The age of a hammerhead is estimated from alternating paired opaque and translucent bands (in which a single pair represents annual growth). The birthmark was identified within each vertebra and measurements were made from the focus to the birthmark as well as to each translucent band and to the vertebra edge. These measurements were used to convert the laser transect time and distance across a vertebra into respective ages, and then elemental concentrations were integrated along vertebrae sections of the laser transect that were assigned a life history stage (in-utero (IU), young-of-year (YOY), early juvenile (EJ), late juvenile (LJ) and adult (AD)). The trace elements used for analyses were Sr (strontium), Ba (Barium), Mg (magnesium), Mn (manganese) and Li (lithium). Ca (calcium) was used as an internal reference, as concentrations vary minimally within vertebrae (Tillett et al. 2011). Raw count data were normalized by ^{43}Ca (using an internal standard concentration of 43% following literature values) to adjust for variation in instrument sensitivity and ablated maternal amount. Calculated concentrations are reported relative to calcium as element:Ca ratios.

Nursery signal concentrations (i.e. from the vertebrae section from birthmark to the edge) were compared across different trace element concentrations from YOY hammerheads caught in the three nursery areas. Comparisons were tested using Principal Components Analysis (PCA), two-sample T-tests, and Analysis of variance (ANOVA) or Kruskal-Wallis tests followed by a Tukey HSD or Dunn's test for pairwise comparisons of normal or non-normal data, respectively. Due to interspecific differences in nursery signals (determined using only YOY hammerheads from Bulls Bay), element concentrations between nurseries for scalloped and Carolina hammerheads were assessed separately. Scalloped hammerheads were compared between all three nursery areas, while Carolina hammerheads were compared between Bulls Bay and Cape Canaveral only (as none were caught in Tolomato River).

Scalloped hammerhead elemental concentrations differed between Bulls Bay and Cape Canaveral nurseries more so than Tolomato River compared to either of the other nurseries (Figure 3). Bulls Bay and Cape Canaveral concentrations significantly differed in Mg, while Tolomato River only differed from Bulls Bay in Mg (ANOVA, $p = 0.01$; Figure 3). Carolina hammerheads significantly differed between nurseries in Sr and Mn (two sample t-test, $p < 0.01$; Figure 4).

<u>Significant deviations:</u>

A minimal number of Carolina hammerheads were captured outside of South Carolina waters, and therefore sample size was too low to perform a comparison between known nursery areas (Bulls Bay, South Carolina and Tolomato River and Cape Canaveral, Florida). A total of 8 Carolina hammerheads were sampled from GA nearshore waters, which may be another nursery area for YOY hammerheads (Barker et al. 2021), and therefore will be included in future analyses to compare natal signatures.

<u>Objective 4:</u> Determine signatures of juvenile and adult hammerheads across multiple years using LA-ICP-MS (vertebrae) and SIA (tissue run from multiple zones of eye lens corresponding with age/maturity).

<u>Accomplishments</u>: Life stage signatures (IU, YOY, EJ, LJ and AD; derived from element:Ca ratio concentrations within associated vertebral sections of five trace elements (Sr, Ba, Mg, Mn and Li) were compared between scalloped and Carolina hammerheads caught between 2015-2020 and then within each species.

Differences in scalloped and Carolina hammerhead in-utero concentrations (which is a proxy for pregnant female signatures) were observed in the PCA, in which principal component 1 (Dim1) explained the majority (54.8%) of the variation among data points and Dim2 explained 18.9% (Figure 5A). The element with the most influence along Dim1 was Li, and Mg had the most influence on Dim 2, both with positive loadings. Statistical comparisons between species determined that Mg, Mn, and Li were significantly different (Mann-Whitney; $p < 0.001$; Figure

6) and driving the pattern seen on the PCA. Carolina hammerheads exhibited higher in-utero concentrations for Mg and Mn than scalloped hammerheads, but a lower Li concentration.

In comparing YOY vertebrae section concentrations, Carolina and scalloped hammerhead signatures were more similar to each other than in-utero signatures as seen in the PCA (Figure 5B); however, the concentration between species differed in the same elements, Mg, Mn, and Li (Mann-Whitney, $p < 0.001$; Figure 7). Similar to the in-utero section, Carolina hammerheads exhibited higher nursery concentrations for Mg and Mn than scalloped hammerheads, but a lower Li concentration. In the PCA, Dim1 explained 46.9% of the variation among data points, while PC2 explained 19.6%. Ba was the most influential element along Dim1, while Mn was the most influential along Dim2, both with positive loadings. Distinct signals from nursery areas could potentially affect any differences; however, when YOY hammerheads from Bulls Bay only were compared to reduce any nursery or latitudinal differences, the species differed in Mg and Mn (Mann-Whitney, $p = 0.02$ and $p < 0.01$, respectively).

There was a more defined separation between Carolina and scalloped hammerhead early juvenile vertebrae sections in the PCA, with Dim1 explaining 37.2% of the variation among data points and Dim2 explaining 25.6% variation (Figure 5C). Mainly driving the difference between species were Mg, Mn and Sr (positive loadings) along Dim1 and Li (positive loading) along Dim2. Statistical comparisons detected significant interspecific differences for Sr, Mg, Mn and Li (Mann-Whitney, $p < 0.01$) in which Carolina hammerheads had higher concentrations of Sr, Mg, and Mn compared to scalloped hammerheads but lower Li (Figure 8).

Statistical comparisons between late juvenile and adult vertebrae sections were limited due to small sample sizes of older Carolina hammerheads (3 late juveniles and 1 adult sample). However, the PCA and boxplots based on potential differences across elements (as indicated by the contributions of elements in the PCA) were similar between these vertebrae sections and species. Carolina hammerheads showed a lower concentration in Ba and a higher concentration of Mg for both late juvenile and adult life stages, and a lower concentration in Li for the adult life stage (Figures 9 and 10). The Carolina points fell in a similar area on the late juvenile and adult PCA plots in comparison to the scalloped hammerhead ellipse, and the same elements were responsible for the most contribution on Dim1 and Dim2 (Figure 5D and 5E). For both the late juvenile (Figure 5D) and adult (Figure 5E) stages, Sr and Mg had the most influence on Dim1 (positive loadings), while Ba and Li had equal influence on Dim2 (positive loadings).

Elemental concentration differences across vertebrae life stages within each species were explored as well. Carolina and scalloped hammerheads had similar patterns across life stages for Sr, Mn, and Li (Figure 11A, D and E). In-utero and nursery concentrations were similar in Sr and Mn, and both were significantly lower in Sr compared to early juveniles and older sharks (Figure 11A; Dunn's test, $p < 0.001$), but significantly higher for Mn compared to older sharks (Figure 11D; Dunn's test, $p < 0.001$). Li concentration remained similar across all life stages within each species (Figure 11E). IU and YOY concentrations were comparable for Ba and Mg within each species as well, but showed a different pattern between species for EJ, LJ and AD stages. Carolina hammerheads had significantly higher Ba concentrations for the EJ stage compared to those of IU and YOY signatures and LJ and AD concentrations (Figure 11B). There was no statistical difference in Mg across life stage concentrations for Carolina hammerheads (due to small samples sizes in the LJ and AD stages), but the pattern is similar to that of scalloped hammerheads, in which IU, YOY and EJ concentrations were significantly higher than LJ and AD stages (Figure 1C).

Differences appeared between species and across hammerhead maturity stages within each species in terms of overall elemental composition of vertebrae (total transect values) based on PCA (Figure 12). The interspecific difference (when combining all maturity stages) resembles the PCA of the IU vertebrae section, in which there is overlap between the species' ellipses, but a clear grouping occurs based on species (Figure 12A). Sr and Li contribute most to the variation across Dim1 (58.5%) with positive loadings, while Ba and Mn had the most influence on Dim2 (which explains 22.1% of the data variation), both with positive loadings. The element concentration pattern across hammerhead maturity stages was similar between species, with a distinct group for YOY sharks that is separate from late juveniles and adult sharks, with early juveniles falling in between (Figure 12B and 12C). For both species, Sr had the highest contribution to Dim1 (which explained 58.2% and 61.8% of data variation for scalloped and Carolina hammerheads, respectively), followed by Ba and Li for scalloped hammerheads and Li and Mn in Carolina hammerheads (all positive loading). Mg was more influential on Dim2 for scalloped hammerheads, while Mn contributed more to Dim2 for Carolina hammerheads.

The similar pattern between species across maturity stages is reflected in boxplots (Figure 13), though concentration values differ between species for some elements at each maturity stage. Once again, Carolina hammerheads had few samples for LJ and AD so there was a limit to quantitative analyses; however, the concentration values for those individuals were included for visualization of possible differences. The differences in PCA elemental contributions can be explained by differences in concentration values when statistically comparing maturity stages across species. Carolina and scalloped hammerheads had similar Sr YOY concentrations, which increased with age (Figure 13A). Ba concentration increased between YOY and EJ individuals, then remained steady for LJ and AD sharks (Figure 13B). Inversely, Mg and Mn concentration decreased with age for both species (Figure 13C and 13D), though YOY Carolina hammerheads had a higher Mg and much higher Mn than YOY scalloped hammerheads. Li values were lower in YOY compared to older sharks for both species, though scalloped hammerheads had a higher concentration compared to Carolina hammerheads.

Stable isotope data were fitted with Bayesian regression spline models by species, sex, and maturity stage (juvenile versus immature) to visualize ontogenetic patterns in $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ across sequential lens layers. All data were pre-preprocessed with the *bestNormalize* package to standardize each stable isotope ratio independently and put each on the normal scale, and then spline functions were fitted using the *brms* package in R (R Core Team 2021). Different model structures were explored as we did not know *a priori* how trend effects and the intercept would split over maturity, sex, or species (Table 7), with model fit evaluated using the leave-one-out approach with which the expected log predictive density is utilized to compare models. From this evaluated set, the top model identified via the leave-one-out criterion was the spline trend model as a function of sample layer grouped by species, with an individual random effect for sample and a global intercept over species, sex, and maturity (Table 7). This model had an R^2 of 0.67 for $\delta^{13}C$, 0.68 for $\delta^{15}N$, and 0.78 for $\delta^{34}S$. Relationships between eye lens layer became more uncertain for larger sharks as layer-specific sample sizes decreases with layer number (Fig. 14).

<u>Significant deviations:</u> We did not collect a sufficient sample size for late juvenile and adult Carolina hammerheads to statistically compare element concentrations between species for these life stages. Through continued sampling for other grants, we hope to opportunistically bolster the number of older Carolina hammerheads for future analyses.

Objective 5: Use established nursery signatures to assign juvenile and adult hammerheads to nurseries along the east coast of the U.S. (nursery contribution).

Accomplishments: Nursery signatures were determined from element:Ca ratios calculated from the transect between the birthmark to edge of scalloped hammerhead YOY vertebrae. These signatures were compared between hammerheads caught at three main nursery areas along the southeast U.S. coast: Bulls Bay, Tolomato River and Cape Canaveral. Carolina hammerheads were excluded from tests due to significant differences in Mg:Ca and Mn:Ca ratios compared to scalloped hammerheads (ANOVA, $F_1 = 6.605$, $p = 0.02$ and $F_1 = 15.62$, $p<0.001$, respectively) as well as small sample sizes of Carolina hammerheads outside of Bulls Bay (n = 0 from Tolomato River, n = 3 caught in Cape Canaveral).

A Random Forest Analysis was employed to determine if nursery origin for scalloped hammerhead individuals could be predicted based on their element:Ca nursery signatures. A preliminary random forest analysis was performed to evaluate the accuracy of the model and define the model with the lowest out of bag error rate, which was 28.1%, suggesting a classification success of 71.9%. This model was then used for a classification random forest analysis conducted on juvenile and adult individuals, which predicted that 95% of these older hammerheads originated from Bulls Bay nursery, while only 4.4% and 0.06% originated from Tolomato River and Cape Canaveral, respectively. This highlights the importance of Bulls Bay as the main hammerhead nursery along the southeastern U.S. coast.

Significant deviations: Goals of this objective were met.

Objective 6: Analyze trace element concentrations and isotopic signatures to determine if ontogenetic shifts in habitat use occur in Carolina and scalloped hammerheads.

Accomplishments: Differences within trace element concentrations across life stages can indicate a shift in habitat use or diet with growth. Concentrations of certain elements are associated with environmental and ecological variables such as salinity (Sr and Ba), temperature (Ba and Mg) and diet (Mn) (Livernois et al. 2021). Sr and Ba generally increase and decrease, respectively, with increasing salinity (Dorval et al. 2005, Elsdon et al. 2008) and may be considered as proxies for salinity history in elasmobranch vertebrae (McMillan et al. 2017). Mg has been found to decrease with increasing temperature in elasmobranchs (round stingrays; Smith et al. 2013), while dietary sources are thought to be the driving factor for varying Mn concentration in elasmobranch vertebrae as opposed to ambient environmental conditions (Mathews and Fisher 2009). A bio-reduction of Li concentration in organisms occurs along trophic level and therefore organisms at higher trophic levels tend to have lower Li concentrations (Thibon et al. 2021).

The notable shifts in total element concentrations between maturity stages of Carolina and scalloped hammerheads (particularly in Sr:Ca ratios) indicates movement out of nursery areas after their first year of life and subsequent changes in habitat between EJ and mature individuals. The steady increase in Sr from YOY to adults signifies movement from lower to higher salinity waters, or estuarine to coastal and offshore waters. Similar Sr and Ba concentrations in YOY sharks reflect shared nursery areas between species.

Another way to assess possible habitat shifts in respect to salinity is to look at Sr:Ba ratios across the vertebra transect in relation to life stages, in which a higher Sr:Ba signal indicates higher salinity habitat. Though Carolina and scalloped hammerheads have very similar average IU signatures (measured from the focus to the birthmark) for Sr and Ba, a change in concentration within the IU vertebra section may be seen as the Sr:Ba ratio is tracked in respect to distance along the transect. Plots of Sr:Ba signal (average calculated from the raw element counts) along the IU section transect revealed similar patterns for scalloped and Carolina hammerheads (Figure 12). Sr:Ba signal showed an initial overall increase from the focus until both species reached relatively similar levels of Sr:Ba signal just before the birthmark, though Carolina had a higher ratio at the peak, which then decreased at a similar time before parturition. The higher Sr:Ba ratios before birth reflect the maternal environment, which suggests gestation mostly occurs in offshore waters. The decrease in Sr:Ba before parturition suggests the pregnant females migrate closer to the coast to give birth, and the lower Sr:Ba ratios after birth reflect the shared estuarine nursery habitat of the newborn hammerheads.

The Sr:Ba ratio pattern after the birthmark reveals a species-specific pattern in habitat use (Figure 17). The initial decrease immediately after birth once again reflects the nursery signal, but then the Carolina and scalloped hammerhead Sr:Ba ratios diverge soon after the nursery signal in the early juvenile stage. The divergence is followed by an increase in ratio for both species, though the Carolina hammerhead ratio increases steeply until the late juvenile stage where it remains relatively stable through the late juvenile and adult stages. Scalloped hammerhead Sr:Ba ratio had a steadier and more gradual increase that continues through the late juvenile stage and begins to stabilize in the adult stage.

For eye lens data, we generated median sex- and maturity-specific predictions of the $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ as a function of sample layer for each hammerhead species. This was done for sample layers in increments of 0.1 (normal-space) for the range of sample layers measured for a given species, sex, and maturity block (Figure 15). Patterns seen in model predictions are similar to those revealed in the marginal effects plots (Figure 14). Eye lens $\delta^{13}C$ tended to increase ontogenetically for each species, although for scalloped hammerheads the increase is monotonic and nearly linear, while for Carolina hammerheads $\delta^{13}C$ decreased from layers 2 through 6 after an initial increase, and then increased again after layer 6. Hybrid individuals showed a rapid increase in $\delta^{13}C$ until layer 4, then a plateau thereafter. It is unclear what explains the divergent pattern for hybrid animals, especially given it is only based on data from two mature males. For the Carolina and scalloped samples, the $\delta^{13}C$ suggest a marine phytoplankton-based food web throughout life, although the increase in $\delta^{13}C$ for scalloped hammerheads later in life may suggest residency in more oceanic waters later in life. Alternatively, trophic fractionation may also account for some of the increase in $\delta^{13}C$ in later eye lens layers.

<u>Significant deviations:</u> Not applicable. Goals of this objective were met.

<u>Objective 7:</u> Determine the extent of spatial segregation and habitats used by the two species.

<u>Accomplishments</u>: Elemental concentrations were compared inter- and intra-specifically within each vertebral life stage section. Differing values of multiple elements which serve as environmental indicators across life stages of Carolina and scalloped hammerheads reveal different habitat use patterns throughout their lifespan.

Carolina and scalloped hammerheads share nursery habitats along the southeastern U.S. coast (Barker et al. 2021), which is reflected in similar Sr:Ca and Ba:Ca ratios in the YOY vertebrae life stage (Figure 11A-D) as well as similar Sr:Ba ratios in the YOY vertebrae section

(Figures 16 and 17). A relatively low Sr:Ba ratio after birth and in the beginning of the early juvenile stage indicates both species live in estuarine and/or nearshore habitats. A steeper increase in ratio concentration at a smaller distance from the birthmark for Carolina hammerheads suggests that they migrate to higher salinity or offshore waters at a younger age than scalloped hammerheads (Figure 17), which is supported by the higher Sr:Ca ratio in the early juvenile stage compared to scalloped hammerheads (Figure 8A). Carolina hammerheads had a consistently higher Sr:Ba ratio throughout the late juvenile stage, which is supported by a lower Ba:Ca concentration in that stage compared to scalloped hammerheads (Figure 9A). Although there was only 1 adult Carolina hammerhead caught, the Sr:Ba ratio pattern suggests that mature Carolina hammerheads may occupy higher salinity habitats (i.e. further offshore) than scalloped hammerheads.

Mg concentrations in elasmobranch vertebrae are associated with temperature, in which Mg can decrease with temperature (Smith et al. 2013). Temperature also negatively affects incorporation of Ba, and positively affects incorporation of Mn (Smith et al. 2013, Pistevos et al. 2019). Carolina hammerheads consistently had higher Mg:Ca concentrations throughout the vertebral life stages and had higher Mn:Ca ratios in the IU, YOY and EJ stages compared to those of scalloped hammerheads. Ba:Ca was found to have a species-specific difference only in the late juvenile stage, in which Carolina hammerheads had a significantly lower concentration. Taken together, there is conflicting evidence regarding temperature in relation to potential habitat. Temperature gradients exist with water depth, latitude and distance from the coast. Since hammerheads often forage at different depths and movement of older hammerheads off the southeastern U.S. coast is unknown, their habitat patterns are difficult to discern due to temperature.

