THE EFFECTS OF SEA-ICE DURATION ON THE GROWTH AND SHELL CHEMISTRY OF THE ANTARCTIC SCALLOP *ADAMUSSIUM COLBECKI*

by

KELLY E. CRONIN

(Under the Direction of Sally E. Walker)

ABSTRACT

Antarctic sea ice is vital for global climate regulation and local ecosystems. After decades of increase, Antarctic sea-ice extent and persistence has declined precipitously since 2014; declining sea ice has implications for global climate and threatens to upend light, phytoplankton, and disturbance regimes that structure the environments of unique coastal Antarctic benthos. Understanding sea-ice dynamics before satellite images requires paleoenvironmental proxies. The Antarctic scallop *Adamussium colbecki* is an attractive candidate to proxy sea-ice persistence because it is an ecosystem engineer, relatively long-lived, widely geographically distributed, and has a genus history in Antarctica to the Oligocene. This dissertation compares growth and chemistry of *A. colbecki* valves from two sites on western McMurdo Sound that differ by sea-ice duration: Explorers Cove has multiannual sea ice and Bay of Sails has sea ice that breaks out annually. Valve growth is slower for scallops living under multiannual sea ice. Yearly growth is also more variable under multiannual sea ice, suggesting locally heterogenous food distribution. Subannual growth lines (striae) are not good candidates for ontogenetic ageing of *A. colbecki*, but comparison of concurrently growing juveniles suggests that interstrial growth increments reflect environmental conditions, rather than individual biology. Striae are therefore suitable candidates for further environmental analysis. Stable isotopes of oxygen in *A. colbecki* valves are indistinguishable between the sites. In contrast, stable isotopes of carbon in narrow and wide striae groups reflect greater seasonality of nutrient conditions at the annual sea ice site and help differentiate valves living under annual and multiannual sea-ice conditions. Trace element concentrations form clear cycles over ontogeny in valves from the annual sea ice site, and cycles are absent in valves at the multiannual sea ice site. Covariation (wavelet coherence) between trace elements and interstrial growth increments and among individual trace elements is stronger for longer sections of ontogeny under annual sea ice than multiannual sea ice. Moreover, Mn/Ca and Pb/Ca may proxy sea ice. Growth and valve chemistry differ under annual and multiannual sea ice in *A. colbecki* in Antarctica, thus *A. colbecki* is a promising proxy for past sea-ice duration in Antarctica.

INDEX WORDS: sea ice, *Adamussium colbecki*, growth, stable isotopes, trace elements, sclerochronology

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Sea ice in Antarctica

Over the last quarter of the 20th century and the beginning of the 21st, the overall area covered by sea ice in the Antarctic gradually increased, despite regional-scale variability (Zwally 2002; Parkinson and Cavalieri 2012). This pattern is in contrast to dramatic losses in the Arctic sea ice extent and duration over the same time period (Simmonds 2015). Between 2014 and 2017, however, Antarctic sea ice declined rapidly (Parkinson 2019). Sea ice plays a major role in regulating Earth's climate, affecting gas exchange between ocean and atmosphere, deep sea ocean circulation, and the heat budget for the entire planet (Dieckmann and Hellmer 2010), and recent loss at both poles is an important bellwether of global climate change.

Sea ice is a critical factor structuring marine ecosystems in Antarctica. Sea ice increases ecological variability, affects sedimentation, and mediates or prevents iceberg scour, with profound implications for underlying benthic communities (Dayton 1990; Eicken 1992; Moline et al. 2008; Clark et al. 2017). Critically, sea ice attenuates light penetration into the water column, thereby restricting phytoplankton blooms, though algal primary production in sea ice itself is an important food source for ecosystems within and beneath the sea ice (Arrigo et al. 1997; Arrigo 2010). Antarctic ecosystems are unique, having effectively evolved in isolation since the Antarctic Circumpolar Current formed

~14 million years ago (Aronson et al. 2011). The Antarctic benthos have been compared to the Paleozoic fauna for their abundance of echinoderms and brachiopods and relative dearth of shell-crushing predators (Dayton et al. 1994; Aronson et al. 2011). Sea ice may break out every summer (annual sea ice) or persist for multiple years to decades (multiannual sea ice), and changes in sea-ice persistence can radically restructure underlying marine communities (Thrush et al. 2006; Clark et al. 2015; Dayton et al. 2019; Kim et al. 2019). Predicting the future impacts of changes in sea-ice persistence on these unique communities requires an understanding of the past variability in sea ice persistence around Antarctica.

Highly precise monitoring of the geographic extent and temporal duration of sea ice in the Antarctic is possible only after the 1970s and the advent of satellite data. To understand sea-ice dynamics prior to the last few decades, we must rely on proxies to reconstruct sea-ice conditions. Maximum sea-ice extent at a given time and locality can be known from diatoms and biomarkers from sediment cores, and the regional area of sea ice can be known from certain aerosolized chemicals in ice cores (Abram et al. 2013; Weckström et al. 2013), but sea-ice formation and break out is a seasonal or annual event at some sites and an intermittent one at other sites. Aside from glacial lake varves, even high temporal resolution in sediment cores is on the order of 4–8 years (Arnaud et al. 2005; Wormer et al. 2014) and unable to resolve subannual processes. High temporal resolution, but not high spatial resolution, is possible with aerosolized proxies from ice cores (Abram et al. 2013). In contrast, bivalve mollusks, especially long-lived bivalve mollusks can resolve multiannual and subannual environmental conditions, even providing annual paleoclimate information over several centuries, as in *Arctica islandica* (Schöne et al. 2011; Butler et al. 2013).

Bivalve sclerochronology and its potential to proxy sea-ice persistence

Physical and chemical properties of the hard shells of bivalves are important tools for reconstruction of past environments. The sequential accretion of valve layers preserves a record of growth and changes in valve chemistry over the lifetime of the animal. Changes in growth rates and valve chemistry have been related to an annually expanding list of environmental and ecophysiological conditions (for reviews see, e.g. Schöne and Gillikin 2013; Butler and Schöne 2017; Prendergast et al. 2017; Gillikin et al. 2019). Critically for this dissertation, growth and valve chemistry in bivalves are affected by sea-ice duration and related processes, although the impacts are under studied.

Generally, bivalve growth rates decrease and lifespans increase with increasing latitude (Moss et al. 2016). This trend has been attributed to decreased temperature and nutrient restriction, and fossil evidence from a warmer Antarctic during the early Cenozoic suggests that nutrient restriction might be primarily responsible (Moss et al. 2017). Because multiannual sea ice dampens phytoplankton blooms, slower growth rates and longer lifespans might be expected under multiannual sea ice than under annual sea ice. Evidence from the Arctic bivalve *Clinocardium robustum* suggests that growth rates do increase with decreased sea-ice duration (Sejr et al. 2009).

Trace element concentrations in bivalve shells also differ under annual and multiannual sea ice. In particular, trace elements concentrations of manganese, magnesium, iron, and lead may increase as a result of sea-ice breakout, and barium might increase with phytoplankton blooms subsequent to sea-ice breakout (Lartaud et al. 2010). Additionally, changes in valve concentrations of magnesium may be attributable to either sea-ice breakout or valve growth rate (Lartaud et al. 2010). A suite of trace elements connected to salinity and water column chemistry may have higher valve concentrations under with longer sea-ice persistence, whereas trace elements like lead that are quickly removed from the water column through adsorption onto particulate matter have higher concentrations under less persistent sea ice (Wing et al. 2020).

Sea ice affects seawater chemistry, nutrient availability, and growth and valve chemistry of bivalves. The development of a reliable, broadly distributed Antarctic bivalve as a proxy for Antarctic sea-ice duration would expand our knowledge of sea-ice variability over time.

***Adamussium colbecki*, Antarctic scallop and ecosystem engineer**

The Antarctic scallop *Adamussium colbecki* is a vital member of Antarctic benthic ecosystems. It can be highly locally abundant (covering up to 100% of the substrate in some areas; Chiantore et al. 2000; Heilmayer et al. 2003) and comprises a large portion of the benthic biomass (Stockton 1984; Hancock et al. 2015). *Adamussium colbecki* is an ecosystem engineer: it plays an important role in benthic-pelagic nutrient coupling (Cattaneo-Vietti et al. 1997; Chiantore et al. 1998), and valves provide hard substrate and dispersal assistance for a host of epibionts, increasing biodiversity in sites with otherwise soft sediment (Berkman 1994*a*; Cummings et al. 2006; Cerrano et al. 2009). The ecological importance of *A. colbecki* enhances its usefulness as a paleoenvironmental proxy; changes to growth in ecosystem engineers can have cascading effects on ecosystems (Wild et al. 2013).

Adamussium colbecki has wide geographic and temporal ranges, a large shell, and a long lifespan. Combined, these traits enable high spatial and temporal resolution for paleoenvironmental investigations. Its geographic distribution is patchy, but circumpolar, and it maintains populations in both the high Antarctic and on the Antarctic peninsula (Schiaparelli and Linse 2006). The species has a fossil history in coastal Antarctica through the Pleistocene and the genus *Adamussium* extends to the Oligocene (Berkman and Prentice 1996; Quaglio et al. 2008, 2010; Beu and Taviani 2014). Both annual and subannual growth bands are recognized in *A. colbecki* valves; large valve size combined with subannual growth divisions could provide high temporal resolution for sclerochronological studies. X-ray bands have been validated as annual growth markers coincident with winter $\delta^{18}O_{shell}$ maxima in Terra Nova Bay (Heilmayer et al. 2003; Trevisiol et al. 2013). Moreover, small, co-marginal growth ridges (striae) form approximately fortnightly in summer juvenile growth (Lartaud et al. 2010) and groups of striae with narrow and wide interstrial growth increments have been proposed as seasonal growth markers and used to age *A. colbecki* at Explorers Cove (Stockton 1984; Berkman 1990). Valves likely represent 2+ decades of growth (Heilmayer et al. 2003; Cronin et al. 2020), though longer age estimates of 40+ to 100+ years have also been made (Lohmann et al. 2001; Berkman et al. 2004; Abele et al. 2009).

Valve chemistry provides insights into *A. colbecki* life history and environment. Stable isotopes of oxygen have been used in *A. colbecki* to reconstruct summer seawater temperatures, ambient air temperatures, and glacial meltwater influxes (Berkman 1994*b*;

Lohmann et al. 2001; Trevisiol et al. 2013). Several trace elements in *A. colbecki* valves are promising proxies for sea-ice breakout itself or for related phenomena such as phytoplankton blooms, growth rate, or glacial meltwater input (Berkman 1994*b*; Lartaud et al. 2010). *Adamussium colbecki* has the potential to proxy sea-ice persistence, over several years per individual valve, through large portions of the Cenozoic. An understanding of sea-ice variability through Antarctic history could help predict the future of unique Antarctic ecosystems in a warming world.

Purpose of Study

The purpose of this dissertation is to understand how the growth, lifespan, and shell chemistry of the Antarctic scallop and ecosystem engineer *Adamussium colbecki* are affected by sea-ice persistence to potentially enable *A. colbecki*'s use as a proxy for coastal Antarctic sea-ice persistence. Live and subfossil scallops were collected from two sites on western McMurdo Sound with similar seawater temperatures and hydrological conditions but differ in sea-ice duration: Explorers Cove maintains multiannual sea ice and sea ice at Bay of Sails breaks out annually. Lifespan, growth, stable isotopes of oxygen and carbon, and trace were evaluated in scallops that lived under annual and multiannual sea ice. Trace elements were also sampled from subfossils from Explorers Cove and Bay of Sails to investigate past local variability of sea-ice persistence. Ultimately, an understanding of past variability in Antarctic sea-ice duration could help predict the future of the unique Antarctic benthic fauna in a warming world.

In Chapter 2, I test whether growth or lifespan of *A. colbecki* differs meaningfully under annual and multiannual sea ice. Owing to hypothesized heightened caloric restriction under multiannual sea ice, I expected lifespan to be longer and growth to be slower at Explorers Cove. External annuli (a new method for this species) were used to establish an ontogenetic age and yearly growth rates for *A. colbecki* from Explorers Cove and Bay of Sails. Growth was compared between the sites using yearly growth rates and the von Bertalanffy growth model. Contrary to expectations, lifespan is essentially identical between the sites, but growth is slower and more individually variable under multiannual sea ice: von Bertalanffy *k* and adult and juvenile growth rates are lower at Explorers Cove. Explorers Cove individuals also have more variable values of *k*, which I attribute to heterogenous nutrient distribution under multiannual sea ice. Finally, there is no evidence of extreme (100+ year) longevity postulated by other researchers. Instead, *A. colbecki* likely live ~20+ years.