Mn and Li are thought to be incorporated into elasmobranch vertebrae via dietary sources (Mathews and Fisher 2009, Thibon et al. 2021), with decreasing Li concentrations suggesting higher trophic levels. YOY hammerheads share similar dietary habits in Bulls Bay (Galloway et al. 2024 *in press*), but a significant difference in the Mn nursery signature between species within Bulls Bay (Mann-Whitney, $p < 0.01$) suggests a slight difference in diet with a higher Mn concentration in Carolina hammerheads. This pattern is similar in the IU and EJ vertebrae sections. Carolina hammerheads had a significantly lower Li:Ca than that of scalloped for IU, YOY and EJ vertebrae sections, which is indicative of feeding at a higher trophic level. The single adult Carolina hammerhead had a lower Li as well but was could not be compared statistically. Dietary patterns are often related to habitat, as certain prey items reside in specific habitats. The diet of hammerheads older than YOY has not yet been explored off the southeastern U.S. coast, but with the Sr:Ba ratio divergence in early juveniles and significantly different concentrations of Mn and Li for younger sharks, Carolina and scalloped hammerheads may feed in different habitats as they move out of the nursery grounds into coastal waters.

For stable isotope data, trends in $\delta^{15}N$ are fairly similar among species. Core $\delta^{15}N$ values start relatively high (e.g., 13.5-14.0‰) and then decline rapidly through layer 2. This is likely due to maternal effects during gestation for these fish, with early juvenile sharks feeding at nearly a full trophic level below adults. Eye lens $\delta^{15}N$, hence trophic position, tended to increase for individual scalloped and hybrid hammerheads throughout life, while $\delta^{15}N$ plateaued for Carolina individuals after eye lens layer 4. Perhaps that pattern, as well as the pattern observed in $\delta^{13}C$, indicates a more coastal existence for Carolina hammerheads that persist on a diet of lower trophic-level prey than either scalloped or hybrid hammerheads. That said, as we obtain additional samples, these results may change as this contrasts with the pattern observed in the trace element data.

Eye lens $\delta^{34}S$ data and predicted trends tend to follow the same pattern observed in the $\delta^{15}N$ data. This includes a rapid decline following birth, and a nadir at layers 1 or 2, and then increasing values thereafter. The value of ~18‰ observed in lens cores and layers >6 suggest trophic contributions from water column versus more benthic prey (Tarnecki and Patterson 2015; Fry 2006). This pattern is consistent among species, despite the plateauing of eye lens $\delta^{15}N$ for Carolina hammerheads after layer 4. The data suggest the Carolina fish shift to more pelagic prey after their first few years of life, but that shift is not concurrent with a shift to higher trophic level prey. One caveat to that interpretation is that if Carolina hammerheads are fully oceanic, their lower $\delta^{15}N$ values later in life, relative to the either scalloped or hybrid individuals, could be due to the prevalence of diazotrophy in oceanic waters where nutrients, particularly N, are limiting (Brandes and Devol 2002; Capone et al. 1997).

Significant deviations: Not applicable. Goals of this objective were met.

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Tables:

Processed paired samples: vert and eye			
	NC	SC	FL
Carolina	0		0
YOY	0	4	0
Juvenile	6	0	0
Adult	0	1	0
Scalloped			
YOY	0	8	1
Juvenile	19	1	0
Adult	11	1	0
Hybrid			
Adult	1	0	0
Total	37	15	1

Table 1. Paired vertebrae and eye samples from various life stages (young-of-year (YOY), juvenile and adult) of Carolina and scalloped hammerheads collected from North Carolina (NC), South Carolina (SC) and Florida (FL).

	YOY	EJ	LJ	AD	Total
Carolina Hammerhead	28	11	1	1	41
Scalloped hammerhead	49	12	5	12	78
Total	77	23	6	13	119

Table 2. Carolina and scalloped hammerhead sample sizes across maturity stages (young-of-year (YOY), early juvenile (EJ) late juvenile (LJ) and adult (AD)) that were analyzed for overall vertebrae transect concentration (i.e. total transect concentration).

Species	Life stage	Sex	n	Mean age y	Age range y	Mean eye lens layers	Eye lens layer range
CHH	YOY early	F	6	0.0	–	1.0	–
CHH	YOY early	M	5	0.0	–	1.0	–
CHH	YOY late	F	15	0.0	–	1.0	–
CHH	YOY late	M	14	0.0	–	1.0	–
CHH	early juv	F	6	2.0	–	1.7	1–3
CHH	early juv	M	5	2.2	1–3	2.4	2–4
CHH	mid juv	F	2	4.0	–	3.0	2–4
CHH	mid juv	M	0				
CHH	late juv	F	0				
CHH	late juv	M	0				
CHH	late juv-mature	F	0				
CHH	late juv-mature	M	0				
CHH	mature	F	0				
CHH	mature	M	2	17.5	12–23	11.0	–
SHH	YOY early	F	8	0.0	–	1.0	–
SHH	YOY early	M	6	0.0	–	1.0	–
SHH	YOY late	F	10	0.0	–	1.0	–
SHH	YOY late	M	15	0.0	–	1.0	–
SHH	early juv	F	2	2.5	2–3	3.0	2–4
SHH	early juv	M	4	2.5	2–3	3.3	2–5
SHH	mid juv	F	3	6.3	4–7	5.3	5–6
SHH	mid juv	M	5	5.0	4–6	5.0	4–6
SHH	late juv	F	1	11.0	–	11.0	–
SHH	late juv	M	2	7.0	6–8	6.5	6–7
SHH	late juv-mature	F	0				
SHH	late juv-mature	M	4	9.3	7–11	7.3	6–9
SHH	mature	F	0				
SHH	mature	M	13	21.9	10-39	10.5	7–13
Hybrid	YOY early	F	0				
Hybrid	YOY early	M	0				
Hybrid	YOY late	F	1	0.0	–	1.0	–
Hybrid	YOY late	M	2	0.0	–	1.0	–
Hybrid	early juv	F	1	1.0	–	2.0	–
Hybrid	early juv	M	1	2.0	–	2.0	–
Hybrid	mid juv	F	0				
Hybrid	mid juv	M	1	4.0	–	4.0	–
Hybrid	late juv	F	0				
Hybrid	late juv	M	0				
Hybrid	late juv-mature	F	0				
Hybrid	late juv-mature	M	0				

Hybrid	mature	F	0				
Hybrid	mature	M	2	27.0	25–29	8.5	7–10

Table 3. Age and eye lens layer descriptive data for Carolina, scalloped, and hybrid hammerhead samples analyzed for eye lens protein d[13]C, d[15]N, and d[34]S.

	n	Total
Scalloped		133
YOY	56	
EJ	47	
LJ	12	
AD	18	
Carolina		47
YOY	31	
EJ	14	
LJ	1	
AD	1	
Hybrid		1
AD	1	
Total		181

Table 4. Genetically identified Carolina and scalloped hammerhead counts across maturity stages (young-of-year (YOY), early juvenile (EJ) late juvenile (LJ) and adult (AD)).

		Vertebrae sections				
Species	Maturity stage	IU	YOY	EJ	LJ	AD
Carolina	YOY	16	16	16	16	16
	EJ	12	12	12	12	12
	LJ	1	1	1	1	1
	AD	1	1	1	1	1
	Total	**30**				
Scalloped	YOY	22	22	22	22	22
	EJ	44	44	44	44	44
	LJ	10	10	10	10	10
	AD	12	12	12	12	12
	Total	**88**				

Table 5. Sample size of Carolina and scalloped hammerhead individuals used for each vertebrae life stage analysis (vertebrae sections) and across maturity stages. For both maturity stage and vertebrae section: IU = in-utero, YOY = young-of-year, EJ = early juvenile, LJ = late juvenile and AD = adult or mature.

	NC	SC	GA	FL	Total
Carolina	11	15	1	3	30
YOY		13		3	16
EJ	10	1	1		12
LJ	1				1
AD		1			1
Scalloped	45	31	3	9	88
YOY		14		8	22
EJ	39	1	3	1	44
LJ	6	4			10
AD		12			12
Total	56	46	4	12	118

Table 6. Carolina and scalloped hammerhead sample sizes across maturity stages (young-of-year (YOY), early juvenile (EJ) late juvenile (LJ) and adult (AD)) and collected from North Carolina (NC), South Carolina (SC) and Florida (FL) that were analyzed by vertebrae life stage.

Trend structure	Trend covariate	Trend grouping	Intercept
Spline	Sample layers	Species	Species + Sex + Maturity
Spline	Sample layers	Species + Sex + Maturity	Pooled
Spline	Sample layers	Species	Ind. Random Effect
Spline	Sample layers	Species	Species + Sex + Maturity + Ind. RE

Table 7. Candidate Bayesian regression models fitted to hammerhead shark species $d^{13}C$, $d^{15}N$, and $d^{34}S$ data to predict the relationship between stable isotope ratios and eye lens layers. The candidate model, depicted in blue font, was evaluated to have the best fit to the data, which was identified via the leave-on-out criterion. It had an individual random effect for sample and a global intercept of species, sex, and maturity.

Figures:

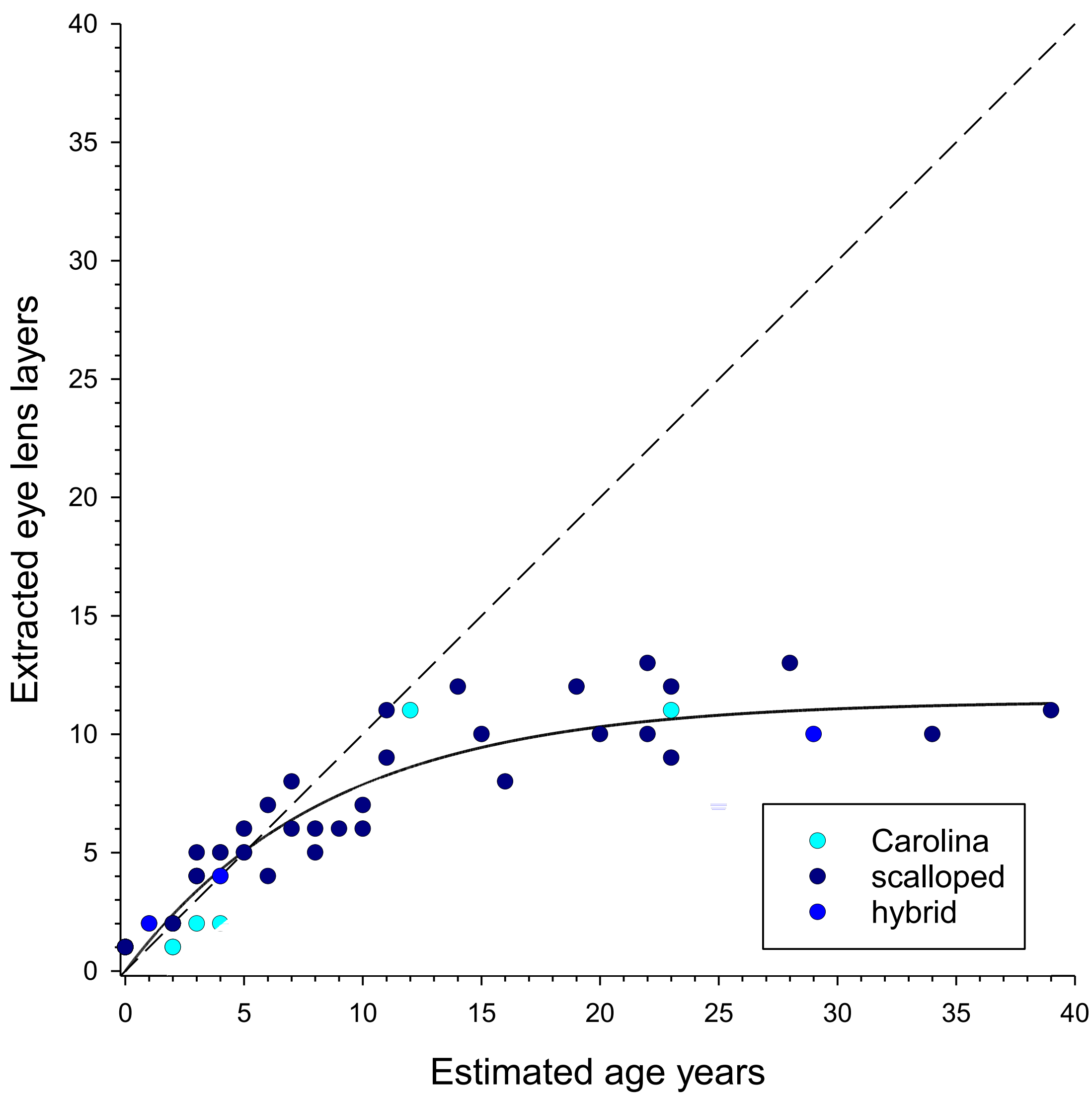
40
35
30
25
20
15
10
5
0
Extracted eye lens layers
0
5
10
15
20
25
30
35
40
Estimated age years
Carolina
scalloped
hybrid

Figure 1. Extracted hammerhead shark eye lens layers analyzed for protein $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ versus estimated age in years. Solid black line is a non-linear regression fitted to the data ($p<0.001$; $R^2 = 0.88$). Shaded gray region indicates 95% prediction intervals. Dashed diagonal line shows line of 1:1 agreement.

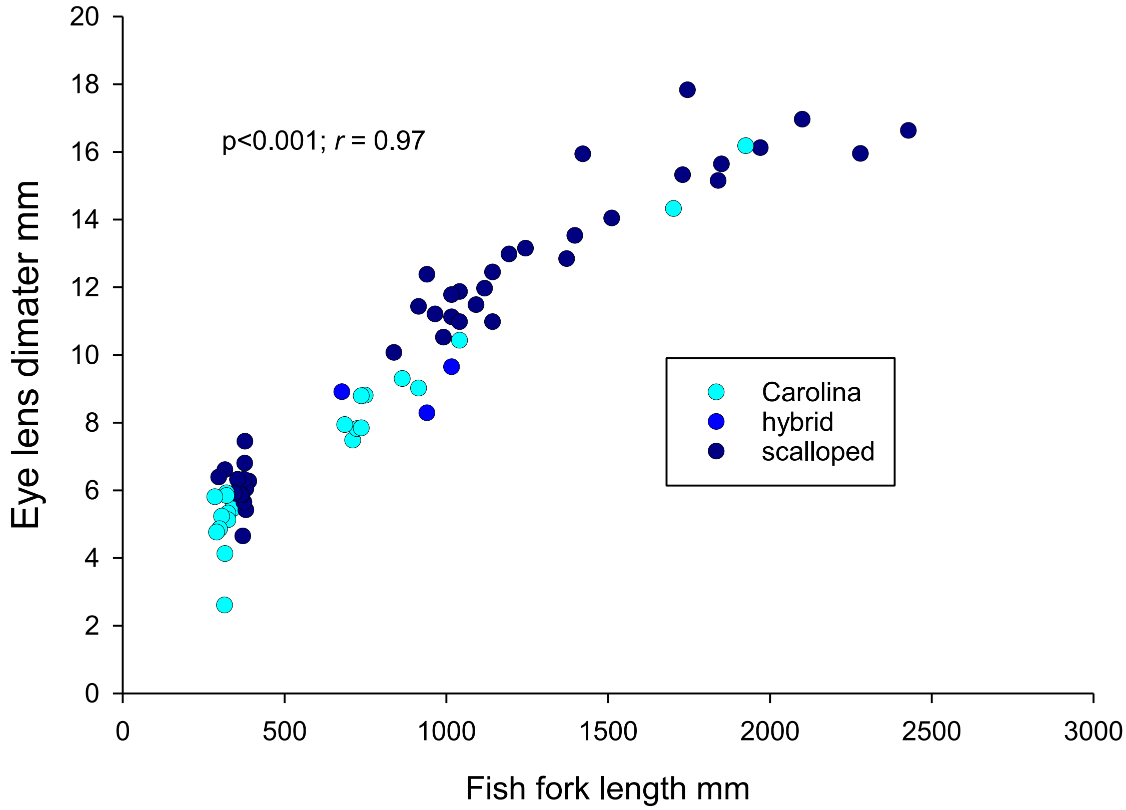

Figure 2. Scatterplot of hammerhead eye lens diameter versus fish fork length. Pearson correlation statistics appear on the panel.

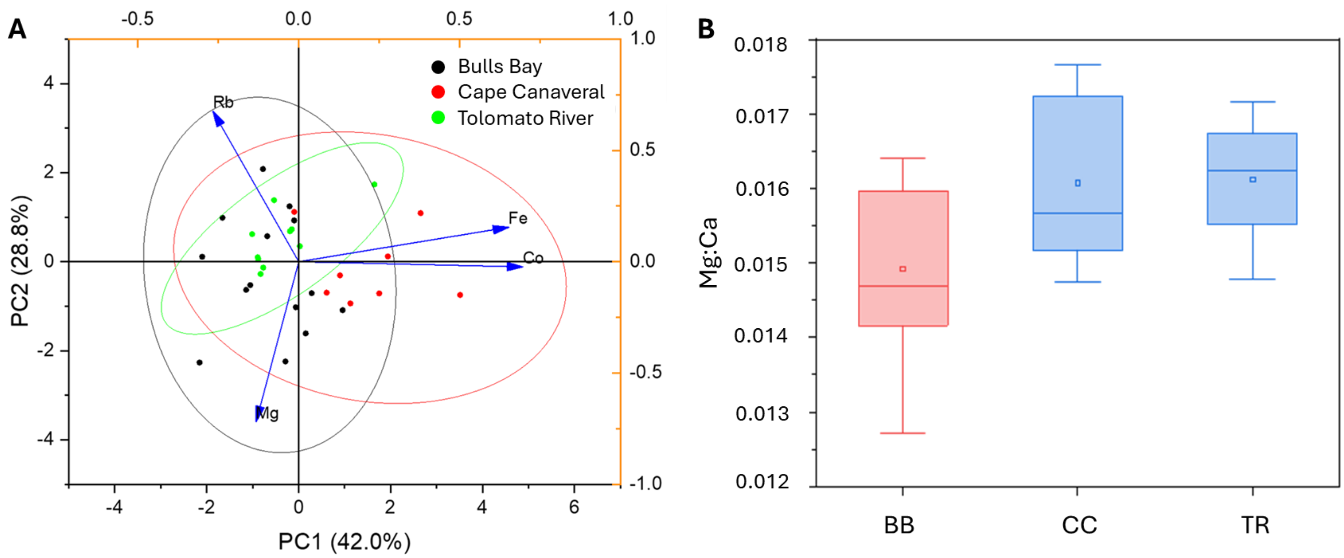

Figure 3: Principal Component Analysis (A) and boxplot (B) of young-of-year scalloped hammerhead vertebrae section element:Ca ratios (µg/g) from Bulls Bay (BB, n = 14), South Carolina, Cape Canaveral (CC, n = 8), Florida, and Tolomato River (TR, n = 11), Florida, nursery areas. Samples were grouped by nursery area. PCA loadings are represented by blue arrows and ellipses represent 95% confidence. Boxplot colors indicate significance between nurseries: the YOY vertebral signature from BB (in red) differs from those from CC or TR (in blue).

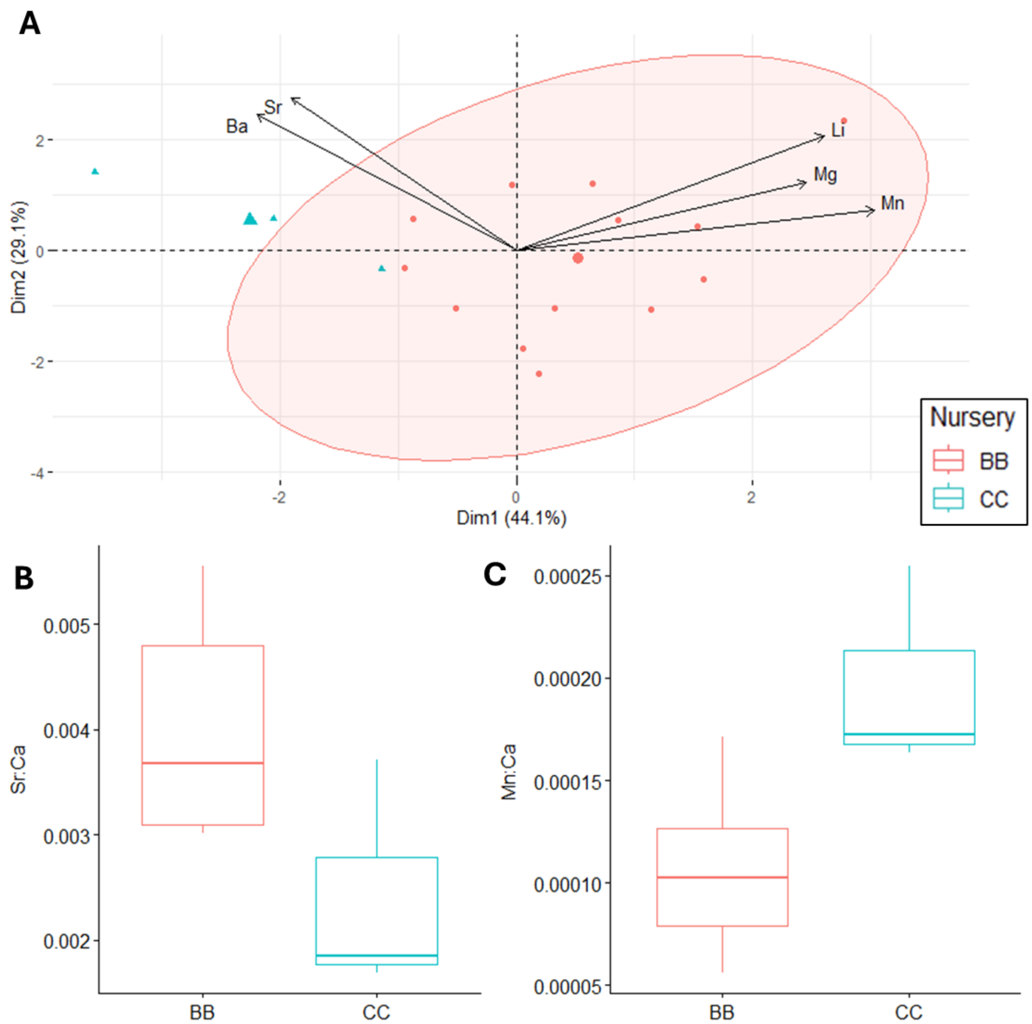

Figure 4. Principal Component Analysis (A) and boxplots (B and C) of YOY Carolina hammerhead nursery vertebrae section element:Ca ratio concentration (Sr:Ca (B) Mn:Ca (C)) that significantly differed between Bulls Bay (BB, n = 13), South Carolina and Cape Canaveral (CC, n = 3), Florida nursery areas. Samples were grouped by nursery area. PCA loadings are represented by black arrows and the ellipse represents 95% confidence (no ellipse was drawn for CC nursery due to small sample size). Element:Ca ratio units are µg/g. Colors indicate nurseries: the YOY vertebral signature from BB (in red) differs from those from CC or TR (in blue).

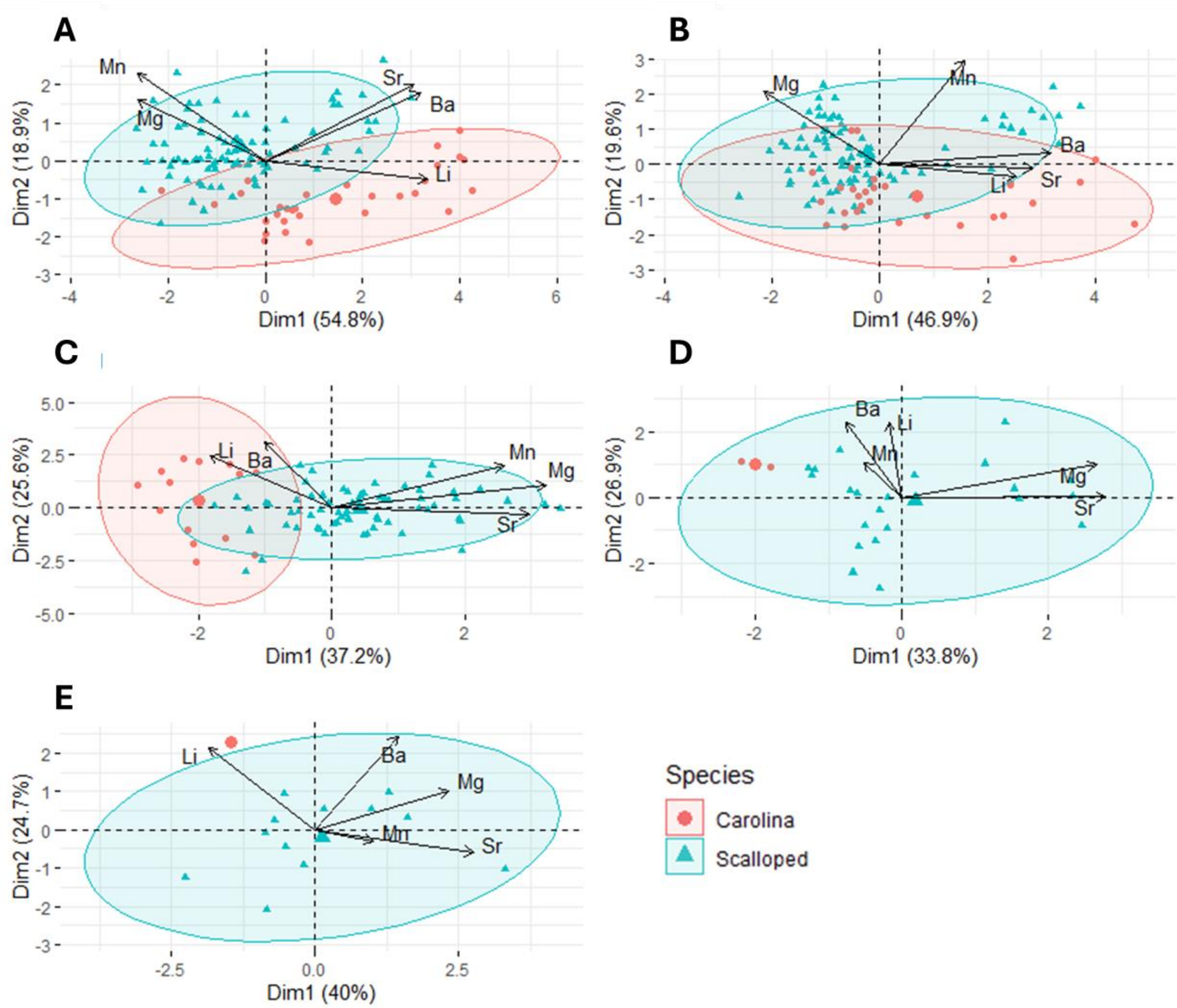

Figure 5. Principal Component Analysis of Carolina and scalloped hammerheads life stage vertebrae section element:Ca ratios. Integrated vertebrae sections for distinct life stage signatures are A) IU (in-utero), B) YOY (young-of-year or nursery), C) EJ (early juveniles), D) LJ (late juveniles) and E) AD (adult). Samples were grouped by species, PCA loadings are represented by black arrows and ellipses represent 95% confidence.

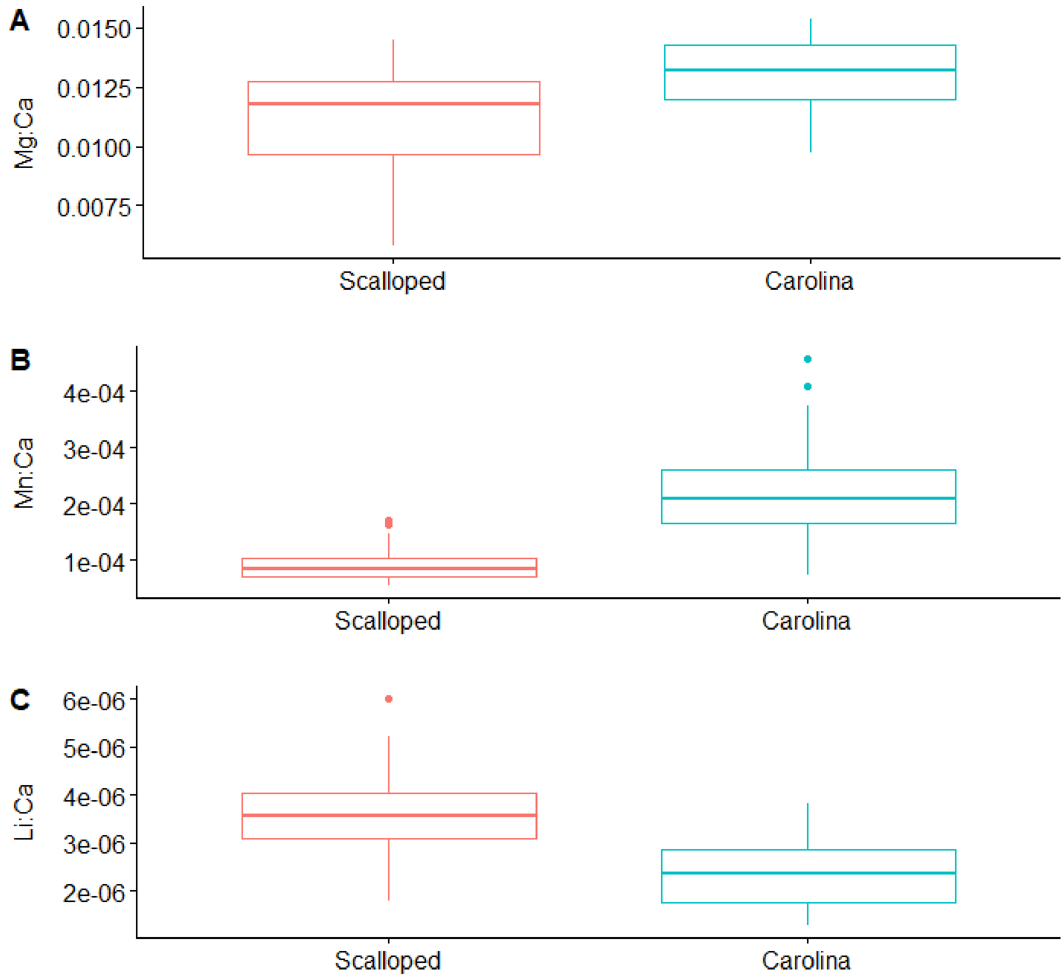

Figure 6. In-utero vertebrae section element:Ca ratio concentrations (µg/g) for A) Mg, B) Mn, and C) Li, that differed between scalloped (n = 88, in red) and Carolina (n = 30, in blue) hammerheads ($p < 0.001$).

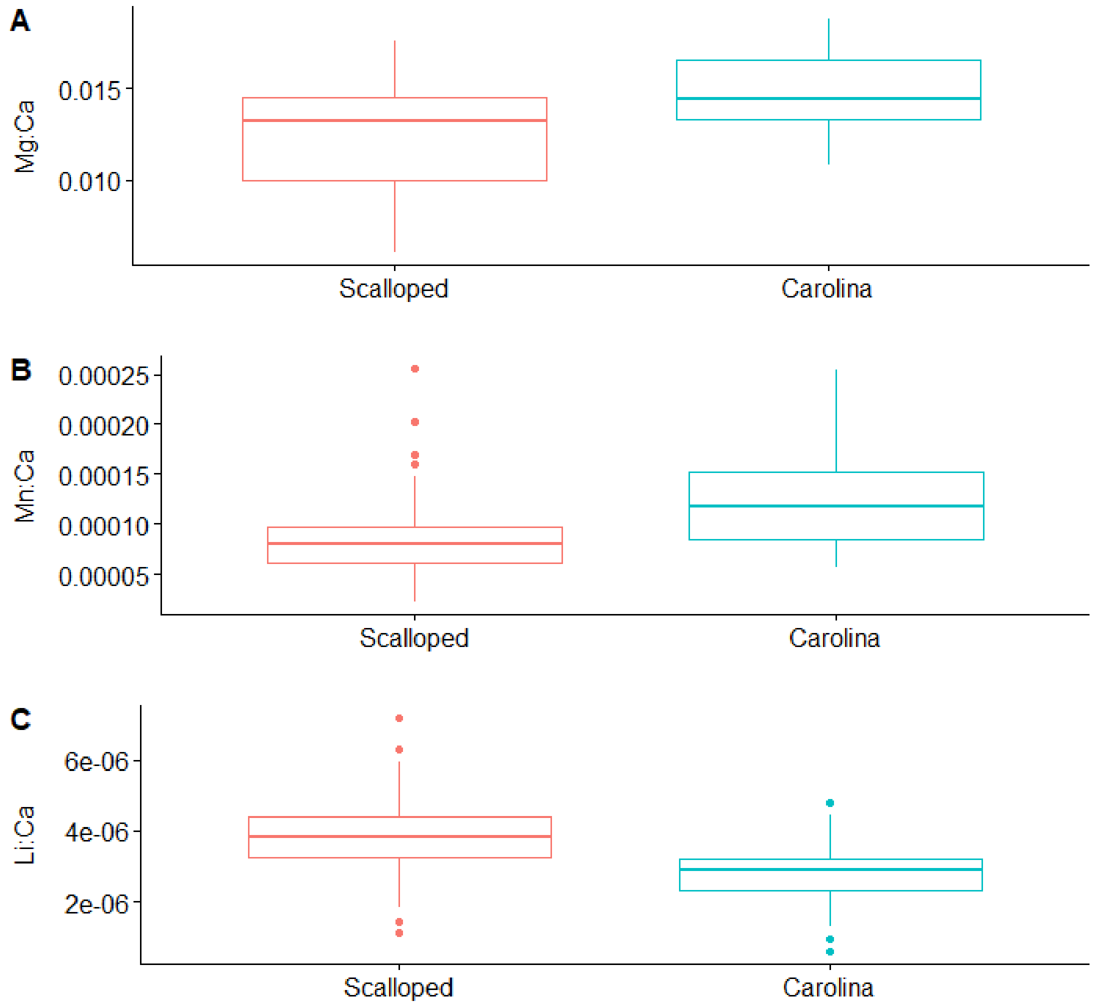

Figure 7. Nursery vertebrae section (YOY) element:Ca ratio concentrations (µg/g) for A) Mg, B) Mn, and C) Li, that differed between scalloped (n = 88, in red) and Carolina (n = 30, in blue) hammerheads ($p < 0.001$).

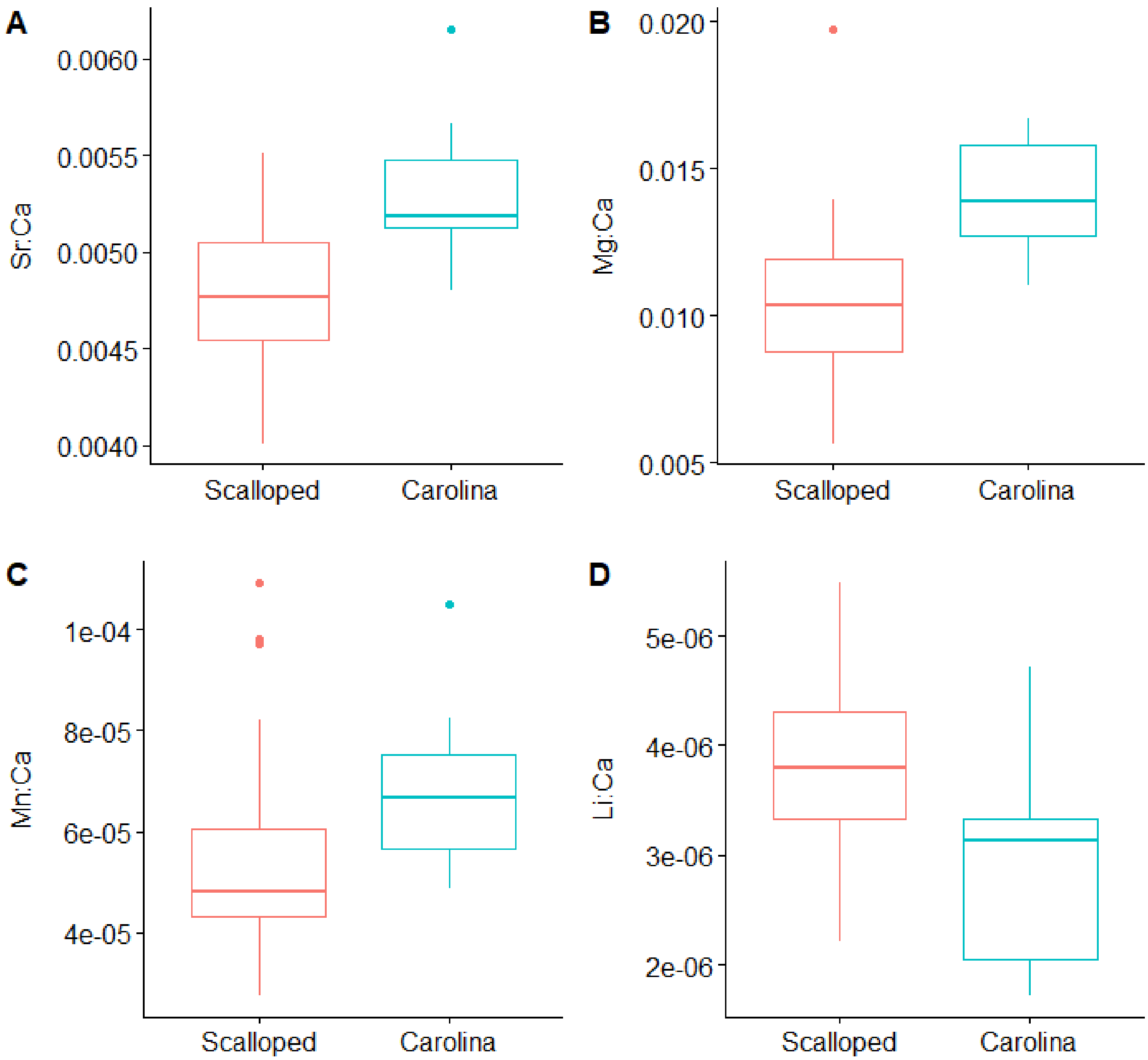

Figure 8. Early juvenile vertebrae section element:Ca ratio concentrations (µg/g) for A) Sr, B) Mg, C) Mn, and D) Li, that differed between scalloped (n = 66, in red) and Carolina (n = 14, in blue) hammerheads ($p < 0.01$).