In Chapter 3, I test the hypotheses of previous authors regarding striae, small commarginal ridges on valve surfaces. Striae putatively form fortnightly (Lartaud et al. 2010) in groups of alternate narrow and wide spacing, which are interpreted to represent slow winter growth and fast summer growth, respectively (Stockton 1984; Berkman 1990). If both of these descriptions of striae are true, and if striae are to be used as reliable growth markers on *A. colbecki* valves, there should be a consistent number of striae in narrow and wide groups among individual scallops, and the interstrial growth increments should vary with a periodicity of ~26 striae. I quantified the number of striae per group and yearly cycle throughout juvenile growth of valves from Explorers Cove and Bay of Sails, used wavelet analysis to assess the periodicity of interstrial growth increments, and compared the interstrial growth increments during concurrent growth of juveniles collected in 2016. There is high inter-and intra-individual variability of the number of striae per group and putative yearly cycle, and only one valve from each site maintains periodic variation in interstrial distances at ~26 striae continuously throughout juvenile growth. Striae are therefore too inconsistent to be used as reliable age markers in *A. colbecki*. However, the strong similarity in the pattern of interstrial growth increments among the concurrently growing juveniles collected in 2016 suggest a strong environmental control on growth increments, which is further explored with stable isotopes and trace elements in Chapters 4 and 5. Finally, interstrial growth increments are larger annual sea ice site than under multiannual sea ice, suggesting faster growth under annual sea ice and supporting conclusions from Chapter 2.

In Chapter 4, I compare the stable isotopes in *A. colbecki* valves from Explorers Cove and Bay of Sails to understand how they varied with sea-ice persistence, validate annuli using oxygen isotopes, and test whether groups of wide and narrow striae vary seasonally (after Stockton 1984). Three adult valves collected from each site in 2008 and two juvenile valves collected from Explorers Cove in 2016 were analyzed for stable isotopes of oxygen and carbon. I hypothesized that the oxygen isotopes should be similar at Explorers Cove and Bay of Sails unless there is a difference in glacial meltwater input between them, and that annuli would coincide with $\delta^{18}O_{shell}$ maxima unless growth is different between these sites and a seasonally warmer site on western McMurdo Sound. Carbon isotopes should have higher amplitude variability at the annual sea ice site and be less positive overall at the annual sea ice site if $\delta^{13}C_{shell}$ reflects $\delta^{13}C_{DIC}$. If narrow and wide striae groups correspond to seasonal growth differences, $\delta^{18}O_{shell}$ should be less positive and $\delta^{13}C_{shell}$ should be more positive in wide striae groups. Oxygen isotopes are statistically indistinguishable between the sites. Annuli coincide more often with $\delta^{18}O_{shell}$

minima at Bay of Sails and with both $\delta^{18}O_{shell}$ minima and maxima at Explorers Cove, suggesting that *A. colbecki* living in the coldest waters on Earth may have different growth patterns than populations in seasonally warmer water. $\delta^{18}O_{shell}$ is similar in narrow striae groups and wide striae groups, but $\delta^{13}C_{shell}$ is more positive in wide striae groups than narrow striae groups only under annual sea-ice conditions, suggesting that the shells may be preserving a $\delta^{13}C_{DIC}$ signal and that carbon isotopes in striae groups may be proxies for sea-ice persistence.

In Chapter 5, I compare the trace element composition of valves from Bay of Sails and Explorers Cove and include both modern and subfossil *A. colbecki* valves in the analysis. Li, Mg, Mn, Ba, and Pb were sampled from subannual growth increments over *A. colbecki* ontogeny using LA-ICP-MS and the relationships among trace elements and between each trace element and growth were evaluated. Trace element concentrations, especially Li/Ca, Mg/Ca, Mn/Ca, and Ba/Ca, form distinct cycles in valves from the annual sea ice site, but not the multiannual sea ice site. Additionally, wavelet coherence among trace elements and between trace elements and growth are stronger and persisted longer through ontogeny in valves from the annual sea ice site. Mn/Ca and Pb/Ca are supported as sea ice proxies, whereas Li/Ca and Mg/Ca may be strongly affected by physiological processes. Together, these results support the use of trace elements in *A. colbecki* valves as proxies for sea-ice persistence in Antarctica. Trace elements from subfossil valves suggest that Bay of Sails might have maintained multiannual sea ice in the past.

CHAPTER 2

GROWTH AND LONGEVITY OF THE ANTARCTIC SCALLOP *ADMUSSIUM COLBECKI* UNDER ANNUAL AND MULTIANNUAL SEA ICE[1]

[1] Cronin, K.E., Walker, S.E., Mann, R., Chute, A.S., Long, M.C., Bowser, S.S., 2020. Growth and longevity of the Antarctic scallop Adamussium colbecki under annual and multiannual sea ice. Antarctic Science 1–10. https://doi.org/10.1017/S0954102020000322. Reprinted here with permission from the publisher

Abstract

Ecosystem engineers such as the Antarctic scallop (Adamussium colbecki) shape marine communities. Thus, changes to their lifespan and growth could have far-reaching effects on other organisms. Sea ice is critical to polar marine ecosystem function, attenuating light and thereby affecting nutrient availability. Sea ice could therefore impact longevity and growth in polar bivalves unless temperature is the overriding factor. Here, we compare the longevity and growth of A. colbecki from two Antarctic sites: Explorers Cove and Bay of Sails, which differ by sea-ice cover, but share similar seawater temperatures, the coldest on Earth (-1.97 °C). We hypothesize that scallops from the multiannual sea-ice site will have slower growth and greater longevity. We found maximum ages to be similar at both sites (18–19 years). Growth was slower, with higher inter-individual variability, under multiannual sea ice than under annual sea ice, which we attribute to patchier nutrient availability under multiannual sea ice. Contrary to expectations, A. colbecki growth, but not longevity, is affected by sea-ice duration when temperatures are comparable. Recent dramatic reductions in Antarctic sea ice and predicted temperature increases may irrevocably alter the life histories of this ecosystem engineer and other polar organisms.

Introduction

Ecosystem engineers, such as epibenthic bivalves (e.g. oysters, mussels and scallops), not only support fisheries and enhance water clarity, but also increase habitat complexity, leading to increased biotic diversity (Gutiérrez et al. 2003). Environmental perturbations and climate change alter the growth of ecosystem engineers (e.g. Menge et al. 2008), which can cause cascading effects through biotic communities (Wild et al. 2013). The response of polar ecosystem engineers to changing environments remains unclear, as most studies have focused on temperate and tropical regions. Polar regions are particularly vulnerable to the effects of climate change (Turner et al. 2014), and recent studies show strong shifts in community composition in response to changing ice dynamics (Dayton et al. 2019, Kim et al. 2019); therefore, additional understanding of the growth and lifespan of these vital organisms is critical to predicting their response, and thus the response of polar ecosystems, to future environmental change.

The Antarctic scallop (*Adamussium colbecki*) helps structure coastal Antarctic ecosystems. Their shells are often the only hard substrate in soft-sediment environments, hosting a diverse array of biotic communities and providing major contributions of calcium carbonate biomass to the Antarctic regions where *A. colbecki* occurs (Cummings et al. 2006, Cerrano et al. 2009, Hancock et al. 2015). Circumpolar in distribution and locally abundant (sometimes reaching densities of over 90 individuals m-2), *A. colbecki* also plays an integral role in pelagic–benthic nutrient coupling by filter feeding, bio-depositing and re-suspending organic-rich detritus when phytoplankton production is insufficient to generate nutrients (Stockton 1984, Cattaneo-Vietti et al. 1997, Chiantore et al. 1998, Heilmayer et al. 2003, Schiaparelli & Linse 2006, Norkko et al. 2007).

Despite its ecological importance, the maximum lifespan of *A. colbecki* is not well constrained. Maximum lifespan estimates range from 6 years to over a century (Ralph & Maxwell 1977, Berkman 1990, Heilmayer et al. 2003). In general, high-latitude bivalves have slower growth and live longer than temperate bivalves. Nevertheless, a century-long lifespan would make *A. colbecki* the longest-lived scallop by far. Furthermore, the highest growth estimates (K) derived from von Bertalanffy growth models (VBGMs) for this species are nearly triple the lowest growth estimates (Berkman 1990, Chiantore et al. 2003, Heilmayer et al. 2003, Schiaparelli & Aliani 2019). Variation in estimates of lifespan and growth could result from a variety of factors, such as differences in age determination methods, environment (water temperature, primary production related to sea-ice conditions) and latitude (Stockton 1984, Heilmayer et al. 2003, Hancock et al. 2015).

Sea ice is critical in structuring polar ecosystems (Eicken 1992, Clark et al. 2015), and bivalve growth reflects changes in sea-ice extent and duration in the Arctic (Sejr et al. 2009). The type of sea ice in an area (annual or multiannual) has important implications for primary production and therefore nutrient availability for Antarctic benthic organisms. Annual sea ice is thinner than multiannual sea ice, allowing more light penetration into the water column that facilitates phytoplankton blooms under the ice (Arrigo et al. 2012). Break out of annual sea ice also allows yet more light to penetrate the water column, further increasing primary productivity (Dayton 1990, Clark et al. 2015), whereas multiannual sea ice dampens productivity (Norkko et al. 2007, Clark et al. 2015). Additionally, primary productivity of sea-ice algae is higher under annual sea ice than under multiannual sea ice in Antarctica (Arrigo et al. 1997). *Adamussium colbecki* populations consume more detritus and less phytoplankton at sites with multiannual sea ice and more phytoplankton at annual sea-ice sites (Norkko et al. 2007). Nutrient limitation and low temperatures reduce metabolism and are thought to drive increased longevity and decreased growth rates in high-latitude bivalves (Moss et al. 2016), and caloric restriction, specifically, increases longevity across a wide range of animals (Fontana et al. 2010). Thus, *A. colbecki* living under multiannual sea ice may be longer lived and slower growing than their counterparts under annual sea ice when seawater temperatures are similar.

Our study compares the growth and longevity of *A. colbecki* from two sites located within western McMurdo Sound, Antarctica, which vary in sea-ice duration but not seawater temperature. We postulate that scallops from the multiannual sea-ice site will have a longer maximum lifespan and slower growth than scallops from the annual sea-ice site. However, if growth and lifespan estimates are similar at both sites, then some other environmental variable (i.e. temperature; Menge et al. 2008) must be the overriding factor affecting their growth and, ultimately, their lifespan. Additionally, we compared our age estimates with results from previous studies that used alternative age estimates for *A. colbecki* to determine whether the age estimation method also influences lifespan estimates.

Methods

Background: longevity and growth in A. colbecki

Adamussium colbecki is endemic to the Southern Ocean, and its distribution is primarily restricted to coastal Antarctica (Schiaparelli & Linse 2006). Sites where its growth and lifespan were examined span ~12 degrees of latitude within a seawater temperature range of ~4 °C (Fig. 1). Nevertheless, growth and lifespan estimates have varied widely for this species (Ralph & Maxwell 1977, Stockton 1984, Berkman 1990, Heilmayer *et al.* 2003, Berkman *et al.* 2004), which is possibly attributable to latitudinal differences among populations, the use of various methods to analyse growth and longevity in *A. colbecki* or other environmental factors not considered here (e.g. differences in pH, salinity, carbonate concentration, etc.).

Estimates of *A. colbecki* growth and lifespan were previously made at three sites: Explorers Cove (EC) at the southern end of western McMurdo Sound; Stonington Island, located off the west coast of the Antarctic Peninsula; and Terra Nova Bay, a polynya at the northern end of western McMurdo Sound (Fig. 1). Additionally, juvenile summer growth rates were measured at Dumont d'Urville Station, though lifespan was not estimated. Explorers Cove, the highest-latitude and coldest site, maintains temperatures near the freezing point of seawater (-1.97 °C), and *A. colbecki* at that locality have the slowest growth and greatest lifespan estimates (Brody growth constant, K = 0.09 yr^{-1}; 100+ yr lifespan; Berkman 1990, Berkman *et al.* 2004). Stonington Island, the lowest-latitude and warmest site, had the second highest growth estimate and the shortest lifespan (K = 0.24 yr^{-1}; 6–7 yr lifespan; Ralph & Maxwell 1977). Lastly, Terra Nova Bay is intermediate between EC and Stonington Island in both latitude and temperature, as well as growth and lifespan estimates (K = 0.11–0.26 yr^{-1}; 18+ yr lifespan; Chiantore *et al.* 2003, Heilmayer *et al*. 2003, Schiaparelli & Aliani 2019). At all of the sites, *A. colbecki* growth slows through ontogeny, but multiple authors have remarked upon the high inter-individual variability in growth rates (Chiantore *et al.* 2003, Lartaud *et al.* 2010, Trevisiol *et al.* 2013).

Researchers have used two different valve features to analyse growth and lifespan, which may contribute to the disparate longevity and growth estimates. Small sub-annual bands (striae; Fig. 2a) were used either individually or in groups to analyse growth at EC. At that site, individual striae were counted and growth rates ranging from 0.29 to 0.53 mm yr^{-1} were estimated on recaptured scallops, leading the authors to conclude that the largest known *A. colbecki* (108 mm) could be over a century old (Berkman *et al.* 2004). Other studies, using grouped striae, suggest that *A. colbecki* lives for 13–20 years at EC (Stockton 1984, Berkman 1990). Rather than using striae, bands visible under X-ray (Fig. 2b) were used for *A. colbecki* from Stonington Island and Terra Nova Bay. Using X-ray bands, *A. colbecki*'s lifespan could be 6–18+ years (Ralph & Maxwell 1977, Heilmayer *et al.* 2003, Trevisiol *et al.* 2013, Schiaparelli & Aliani 2019). The disparity in growth and lifespan estimates for *A. colbecki* necessitates a comparison of estimates from various sites using a consistent method.