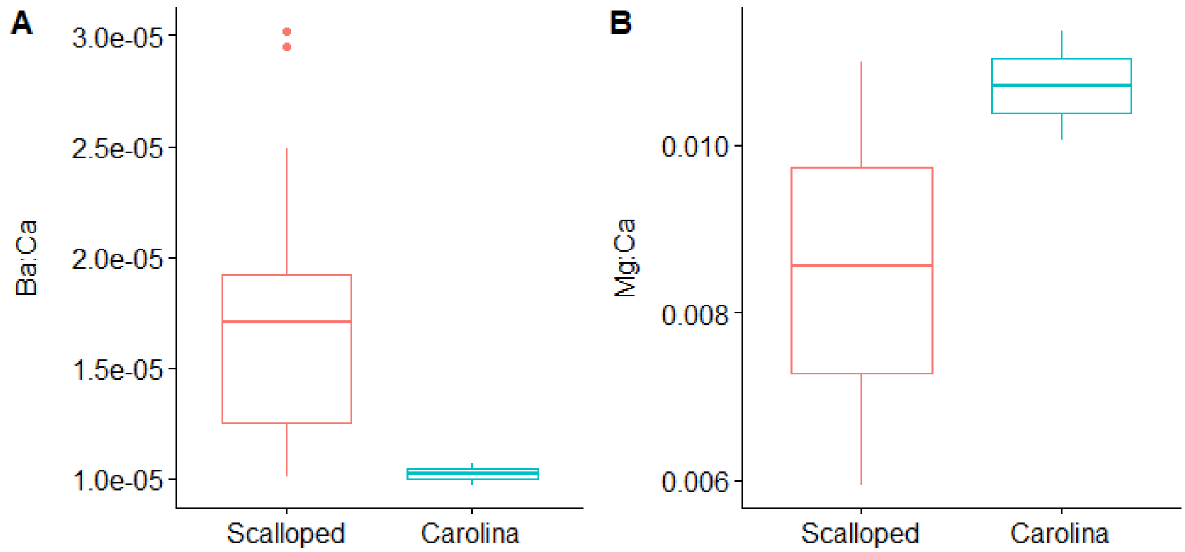

Figure 9. Late juvenile vertebrae section element:Ca ratio concentrations (µg/g) for A) Ba and B) Mg, that differed between scalloped (n = 22, in red) and Carolina (n = 2, in blue) hammerheads ($p < 0.05$).

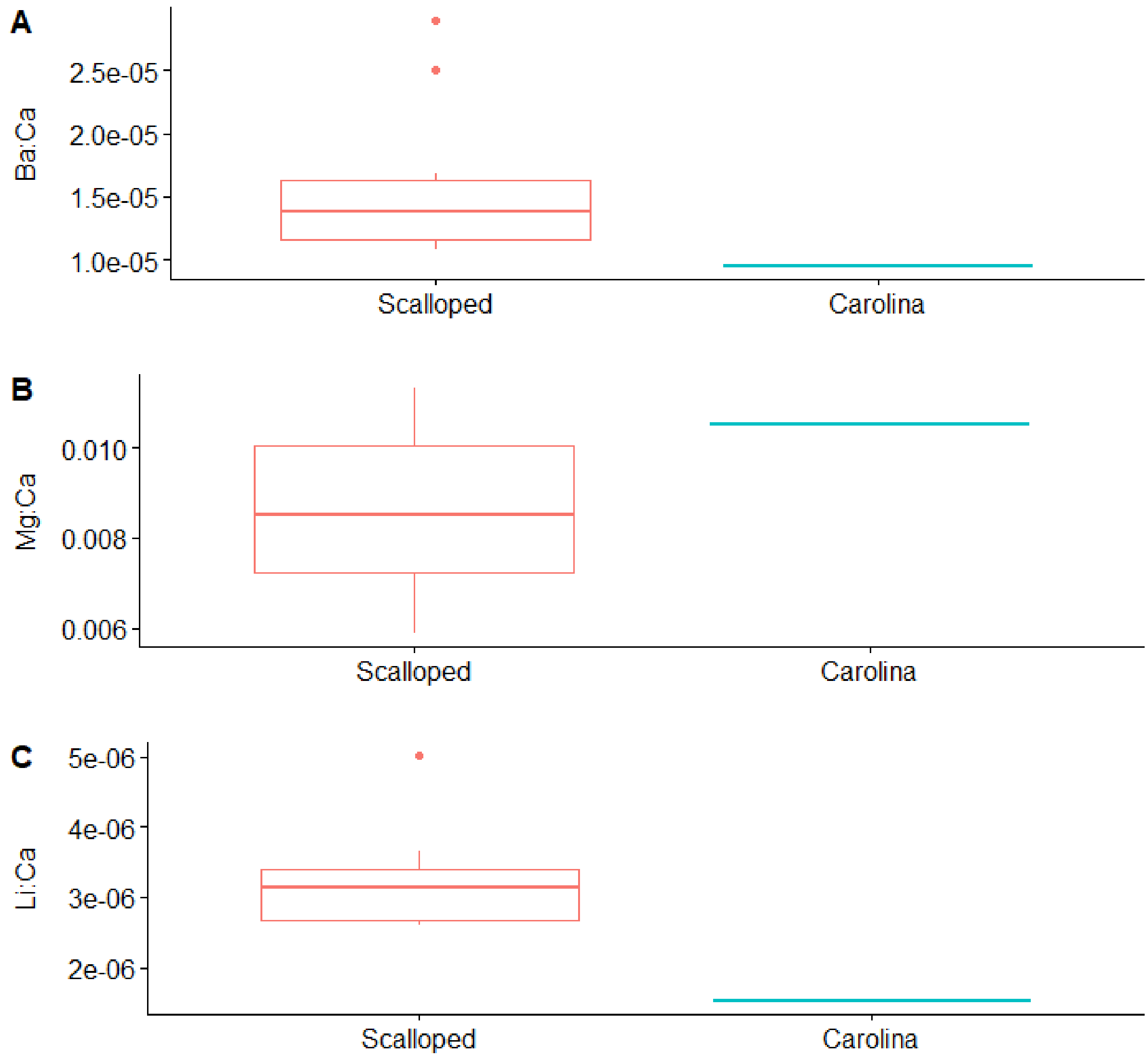

Figure 10. Adult vertebrae section element:Ca ratio concentrations (µg/g) for A) Ba, B) Mg, and C) Li, with potential differences between scalloped (n = 12, in red) and Carolina (n = 1, in blue) hammerheads. Statistical analyses and significance could not be calculated due to the small Carolina hammerhead sample size.

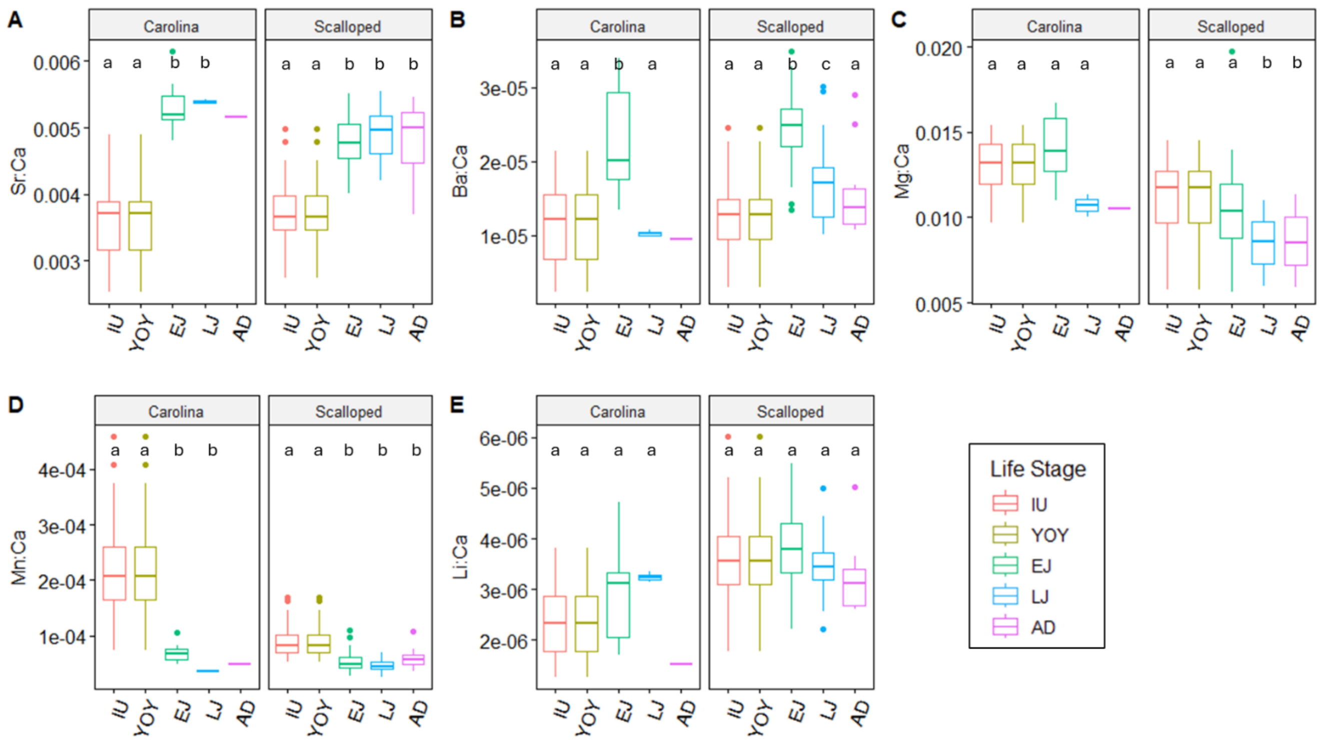

Figure 11. Boxplots of element:Ca ratio concentration (µg/g) differences across integrated vertebrae sections (i.e. life stages) for Carolina and scalloped hammerheads for A) Sr:Ca , B) Ba:Ca, C) Mg:Ca, D) Mn:Ca, and E) Li:Ca. Vertebrae sections denoted by a different letter indicate significant differences between IU, YOY, EJ, LJ or AD vertebrae section element concentration values (Dunn's test, $p < 0.001$). There were no statistical comparisons made between the Carolina hammerhead AD vertebrae life stage since there was only 1 individual.

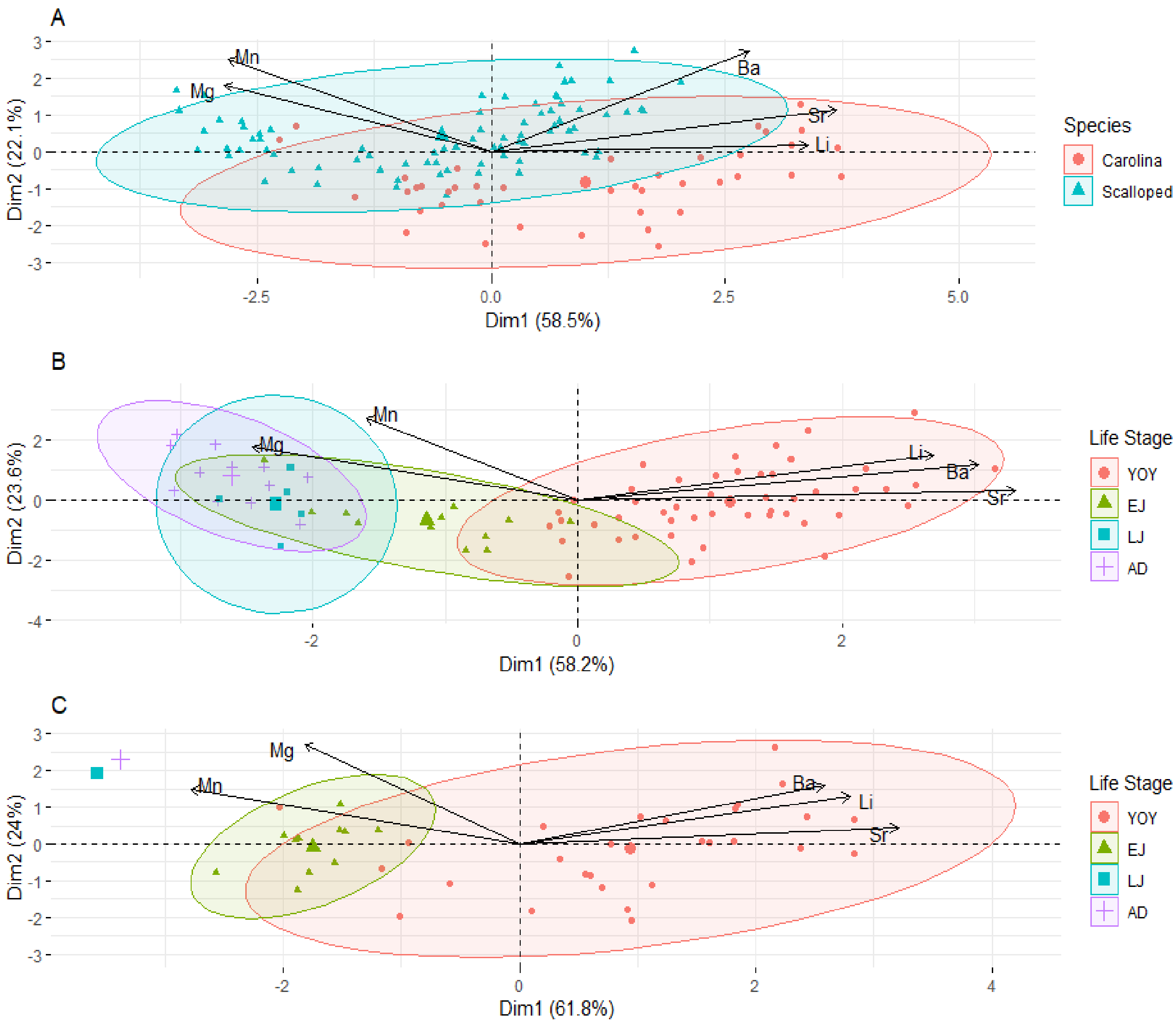

Figure 12. Principal Component Analysis of overall vertebrae transect element:Ca ratios grouped by hammerhead species (panel A) and scalloped (panel B) and Carolina (panel C) hammerhead vertebrae transect element:Ca ratios grouped by hammerhead maturity stage (YOY or young-of-year, EJ or early juvenile, LJ or late juvenile and AD or adult). Element concentration loadings are represented by black arrows and ellipses represent 95% confidence.

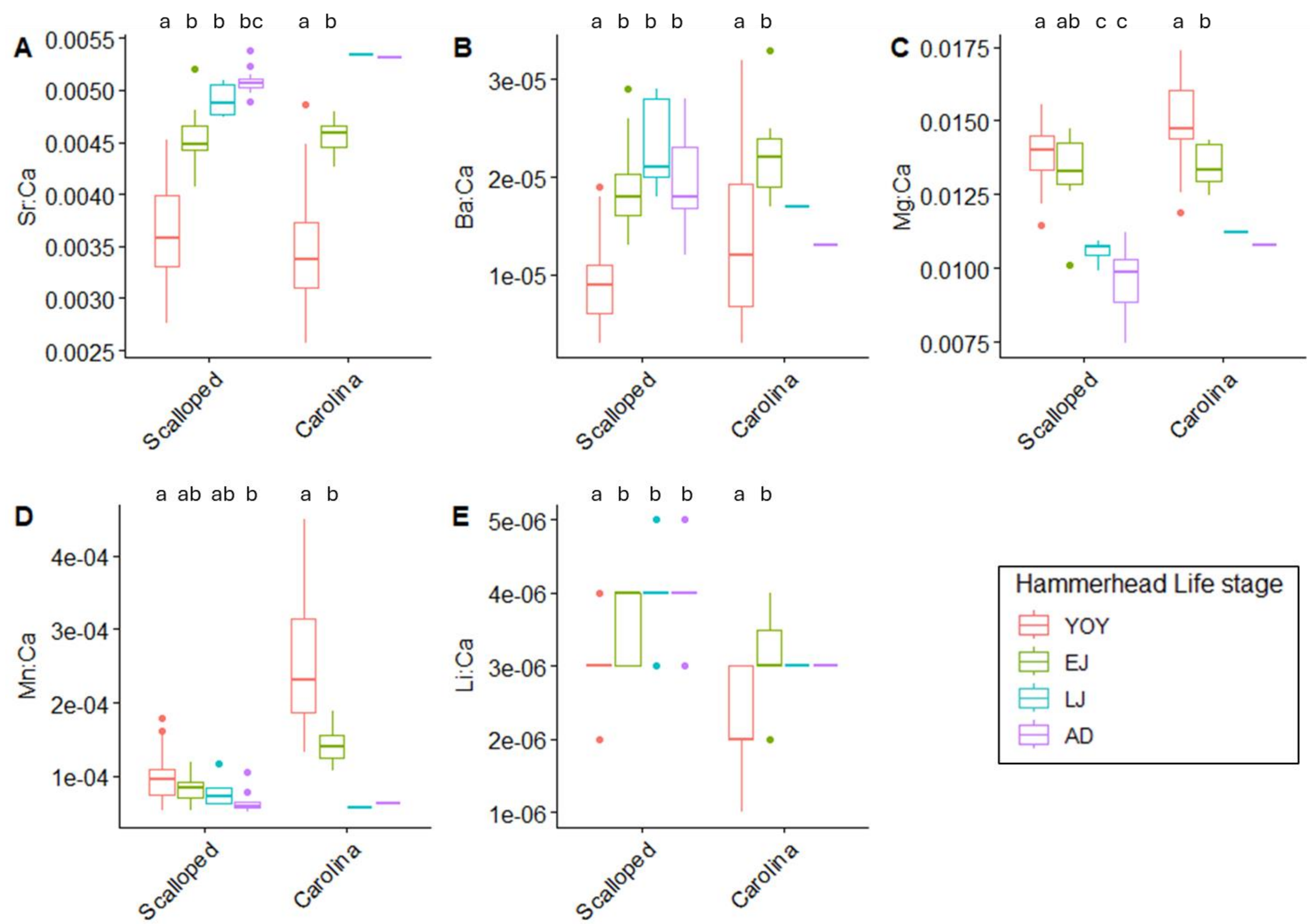

Figure 13. Boxplots of overall vertebrae transect element:Ca ratio concentrations in scalloped and Carolina hammerheads across different maturity stages (young-of-year (YOY), early juvenile (EJ), late juvenile (LJ) and adult (AD)) for A) Sr:Ca, B) Ba:Ca, C) Mg:Ca, D) Mn:Ca, and E) Li:Ca. Vertebrae sections denoted by a different letter indicate significant differences between element concentration values for YOY, EJ, LJ or AD hammerheads (Tukey HSD or Dunn's test, $p < 0.05$). There were no statistical comparisons made between LJ or AD Carolina hammerheads since there was only 1 individual.