Study site and collection

Adult scallops were haphazardly collected live by divers in November 2008 from water depths between ~9 and 18 m from areas totalling ~300 m^2 from two sites in western McMurdo Sound, Ross Sea, Antarctica (Fig. 3). The sites were chosen based on similarity in water temperature (-1.97 °C), proximity to each other and differences in sea-ice persistence. The lower valves of 37 scallops collected from EC and 19 collected from Bay of Sails (BOS) were used in this study. Scallops from EC were slightly smaller than scallops from BOS (EC mean valve height = 78.7 mm, 95% confidence interval (CI): 76.3–81.0 mm; BOS mean valve height = 80.7, 95% CI: 76.9–84.2 mm).

Both EC and BOS are characterized by gently sloping topography and negligible water currents except for tidal flow ranging from ~1.0 to 2.6 cm s^{-1} (Barry & Dayton 1988, Hancock *et al.* 2015). Both sites are considered oligotrophic: organic carbon and diatom fluxes are two orders of magnitude lower than in eastern McMurdo Sound due to current flow under the Ross Ice Shelf (Leventer & Dunbar 1987).

Explorers Cove is an embayment located at the mouth of the Taylor Valley and maintains multiannual to decadal sea-ice cover. Sea ice broke out partially in 1999 and more extensively in 2002, but has otherwise remained intact since 1993. Sea ice at EC during the 1990–2011 field seasons was typically multiyear and ~3.25–4.00 m thick (Bowser, personal observations). Sediment at EC is composed of polymictic fine silty sands with a modal grain size of 125–300 μm (Radford *et al.* 2014). Additionally, an ice wall along the shoreline at ~5 m depth creates a moat containing nutrient-rich brackish water that enters EC periodically (during spring high tides) and supplies nutrients to areas within 100–200 m (Dayton *et al.* 2019). Scallops collected for this study were found within the area that would be influenced by the nutrients from the ice wall.

Bay of Sails is located ~25 km north of EC, offshore of Wilson Piedmont Glacier. Sea-ice breaks out annually at BOS and iceberg disturbance is probably higher at BOS than at EC (Hancock *et al.* 2015). Sediment at BOS is comprised of polymictic very fine sands with a modal grain size of 63–125 μm (Radford *et al.* 2014).

Annuli identification and growth increment measurement

We used annual bands visible on shell surfaces (annuli) to compare growth and lifespan at EC and BOS (after Merrill *et al.* 1966) for three reasons. First, though X-ray bands in *A. colbecki* valves have been validated as annual using $\delta^{18}O$ (Heilmayer *et al.* 2003), Heilmayer *et al.* (2003) also identified annuli on valve surfaces and found ~90% agreement between the numbers of X-ray bands and annuli per valve. Therefore, counts of X-ray bands and annuli should result in comparable lifespan estimates for *A. colbecki*. Second, we had difficulties interpreting X-ray bands in *A. colbecki*'s thin shells, difficulties also encountered by a previous author (Stockton, 1984). We found annual X-ray bands were impossible to distinguish from other irregularities in growth that produced similar rings, possibly shock rings (Merrill *et al.* 1966). Third, annuli are commonly employed to age scallops in fisheries studies, making results from this method comparable to other scallop research.

Annuli were recognized by changes in valve colour and curvature. These annuli represent annual slowing or cessation in growth (Merrill *et al.* 1966). We found that *A. colbecki* had two distinct annuli types (Fig. 4). The first type of annuli appear as whitish rings in slight concave depressions against the brown surface colour of the shell, which we interpret as slower growth, but not growth cessation. The second type of annuli are still whitish rings, but also have a shingled appearance and occur during late adult growth (near valve margins). We interpret the second annuli type as growth cessation; the shingled appearance results from new growth beginning under, then growing past, the previous shell margin.

The age of each valve was determined by counting discernible annuli. Median ages and 95% CIs for each site were calculated using bootstrap resampling and compared to determine whether sea-ice duration affected age.

The distance from the umbo to each annulus along the central axis of each valve was measured using electronic callipers (accuracy: ± 0.01 mm) yielding height-at-age measurements. Yearly growth increments (yearly growth rates) were calculated by subtracting the height at age t from the height at age t + 1.

Shell height-at-age measurements were also used to model *A. colbecki* growth using the VBGM. We used the typical von Bertalanffy growth equation in Eq. (1):

$$L_t = L_\infty(1 - e^{-K(t - t0)}) \quad (1)$$

where L_t is the shell height at time t, L_∞ is the asymptotic average height (the theoretical maximum height of the average individual in a population and the asymptote that the curve approaches), the Brody growth constant (K) describes how quickly valve height approaches L_∞ and t_0 represents the time at which the valve would have a height of zero. Curves were fitted to height-at-age data using non-linear least square regression (R Core Team 2017, https://github.com/droglenc/FSA).

The VBGM characterizes the average growth at each site and the typical VBGM equation is commonly used in *A. colbecki* studies (Ralph & Maxwell 1977, Berkman 1990, Chiantore *et al.* 2003, but see Heilmayer *et al.* 2003, Schiaparelli & Aliani 2019). We therefore use the typical VBGM to compare our results to previous work. We fit VBGM curves to the height-at-age data for EC and BOS valves to compare average growth.

The similarity of the VBGM curves fitted to the EC and BOS height-at-age data was compared with maximum likelihood methods (Nelson 2017). First, four hypothetical curves were fitted to the EC and BOS data. Three of the hypothetical curves have identical values for a single VBGM parameter (K, L_∞, t_0), positing that EC and BOS share a VBGM parameter in common. The fourth hypothetical curve has equal values for all three VBGM parameters, in essence positing that the growth at EC and BOS is indistinguishable. Second, the residual sum of squares is then calculated for the fit of all four hypothetical curves and for the actual curves fitted to the height-at-age data for each site. The curve, whether hypothetical or actual, with the smallest residual sum of squares is said to have the best fit, and support for each model was represented using the Akaike information criterion (ΔAIC), such that the lowest ΔAIC indicates the curve that best fits the data (Nelson 2017, R Core Team 2017).

We analysed individual variation in growth (K and L_∞) using Ford–Walford plots for each valve. Ford–Walford plots are used to model individual growth when there is variability in K and L_∞ within a population (Hart & Chute 2018). In a Ford–Walford plot, height at age t is plotted against height at $t + 1$, and both K and L_∞ can be calculated from a linear regression using Eqs (2) and (3):

$$K = -\ln\beta \qquad (2)$$

$$L_\infty = \alpha/1 - \beta \qquad (3)$$

where β is the slope and α is the *y*-intercept of the Ford–Walford linear regression (Walford 1946). To alleviate ambiguity in reporting K and L_∞ derived from two different methods, K_{VBGM} and $L_{\infty VBGM}$ will denote results from VBGM models and K_{FW} and $L_{\infty FW}$ will denote results from Ford–Walford plots. The means and 95% CIs of K_{FW} and $L_{\infty FW}$ for scallops from each site were calculated using bootstrap resampling. The coefficients of variation of K_{FW} and $L_{\infty FW}$ were calculated to evaluate the amount of individual variability for each site. Valves ≤ 70 mm in height were excluded from individual Ford–Walford analyses; therefore, 31 valves from EC and 14 valves from BOS were included.

Results

Lifespan estimates

Adult *A. colbecki* from EC and BOS had identical median ages of 14 years (Fig. 5), though BOS scallops had a greater maximum age (19 years) than EC scallops (18 years).

Yearly growth rate estimates for A. colbecki at EC and BOS

As with other bivalves, *A. colbecki* yearly growth is fastest in juveniles and slows throughout ontogeny. At both sites, mean growth rates were fastest at 4 years of age and declined thereafter (Fig. 6a & b). Juvenile ($\leq$ 6 years of age) mean yearly growth rate was slower at EC (8.6 mm yr^{-1}) than at BOS (10.2 mm yr^{-1}), but adult growth was faster at EC (3.6 mm yr^{-1}) than at BOS (2.8 mm yr^{-1}) (Fig. 6c).

von Bertalanffy growth models

Growth parameters calculated from fitted VBGM equations indicated that EC scallops have slower growth rates and greater maximum heights than BOS scallops (EC K_{VBGM} = 0.15; BOS K_{VBGM} = 0.21; EC $L_{\infty VBGM}$ = 94.5 mm; BOS $L_{\infty VBGM}$ = 89.7) (Fig. 7). Comparisons of VBGMs using likelihood methods suggested growth at EC and BOS is indeed dissimilar. Of the four hypothetical VBGMs, the model that posited EC and BOS share an identical t_0 best fit the data, but the model positing that no parameters were equal between the sites also had strong support (Table I). The hypothetical model with the weakest support posited that $L_{\infty VBGM}$ or K_{VBGM} are equal for EC and BOS (Table I).

Among individual valves, K_{FW} and $L_{\infty FW}$ were both more variable at EC than BOS, suggesting that there may be more inter-individual variability in growth at EC than BOS. The coefficient of variation for K_{FW} and was higher at EC (0.32) than at BOS (0.13). Similarly, the coefficient of variation for $L_{\infty FW}$ was higher at EC (0.11) than at BOS (0.07). Furthermore, the range of K_{FW} was larger at EC (0.07–0.23 yr^{-1}) than at BOS (0.14–0.22 yr^{-1}), and the range of $L_{\infty FW}$ was also higher at EC (86–135 mm) than at BOS (86–106 mm). Finally, the mean of individual K_{FW} values was lower and the mean of individual $L_{\infty FW}$ values was higher at EC than at BOS, supporting the results from the fitted von Bertalanffy equations indicating that EC scallops grow more slowly than BOS scallops (Fig. 8).

Discussion

Effects of sea-ice persistence on lifespan

Sea-ice condition appears to have no effect on *A. colbecki* lifespan; the median age of individuals living under primarily multiannual sea ice (EC) was indistinguishable from that of those living under annual sea ice (BOS). If sea-ice condition is irrelevant, some other factor must control lifespan. The comparable water temperatures at BOS and EC are consistent with longevity being controlled by temperature.

Theoretical maximum lifespan

We found no direct evidence of extreme longevity in *A. colbecki*. Instead, we found < 20 year maximum ages at both western McMurdo sites of EC and BOS. Our maximum ages agree well with the 18+ year longevity estimate from Terra Nova Bay (Heilmayer *et al.* 2003), but are considerably lower than the highest estimate from EC. The century-long age estimation for *A. colbecki* stems from measuring growth rates (0.24–0.53 mm yr^{-1}) of marked and recaptured individuals at EC, then extrapolating the rates to the largest known *A. colbecki* (108 mm; Berkman 1990, Berkman *et al.* 2004). It should be noted that sea ice at EC was typically multiyear prior to the collection of these two scallops in 1986 (Bowser, personal communication), but extrapolating from these very low growth rates may overestimate the *A. colbecki* maximum lifespan. For instance, if our average scallop (~14 years old, ~80 mm shell height) grew at 0.53 mm yr^{-1} for 76 years, it would be over 125 mm (> 15 mm larger than the largest known *A. colbecki*) when it reached 100 years old. On the other hand, if we assume the oldest scallop in our study (80 mm at 19 years) grew at its final yearly growth rate (0.24 mm yr^{-1}) for 80 years, it would be just over 100 mm by

100 years of age. It is therefore theoretically possible to have a century-old *A. colbecki*, but this is improbable.

Nevertheless, maximum ages from our study should not be considered an upper limit on *A. colbecki* maximum lifespan for two reasons. First, our largest individual was ~12 mm smaller than the largest recorded *A. colbecki*, and this species can sustain very low growth rates over multiple years (Berkman *et al.* 2004, this study). Second, the maximum bivalve lifespan typically increases with latitude (Moss *et al.* 2016), and some species of lower-latitude scallops have higher recorded maximum ages, such as *Chlamys islandica* (35 years from Svalbard; Fevolden 1992). A multi-decadal (≥ 20 year) lifespan for *A. colbecki* is therefore probable, though we did not observe direct evidence for this.

Age estimation methods compared

Age estimation methods appear to strongly affect lifespan estimates for *A. colbecki*. Maximum ages from our study (18–19 years) were more similar to the maximum age from Terra Nova Bay based on X-ray bands (18+ years; Heilmayer *et al.* 2003) than to maximum ages from striae-based EC studies (13–100+ years; Stockton 1984, Berkman 1990, Berkman *et al.* 2004). Moreover, lifespan estimates are more variable for striae methods: maximum lifespans estimated from EC scallops were 13, 20 or 100+ years (Stockton 1984, Berkman 1990, Berkman *et al.* 2004). In contrast, maximum lifespans based on X-ray bands produced estimates of 6 years from Stonington Island (Ralph & Maxwell 1977) and 18+ years from Terra Nova Bay (Heilmayer *et al.* 2003). Counting annuli provides a maximum age estimate of 19+ years (this study). The similarity between our age estimates and those from Terra Nova Bay suggests that discrepancies in age estimation methods might be contributing to the wide range of lifespans reported for *A. colbecki*.