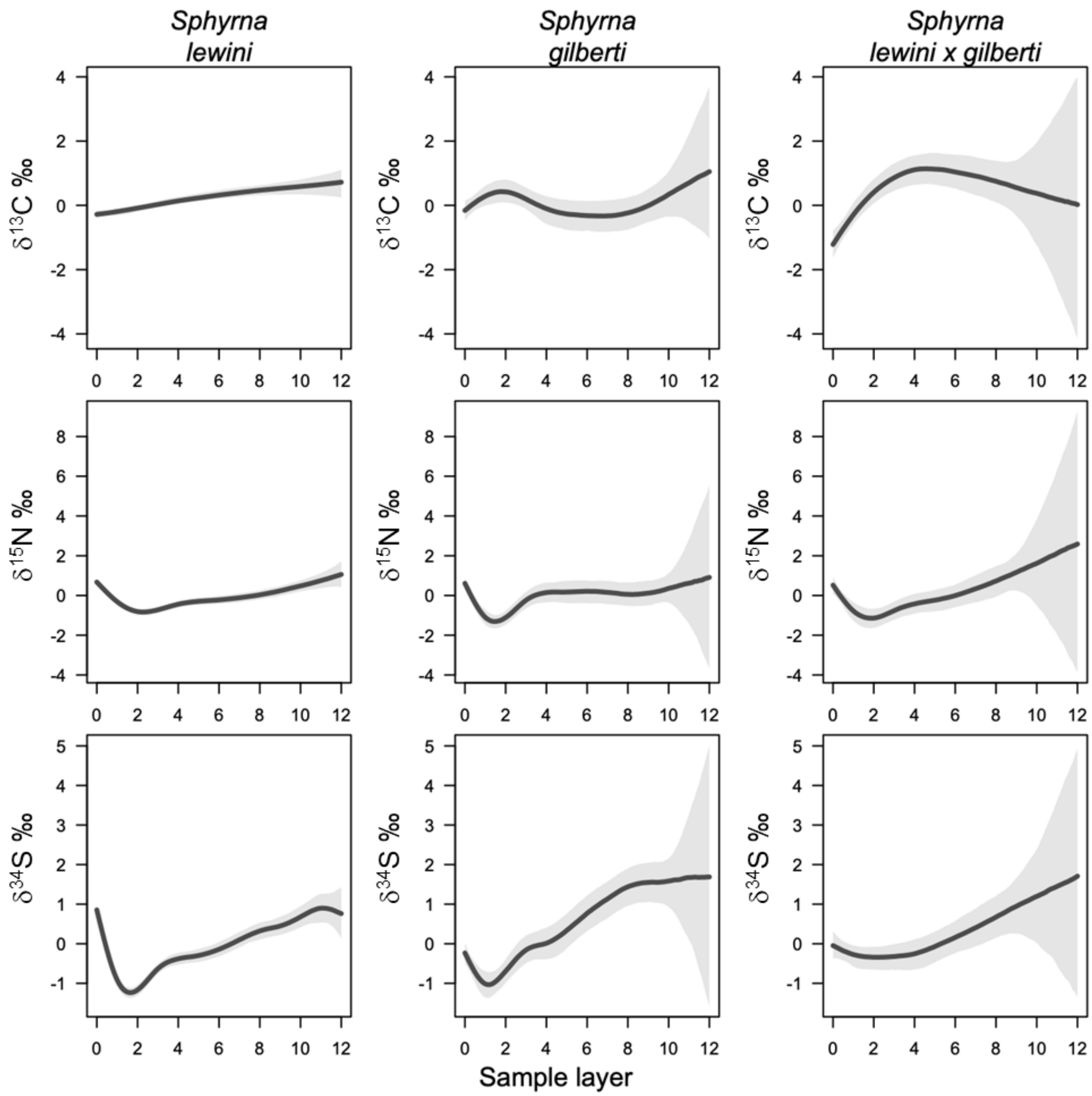

Figure 14. Marginal effect of eye lens sample layer on $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ (rows) by hammerhead species (columns) predicted with Bayesian regression spline models across all life stages. Solid black lines indicate median fit and gray shaded area indicates 95% credible intervals.

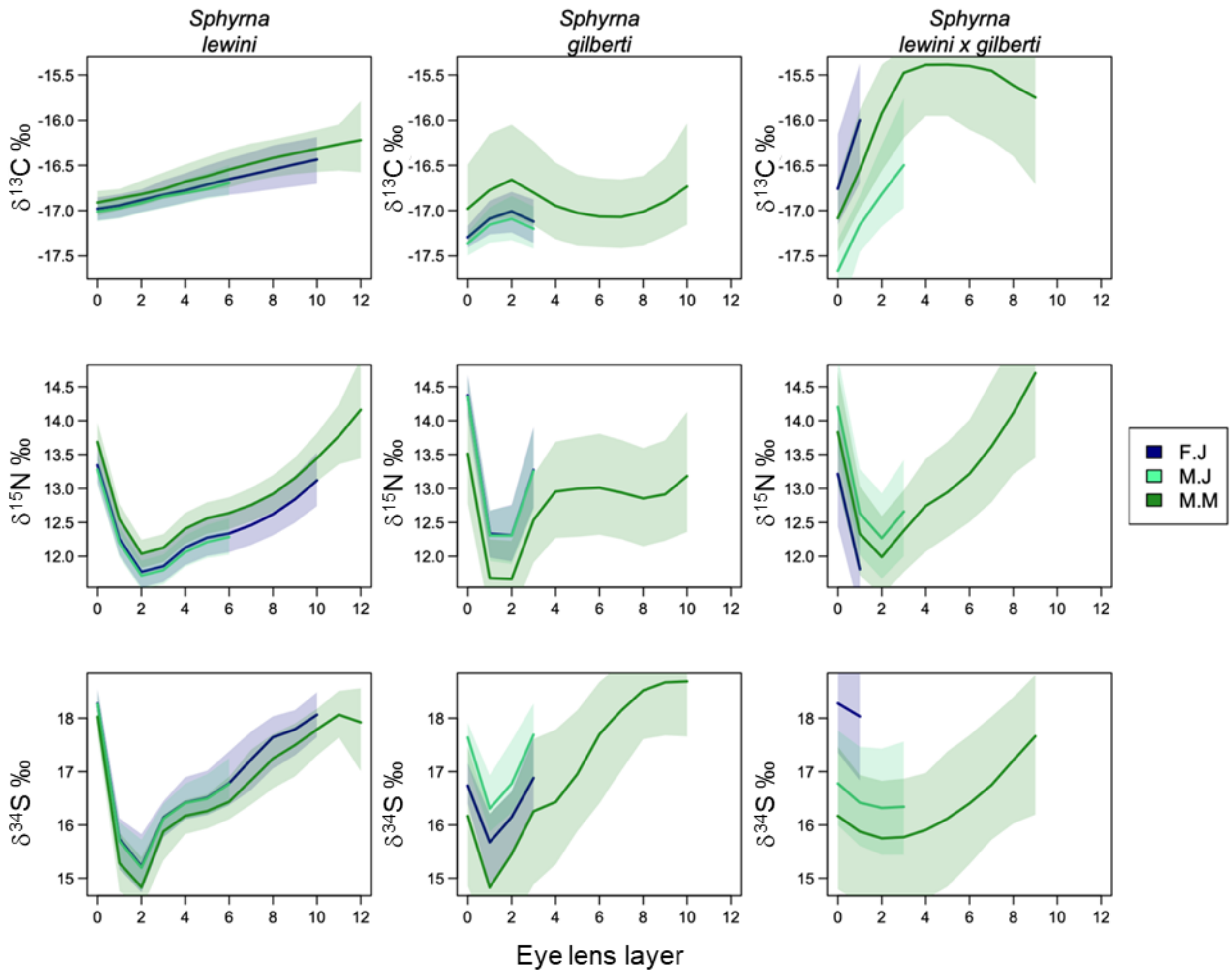

Figure 15: Species-specific hammerhead (columns) Bayesian regression spline models fitted to predict eye lens protein $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ (rows) by species (columns) as a function of eye lens sample layer for different life history and sex groupings. Colors indicate sex (female – F; male – M) and maturity status (juvenile – J, mature – M) of samples. Solid lines indicate model fit; shaded regions indicate 95% credible intervals.

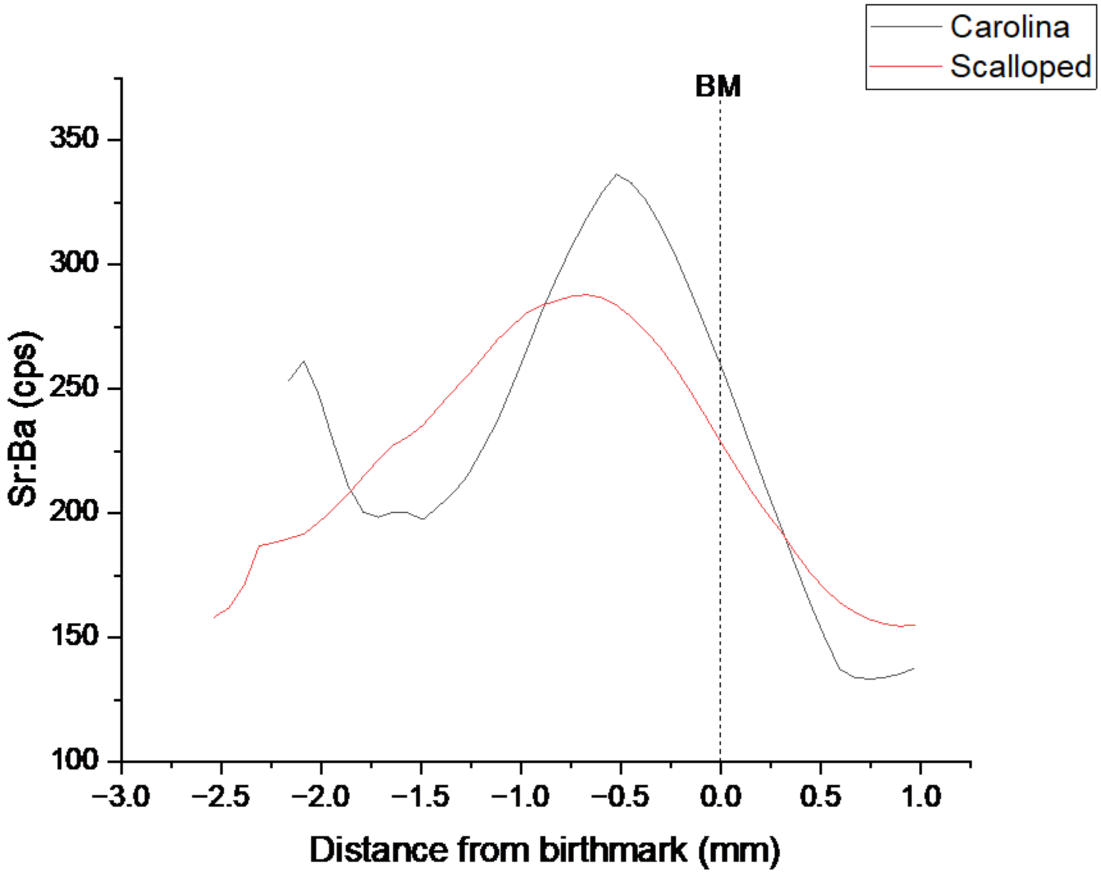

Figure 16: Average scalloped and Carolina hammerhead In-Utero vertebrae section Sr:Ba signal plotted along distance from the birthmark. A 15-point rolling average was conducted on the species average Sr:Ba counts per second. The In-Utero vertebrae section is left of BM. (BM: birthmark)

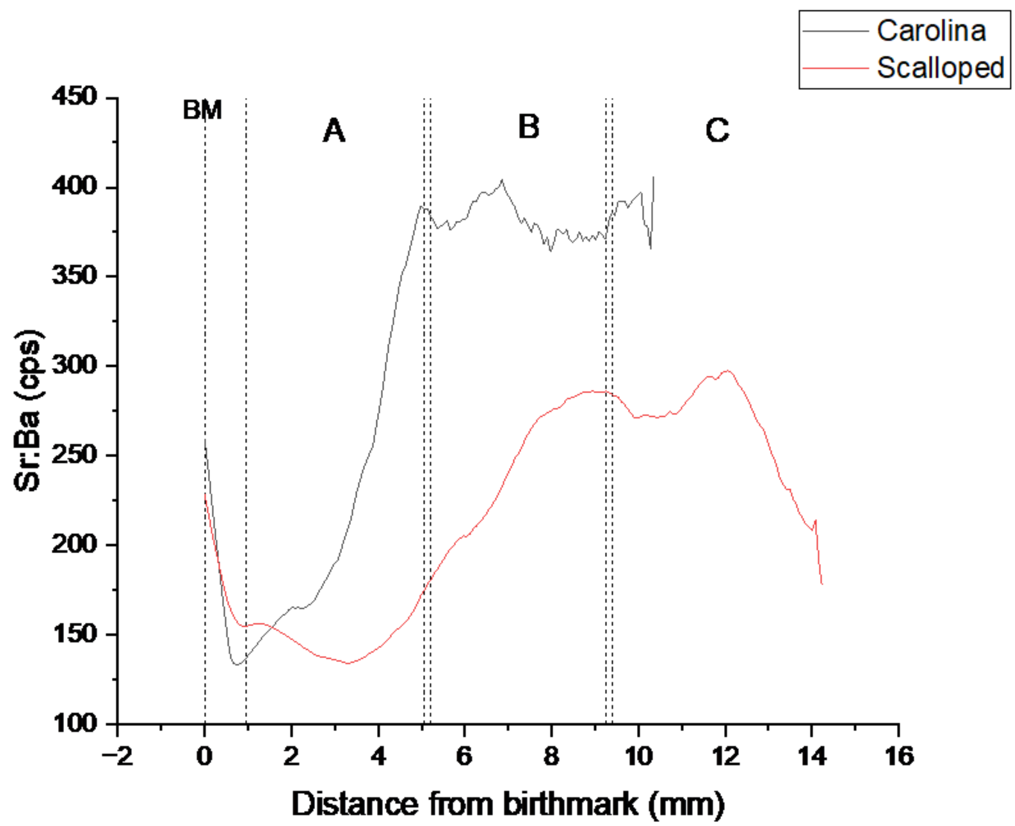

Figure 17: Average scalloped and Carolina hammerhead Sr:Ba signal (calculated from raw element counts) plotted along distance from the birthmark. Vertical dash marks signify distinct life stage vertebrae sections: A) Early Juvenile Vertebrae Section B) Late Juvenile Vertebrae Section C) Adult Vertebrae Section (BM: birthmark).

Supplementary Table 1. Eye lens stable isotope ratio data for Carolina, scalloped, and hybrid hammerheads. Units for fork length (FL) and total length (TL) are mm. YOY = young of the year. Units for layer mass are mg. Layer indicates eye lens layer extracted for analysis; core = layer 0. Units for $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ are ‰.

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$\delta^{13}C$	$\delta^{15}N$	$\delta^{34}S$
SC-3377	2019	CHH	325	423	YOY-early	0	F	30.29	0	17.65	53.59	2.16	3.04	-17.14	15.48	14.09
SC-3389	2019	CHH	299	387	YOY-early	0	M	24.74	0	17.17	51.44	2.08	3.00	-16.99	15.08	16.39
SC-3394	2019	CHH	290	378	YOY-early	0	F	23.21	0	17.45	51.81	2.15	2.97	-16.26	16.35	15.14
SC-3469	2019	CHH	285	371	YOY-early	0	F	31.66	0	17.68	51.77	2.13	2.93	-16.78	15.49	14.96
SC-3475	2019	CHH	339	442	YOY-early	0	M	37.52	0	17.54	50.88	2.18	2.90	-16.83	14.67	16.16
SC-4332	2023	CHH	321	418	YOY-early	0	M	33.59	0	17.37	49.10	2.09	2.83	-18.72	14.35	16.28
SC-4333	2023	CHH	325	422	YOY-early	0	F	22.05	0	18.39	52.75	2.25	2.87	-17.55	14.98	15.96
SC-4334	2023	CHH	321	418	YOY-early	0	M	34.50	0	18.13	51.16	2.13	2.82	-17.66	15.51	16.44
SC-4335	2023	CHH	306	396	YOY-early	0	F	27.80	0	17.66	50.41	2.12	2.85	-17.09	14.70	17.65
SC-4336	2023	CHH	315	405	YOY-early	0	M	12.32	0	18.01	51.40	2.27	2.85	-17.41	15.11	16.63
SC-4342	2023	CHH	316	408	YOY-early	0	F	22.27	0	18.18	50.05	2.14	2.75	-19.52	14.33	16.31
SC-3373	2019	SHH	375	493	YOY-early	0	F	43.30	0	17.47	51.86	2.10	2.97	-16.29	14.31	17.45
SC-3379	2019	SHH	366	483	YOY-early	0	M	43.52	0	17.40	52.18	2.11	3.00	-16.66	14.43	17.46
SC-3382	2019	SHH	316	425	YOY-early	0	F	45.32	0	17.67	53.02	2.15	3.00	-16.89	13.84	17.37
SC-3383	2019	SHH	381	509	YOY-early	0	M	37.17	0	18.13	53.60	2.21	2.96	-16.40	13.77	17.42
SC-3384	2019	SHH	375	494	YOY-early	0	M	58.23	0	19.24	56.97	2.31	2.96	-16.58	13.06	17.54
SC-3387	2019	SHH	390	513	YOY-early	0	F	54.34	0	17.81	52.52	2.17	2.95	-16.70	12.89	18.14
SC-3391	2019	SHH	369	487	YOY-early	0	F	52.90	0	18.00	52.03	2.15	2.89	-16.48	13.03	18.06
SC-3406	2019	SHH	381	504	YOY-early	0	M	45.90	0	17.87	53.22	2.17	2.98	-16.77	12.40	18.35
SC-3531	2019	SHH	345	460	YOY-early	0	F	38.92	0	17.77	51.28	2.15	2.89	-16.27	14.28	17.47
SC-4331	2023	SHH	377	498	YOY-early	0	F	53.68	0	18.15	51.15	2.14	2.82	-16.80	13.38	18.04
SC-4337	2023	SHH	378	498	YOY-early	0	F	60.73	0	18.50	50.50	2.13	2.73	-16.66	13.07	18.20
SC-4339	2023	SHH	297	392	YOY-early	0	F	47.01	0	18.64	51.45	2.18	2.76	-16.50	14.60	17.53
SC-4341	2023	SHH	355	470	YOY-early	0	M	45.37	0	18.51	50.03	2.16	2.70	-16.55	13.16	18.22
SC-4343	2023	SHH	371	488	YOY-early	0	M	36.90	0	18.66	50.19	2.23	2.69	-16.32	13.92	18.46
SC-2555	2017	CHH	422	553	YOY-late	0	F	18.81	0	17.19	50.87	2.20	2.96	-17.12	14.60	15.46
SC-2568	2017	CHH	437	575	YOY-late	0	F	23.49	0	18.46	54.93	2.28	2.98	-15.64	12.81	18.52
SC-2675	2017	CHH	482	623	YOY-late	0	F	22.68	0	17.93	54.28	2.27	3.03	-17.29	14.55	17.01
SC-2677	2017	CHH	451	590	YOY-late	0	F	20.19	0	17.61	55.76	2.22	3.17	-17.80	14.63	17.34
SC-2678	2017	CHH	448	588	YOY-late	0	F	22.25	0	17.67	55.16	2.27	3.12	-17.67	14.70	15.44
SC-2680	2017	CHH	396	516	YOY-late	0	M	16.85	0	17.16	54.06	2.21	3.15	-16.58	12.97	19.24
SC-2682	2017	CHH	381	496	YOY-late	0	M	17.37	0	17.78	55.41	2.30	3.12	-17.11	12.61	19.08
SC-2686	2017	CHH	440	573	YOY-late	0	M	17.69	0	18.06	55.69	2.35	3.08	-17.36	14.96	15.91
SC-2692	2017	CHH	455	597	YOY-late	0	F	21.02	0	18.07	55.24	2.25	3.06	-17.21	14.03	16.93
SC-2741	2017	CHH	455	593	YOY-late	0	F	20.07	0	17.39	53.96	2.27	3.10	-16.95	15.06	16.42
SC-2744	2017	CHH	470	614	YOY-late	0	F	23.06	0	17.79	54.71	2.26	3.08	-17.24	14.05	17.46
SC-2752	2017	CHH	435	559	YOY-late	0	F	21.40	0	17.79	53.82	2.24	3.03	-16.42	12.48	18.96
SC-2753	2017	CHH	441	573	YOY-late	0	F	18.11	0	15.83	55.55	1.97	3.51	-18.72	14.74	16.00
SC-2754	2017	CHH	409	531	YOY-late	0	M	17.37	0	17.53	54.64	2.24	3.12	-16.94	13.13	19.03