Annuli- or X-ray-based age estimation methods produce more consistent lifespan estimates than striae-based methods, possibly because of incorrect assumptions about the timing of striae formation in adults. *Adamussium colbecki* striae accrete approximately fortnightly in juveniles (Lartaud *et al.* 2010), but fortnightly striae formation probably does not continue through adulthood. For example, in a mark-recapture study at EC, one adult scallop was recaptured after 8 years and another adult was recaptured after 12 years, but they had accreted 19 and 105 striae, respectively (Berkman *et al.* 2004). Their results suggest that striae do not form at consistent time intervals in adults. Estimating age in *A. colbecki* using the grouped striae method implicitly assumes that striae form at consistent time intervals throughout both juvenile and adult growth. Theoretically, the grouped striae method would underestimate scallop ages if striae form at irregular time intervals. For example, the largest known *A. colbecki* (108 mm) was estimated to be 20 years old based on extrapolation from a VBGM for EC scallops whose ages were determined using the grouped striae method (Berkman 1990); in contrast, our 19 year-old individual was ~80 mm. Striae do not appear to be reliable for age estimation in adult *A. colbecki*, and therefore annuli or X-ray bands should be used.

Effects of sea-ice persistence and temperature on growth

Sea-ice duration affects *A. colbecki* growth rates and variability; growth (proxied by K_{VBGM}, K_{FW} and mean juvenile growth rates) is slower and more variable at EC than at BOS. Seawater temperature is comparable at EC and BOS; we therefore postulate that growth differences result from differences in nutrient availability. Sea ice is a critical factor controlling nutrient supply to benthic organisms. Specifically, *A. colbecki* is known to consume more re-suspended detritus under multiannual sea ice at EC where less phytoplankton is available and more phytoplankton at Terra Nova Bay, which has a long open-water period (Norkko *et al.* 2007). Furthermore, phytoplankton consumption by *A. colbecki* decreases with increasing sea-ice duration (Norkko *et al.* 2007). In laboratory experiments, *A. colbecki* metabolism was higher for individuals provided with summer-like nutrient quantities than for individuals provided with winter-like nutrient quantities, even though temperature was held relatively constant (Heilmayer & Brey 2003). Therefore, it is plausible that sea-ice-mediated dietary differences resulting in fewer and more episodic nutrients may explain the slower and more variable growth at EC, our multiannual sea ice site.

Higher individual variability in K_{FW} at EC reinforces our interpretation that overall slower growth at EC is caused by nutrient limitation related to persistent multiannual sea ice. K is negatively correlated with latitude in bivalves, a trend that is attributed to nutrient restriction (Moss *et al.* 2016). Higher individual variability in K_{FW} at the multiannual sea-ice site may result from episodic, unevenly distributed nutrient availability under multiannual sea ice than under annual sea ice. In an overall lower-nutrient environment with episodic and patchily distributed input of sea-ice algae and nutrient-rich waters from behind the ice wall, we posit that some individuals will acquire more nutrients and grow faster than others, resulting in more individual variability in growth. Conversely, annual sea-ice break out should supply phytoplankton consistently to an entire population and reduce individual variability in K_{FW}, similarly to the results at BOS.

The slower adult growth rate in *A. colbecki* at BOS is reinforced by the higher K_{VBGM} value at BOS. Though K_{VBGM} is not a growth rate *per se*, it does describe how quickly the population approaches its theoretical maximum size ($L_{\infty VBGM}$). A higher K

value indicates that a population reaches its maximum size faster than a population with a lower *K* value. If the BOS population approaches $L_{\infty VBGM}$ more quickly than the EC population, as indicated by its higher K_{VBGM}, then adult growth rates should be slower at BOS because the BOS scallops are slowing their growth as they approach their theoretical maximum size. Conversely, growth rates are higher at comparable adult ages at EC because the EC scallops included in this study are further from their theoretical maximum height. Based on the VBGM results, it is possible that EC scallops live longer than BOS scallops, but our directly aged samples did not corroborate this.

Despite generally slower growth at EC, yearly mean growth rates followed similar trajectories over ontogeny at both sites; mean yearly growth rate reached a maximum at year 4 and fell thereafter. Studies based on gonadal analysis and shell morphology from Terra Nova Bay placed *A. colbecki* sexual maturity at 6 or 7 years of age (Cattaneo-Vietti *et al.* 1997). Peak growth rates during year 4 suggest that scallops might start devoting energy to gonad development by as early as year 5 at EC and BOS, but studies of gonadal tissue are needed to confirm this observation.

The effects of temperature on *A. colbecki* growth rates are supported by both laboratory and *in situ* studies. When shell growth was monitored for 1 week in laboratory conditions, juvenile *A. colbecki* kept in 3 °C water grew faster than juvenile *A. colbecki* kept at 0 °C under the same light and food regimes (Heilmayer *et al.* 2005). Moreover, when compared with temperate scallops, *A. colbecki* metabolism is low but proportional to the temperature and latitudinal context in which they live (Heilmayer & Brey 2003). Effects of temperature are also evident in growth over the entire lifetime of scallops, proxied by *K*. Based on previous reports, the shortest estimated lifespan and highest *K* occurred in *A. colbecki* living in the nearshore waters of Stonington Island, where summer water temperatures can reach 2 °C (Ralph & Maxwell 1977). All other reports suggest that *A. colbecki* live longer and grow more slowly in the colder water around mainland Antarctica (Berkman 1990, Heilmayer *et al.* 2003). *Adamussium colbecki* also has a low tolerance for increased water temperature, further supporting temperature effects on growth. For example, laboratory experiments demonstrated that swimming ability in *A. colbecki* declines at water temperatures > 0 °C; temperatures of ~4 °C resulted in 50% mortality at 19 days (Peck et al., 2004). Explorers Cove and BOS maintain *A. colbecki* populations near the freezing point of seawater, and populations can be found as far north as the Antarctic Peninsula, where seawater reaches 2 °C during summer.

A combined role for temperature and nutrients determining growth would not be unusual. Temperature and nutrients were implicated as factors that determine growth in other scallop species (Pilditch, 1999). Additionally, a study comparing the strength of factors affecting the growth of the temperate ecosystem engineer *Mytilus* found that temperature accounted for 32.0% of growth variation and nutrients accounted for 12.5% (Menge *et al.* 2008). We posit that nutrient availability through sea-ice persistence affects *A. colbecki* growth, though temperature also plays a role.

Effects of growth estimation methods

Previously recorded *A. colbecki* growth rates for all juvenile growth overlap at EC, BOS and Terra Nova Bay, despite sea-ice, seasonal temperature and methodological differences (Cattaneo-Vietti *et al.* 1997, Stockton 1984, Chiantore *et al.* 2003, Trevisiol *et al.* 2013, Schiaparelli & Aliani 2019). Juvenile growth rates from this study fall within the ranges from these previous studies. In contrast, previously reported adult growth rates vary widely among EC, BOS and Terra Nova Bay, but the differences appear to be driven mainly by the ontogenetic ages of the adult scallops included in each study. Including only young individuals in studies will increase reported adult growth rates, while exclusively using older individuals will decrease them, because *A. colbecki* growth slows over its lifetime. We excluded neither old nor young adults from our calculations, and therefore adult growth rates from our study are higher than those previously reported from an EC study that included only older adults (Berkman *et al.* 2004) and lower than those previously reported from a Terra Nova Bay study that included only younger adults (Chiantore *et al.* 2003, Trevisiol *et al.* 2013).

Estimates of *K* allow for more direct comparison among the sites, but VBGMs are modelled from size-at-age data, and size-at-age data depend upon the age determination method. Consequently, comparison among studies of the same species that use various age determination methods should be made carefully. Our K_{VBGM} results from BOS scallops were closer to reported *K* values from studies using X-ray bands, though the sites (Terra Nova Bay and Stonington Island) are seasonally warmer than EC and BOS (Ralph & Maxwell 1977, Chiantore *et al.* 2003, Schiaparelli & Aliani 2019), and our EC K_{VBGM} results were higher than the reported *K* values from an EC study (Berkman 1990) using the grouped striae method. The grouped striae method therefore appears to underestimate *K* compared to annual band methods (annuli or X-ray).

Conclusions

No evidence was found suggesting that sea-ice persistence controls *A. colbecki* lifespan, but growth was slower and more variable for scallops living under multiannual sea ice than for scallops living under annual sea ice. Large discrepancies in age estimates are probably the result of using various and incompatible age estimation methods for this species. Based on counting annuli, the maximum lifespan of *A. colbecki* from our sites is probably 19+ years and is in good agreement with estimates using X-ray bands from Terra Nova Bay. We recommend the use of either annuli or X-ray bands for age estimation in this species, although we found X-ray bands difficult to interpret. Counting groups of striae is a common method for ageing *A. colbecki* at EC, but it may lead to misestimates of lifespan and growth.

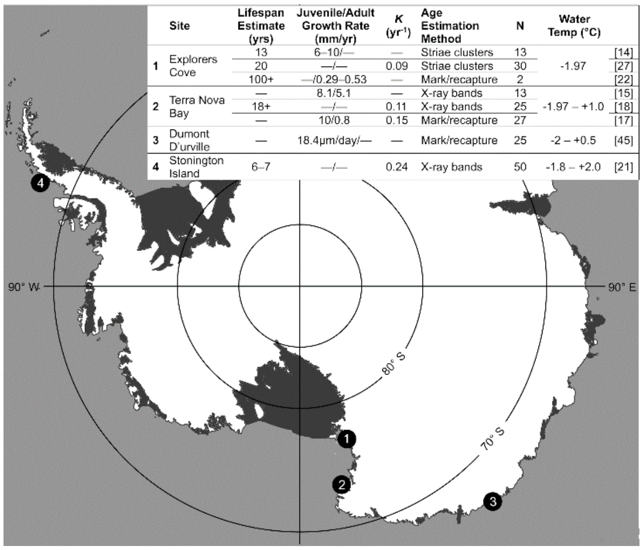
A comparison of the growth and lifespan of historical and modern populations on Stonington Island, where climate change-induced temperature increases are more pronounced, is warranted to predict *A. colbecki*'s future in a warmer Antarctica. Warmer water and reduced sea-ice duration would increase primary productivity but may also dramatically alter the life history of this Antarctic ecosystem engineer and the biotic communities that depend on it.

Tables

Table 2.1: Likelihood ratio test of von Bertalanffy model for *A. colbecki* by site. Bold ΔAIC values indicate the models with the strongest support (lowest ΔAIC).

Hypothesis	**AIC**	**Δ AIC**
No parameters are equal	**189.37**	**1.14**
$L_{\infty VBGM} = L_{\infty VBGM}$	191.62	3.39
$K_{VBGM} = K_{VBGM}$	201.62	13.39
$t_0 = t_0$	**188.23**	**0**
All parameters are equal	208.82	20.59

Figures



	Site	Lifespan Estimate (yrs)	Juvenile/Adult Growth Rate (mm/yr)	K (yr⁻¹)	Age Estimation Method	N	Water Temp (°C)	
1	Explorers Cove	13	6–10/—	—	Striae clusters	13	-1.97	[14]
		20	—/—	0.09	Striae clusters	30		[27]
		100+	—/0.29–0.53	—	Mark/recapture	2		[22]
2	Terra Nova Bay	—	8.1/5.1	—	X-ray bands	13	-1.97 – +1.0	[15]
		18+	—/—	0.11	X-ray bands	25		[18]
		—	10/0.8	0.15	Mark/recapture	27		[17]
3	Dumont D'urville	—	18.4μm/day/—	—	Mark/recapture	25	-2 – +0.5	[45]
4	Stonington Island	6–7	—/—	0.24	X-ray bands	50	-1.8 – +2.0	[21]

Figure 2.1. Growth and lifespan estimates for *A. colbecki* in Antarctica. Previous studies of *A. colbecki* longevity and growth from four Antarctic sites (Explorers Cove, Terra Nova Bay, Dumont d'Urville Station, and Stonington Island) resulted in a range of lifespan and growth estimates. Study sites are indicated with numbered circles; numbers correspond to results in the table inset; N refers to sample size, water temperature from (Hancock *et al.* 2015, Heilmayer & Brey 2003, Lartaud *et al.* 2010, Stockton 1984; P. Cziko, personal communication).

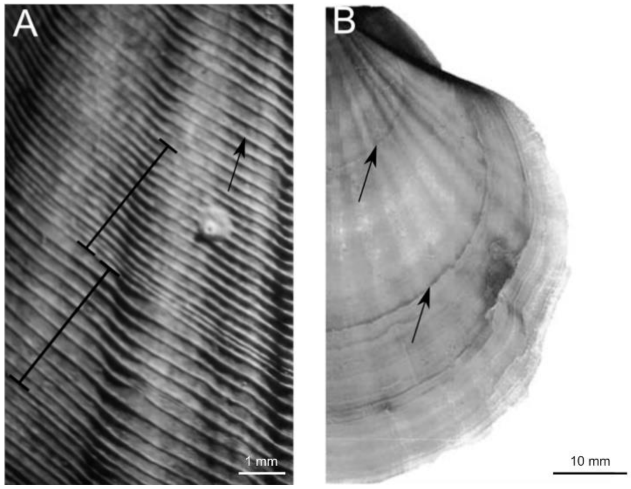


Figure 2.2. Age estimation in *A. colbecki*. Striae (small raised co-marginal ridges on valve surfaces) and X-ray bands are used for age estimation in *A. colbecki*. (A) *Grouped striae*: One year is thought to represent a group of widely-spaced striae coupled with a group of narrowly-spaced striae (Stockton, 1984; Berkman 1990). Black brackets span one widely-spaced group and also one narrowly-spaced group; a single stria is indicated by the arrow. (B) *X-ray bands*: bands visible in X-ray are used as yearly markers (Cattaneo-Vietti et al., 1997; Heilmayer et al., 2003; Ralph and Maxwell, 1977). Arrows point to X-ray bands.