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	δ13C	δ15N	δ34S
SC-2756	2017	CHH	445	583	YOY-late	0	F	22.77	0	18.34	55.72	2.31	3.04	-17.36	14.76	16.78
SC-2757	2017	CHH	431	563	YOY-late	0	M	16.88	0	17.24	53.83	2.16	3.12	-17.08	15.42	18.10
SC-2759	2017	CHH	500	656	YOY-late	0	M	23.65	0	17.58	53.28	2.16	3.03	-17.16	15.01	17.93
SC-3662	2020	CHH	385	506	YOY-late	0	M	19.93	0	17.16	52.13	2.08	3.04	-17.54	14.48	17.78
SC-3664	2020	CHH	438	572	YOY-late	0	M	21.63	0	18.23	55.03	2.23	3.02	-17.58	14.81	16.48
SC-3700	2020	CHH	495	642	YOY-late	0	F	26.28	0	17.66	52.07	2.08	2.95	-15.87	12.81	19.89
SC-4416	2023	CHH	312	411	YOY-late	0	M	17.68	0	17.66	53.40	2.13	3.02	-17.54	15.23	17.29
SC-4432	2023	CHH	340	442	YOY-late	0	F	14.96	0	17.24	52.60	2.04	3.05	-18.09	15.60	17.20
SC-4439	2023	CHH	359	470	YOY-late	0	M	16.74	0	17.80	54.45	2.14	3.06	-18.86	14.40	17.45
SC-4445	2023	CHH	380	504	YOY-late	0	M	16.15	0	17.94	54.31	2.10	3.03	-19.45	14.80	17.16
SC-4459	2023	CHH	428	564	YOY-late	0	F	21.79	0	17.59	51.80	2.11	2.94	-17.32	15.27	17.58
SC-4465	2023	CHH	340	–	YOY-late	0	M	16.58	0	16.96	53.20	2.04	3.14	-17.80	15.35	18.11
SC-4476	2023	CHH	409	538	YOY-late	0	M	32.22	0	17.99	52.74	2.10	2.93	-17.54	15.16	18.07
SC-4481	2023	CHH	365	477	YOY-late	0	M	18.53	0	16.81	53.72	1.97	3.20	-17.08	13.06	20.04
SC-4490	2023	CHH	325	424	YOY-late	0	F	15.25	0	16.50	52.92	2.04	3.21	-17.91	14.98	17.25
SC-2747	2017	Hybrid	446	590	YOY-late	0	F	28.66	0	17.85	53.78	2.22	3.01	-15.65	11.87	19.31
SC-3665	2020	Hybrid	436	578	YOY-late	0	M	24.68	0	17.66	52.83	2.16	2.99	-17.44	14.83	16.81
SC-4406	2023	Hybrid	317	423	YOY-late	0	M	14.27	0	17.19	51.76	2.10	3.01	-17.69	14.85	18.70
SC-2566	2017	SHH	496	658	YOY-late	0	F	35.45	0	18.06	56.98	2.43	3.16	-17.27	13.91	17.28
SC-2674	2017	SHH	464	613	YOY-late	0	M	27.14	0	17.92	54.00	2.34	3.01	-16.83	13.46	17.78
SC-2691	2017	SHH	535	707	YOY-late	0	M	33.08	0	18.00	54.11	2.26	3.01	-16.65	13.59	17.39
SC-2694	2017	SHH	428	574	YOY-late	0	M	27.43	0	17.60	53.36	2.23	3.03	-16.68	13.78	17.86
SC-2696	2017	SHH	464	620	YOY-late	0	F	28.76	0	17.66	53.22	2.25	3.01	-16.82	14.01	17.95
SC-2748	2017	SHH	493	655	YOY-late	0	M	28.85	0	18.14	54.36	2.35	3.00	-16.87	13.70	17.78
SC-2755	2017	SHH	499	657	YOY-late	0	F	37.13	0	18.28	54.78	2.29	3.00	-16.57	12.05	19.17
SC-3426	2019	SHH	435	567	YOY-late	0	M	24.21	0	18.43	53.55	2.16	2.91	-16.78	14.35	18.70
SC-3430	2019	SHH	440	586	YOY-late	0	F	25.45	0	18.09	53.09	2.17	2.93	-17.09	13.54	18.68
SC-3431	2019	SHH	465	610	YOY-late	0	M	25.21	0	18.42	54.14	2.20	2.94	-17.07	13.54	19.12
SC-3432	2019	SHH	505	672	YOY-late	0	M	31.04	0	17.87	52.56	2.09	2.94	-16.84	13.81	18.30
SC-3663	2020	SHH	485	651	YOY-late	0	M	29.66	0	17.68	52.93	2.14	2.99	-16.92	14.79	18.45
SC-3667	2020	SHH	492	655	YOY-late	0	M	32.10	0	17.35	52.37	2.12	3.02	-17.23	13.42	18.78
SC-3669	2020	SHH	468	616	YOY-late	0	M	27.29	0	17.83	53.71	2.18	3.01	-17.35	12.88	19.03
SC-3672	2020	SHH	449	594	YOY-late	0	M	29.45	0	17.37	52.54	2.10	3.02	-17.08	14.07	18.51
SC-3673	2020	SHH	381	502	YOY-late	0	F	17.38	0	17.16	52.44	2.09	3.06	-17.66	15.00	17.59
SC-4387	2023	SHH	408	543	YOY-late	0	M	21.10	0	17.98	52.88	2.22	2.94	-17.18	13.52	19.02
SC-4405	2023	SHH	363	480	YOY-late	0	M	15.69	0	17.28	52.27	2.14	3.02	-17.60	13.30	18.58
SC-4414	2023	SHH	401	536	YOY-late	0	M	23.14	0	18.25	53.30	2.22	2.92	-17.19	13.36	19.35
SC-4436	2023	SHH	426	563	YOY-late	0	F	27.48	0	18.06	52.96	2.17	2.93	-17.30	13.38	19.11
SC-4458	2023	SHH	410	545	YOY-late	0	F	17.83	0	16.51	53.14	1.98	3.22	-17.92	13.22	18.40
SC-4471	2023	SHH	363	482	YOY-late	0	F	23.53	0	17.57	51.59	2.10	2.94	-17.00	12.43	19.69
SC-4472	2023	SHH	456	608	YOY-late	0	M	28.13	0	18.17	53.41	2.16	2.94	-17.17	13.16	19.34

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	d^{13}C	d^{15}N	d^{34}S
SC-4479	2023	SHH	414	555	YOY-late	0	F	22.98	0	17.90	52.62	2.09	2.94	-17.01	14.64	18.46
SC-4493	2023	SHH	372	495	YOY-late	0	F	20.91	0	18.16	54.49	2.18	3.00	-17.25	13.46	18.83
SC-3595	2019	CHH	749	991	early juv	2	F	68.55	0	18.37	54.58	2.08	2.97	-17.45	14.09	17.11
SC-3595	2019	CHH	749	991	early juv	2	F	48.38	1	17.10	49.68	1.68	2.91	-17.32	12.28	15.37
SC-3597	2019	CHH	724	965	early juv	2	M	52.33	0	18.04	53.22	2.05	2.95	-17.38	14.64	17.64
SC-3597	2019	CHH	724	965	early juv	2	M	63.69	1	17.48	49.95	1.78	2.86	-17.23	12.86	16.51
SC-3601	2019	CHH	686	991	early juv	2	M	61.30	0	18.08	54.06	2.03	2.99	-17.46	14.29	17.55
SC-3601	2019	CHH	686	991	early juv	2	M	53.19	1	17.13	51.92	1.69	3.03	-17.39	12.36	14.90
SC-3602	2019	CHH	737	965	early juv	2	F	58.90	0	17.48	52.25	2.02	2.99	-17.62	14.79	16.90
SC-3602	2019	CHH	737	965	early juv	2	F	77.31	1	17.29	49.92	1.77	2.89	-17.69	12.37	15.62
SC-3603	2019	CHH	814	1219	early juv	na	F	61.77	0	16.51	50.47	2.05	3.06	-17.80	14.23	14.84
SC-3603	2019	CHH	814	1219	early juv	na	F	19.28	1	16.65	48.10	1.99	2.89	-16.85	11.53	14.87
SC-3603	2019	CHH	814	1219	early juv	na	F	141.19	2	16.99	48.59	1.84	2.86	-17.02	12.76	17.12
SC-3604	2019	CHH	711	940	early juv	1	M	51.24	0	17.21	52.08	2.06	3.03	-16.84	13.16	18.16
SC-3604	2019	CHH	711	940	early juv	1	M	54.50	1	17.09	50.60	1.85	2.96	-16.65	12.00	13.87
SC-3605	2019	CHH	864	1168	early juv	2	F	90.95	0	17.99	54.84	2.12	3.05	-16.97	12.27	16.83
SC-3605	2019	CHH	864	1168	early juv	2	F	53.22	1	16.86	50.68	1.68	3.01	-17.30	12.99	16.26
SC-3606	2019	CHH	737	940	early juv	2	F	64.29	0	18.10	53.57	2.14	2.96	-17.46	14.19	16.41
SC-3606	2019	CHH	737	940	early juv	2	F	48.59	1	16.94	48.92	1.77	2.89	-17.37	12.24	14.93
SC-3596	2019	CHH	914	1219	early juv	3	M	113.01	0	16.69	50.98	2.01	3.05	-17.42	14.08	15.89
SC-3596	2019	CHH	914	1219	early juv	3	M	17.28	1	16.53	51.07	1.96	3.09	-17.27	10.67	15.48
SC-3596	2019	CHH	914	1219	early juv	3	M	22.70	2	16.98	51.29	1.83	3.02	-16.76	11.57	16.49
SC-3596	2019	CHH	914	1219	early juv	3	M	64.79	3	17.03	49.88	1.67	2.93	-17.15	13.39	17.09
SC-3405	2019	Hybrid	677	917	early juv	1	F	70.20	0	18.41	54.58	2.13	2.97	-16.78	14.13	18.27
SC-3405	2019	Hybrid	677	917	early juv	1	F	54.67	1	18.09	52.96	1.78	2.93	-16.87	12.30	16.33
SC-3607	2019	Hybrid	940	1245	early juv	2	M	90.88	0	18.06	53.85	2.12	2.98	-17.26	13.47	15.09
SC-3607	2019	Hybrid	940	1245	early juv	2	M	45.42	1	17.64	52.79	1.76	2.99	-17.16	13.03	16.51
NC-68	2020	SHH	914	1194	early juv	2	F	124.26	0	18.02	52.96	2.04	2.94	-17.23	12.85	17.21
NC-68	2020	SHH	914	1194	early juv	2	F	207.40	1	17.78	50.37	1.82	2.83	-17.10	12.11	16.52
NC-83	2020	SHH	838	1130	early juv	2	M	107.53	0	18.47	53.05	2.01	2.87	-17.23	13.32	17.07
NC-83	2020	SHH	838	1130	early juv	2	M	138.30	1	17.90	48.94	1.76	2.73	-16.97	12.10	16.91
SC-3610	2019	SHH	991	1321	early juv	2	M	121.32	0	18.17	53.68	2.14	2.95	-16.76	12.75	15.86
SC-3610	2019	SHH	991	1321	early juv	2	M	100.24	1	17.54	50.68	1.79	2.89	-17.04	12.53	16.56
NC-70	2020	SHH	1041	1346	early juv	3	M	68.18	0	17.50	51.84	2.08	2.96	-16.85	14.11	17.37
NC-70	2020	SHH	1041	1346	early juv	3	M	21.01	1	16.96	49.77	1.95	2.93	-16.98	12.73	14.66
NC-70	2020	SHH	1041	1346	early juv	3	M	53.90	2	17.31	50.57	1.93	2.92	-16.92	11.65	14.30
NC-70	2020	SHH	1041	1346	early juv	3	M	48.96	3	19.23	55.37	2.09	2.88	-16.84	11.43	15.84
NC-67	2020	SHH	940	1245	early juv	3	F	52.94	0	16.75	49.43	2.02	2.95	-16.97	12.96	18.58
NC-67	2020	SHH	940	1245	early juv	3	F	53.79	1	18.62	54.45	2.13	2.92	-17.09	11.79	16.30
NC-67	2020	SHH	940	1245	early juv	3	F	91.89	2	17.20	49.36	1.89	2.87	-16.50	11.46	16.10
NC-67	2020	SHH	940	1245	early juv	3	F	272.44	3	16.59	47.33	1.64	2.85	-16.84	12.52	16.30

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$d^{13}C$	$d^{15}N$	$d^{34}S$
NC-70	2020	SHH	1041	1346	early juv	3	M	234.32	4	17.59	49.97	1.73	2.84	-16.95	12.60	16.47
NC-79	2020	SHH	965	1245	early juv	3	M	60.80	0	17.16	50.73	2.07	2.96	-17.14	12.42	18.77
NC-79	2020	SHH	965	1245	early juv	3	M	46.31	1	17.50	51.32	2.01	2.93	-17.05	12.07	16.13
NC-79	2020	SHH	965	1245	early juv	3	M	28.00	2	17.23	50.55	1.93	2.93	-17.32	11.58	14.93
NC-79	2020	SHH	965	1245	early juv	3	M	211.93	3	17.89	50.68	1.82	2.83	-17.01	12.09	16.23
SC-3612	2019	CHH	1041	1346	mid juv	4	F	58.30	0	16.80	51.76	2.04	3.08	-17.55	13.91	16.70
SC-3612	2019	CHH	1041	1346	mid juv	4	F	25.84	1	16.56	50.83	1.90	3.07	-16.79	11.53	14.63
SC-3612	2019	CHH	1041	1346	mid juv	4	F	40.03	2	17.23	53.52	1.91	3.11	-16.98	11.43	15.65
SC-3612	2019	CHH	1041	1346	mid juv	4	F	116.52	3	17.04	49.59	1.62	2.91	-17.02	13.41	17.32
SC-3615	2019	Hybrid	1016	1359	mid juv	4	M	52.09	0	16.32	49.50	1.94	3.03	-17.42	14.49	16.32
SC-3615	2019	Hybrid	1016	1359	mid juv	4	M	19.35	1	16.95	51.83	1.97	3.06	-17.30	11.78	14.14
SC-3615	2019	Hybrid	1016	1359	mid juv	4	M	40.22	2	16.34	50.51	1.82	3.09	-17.06	11.08	15.30
SC-3615	2019	Hybrid	1016	1359	mid juv	4	M	85.24	3	17.16	50.01	1.70	2.91	-17.29	13.31	16.94
NC-66	2020	SHH	1016	1321	mid juv	4	F	63.05	0	17.17	50.57	2.05	2.95	-16.82	12.23	18.81
NC-66	2020	SHH	1016	1321	mid juv	4	F	11.09	1	17.57	52.46	2.05	2.99	-17.12	11.69	15.64
NC-66	2020	SHH	1016	1321	mid juv	4	F	55.57	2	16.92	51.16	1.95	3.02	-17.03	10.93	14.72
NC-66	2020	SHH	1016	1321	mid juv	4	F	62.43	3	17.26	51.87	1.91	3.01	-16.75	11.24	16.65
NC-66	2020	SHH	1016	1321	mid juv	4	F	141.31	4	16.65	48.63	1.61	2.92	-17.25	12.26	16.55
NC-69	2020	SHH	1092	1422	mid juv	4	M	63.91	0	17.04	50.77	2.08	2.98	-16.90	13.29	18.89
NC-69	2020	SHH	1092	1422	mid juv	4	M	33.42	1	17.11	51.95	1.95	3.04	-17.68	12.36	15.75
NC-69	2020	SHH	1092	1422	mid juv	4	M	46.72	2	17.15	51.73	1.92	3.02	-17.66	11.53	14.86
NC-69	2020	SHH	1092	1422	mid juv	4	M	45.69	3	16.51	49.61	1.81	3.00	-16.92	11.43	16.38
NC-69	2020	SHH	1092	1422	mid juv	4	M	176.14	4	16.63	48.44	1.64	2.91	-16.89	12.33	16.95
NC-53	2020	SHH	1016	1346	mid juv	6	M	58.61	0	17.08	50.55	2.01	2.96	-16.84	12.78	18.65
NC-53	2020	SHH	1016	1346	mid juv	6	M	36.35	1	17.03	51.52	1.90	3.03	-17.45	11.71	15.89
NC-53	2020	SHH	1016	1346	mid juv	6	M	89.33	2	16.85	50.08	1.80	2.97	-16.87	11.51	15.94
NC-53	2020	SHH	1016	1346	mid juv	6	M	201.87	3	18.33	51.32	1.66	2.80	-16.82	12.32	16.43
NC-58	2020	SHH	1118	1473	mid juv	5	M	71.15	0	17.27	52.35	2.04	3.03	-17.30	14.04	17.69
NC-58	2020	SHH	1118	1473	mid juv	5	M	34.40	1	17.29	50.37	1.91	2.91	-17.48	11.81	14.51
NC-58	2020	SHH	1118	1473	mid juv	5	M	37.52	2	17.20	49.74	1.86	2.89	-17.39	11.17	14.57
NC-58	2020	SHH	1118	1473	mid juv	5	M	47.98	3	17.23	48.84	1.82	2.83	-16.80	11.71	16.49
NC-58	2020	SHH	1118	1473	mid juv	5	M	265.36	4	17.67	48.47	1.78	2.74	-17.13	12.26	16.99
NC-77	2020	SHH	1168	1524	mid juv	7	F	60.79	0	17.13	51.30	2.02	2.99	-16.92	13.65	17.84
NC-77	2020	SHH	1168	1524	mid juv	7	F	20.84	1	17.15	51.24	1.91	2.99	-16.42	12.96	16.38
NC-77	2020	SHH	1168	1524	mid juv	7	F	22.24	2	16.91	51.08	1.87	3.02	-16.40	11.69	15.44
NC-77	2020	SHH	1168	1524	mid juv	7	F	35.04	3	16.41	51.06	1.76	3.11	-16.92	11.12	15.41
NC-77	2020	SHH	1168	1524	mid juv	7	F	70.79	4	16.53	50.30	1.74	3.04	-16.65	11.09	15.96
NC-77	2020	SHH	1168	1524	mid juv	7	F	77.70	5	16.13	48.21	1.49	2.99	-16.81	12.41	16.49
SC-3574	2020	SHH	1143	1499	mid juv	5	M	66.42	0	17.34	52.61	2.03	3.03	-17.33	14.11	17.22
SC-3574	2020	SHH	1143	1499	mid juv	5	M	25.61	1	17.63	51.61	1.91	2.93	-18.36	11.28	13.78
SC-3574	2020	SHH	1143	1499	mid juv	5	M	31.65	2	17.32	50.08	1.83	2.89	-17.91	10.73	14.76