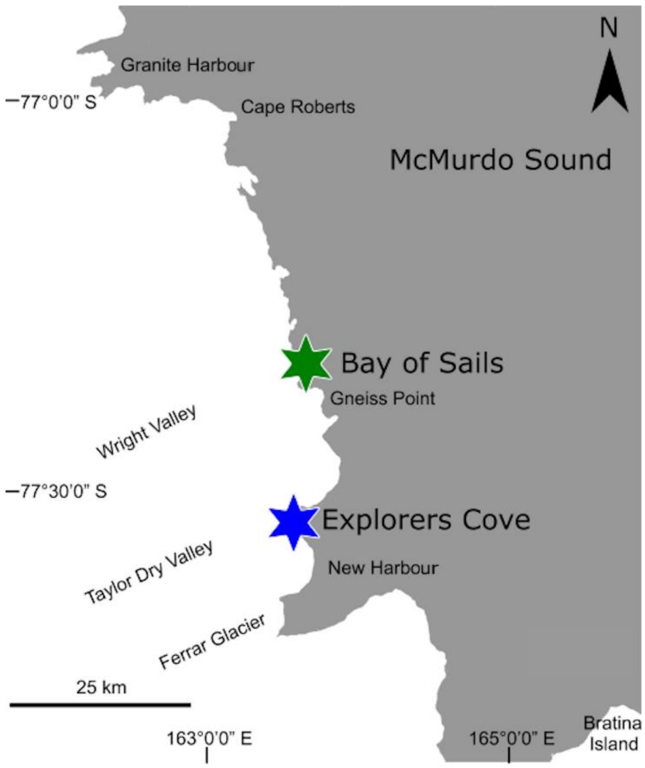


Figure 2.3. Study Sites of Explorers Cove (EC) and Bay of Sails (BOS), western McMurdo Sound, Antarctica. EC (77°34.259'S, 163°30.699'E) is a marine embayment at the mouth of Taylor Dry Valley and is ~25 km south of BOS (77°21.911'S, 163°32.594'E). At BOS, sea ice melts annually, whereas sea ice at EC persists for multiple years.

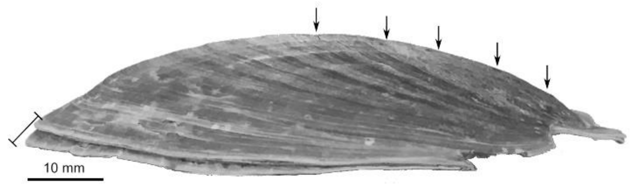


Figure 2.4. Annuli identification on *A. colbecki* valves. Annuli (indicated by arrows) appear as whitish rings in concave depressions against the brown, convex shell surface. Shingled annuli representing late adult growth indicated by brackets.

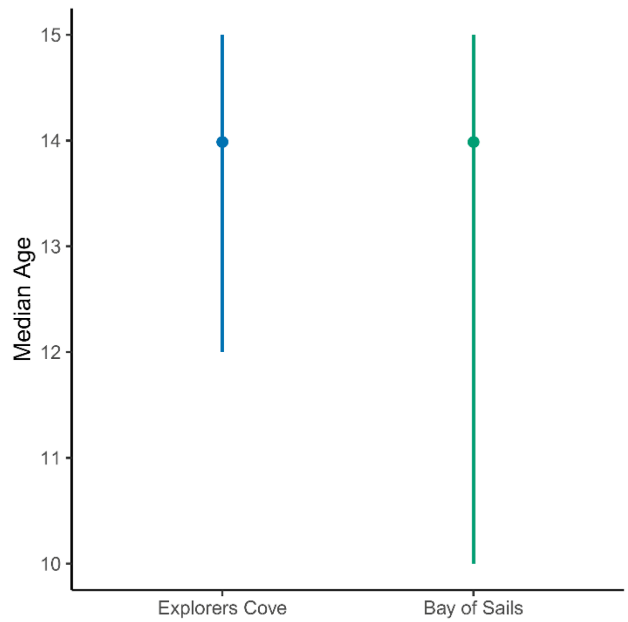


Figure 2.5. Median valve ages by site. Points indicate median age; lines delineate 95% confidence intervals on the medians.

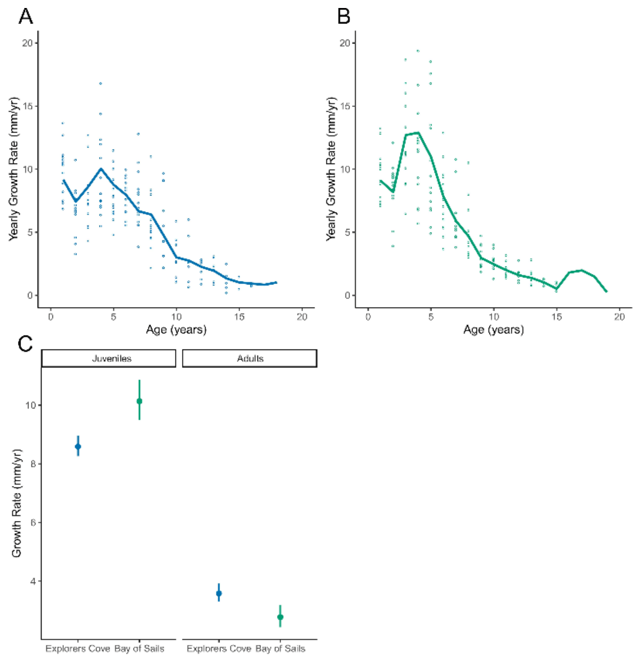


Figure 2.6. Growth rates by site (A) Mean yearly growth rates at EC. (B) Mean yearly growth rates at BOS. Open circles indicate yearly growth rate for each individual and the line indicates mean yearly growth rate. (C) Mean juvenile and adult growth rates by site. Juveniles include valve growth rates for ages ≤ 6 yrs. Adult growth rates include growth rates for ages > 6 yrs. Points indicate mean growth rate; lines delineate 95% confidence intervals on the means.

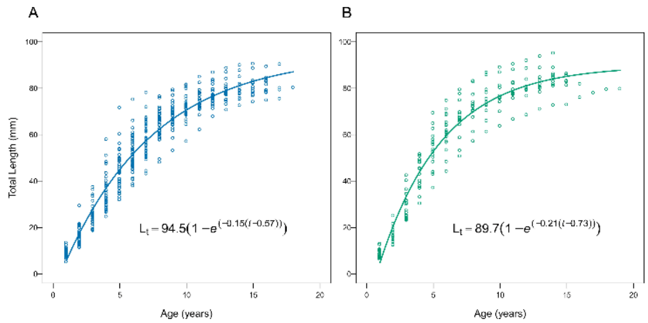


Figure 2.7. von Bertalanffy growth models for *A. colbecki* by site (A) EC. (B) BOS Circles indicate individual heights–at–age and solid line indicates the von Bertalanffy growth model.

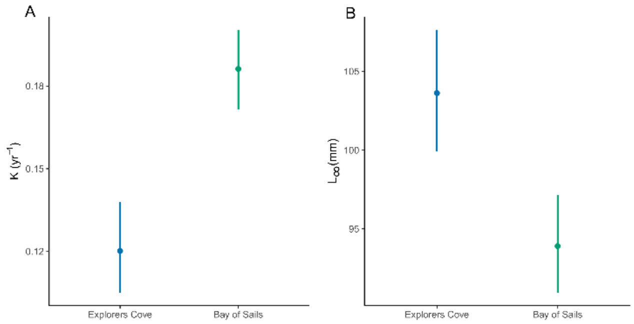


Figure 2.8. Mean *K* and L_∞ derived from Ford Walford plots for individual valves

(A) *K* comparison by site. (B) L_∞ comparison by site. Points indicate mean *K* and L_∞; lines delineate 95% confidence intervals on the means.

CHAPTER 3

STRIAE IN THE ANTARCTIC SCALLOP *ADAMUSSIUM COLBECKI* PROVIDE ENVIRONMENTAL INSIGHTS BUT NOT RELIABLE AGE INCREMENTS[2]

[2] Cronin, K. E., S. E. Walker, S. S. Bowser. Submitted to Polar Biology

Abstract

Subannual growth increments in bivalves provide unparalleled insight into past seasonal seawater conditions. The Antarctic scallop *Adamussium colbecki* (Smith 1902) accretes putatively fortnightly surficial growth lines (striae), and interstrial growth increments may archive seasonal environmental variations. Cycles of paired groups of wide and narrow striae are sometimes used to determine ontogenetic age in these scallops, but previous quantitative work describing strial grouping and formation is limited to a few months of juvenile growth. Here, we analyze strial patterns in *A. colbecki* collected from two sites on western McMurdo Sound that differ by sea-ice duration: Explorers Cove with multiannual sea ice and Bay of Sails with annual sea ice. At both sites, visual analysis of striae groups and cycles (using the methods of previous authors) and wavelet analysis of interstrial increments suggest that striae groups are too variable to age *A. colbecki*. Only ~40% of striae groups and cycles conformed to the expected ~26 striae per annual cycle, where each striae records growth during one fortnight. Moreover, only one scallop from each study site displayed consistent periodicity at ~26 striae throughout juvenile growth in wavelet analysis. Though strial grouping was inconsistent, analysis of concurrent growth of juvenile scallops from Explorers Cove suggested strong environmental control on interstrial increment size and thus that strial increments are suitable for further environmental analysis. Finally, the multiannual sea ice site had smaller interstrial growth increments and less valve wear than the annual sea ice site, indicating overall slower growth and possibly lower metabolic activity.

Introduction

The Antarctic scallop *Adamussium colbecki* is a potentially important high-resolution proxy for seawater conditions in the Southern Ocean (Lartaud et al. 2010). Though patchy, the modern distribution of *A. colbecki* is circum-Antarctic (Schiaparelli and Linse 2006) and the genus *Adamussium* has a fossil record extending back to the Oligocene (Quaglio et al. 2010). Valves provide a hard substrate for encrusting organisms, thereby increasing local diversity (Berkman 1994; Cummings et al. 2006; Cerrano et al. 2009; Hancock et al. 2015), and the living scallops play a vital role in benthic-pelagic nutrient coupling (Stockton 1984; Cattaneo-Vietti et al. 1997; Chiantore et al. 2000; Norkko et al. 2007). Furthermore, *A. colbecki* growth is affected by sea-ice duration at the annual scale (Cronin et al. In press), thus a more complete understanding of subannual growth patterns could make *A. colbecki* a powerful paleoenvironmental proxy for sea-ice variability.

Adamussium colbecki form striae, small commarginal growth ridges on valve surfaces. Striae are common to several scallop species, and growth increments between adjacent striae (interstrial growth increments; ISIs) correspond with environmental and metabolic conditions (Chauvaud et al. 1998, 2005; Owen et al. 2002; Aguirre Velarde et al. 2015). Previous work suggests that patterns in ISI on *A. colbecki* valves indicate seasonality: Groups of widely spaced striae (putative faster summer growth) alternate with groups of narrowly spaced striae (putative slower winter growth) throughout ontogeny (Stockton 1984; Berkman 1990; Lartaud et al. 2010). Adjacent wide and narrow groups are thought to be yearly cycles and are used to ontogenetically age *A. colbecki* (Stockton 1984; Berkman 1990). The yearly cycles contain ~28 (±2) striae

(Lartaud et al. 2010). Moreover, mark-recapture evidence suggests that striae in *A. colbecki* form fortnightly and co-incident with spring tides (Lartaud et al. 2010). If striae form approximately fortnightly a one-year cycle should contain ~26 striae. If the ISIs between adjacent striae vary seasonally, and if striae form regularly. striae on *A. colbecki* valves could provide unparalleled temporal resolution for Antarctic paleoenvironmental investigations.

Fortnightly periodicity in strial formation may be unique among scallops. Daily periodicity is suggested for several species (Antoine 1978; Broom and Mason 1978; Helm and Malouf 1983; Chauvaud et al. 1998), although two-day periodicity is also recorded (Thébault et al. 2006). Though studies that establish the timing of strial formation usually examine only a truncated portion of juvenile growth (Johnson et al. 2000; Lartaud et al. 2010; Aguirre Velarde et al. 2015), the timing of strial formation can change throughout the year (Broom and Mason 1978; Gruffydd 1981; Joll 1988; Owen et al. 2002) or throughout ontogeny (Antoine 1978; Berkman et al. 2004).

Timing of strial formation and the number of striae in yearly cycles remains poorly understood in *A. colbecki* except during summer growth in juveniles (Lartaud et al. 2010) and in late adulthood, where strial formation appears to be infrequent and irregular (Berkman et al. 2004). Despite irregularities, ISIs can still be used as a high-resolution sclerochronological tool when striae are well understood for a particular species (Chauvaud et al. 2005).

Our study tests whether striae on *A. colbecki* have consistent periodicity throughout juvenile growth (≤ 50 mm shell height; Cattaneo-Vietti et al., 1997) and whether sea-ice duration affects strial formation in this scallop. We analyzed two aspects of strial growth patterns to determine if they are consistent with fortnightly formation. First, we determined the number of striae per summer and winter group as well as the yearly cycle among individuals. Second, we examined the periodicity in ISIs. We then assessed the similarity in ISI patterns among concurrent growth in juveniles to parse out whether ISI primarily reflects endogenous or environmental controls. Finally, we examined if sea-ice duration affects strial formation.

Methods

Study sites and sample collection

Scallops were collected from two sites in western McMurdo Sound, Ross Sea, Antarctica: Explorers Cove (EC) and Bay of Sails (BOS) share similar, topography, currents, and water temperature. Sediment is finer at EC than BOS owing to the abundance of silt. Within the sand fraction, however, sediment is coarser at EC (125–300 µm vs 63–125 µm). Crucially, sea ice melts annually at BOS and persists for multiple years at EC (Fig. 3.1; Bernhard 1987; Barry and Dayton 1988; Bowser and Bernhard 1993; Thrush et al. 2010; Radford et al. 2014; Hancock et al. 2015). In 2008, eleven adult (> 70 mm shell height) scallops were collected live from EC, and seven adult scallops were collected live from BOS (> 70 mm shell height). An additional five juveniles (four juveniles < 20 mm shell height; one juvenile < 50 mm shell height) were collected live after a recruitment event in 2016. Their contemporaneous growth can be compared to evaluate whether ISIs are predominantly controlled by the environment or individual biology during summer juvenile growth, when strial formation timing is known (approximately fortnightly; Lartaud et al., 2010).

Striae digitization

Only right (lower) valves were analyzed for this study. Right valves are less convex than left valves in *A. colbecki*, which minimized distortion in digital measurement of photographs. Valves with the least amount of wear were used because lower valves are susceptible to wear from abrasion that can destroy striae. Only the juvenile portion of shell growth—between the umbo and 50 mm shell height (after Cattaneo-Vietti et al., 1997)—was analyzed on the adult scallops. For the juveniles collected from EC in 2016, the entire right valve was analyzed.

Valves were digitally photographed under 25X magnification, and the photos were stitched to create a continuous profile along the central growth axis. All subsequent data were collected from the photos. Each discernable stria was identified, and the distance between adjacent striae (ISIs) was measured using ObjectJ in FIJI (Schindelin et al. 2012).

Striae group analysis

Groups of widely spaced or narrowly spaced striae were identified on each valve and adjacent wide and narrow groups were classified as yearly cycles (after Stockton 1984). We further defined a group to contain a minimum of three striae. To ensure that visually identified groups reflected meaningful differences in interstrial increment size, the mean ISI of each group was calculated and compared to the mean of each adjacent group using Student's *t*-tests. Differences between ISI of all striae between BOS and EC were evaluated using means and 95% confidence intervals generated from bootstrap resampling. The number of striae within each wide or narrow striae group and within each yearly cycle were counted. The median number of striae per wide group, narrow group, and yearly cycle was evaluated using the maximum likelihood estimator of the Poisson rate parameter and their 95% confidence intervals. The median number of striae per striae group and cycle were compared between EC and BOS to assess the possible influence of sea-ice duration on strial grouping. All statistical analyses were performed in R Statistical Software (R Core Team 2017).

Despite selecting for unworn valves, portions of some lower valves were abraded such that striae were obscured or absent along portions of the central axis. In these cases, the obscured section of the central axis was measured, and the total obscured portion for each valve was calculated:

$$\frac{total\ abraded\ valve\ height}{50\ mm} = worn\ fraction$$

Differences between valves from BOS and EC in worn fraction were evaluated using means and 95% confidence intervals generated from bootstrap resampling. The worn portion of each valve is used here as a potential proxy for metabolic activity: higher worn fraction is assumed to indicate more valve movement against the sediment, whereas lower worn fraction is assumed to indicate more sedentary scallops.

Time series analysis of interstrial growth increments

Visual assignment of striae to wide or narrow groups is somewhat subjective, we therefore used time series analysis to uncover patterns in ISIs that could be overlooked even by a careful observer to assess the periodicity of ISI for consistency with yearly cycles based on fortnightly-forming striae. For this time series, we used wavelet analysis, which allows evaluation of important frequencies through time and accommodates non-stationary time series (Torrence and Compo 1988). Wavelet analysis permits assessment of any changes in periodic behavior of interstrial increments throughout juvenile ontogeny. One continuous sequence of striae was analyzed for each valve: from the first visible striae after the umbo to either 50 mm valve height or to the first portion of the valve obscured by wear (including all identifiable striae grouped and ungrouped). Each adult valve had a continuous sequence of at least 48 striae. Wavelet analysis was performed using the R package WaveletComp1.1 (Roesch and Schmidbauer 2018).

Comparison of interstrial growth increments on EC juveniles

Striae increment measurements from the five 2016 EC juveniles were compared to each other to evaluate the suitability of strial measurements for environmental analysis. The adult valves cannot be compared to one another in this way because their juvenile portions grew during different years. Thus, a direct comparison of ISI sequences is possible only with the 2016 juveniles, which grew concurrently. Similar strial patterns among several individuals over a concurrent growth period provides evidence of an external or environmental control on ISI, making striae suitable for seasonal or environmental analysis. In contrast, different patterns in ISI among several individuals from the same location over the same time period suggests strong endogenous or biological control, making ISI unsuitable for environmental analysis.

Results

Striae as age indicators

Striae groups and cycles

Alternating groups of wide and narrow striae (striae cycles) are apparent on all juvenile portions of adult valves from both sites (Fig. 2A). Moreover, the groups that we visually defined represent meaningful differences in ISI; 98% of adjacent striae groups have mean ISIs that are different than means of adjacent groups (Supplemental Information).

Beginning at the first striae after the umbo, at least two complete striae cycles are observed on the juvenile portion of all adult valves at both sites, but on some valves, some striae are either not in recognizable groups (ungrouped striae) or are affected by valve wear. Approximately 40% of the valves from both sites (EC: 45%: 5/11; BOS 42%: 3/7 valves) contain striae that cannot be visually assigned to wide or narrow groups. Ungrouped striae have sequences of striae that did not meet the minimum requirements of three widely spaced or narrowly spaced striae per group, but instead alternate between 1–3 wide striae followed by 1–3 narrow striae without ever forming a visually identifiable group (Fig. 2B). The ISIs of ungrouped striae are measured, and they are included in time series analyses but are excluded from analyses of striae groups and cycles.

In total, 143 striae groups and 62 striae cycles are identified across the juvenile portion of eleven EC valves, and 58 striae groups and 27 striae cycles are identified across the juvenile portion of all seven BOS valves. EC and BOS have similar median numbers of striae in each group (EC:12.6 striae; BOS: 13.6 striae; Fig. 3A) and cycle (EC: 25.7 striae; BOS: 28.5 striae; Fig. 3B), but overlapping confidence intervals suggest that differences between the sites cannot be distinguished. For both sites, the median number of striae per group and striae per cycle are close to our expectations for striae that accrete fortnightly in a yearly cycle of wide and narrow ISIs (~13 striae per group and ~26 striae per cycle) and comparable to previous visual findings (~28 ± 2 striae per cycle; Lartaud et al., 2010).

In contrast, the number of striae in any single group or cycle is quite variable. The range of striae per group is large at both sites (3–38 striae), as is the range of striae per yearly cycle (EC: 9–64 striae; BOS: 11–60 striae). More striae groups and cycles deviate from the expected values than conform to them. Only 37% (75/201) of striae groups from both sites have 10–16 striae, while 39% (39/89) of the yearly cycles have 20–32 striae. These results indicate that a majority (> 60%) of individual striae groups and yearly cycles contain too many or too few striae to be consistent with fortnightly strial formation in a yearly cycle.

Time series analysis of interstrial growth increments

If striae form fortnightly throughout juvenile growth and if the increments between them vary seasonally, sequences of interstrial increments should conform to two expectations in wavelet analysis. First, there should be a statistically significant period (different from background noise) at ~26 striae, indicating a repeating pattern in interstrial increments every 26 striae (one year of fortnights). Second, the periodic behavior should remain consistent and near 26 throughout juvenile ontogeny without much change over time. Of the eleven adult valves from EC and seven from BOS, only one valve from each site meet both expectations, with consistent, statistically significant periodicity near 26 striae throughout juvenile ontogeny (EC valve #4 and BOS valve #7; Figs. 4, 5). The remaining valves violate at least one of the expectations. Some have significant, but short-lived periods near 26 striae (i.e. EC valves #2 and #11; BOS valve #4). Others have periods that rise or fall by 4–13 striae through juvenile growth (i.e. EC valves #1, #5, #6, and #7; BOS valves #1, #2 and #5). Finally, some have periods that persist through ontogeny (varied by ≤ 2 striae) but are not near 26 striae (i.e. ~40 striae in

EC valve #2, ~50 striae in EC valve #3, 21 striae in EC valve #9, and 31 striae in BOS valve #6).

Striae as environmental information

Comparison of interstrial growth increments on EC 2016 juveniles

Four of the juveniles collected in 2016 have only one full yearly cycle (containing both a wide and narrow group of striae). The two remaining valves have ~1.5 cycles and 3 yearly cycles. The portions of valves that represent concurrent growth have very similar patterns in ISI, regardless of the total number of striae cycles present on each valve (Fig. 6), suggesting that ISI is primarily controlled by exogenous (environmental) factors, rather than endogenous (individual biological) factors.

Striae groups and cycles under annual and multiannual sea ice

ISI and valve wear differ under annual and multiannual sea ice. The mean ISI of all measured striae is larger at BOS than at EC. Mean BOS ISI is 26 mm (95% CI: 0.25–0.27), whereas mean EC ISI is 0.22 mm (95% CI: 0.22–0.23 mm). ISI range is also wider at BOS than at EC (BOS: 0.006–1.15 mm; EC: 0.026–0.70 mm). More BOS valves are abraded such that striae cannot be discerned compared to EC valves (EC: 4/11 valves; BOS: 5/7 valves.) Similarly, valve wear is greater at BOS than EC: the wear fraction at BOS is 0.29 (95% CI: 0.13–0.50) but 0.06 at EC (95% CI: 0.03–0.09).

Despite differences in mean ISI, both sites have approximately equal numbers of striae in their wide groups as in their narrow groups. At EC, narrow striae groups contain 12.2 striae (95% CI:11.4–13.0 striae) and wide groups contain 12.9 striae (95% CI: 12.1–13.7 striae). At BOS, narrow striae groups contain 13.2 striae (95% CI: 11.9–14.6 striae) and wide striae groups contain 13.9 striae (95% CI: 12.6–15.3 striae).

Discussion

Striae groups and cycles as age indicators

If analysis of striae is restricted to means and medians, striae groups and cycles appear to match expectations consistent with yearly cycles and fortnightly formation. For instance, alternating groups of wide and narrow striae are apparent on all *A. colbecki* valves, consistent with descriptions from previous work (Stockton 1984; Berkman 1990; Lartaud et al. 2010). Additionally, the median number of striae per group (12.6 at EC vs 13.6 at BOS) are roughly equivalent to values expected if striae form fortnightly (~13 striae) (after Lartaud et al., 2010). Nonetheless, when individual valves are examined, the large variation and inconsistency in number of striae in any individual group or cycle, combined with the occurrence of ungrouped striae on several valves, suggests that visual analysis of striae groups and cycles is an unreliable method for ontogenetic age determination of *A. colbecki* shells.

The number of striae in any single group or cycle ranges from fewer than half the number expected to more than double. Fewer than 40% of striae groups or cycles conform to expectations based on fortnightly formation or data from previous authors (Lartaud et al. 2010). This result highlights the importance of expanding analyses of subannual growth increments to include and report data from both more individuals and longer periods of shell growth.

Wavelet analysis of ISI on individual valves reinforces the inconsistencies observed in visual analysis of strial grouping. Only two valves, one each from EC and BOS, have the expected number of 26 striae per cycle throughout juvenile growth. More commonly, valves display either cycles that repeat at higher periods than expected (~32+

striae) or at periods that change throughout juvenile growth (up to 13 striae), and sometimes both (Figs. 4, 5). Because of high inter- and intra- individual variability, most valves do not conform to previous expectations of strial grouping or periodicity, further evidence striae groups should not be used to age *A. colbecki*.

A potential explanation for the coincidence of strial formation with spring tides at Dumont D'Urville (Lartaud et al. 2010) and the apparent irregularity of strial formation at EC and BOS is the tidal regime in the Ross Sea. In contrast to the mixed diurnal/semidiurnal tides that occur at Dumont D'Urville (Lartaud et al. 2010), the Ross Sea has diurnal declinational tides governed by the moon's transit of the equator with a period of 13.66 days (Goring and Pyne 2003). Goring and Pyne (2003) suggest that tidally influenced biological rhythms may conform to ~13.66 day periodicity rather than the more common ~14.77 day periodicity expected in a lunar fortnight (Tran et al. 2011). Possible links between strial formation and tidal patterns at EC, BOS, and other Ross Sea sites merits further exploration.