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$d^{13}C$	$d^{15}N$	$d^{34}S$
SC-3574	2020	SHH	1143	1499	mid juv	5	M	35.59	3	16.92	49.34	1.76	2.92	-17.07	10.95	15.77
SC-3574	2020	SHH	1143	1499	mid juv	5	M	57.44	4	17.12	48.07	1.71	2.81	-16.90	11.69	15.89
SC-3574	2020	SHH	1143	1499	mid juv	5	M	376.02	5	18.42	49.78	1.65	2.70	-16.62	12.20	16.98
SC-3579	2020	SHH	1041	1346	mid juv	5	M	67.35	0	17.08	49.68	1.97	2.91	-16.67	12.91	18.55
SC-3579	2020	SHH	1041	1346	mid juv	5	M	22.83	1	17.62	50.91	1.96	2.89	-16.80	11.55	15.42
SC-3579	2020	SHH	1041	1346	mid juv	5	M	30.63	2	17.19	50.57	1.83	2.94	-17.28	11.20	14.61
SC-3579	2020	SHH	1041	1346	mid juv	5	M	55.11	3	17.03	49.36	1.76	2.90	-16.63	11.08	16.10
SC-3579	2020	SHH	1041	1346	mid juv	5	M	155.64	4	17.39	48.77	1.64	2.80	-16.60	12.21	16.34
SC-3586	2020	SHH	1245	1626	mid juv	8	F	59.23	0	17.50	50.33	1.99	2.88	-16.54	14.28	17.69
SC-3586	2020	SHH	1245	1626	mid juv	8	F	33.07	1	17.77	51.96	1.92	2.92	-17.11	12.56	14.69
SC-3586	2020	SHH	1245	1626	mid juv	8	F	65.96	2	17.28	50.70	1.83	2.93	-17.24	11.24	13.95
SC-3586	2020	SHH	1245	1626	mid juv	8	F	120.47	3	17.35	50.31	1.68	2.90	-17.20	11.68	14.99
SC-3586	2020	SHH	1245	1626	mid juv	8	F	266.47	4	17.61	48.67	1.44	2.76	-16.98	12.08	16.41
NC-51	2020	SHH	1143	1524	late juv	8	M	70.69	0	18.61	53.33	2.09	2.86	-16.96	10.66	18.85
NC-51	2020	SHH	1143	1524	late juv	8	M	26.78	1	16.73	48.15	1.77	2.88	-17.03	11.05	14.75
NC-51	2020	SHH	1143	1524	late juv	8	M	49.84	2	17.71	51.37	1.84	2.90	-17.07	10.93	14.70
NC-51	2020	SHH	1143	1524	late juv	8	M	44.24	3	17.32	50.47	1.76	2.91	-16.77	11.17	15.99
NC-51	2020	SHH	1143	1524	late juv	8	M	37.12	4	17.73	51.33	1.72	2.89	-17.16	11.88	16.10
NC-51	2020	SHH	1143	1524	late juv	8	M	214.87	5	18.38	50.42	1.64	2.74	-16.55	12.22	16.96
SC-3347	2019	SHH	1450	1958	late juv	11	F	78.91	0	16.80	54.23	1.88	3.23	-17.01	11.90	18.90
SC-3347	2019	SHH	1450	1958	late juv	11	F	23.10	1	17.00	53.65	1.77	3.16	-16.97	12.53	16.95
SC-3347	2019	SHH	1450	1958	late juv	11	F	35.06	2	16.63	52.47	1.67	3.15	-16.99	12.24	17.02
SC-3347	2019	SHH	1450	1958	late juv	11	F	17.69	3	17.24	53.28	1.67	3.09	-16.70	11.81	17.71
SC-3347	2019	SHH	1450	1958	late juv	11	F	29.30	4	17.08	53.13	1.64	3.11	-16.86	11.74	17.65
SC-3347	2019	SHH	1450	1958	late juv	11	F	30.81	5	17.12	52.18	1.59	3.05	-16.93	12.15	17.67
SC-3347	2019	SHH	1450	1958	late juv	11	F	26.06	6	17.95	54.17	1.62	3.02	-17.20	12.44	17.60
SC-3347	2019	SHH	1450	1958	late juv	11	F	51.99	7	17.29	51.62	1.50	2.99	-17.03	11.95	18.39
SC-3347	2019	SHH	1450	1958	late juv	11	F	84.00	8	17.04	50.98	1.46	2.99	-16.81	11.94	18.79
SC-3347	2019	SHH	1450	1958	late juv	11	F	92.14	9	15.95	47.73	1.25	2.99	-17.11	12.02	19.03
SC-3347	2019	SHH	1450	1958	late juv	11	F	442.13	10	17.96	50.83	1.24	2.83	-16.43	12.54	18.53
SC-3562	2020	SHH	1194	1575	late juv	6	M	65.11	0	17.99	52.26	2.07	2.90	-16.88	13.67	17.93
SC-3562	2020	SHH	1194	1575	late juv	6	M	21.50	1	17.60	50.20	1.94	2.85	-16.56	14.13	16.25
SC-3562	2020	SHH	1194	1575	late juv	6	M	23.18	2	17.08	50.45	1.80	2.95	-17.11	11.67	14.14
SC-3562	2020	SHH	1194	1575	late juv	6	M	27.69	3	16.50	48.18	1.73	2.92	-16.98	10.99	14.01
SC-3562	2020	SHH	1194	1575	late juv	6	M	61.35	4	17.28	49.68	1.76	2.87	-16.69	11.10	15.45
SC-3562	2020	SHH	1194	1575	late juv	6	M	64.50	5	17.45	49.73	1.76	2.85	-16.96	11.76	15.45
SC-3562	2020	SHH	1194	1575	late juv	6	M	291.88	6	17.83	49.10	1.58	2.75	-16.76	12.12	16.23
SC-3591	2020	SHH	1422	1778	late juv-mat	10	M	67.65	0	17.01	51.81	1.83	3.05	-16.62	12.29	19.30
SC-3591	2020	SHH	1422	1778	late juv-mat	10	M	43.43	1	17.01	51.94	1.74	3.05	-17.54	13.24	16.52
SC-3591	2020	SHH	1422	1778	late juv-mat	10	M	86.49	2	16.11	49.19	1.66	3.05	-17.16	13.80	15.88
SC-3591	2020	SHH	1422	1778	late juv-mat	10	M	103.69	3	17.06	52.25	1.59	3.06	-16.88	13.32	16.89

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$d^{13}C$	$d^{15}N$	$d^{34}S$
SC-3591	2020	SHH	1422	1778	late juv-mat	10	M	72.03	4	17.00	51.35	1.43	3.02	-16.78	13.18	17.18
SC-3591	2020	SHH	1422	1778	late juv-mat	10	M	571.86	5	18.22	50.10	1.40	2.75	-16.55	13.61	18.02
SC-3598	2019	SHH	1372	1854	late juv-mat	9	M	69.31	0	17.72	52.21	2.10	2.95	-16.82	13.53	17.23
SC-3598	2019	SHH	1372	1854	late juv-mat	9	M	28.44	1	17.24	51.64	1.91	2.99	-17.41	11.85	13.96
SC-3598	2019	SHH	1372	1854	late juv-mat	9	M	75.52	2	17.33	51.63	1.86	2.98	-17.15	11.92	13.99
SC-3598	2019	SHH	1372	1854	late juv-mat	9	M	35.87	3	17.04	50.82	1.69	2.98	-17.38	12.69	14.44
SC-3598	2019	SHH	1372	1854	late juv-mat	9	M	47.16	4	16.67	49.39	1.61	2.96	-17.25	12.22	14.71
SC-3598	2019	SHH	1372	1854	late juv-mat	9	M	201.19	5	18.31	50.87	1.52	2.78	-16.78	12.66	16.47
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	70.88	0	17.47	50.94	2.02	2.92	-16.91	13.79	17.70
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	18.66	1	17.67	50.53	1.90	2.86	-17.33	12.23	14.40
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	18.19	2	17.46	50.34	1.84	2.88	-17.45	11.63	13.63
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	18.67	3	17.26	49.66	1.80	2.88	-17.42	11.73	13.57
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	44.22	4	17.24	51.11	1.77	2.96	-17.40	11.89	14.30
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	53.34	5	17.43	51.60	1.76	2.96	-17.57	12.49	14.73
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	34.64	6	16.12	50.83	1.51	3.15	-18.19	11.82	15.24
SC-3599	2019	SHH	1397	1854	late juv-mat	7	M	320.12	7	18.01	51.25	1.53	2.85	-16.52	12.33	16.64
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	75.92	0	16.35	52.87	1.72	3.23	-17.32	12.96	18.67
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	29.61	1	17.21	52.45	1.66	3.05	-17.96	13.49	16.08
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	36.85	2	16.77	50.97	1.59	3.04	-18.05	13.76	16.17
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	44.86	3	16.87	51.36	1.55	3.04	-17.47	14.11	16.57
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	40.42	4	16.64	50.82	1.50	3.06	-17.22	13.56	16.89
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	50.02	5	16.91	51.52	1.47	3.05	-17.09	13.28	17.79
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	46.13	6	16.95	51.90	1.44	3.06	-17.17	13.29	17.60
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	42.26	7	16.12	53.68	1.27	3.33	-18.14	13.20	17.85
SC-3620	2019	SHH	1499	2032	late juv-mat	11	M	295.98	8	17.57	52.28	1.25	2.98	-16.76	12.80	18.04
SC-3357	2019	CHH	1925	2495	mature	23	M	61.28	0	16.15	52.31	1.96	3.24	-17.59	14.27	16.76
SC-3357	2019	CHH	1925	2495	mature	23	M	23.40	1	16.63	50.45	1.83	3.03	-16.15	11.35	13.51
SC-3357	2019	CHH	1925	2495	mature	23	M	26.45	2	16.73	50.80	1.79	3.04	-16.23	11.59	14.91
SC-3357	2019	CHH	1925	2495	mature	23	M	34.49	3	16.35	50.01	1.70	3.06	-16.81	12.53	15.68
SC-3357	2019	CHH	1925	2495	mature	23	M	22.48	4	16.87	50.81	1.72	3.01	-16.77	13.45	16.72
SC-3357	2019	CHH	1925	2495	mature	23	M	41.61	5	16.87	50.79	1.65	3.01	-16.68	13.29	17.67
SC-3357	2019	CHH	1925	2495	mature	23	M	35.86	6	16.63	50.05	1.59	3.01	-16.83	12.94	17.87
SC-3357	2019	CHH	1925	2495	mature	23	M	60.26	7	16.65	49.73	1.53	2.99	-16.94	12.74	18.25
SC-3357	2019	CHH	1925	2495	mature	23	M	87.56	8	16.56	49.34	1.45	2.98	-17.11	12.39	18.35
SC-3357	2019	CHH	1925	2495	mature	23	M	103.92	9	16.64	49.93	1.32	3.00	-17.12	12.68	18.15
SC-3357	2019	CHH	1925	2495	mature	23	M	527.47	10	17.34	50.70	1.18	2.92	-16.38	13.22	18.12
SC-3578	2020	CHH	1702	2210	mature	12	M	73.30	0	17.49	51.61	1.72	2.95	-16.94	13.21	16.23
SC-3578	2020	CHH	1702	2210	mature	12	M	11.24	1	17.67	51.10	1.60	2.89	-16.22	11.42	16.01
SC-3578	2020	CHH	1702	2210	mature	12	M	20.15	2	17.69	51.28	1.61	2.90	-16.18	12.02	16.47
SC-3578	2020	CHH	1702	2210	mature	12	M	21.08	3	17.66	50.77	1.55	2.87	-17.18	12.63	16.48
SC-3578	2020	CHH	1702	2210	mature	12	M	21.77	4	17.60	50.43	1.55	2.87	-17.48	12.43	16.06

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$d^{13}C$	$d^{15}N$	$d^{34}S$
SC-3578	2020	CHH	1702	2210	mature	12	M	29.06	5	16.93	48.72	1.45	2.88	-17.37	12.48	16.28
SC-3578	2020	CHH	1702	2210	mature	12	M	60.70	6	17.35	50.14	1.46	2.89	-17.21	13.10	17.50
SC-3578	2020	CHH	1702	2210	mature	12	M	64.36	7	17.30	49.47	1.42	2.86	-17.21	13.29	18.30
SC-3578	2020	CHH	1702	2210	mature	12	M	141.57	8	16.91	49.14	1.31	2.91	-16.98	13.25	18.79
SC-3578	2020	CHH	1702	2210	mature	12	M	208.13	9	16.48	48.54	1.13	2.95	-16.85	13.05	18.98
SC-3578	2020	CHH	1702	2210	mature	12	M	209.96	10	16.44	50.44	0.97	3.07	-16.75	13.20	19.16
SC-3354	2019	Hybrid	2280	2930	mature	25	M	62.09	0	15.38	52.87	1.98	3.44	-18.00	14.97	16.28
SC-3354	2019	Hybrid	2280	2930	mature	25	M	73.96	1	16.61	51.57	1.95	3.10	-16.08	11.48	15.27
SC-3354	2019	Hybrid	2280	2930	mature	25	M	73.52	2	16.55	51.48	1.83	3.11	-16.27	12.42	16.19
SC-3354	2019	Hybrid	2280	2930	mature	25	M	112.92	3	16.57	51.15	1.70	3.09	-15.19	12.55	14.87
SC-3354	2019	Hybrid	2280	2930	mature	25	M	60.64	4	16.97	51.04	1.60	3.01	-15.11	12.70	15.22
SC-3354	2019	Hybrid	2280	2930	mature	25	M	124.76	5	16.73	49.30	1.49	2.95	-15.37	13.08	15.93
SC-3354	2019	Hybrid	2280	2930	mature	25	M	169.11	6	16.59	49.14	1.38	2.96	-16.06	13.36	17.41
SC-3587	2020	Hybrid	2184	2743	mature	29	M	68.64	0	16.32	53.41	2.00	3.27	-17.72	14.19	16.99
SC-3587	2020	Hybrid	2184	2743	mature	29	M	23.91	1	17.08	50.17	1.92	2.94	-15.94	11.64	15.17
SC-3587	2020	Hybrid	2184	2743	mature	29	M	41.00	2	16.94	49.79	1.83	2.94	-15.20	11.86	16.18
SC-3587	2020	Hybrid	2184	2743	mature	29	M	102.79	3	16.89	49.69	1.76	2.94	-15.62	12.52	15.73
SC-3587	2020	Hybrid	2184	2743	mature	29	M	76.73	4	17.46	51.10	1.67	2.93	-15.48	12.62	15.84
SC-3587	2020	Hybrid	2184	2743	mature	29	M	57.80	5	17.03	49.60	1.56	2.91	-15.40	12.75	16.15
SC-3587	2020	Hybrid	2184	2743	mature	29	M	74.01	6	16.94	49.08	1.50	2.90	-15.35	13.09	16.21
SC-3587	2020	Hybrid	2184	2743	mature	29	M	93.58	7	17.07	49.12	1.48	2.88	-15.30	13.48	16.42
SC-3587	2020	Hybrid	2184	2743	mature	29	M	109.86	8	17.37	49.31	1.45	2.84	-15.76	14.04	17.65
SC-3587	2020	Hybrid	2184	2743	mature	29	M	614.80	9	17.58	49.01	1.22	2.79	-15.69	14.67	17.77
SC-3343	2019	SHH	1745	2300	mature	23	M	70.79	0	15.49	54.41	1.94	3.51	-17.87	13.38	18.41
SC-3343	2019	SHH	1745	2300	mature	23	M	15.83	1	16.98	52.97	1.99	3.12	-16.13	12.49	17.11
SC-3343	2019	SHH	1745	2300	mature	23	M	39.28	2	16.59	52.37	1.90	3.16	-16.17	11.93	16.58
SC-3343	2019	SHH	1745	2300	mature	23	M	70.30	3	16.39	51.07	1.80	3.12	-16.22	11.77	16.58
SC-3343	2019	SHH	1745	2300	mature	23	M	29.56	4	16.28	50.15	1.69	3.08	-16.52	12.00	16.13
SC-3343	2019	SHH	1745	2300	mature	23	M	102.85	5	16.92	50.23	1.64	2.97	-15.85	11.80	15.80
SC-3343	2019	SHH	1745	2300	mature	23	M	118.22	6	17.16	49.98	1.55	2.91	-15.92	12.01	16.25
SC-3343	2019	SHH	1745	2300	mature	23	M	192.30	7	16.80	48.91	1.39	2.91	-16.10	12.24	16.75
SC-3343	2019	SHH	1745	2300	mature	23	M	665.16	8	18.04	50.17	1.23	2.78	-16.10	12.03	18.10
SC-3344	2019	SHH	2100	2630	mature	22	M	59.34	0	15.64	52.76	1.95	3.37	-16.97	13.08	18.73
SC-3344	2019	SHH	2100	2630	mature	22	M	31.51	1	16.84	52.76	1.98	3.13	-16.33	13.74	17.49
SC-3344	2019	SHH	2100	2630	mature	22	M	34.88	2	16.50	52.10	1.86	3.16	-16.48	14.38	16.86
SC-3344	2019	SHH	2100	2630	mature	22	M	70.14	3	16.35	51.32	1.91	3.14	-16.49	13.42	18.50
SC-3344	2019	SHH	2100	2630	mature	22	M	36.54	4	16.85	52.51	1.77	3.12	-16.81	13.10	18.51
SC-3344	2019	SHH	2100	2630	mature	22	M	46.26	5	16.99	52.15	1.69	3.07	-16.63	13.13	18.00
SC-3344	2019	SHH	2100	2630	mature	22	M	57.74	6	16.54	50.83	1.61	3.07	-16.31	13.15	17.30
SC-3344	2019	SHH	2100	2630	mature	22	M	51.46	7	16.83	51.25	1.59	3.04	-16.33	13.30	17.78
SC-3344	2019	SHH	2100	2630	mature	22	M	100.52	8	16.67	50.42	1.48	3.03	-16.31	13.55	18.18