For our study, we assume that striae form fortnightly during juvenile growth (after Lartaud et al., 2010). Indeed, the wavelet analysis is predicated upon that assumption. The results of our study do not support this except for one shell from each site, but neither can our study, as designed, refute fortnightly formation. Further, a previous study found irregular strial formation in late adult growth (Berkman et al., 2004). We recommend two things if age studies are to be done with *A. colbecki*: first, that mark-recapture studies include individuals of diverse ages and size classes and second, that striae groups should not be used to age *A. colbecki*, although it is tempting to attribute this pattern to yearly seasonal cycles.

Striae as environmental indicators

Despite our recommendation against striae groups and cycles to age *A. colbecki*, interstrial increments (ISIs) may archive environmental information. Similar patterns in ISI during concurrent growth of the juveniles collected from EC in 2016 suggest a strong exogenous (environmental) control on increment size, and several differences between ISI in BOS and EC may provide evidence of past sea-ice duration in fossil and subfossil valves.

First, the mean ISI at BOS is 15–18% higher than at the annual sea ice site compared to the multiannual sea ice site. Annual growth increments also indicate that scallops from BOS grow faster than scallops from EC (Cronin et al. In press). Growth rates of *A. colbecki* may therefore be a method to differentiate between sea-ice duration around Antarctica, like growth rates of *Clinocardium ciliatum* in the Arctic (Sejr et al. 2009).

Additionally, both the number of abraded valves and the worn fraction on abraded valves are higher at BOS than EC. Though abrasion has the effect of erasing useful striae data, we speculate that it also provides environmental evidence: silt in the EC sediment may reduce valve abrasion compared to BOS. In contrast, the worn fraction of striae may be evidence of sea-ice duration that is preserved on fossil and subfossil valves if more valve abrasion is connected to overall higher metabolic activity and valve movement at the annual sea ice site. This is corroborated by faster growth (larger ISI) at BOS but must be confirmed by behavioral studies and evidence from other *A. colbecki* populations.

Finally, the median number of striae in narrow *versus* wide groups are similar at both EC and BOS. While individual groups vary widely, median striae per narrow or wide group range from ~11–14. The similar number of striae in wide and narrow groups suggest that *A. colbecki* growth may slow, but not stop entirely, during juvenile growth under both annual and multiannual sea ice. In contrast, temperate scallops decrease the number of striae formed as their growth slows or stops (e.g. Chauvaud et al., 2005; Helm and Malouf, 1983; Owen et al., 2002), resulting in unequal numbers of striae accreted during winter growth compared to summer growth (Owen et al. 2002). Continuous growth in juvenile *A. colbecki* is corroborated by lack of obvious growth disruptions on the juvenile growth portion of the valves used in this study (pers. obs.) and by previous analysis of juvenile valves (Lartaud et al. 2010).

If strial grouping is too inconsistent to reliably identify yearly cycles, but ISIs are governed by environmental factors, it raises the question of what environmental factors control growth increments. In temperate scallops, ISIs are correlated with temperature (Chauvaud et al. 2005) and possible seawater pressure (Thébault et al. 2006). Growth rates more generally are correlated with both temperature and nutrients (Macdonald and Thompson 1988; Pilditch 1999; Laing 2000; Kirby and Miller 2005). We suggest further *in situ* growth experiments monitoring seawater conditions and analysis of *A. colbecki* shell chemistry to understand the dominant factors controlling ISI in *A. colbecki*.

Conclusions

Striae groups are too variable to be used as reliable age markers in *A. colbecki*. Inter- and intra-individual variation in the number of striae per group and cycle is unacceptably high in visual analysis of striae groups. Moreover, time series analysis of interstrial growth increments reveals that most valves do not maintain periodicity consistent with ~26 striae yearly cycles throughout juvenile growth. For this and other species, it is vital to report data from multiple valves over longer time periods when characterizing subannual growth increments.

Similarity in interstrial increments (ISI) throughout the concurrent growth of five juveniles suggest strong environmental control over ISI, and therefore these increments may contain environmental information. For instance, larger mean growth increments and may indicate growth under annual, rather than multiannual sea ice.

We recommend that striae groups and cycles not be used to determine age in *A. colbecki*, but that strial increments should be explored as archives of environmental information.

Figures

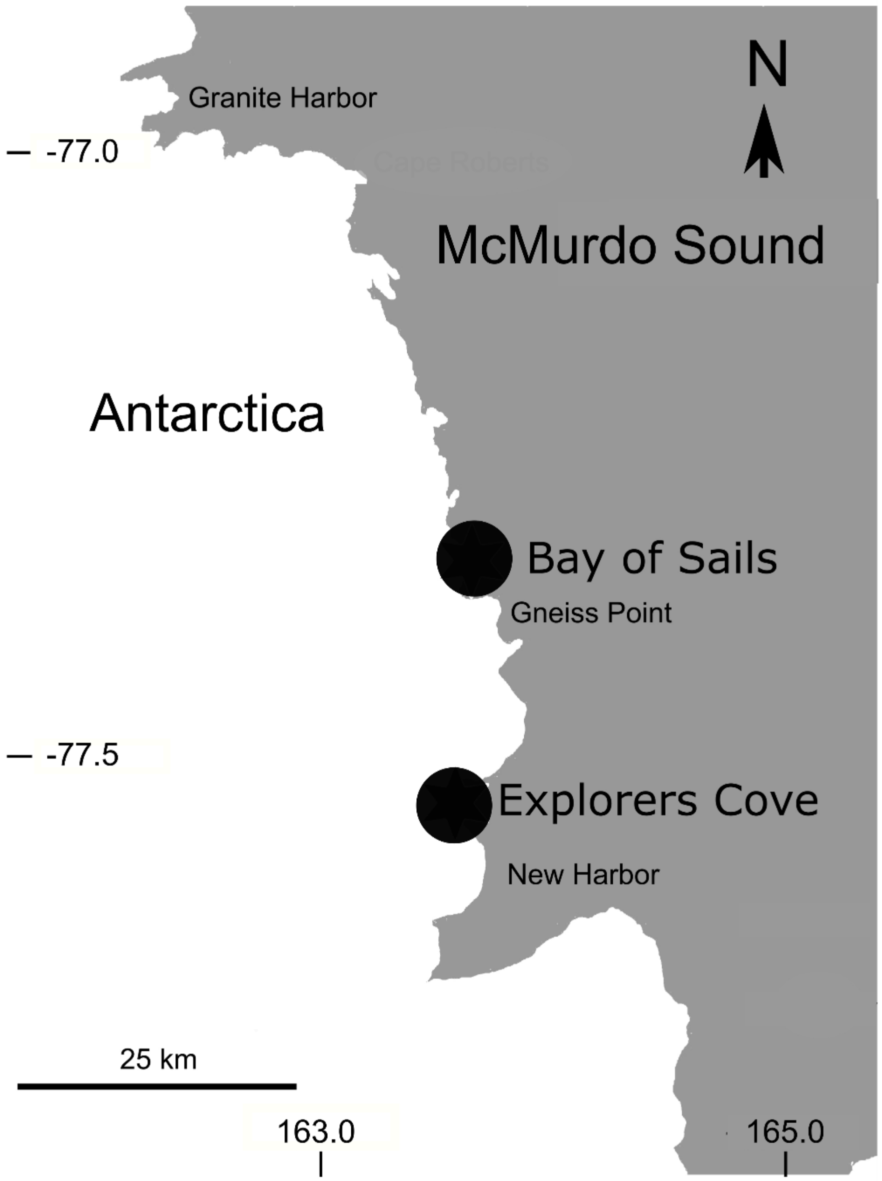


Fig. 3.1: Study Sites of Explorers Cove (EC) and Bay of Sails (BOS), western McMurdo Sound, Antarctica. EC (-77.63861, 163.50167) is a marine embayment in New Harbor ~25 km south of BOS (-77.60306, 163.53472). At BOS, sea ice melts annually, whereas sea ice at EC persists for multiple years.

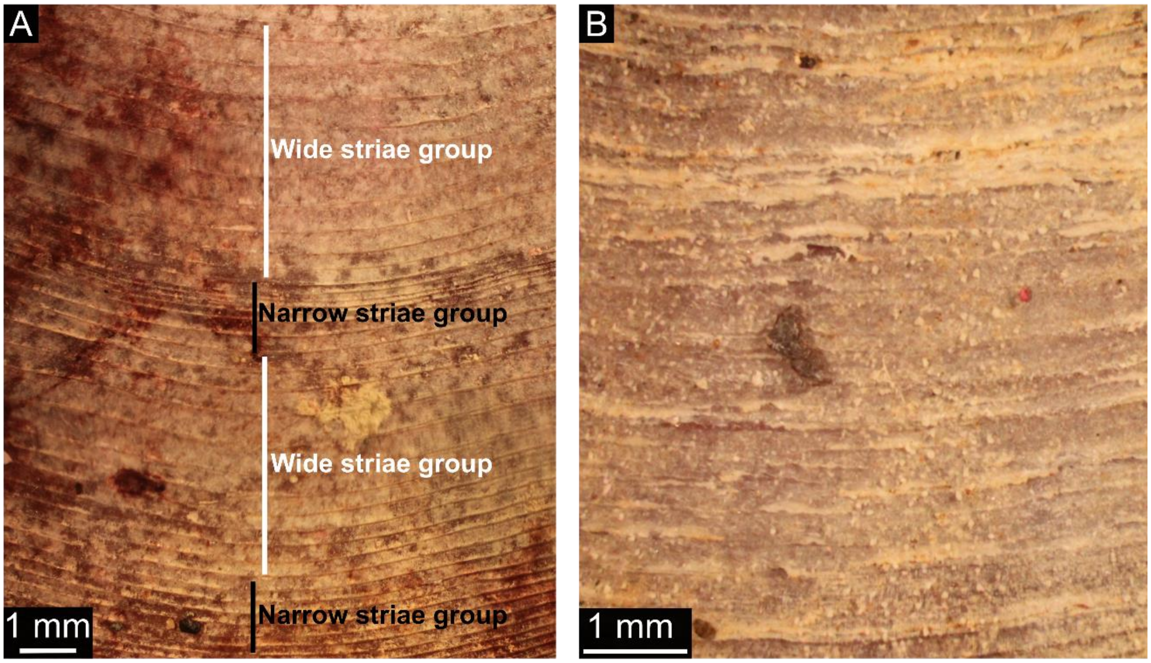


Fig. 3.2: Grouped and ungrouped striae. (A) Grouped striae. The alternating pattern of wide and narrow striae groups was evident on all valves. Photograph from Explorers Cove Valve 6. (B) Ungrouped striae. On some portions of five valves from EC and three valves from BOS, no grouping of wide or narrow striae could be identified. Photograph from Explorers Cove Valve 7.

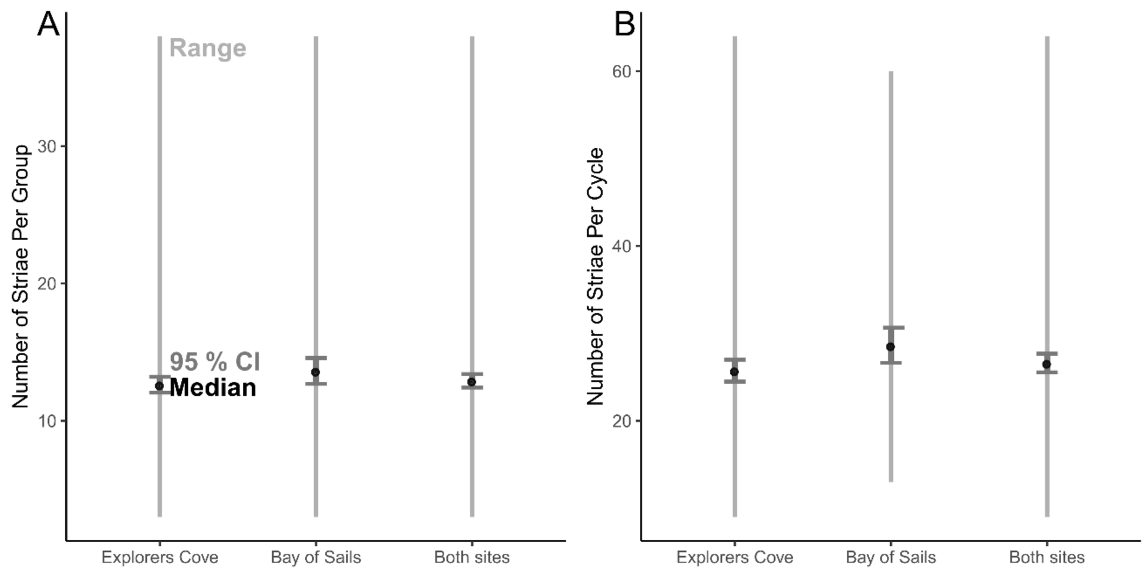


Fig. 3.3: Striae per group and cycle. (A) Striae per group at EC, BOS, and both sites pooled. (B) Striae per cycle at EC, BOS, and both sites pooled.