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$d^{13}C$	$d^{15}N$	$d^{34}S$
SC-3344	2019	SHH	2100	2630	mature	22	M	75.89	9	17.18	51.83	1.42	3.02	-16.41	13.82	17.98
SC-3344	2019	SHH	2100	2630	mature	22	M	84.93	10	17.26	51.67	1.36	2.99	-16.14	13.41	18.28
SC-3344	2019	SHH	2100	2630	mature	22	M	111.34	11	17.05	51.97	1.25	3.05	-16.42	13.32	18.39
SC-3344	2019	SHH	2100	2630	mature	22	M	478.69	12	18.19	50.31	1.05	2.77	-15.74	14.05	18.21
SC-3345	2019	SHH	2230	2860	mature	20	M	70.43	0	16.23	52.49	1.98	3.24	-16.83	12.49	19.36
SC-3345	2019	SHH	2230	2860	mature	20	M	27.04	1	16.69	51.24	1.87	3.07	-16.99	13.07	16.40
SC-3345	2019	SHH	2230	2860	mature	20	M	32.57	2	16.60	50.72	1.81	3.06	-17.03	13.56	15.98
SC-3345	2019	SHH	2230	2860	mature	20	M	36.89	3	17.96	53.74	1.88	2.99	-16.60	12.73	16.57
SC-3345	2019	SHH	2230	2860	mature	20	M	69.09	4	16.92	50.57	1.71	2.99	-16.16	12.79	16.96
SC-3345	2019	SHH	2230	2860	mature	20	M	76.85	5	17.11	50.72	1.61	2.96	-16.19	12.71	17.87
SC-3345	2019	SHH	2230	2860	mature	20	M	78.20	6	16.96	50.83	1.56	3.00	-16.37	12.99	17.91
SC-3345	2019	SHH	2230	2860	mature	20	M	131.60	7	17.19	51.38	1.50	2.99	-16.58	13.60	17.67
SC-3345	2019	SHH	2230	2860	mature	20	M	144.55	8	17.03	51.11	1.31	3.00	-16.63	13.26	17.82
SC-3345	2019	SHH	2230	2860	mature	20	M	482.94	9	18.39	51.12	1.07	2.78	-15.72	12.91	18.03
SC-3350	2019	SHH	1850	2380	mature	22	M	72.38	0	15.97	51.05	1.94	3.20	-17.14	14.38	17.47
SC-3350	2019	SHH	1850	2380	mature	22	M	25.18	1	16.59	50.89	1.86	3.07	-17.29	14.22	16.54
SC-3350	2019	SHH	1850	2380	mature	22	M	49.15	2	16.72	50.54	1.79	3.02	-17.23	14.21	17.14
SC-3350	2019	SHH	1850	2380	mature	22	M	47.20	3	16.39	50.22	1.70	3.06	-17.15	14.19	17.68
SC-3350	2019	SHH	1850	2380	mature	22	M	47.34	4	16.78	51.34	1.69	3.06	-16.82	13.84	17.81
SC-3350	2019	SHH	1850	2380	mature	22	M	107.46	5	16.68	51.27	1.61	3.07	-16.89	13.80	17.64
SC-3350	2019	SHH	1850	2380	mature	22	M	71.63	6	17.07	51.82	1.58	3.04	-16.75	13.71	17.71
SC-3350	2019	SHH	1850	2380	mature	22	M	69.89	7	16.92	50.87	1.44	3.01	-16.70	13.74	18.46
SC-3350	2019	SHH	1850	2380	mature	22	M	152.00	8	17.21	51.20	1.33	2.98	-16.70	13.90	17.92
SC-3350	2019	SHH	1850	2380	mature	22	M	337.79	9	17.70	49.44	1.09	2.79	-15.95	14.03	17.81
SC-3352	2019	SHH	2428	3088	mature	23	M	68.50	0	15.40	50.61	1.93	3.29	-17.20	14.09	17.64
SC-3352	2019	SHH	2428	3088	mature	23	M	22.73	1	16.21	50.66	1.91	3.12	-16.49	11.51	14.08
SC-3352	2019	SHH	2428	3088	mature	23	M	28.45	2	16.33	51.73	1.88	3.17	-16.60	11.01	13.51
SC-3352	2019	SHH	2428	3088	mature	23	M	37.20	3	16.52	52.14	1.84	3.16	-16.43	11.81	14.84
SC-3352	2019	SHH	2428	3088	mature	23	M	48.68	4	16.37	51.19	1.76	3.13	-16.22	11.82	15.60
SC-3352	2019	SHH	2428	3088	mature	23	M	32.19	5	16.29	51.22	1.73	3.14	-16.40	11.83	15.44
SC-3352	2019	SHH	2428	3088	mature	23	M	41.42	6	16.56	52.11	1.70	3.15	-16.37	11.89	15.67
SC-3352	2019	SHH	2428	3088	mature	23	M	61.90	7	16.05	49.75	1.59	3.10	-16.16	12.06	16.23
SC-3352	2019	SHH	2428	3088	mature	23	M	52.18	8	16.74	50.76	1.56	3.03	-16.51	12.27	17.02
SC-3352	2019	SHH	2428	3088	mature	23	M	150.31	9	17.05	50.44	1.49	2.96	-16.75	12.42	17.97
SC-3352	2019	SHH	2428	3088	mature	23	M	216.62	10	16.41	49.13	1.31	2.99	-16.97	12.70	18.69
SC-3352	2019	SHH	2428	3088	mature	23	M	468.05	11	17.24	49.15	1.11	2.85	-16.06	13.95	18.33
SC-3360	2019	SHH	2240	3060	mature	34	M	73.71	0	16.62	53.24	2.10	3.20	-17.36	12.26	18.55
SC-3360	2019	SHH	2240	3060	mature	34	M	18.61	1	17.02	52.04	2.07	3.06	-16.21	11.66	16.15
SC-3360	2019	SHH	2240	3060	mature	34	M	39.34	2	16.45	50.78	1.93	3.09	-16.06	11.00	14.61
SC-3360	2019	SHH	2240	3060	mature	34	M	71.67	3	16.59	51.18	1.87	3.08	-15.74	11.47	16.00
SC-3360	2019	SHH	2240	3060	mature	34	M	30.14	4	16.31	50.38	1.77	3.09	-16.45	11.99	15.47

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	$d^{13}C$	$d^{15}N$	$d^{34}S$
SC-3360	2019	SHH	2240	3060	mature	34	M	150.75	5	16.09	49.74	1.67	3.09	-15.56	11.88	15.87
SC-3360	2019	SHH	2240	3060	mature	34	M	172.16	6	16.74	51.34	1.63	3.07	-15.22	12.50	16.31
SC-3360	2019	SHH	2240	3060	mature	34	M	218.63	7	16.38	48.40	1.40	2.96	-15.37	13.12	16.77
SC-3360	2019	SHH	2240	3060	mature	34	M	308.95	8	16.81	47.73	1.24	2.84	-15.43	14.40	17.62
SC-3360	2019	SHH	2240	3060	mature	34	M	433.25	9	17.08	48.42	1.03	2.84	-15.07	14.58	17.23
SC-3361	2019	SHH	1970	2570	mature	19	M	74.94	0	16.17	52.12	1.98	3.22	-17.26	14.00	17.16
SC-3361	2019	SHH	1970	2570	mature	19	M	33.71	1	16.85	52.30	1.92	3.10	-16.82	11.85	13.19
SC-3361	2019	SHH	1970	2570	mature	19	M	39.93	2	16.81	52.11	1.88	3.10	-16.29	11.01	15.00
SC-3361	2019	SHH	1970	2570	mature	19	M	66.05	3	16.96	52.24	1.80	3.08	-16.21	11.29	16.76
SC-3361	2019	SHH	1970	2570	mature	19	M	38.14	4	16.53	50.86	1.69	3.08	-16.27	11.68	16.03
SC-3361	2019	SHH	1970	2570	mature	19	M	35.73	5	17.23	52.18	1.68	3.03	-15.86	11.67	16.04
SC-3361	2019	SHH	1970	2570	mature	19	M	76.58	6	17.11	51.18	1.60	2.99	-15.79	12.11	16.30
SC-3361	2019	SHH	1970	2570	mature	19	M	73.58	7	16.60	49.87	1.50	3.00	-15.74	12.37	16.22
SC-3361	2019	SHH	1970	2570	mature	19	M	77.77	8	16.86	50.33	1.48	2.98	-15.62	12.52	16.40
SC-3361	2019	SHH	1970	2570	mature	19	M	137.38	9	16.87	50.52	1.37	3.00	-16.11	12.61	16.79
SC-3361	2019	SHH	1970	2570	mature	19	M	57.46	10	17.01	49.07	1.29	2.89	-16.11	12.75	16.82
SC-3361	2019	SHH	1970	2570	mature	19	M	346.67	11	17.95	51.79	1.19	2.88	-15.84	13.77	17.54
SC-3452	2019	SHH	2350	3080	mature	28	M	34.22	0	16.05	51.90	2.09	3.23	-16.62	13.77	18.09
SC-3452	2019	SHH	2350	3080	mature	28	M	56.57	1	16.17	50.46	1.94	3.12	-16.26	11.26	13.16
SC-3452	2019	SHH	2350	3080	mature	28	M	37.07	2	16.06	49.35	1.86	3.07	-16.02	10.88	13.24
SC-3452	2019	SHH	2350	3080	mature	28	M	66.19	3	16.86	50.98	1.90	3.02	-15.39	12.21	15.08
SC-3452	2019	SHH	2350	3080	mature	28	M	43.65	4	16.93	51.69	1.83	3.05	-15.92	12.57	14.83
SC-3452	2019	SHH	2350	3080	mature	28	M	52.03	5	16.58	50.06	1.72	3.02	-15.60	12.40	15.18
SC-3452	2019	SHH	2350	3080	mature	28	M	84.40	6	16.88	50.75	1.68	3.01	-15.65	12.55	15.66
SC-3452	2019	SHH	2350	3080	mature	28	M	80.08	7	16.61	50.02	1.57	3.01	-15.81	12.59	15.93
SC-3452	2019	SHH	2350	3080	mature	28	M	83.44	8	16.80	50.44	1.51	3.00	-15.65	12.75	16.42
SC-3452	2019	SHH	2350	3080	mature	28	M	89.10	9	16.91	50.39	1.47	2.98	-15.57	13.28	16.91
SC-3452	2019	SHH	2350	3080	mature	28	M	132.01	10	16.71	49.90	1.37	2.99	-16.36	14.00	17.97
SC-3452	2019	SHH	2350	3080	mature	28	M	358.25	11	16.93	48.49	1.21	2.86	-15.77	14.53	18.27
SC-3452	2019	SHH	2350	3080	mature	28	M	430.05	12	17.59	51.29	1.02	2.92	-15.63	14.61	17.88
SC-3461	2019	SHH	1840	2440	mature	16	M	77.14	0	16.60	52.88	2.08	3.18	-17.29	14.36	17.04
SC-3461	2019	SHH	1840	2440	mature	16	M	20.48	1	16.69	51.34	1.92	3.08	-17.39	11.91	12.97
SC-3461	2019	SHH	1840	2440	mature	16	M	68.94	2	16.80	51.83	1.89	3.09	-17.01	11.69	14.44
SC-3461	2019	SHH	1840	2440	mature	16	M	66.39	3	16.82	51.28	1.80	3.05	-16.93	12.11	15.62
SC-3461	2019	SHH	1840	2440	mature	16	M	74.36	4	16.83	50.63	1.67	3.01	-16.19	12.04	14.82
SC-3461	2019	SHH	1840	2440	mature	16	M	95.84	5	16.60	48.73	1.52	2.94	-16.45	12.62	15.75
SC-3461	2019	SHH	1840	2440	mature	16	M	148.39	6	16.64	49.95	1.42	3.00	-17.41	13.01	16.96
SC-3461	2019	SHH	1840	2440	mature	16	M	422.58	7	17.94	51.48	1.22	2.87	-16.25	12.91	17.88
SC-3462	2019	SHH	1840	–	mature	14	M	81.11	0	16.07	52.16	2.00	3.25	-17.02	12.18	18.04
SC-3462	2019	SHH	1840	–	mature	14	M	29.24	1	16.65	51.30	1.93	3.08	-17.11	11.67	13.81
SC-3462	2019	SHH	1840	–	mature	14	M	21.30	2	16.94	51.43	1.85	3.04	-16.69	11.65	14.42

ID	Year	Species	FL	TL	Life stage	Age	Sex	Layer mass	Layer	%N	%C	%S	C:N	d^{13}C	d^{15}N	d^{34}S
SC-3462	2019	SHH	1840	–	mature	14	M	24.92	3	17.15	53.46	1.63	3.12	-16.23	11.57	15.67
SC-3462	2019	SHH	1840	–	mature	14	M	28.72	4	17.11	52.98	1.54	3.10	-16.36	12.05	16.33
SC-3462	2019	SHH	1840	–	mature	14	M	30.58	5	16.77	51.58	1.52	3.08	-16.65	12.38	16.11
SC-3462	2019	SHH	1840	–	mature	14	M	30.98	6	16.89	52.16	1.50	3.09	-16.48	12.30	15.59
SC-3462	2019	SHH	1840	–	mature	14	M	63.22	7	16.84	51.95	1.42	3.09	-16.10	11.96	16.17
SC-3462	2019	SHH	1840	–	mature	14	M	47.86	8	16.81	52.32	1.38	3.11	-16.24	11.99	16.21
SC-3462	2019	SHH	1840	–	mature	14	M	78.94	9	16.78	51.46	1.35	3.07	-16.15	11.97	15.89
SC-3462	2019	SHH	1840	–	mature	14	M	99.51	10	16.67	51.62	1.20	3.10	-16.48	12.13	16.29
SC-3462	2019	SHH	1840	–	mature	14	M	357.57	11	17.92	51.53	1.06	2.87	-16.04	12.47	16.69
SC-3464	2019	SHH	1730	2250	mature	15	M	75.25	0	16.21	52.42	2.06	3.23	-17.13	14.31	17.00
SC-3464	2019	SHH	1730	2250	mature	15	M	19.69	1	16.49	50.74	1.94	3.08	-16.32	11.63	13.77
SC-3464	2019	SHH	1730	2250	mature	15	M	22.91	2	16.94	52.14	1.96	3.08	-16.45	11.31	13.60
SC-3464	2019	SHH	1730	2250	mature	15	M	28.46	3	16.80	51.71	1.86	3.08	-16.71	11.83	14.02
SC-3464	2019	SHH	1730	2250	mature	15	M	27.36	4	16.69	51.12	1.80	3.06	-16.75	12.30	14.60
SC-3464	2019	SHH	1730	2250	mature	15	M	25.75	5	17.12	51.77	1.81	3.02	-16.87	12.23	14.21
SC-3464	2019	SHH	1730	2250	mature	15	M	83.60	6	17.50	51.50	1.72	2.94	-16.76	12.07	14.31
SC-3464	2019	SHH	1730	2250	mature	15	M	109.04	7	16.90	49.62	1.59	2.94	-16.65	12.39	15.22
SC-3464	2019	SHH	1730	2250	mature	15	M	181.10	8	16.94	49.24	1.42	2.91	-16.90	12.51	15.99
SC-3464	2019	SHH	1730	2250	mature	15	M	362.44	9	17.73	50.24	1.24	2.83	-16.35	12.72	16.05
SC-3567	2020	SHH	1511	1981	mature	10	M	59.05	0	17.04	52.30	1.80	3.07	-17.06	14.65	17.88
SC-3567	2020	SHH	1511	1981	mature	10	M	21.36	1	17.01	50.63	1.70	2.98	-16.62	13.63	15.80
SC-3567	2020	SHH	1511	1981	mature	10	M	30.38	2	16.94	50.72	1.64	2.99	-16.88	12.07	14.53
SC-3567	2020	SHH	1511	1981	mature	10	M	62.44	3	17.34	51.54	1.62	2.97	-16.75	12.04	16.01
SC-3567	2020	SHH	1511	1981	mature	10	M	51.01	4	17.60	51.96	1.57	2.95	-17.35	12.50	15.48
SC-3567	2020	SHH	1511	1981	mature	10	M	93.03	5	16.39	47.96	1.43	2.93	-17.09	12.17	15.73
SC-3567	2020	SHH	1511	1981	mature	10	M	421.52	6	18.01	51.44	1.32	2.86	-16.54	12.74	16.66
SC-3571	2020	SHH	2286	2870	mature	39	M	51.27	0	16.58	50.49	2.08	3.05	-16.07	14.79	17.62
SC-3571	2020	SHH	2286	2870	mature	39	M	28.05	1	16.76	49.04	1.98	2.93	-15.60	13.39	16.44
SC-3571	2020	SHH	2286	2870	mature	39	M	56.07	2	17.28	50.32	1.92	2.91	-15.52	11.17	14.90
SC-3571	2020	SHH	2286	2870	mature	39	M	81.01	3	17.05	49.19	1.80	2.89	-14.92	12.12	16.10
SC-3571	2020	SHH	2286	2870	mature	39	M	67.05	4	16.91	48.83	1.69	2.89	-15.40	12.35	16.03
SC-3571	2020	SHH	2286	2870	mature	39	M	135.88	5	16.76	48.58	1.65	2.90	-15.45	12.38	16.72
SC-3571	2020	SHH	2286	2870	mature	39	M	97.05	6	17.42	50.23	1.60	2.88	-15.39	12.72	16.52
SC-3571	2020	SHH	2286	2870	mature	39	M	154.01	7	16.91	48.71	1.50	2.88	-15.41	12.96	16.73
SC-3571	2020	SHH	2286	2870	mature	39	M	263.02	8	16.60	47.77	1.38	2.88	-15.48	13.28	18.15
SC-3571	2020	SHH	2286	2870	mature	39	M	256.05	9	17.59	50.27	1.36	2.86	-15.44	14.46	17.93
SC-3571	2020	SHH	2286	2870	mature	39	M	458.43	10	17.23	49.12	1.18	2.85	-15.22	14.42	18.13