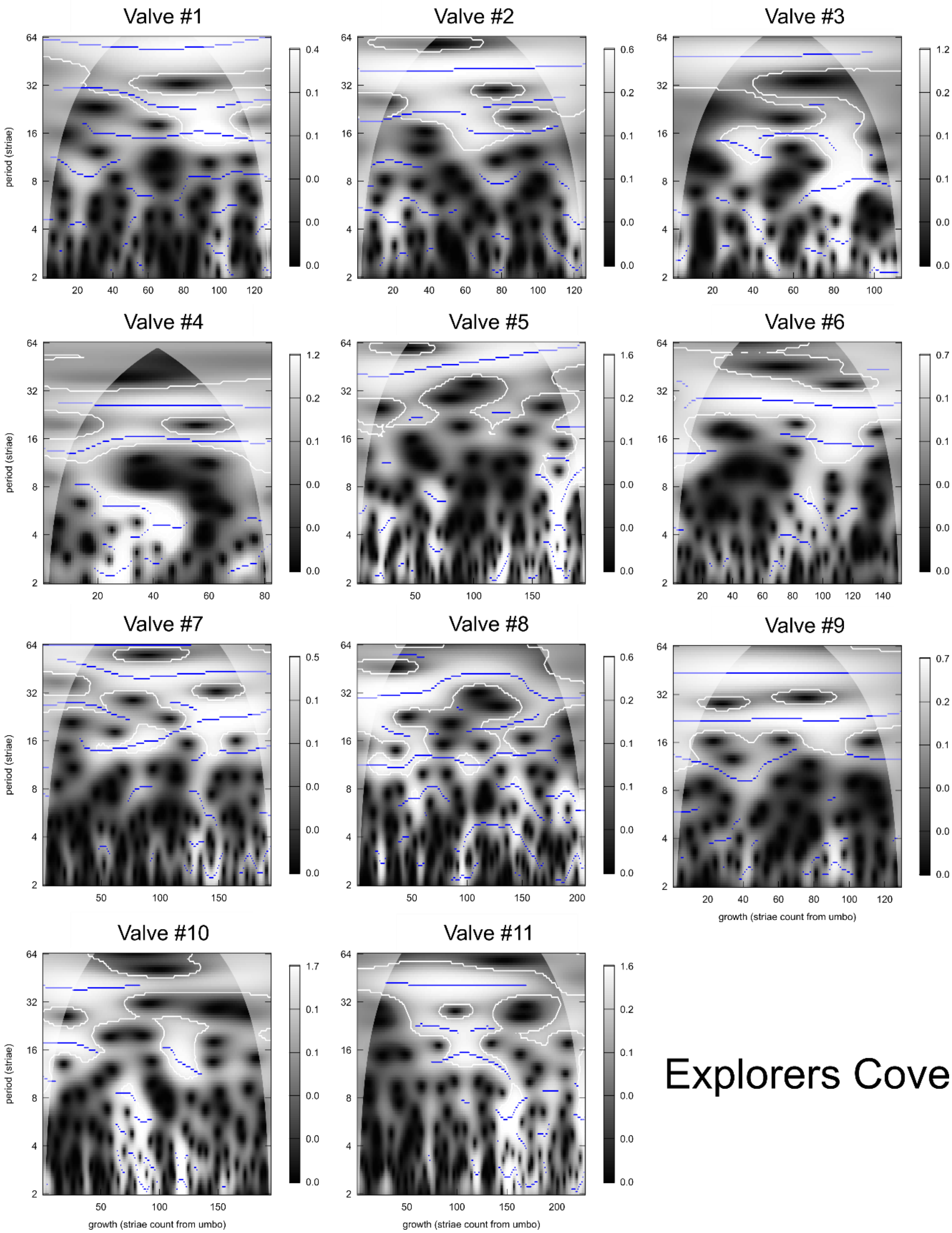


Fig. 3.4: Wavelet power spectra. Blue lines demarcate the strongest periodicity in interstrial increments over ontogeny. Areas bounded by white lines indicate periodicity that is different from white noise at 95% confidence.

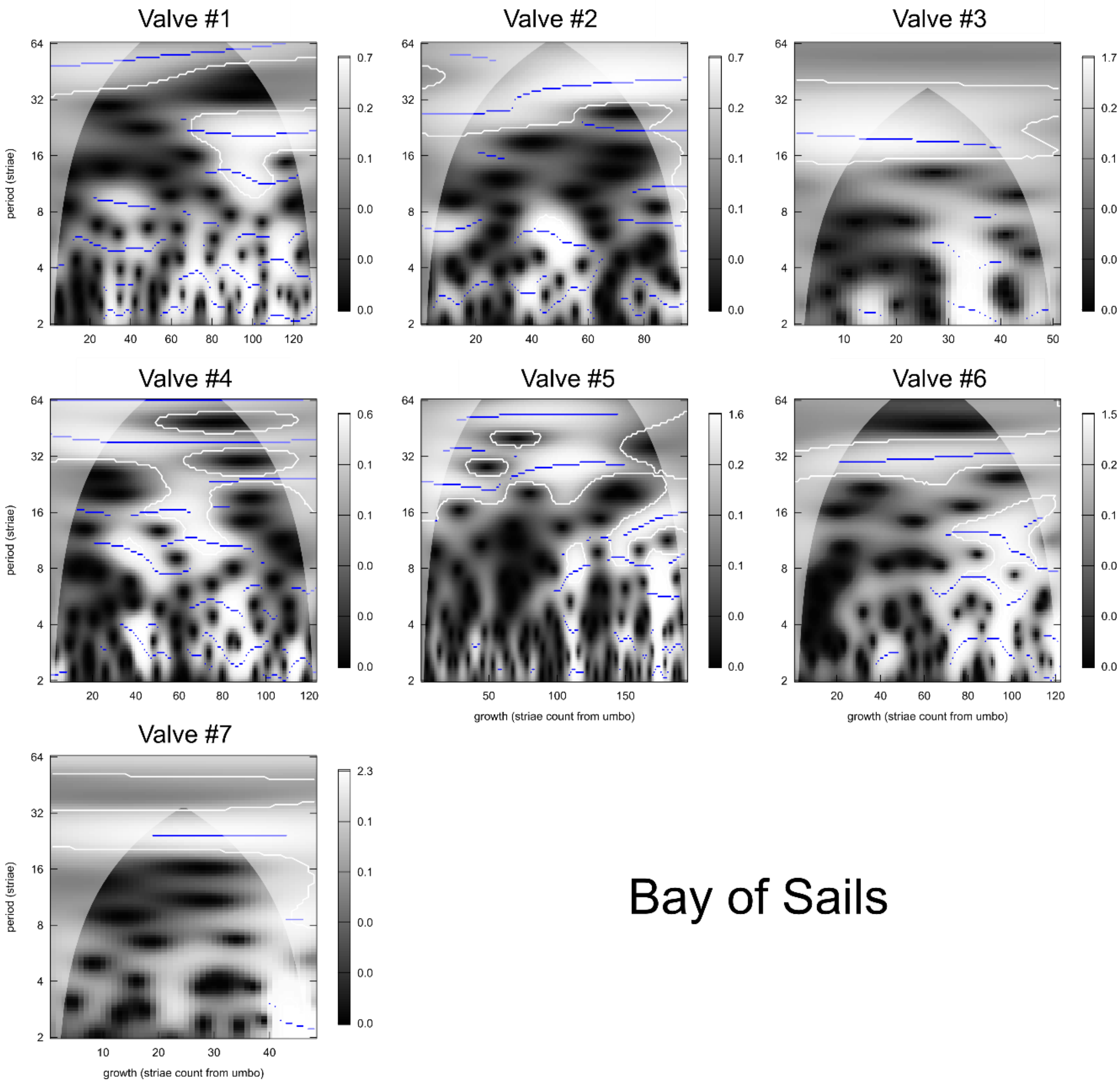


Fig. 3.5: Wavelet power spectra. Blue lines demarcate the strongest periodicity in interstrial increments over ontogeny. Areas bounded by white lines indicate periodicity that is different from white noise at 95% confidence.

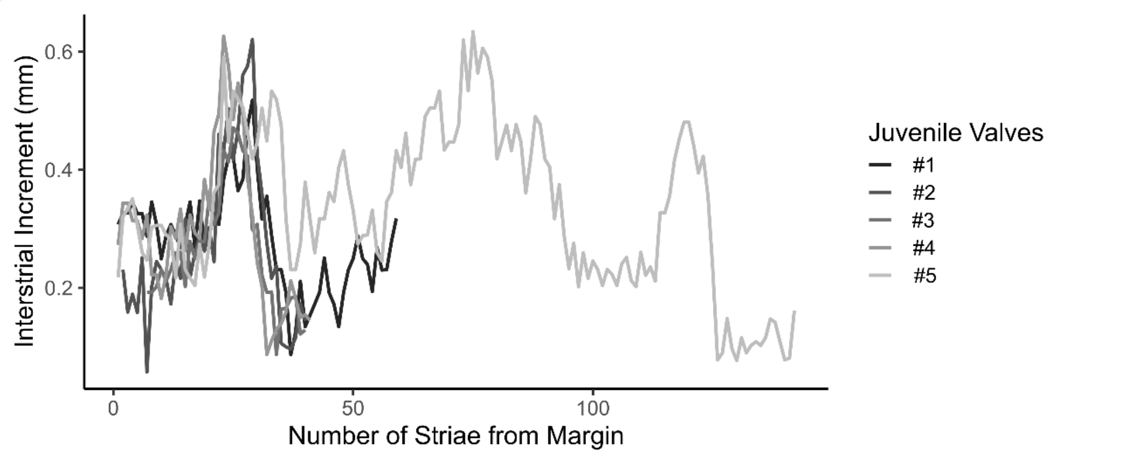


Fig. 3.6: Interstrial growth increments of EC juveniles collected in 2016. Interstrial increments for the five juveniles collected from EC in 2016 show good agreement in growth patterns during times of overlapping growth. Growth direction proceeds right to left; striae 0 is at the margin of each valve.

CHAPTER 4

SEA-ICE EFFECTS ON STABLE ISOTOPES IN SHELLS OF THE ANTARCTIC SCALLOP, *ADAMUSSIUM COLBECKI* [3]

[3] Cronin, K. E. and others, To be submitted to Palaeogeography, Palaeoclimatology, Palaeoecology

Abstract

The Antarctic scallop *Adamussium colbecki* has broad geographic range and potential to proxy sea-ice persistence in Antarctica. With sea ice in decline in the Southern Ocean, it is necessary to develop proxies to understand past sea-ice variability prior to satellite data. We evaluate the differences in stable isotopes of oxygen and carbon in *A. colbecki* valves from two sites on western McMurdo Sound that differ by sea-ice duration: Explorers Cove (EC) has multiannual sea ice, whereas Bay of Sails (BOS) has annual sea ice. Six adult valves (3 each from EC and BOS) were collected in 2008 and two additional juvenile valves were collected from EC in 2016. Valves were aged using external annuli and sampled for stable isotopes of oxygen and carbon. Means and ranges of $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ from adult growth are similar at both sites, and inter-individual variability is high in both $\delta^{18}O_{shell}$ and in $\delta^{13}C_{shell}$ detrended over ontogeny. Oxygen isotopes are similar between the annual and multiannual sea ice site, but mostly lack the clear annual cycles apparent in *A. colbecki* and other Antarctic bivalves from sites with larger annual temperature variation. Moreover, measured seawater temperatures at EC and BOS suggest that most $\delta^{18}O_{shell}$ variation can be attributed to glacial meltwater. In contrast, stable isotopes of carbon sampled from groups of narrow and wide striae could be used to differentiate between scallops living under different sea-ice conditions and therefore to potentially examine the paleoenvironmental history of coastal sea ice in Antarctica.

Introduction

To our knowledge, stable isotopes of oxygen and carbon in bivalve mollusks have not been investigated as a direct proxy for sea-ice duration (but see Dietrich et al., 2007), but sea-ice effects on the underlying water column could affect stable isotopes in bivalve shells. Sea ice plays a vital role in structuring unique Antarctic benthic ecosystems (Dayton 1990; Eicken 1992; Moline et al. 2008; Clark et al. 2015, 2017; Gutt et al. 2015) and global climate (Dieckmann et al. 2010). A bivalve proxy for past sea-ice conditions around coastal Antarctica could develop our understanding of Antarctic sea-ice variability prior to satellite data. The Antarctic scallop *Adamussium colbecki* is an attractive environmental proxy for coastal Antarctica. Its geographic distribution is patchy, but circum-Antarctic, and populations can reach high local abundance (Stockton 1984; Berkman 1990; Cattaneo-Vietti et al. 1997; Chiantore et al. 1998; Schiaparelli and Linse 2006). *Adamussium colbecki* also has a long fossil history in the Southern Ocean, including a species record through the Quaternary and a genus record to the Oligocene (Berkman and Prentice 1996; Quaglio et al. 2008, 2010). Compared with other Antarctic bivalves, *A. colbecki* is large (up to 120 mm; Berkman, 1990) and fast-growing, allowing high temporal resolution when sampling valves for stable isotopes to proxy environmental conditions. Crucially, *A. colbecki* precipitates its shell in isotopic equilibrium with seawater with respect to stable isotopes of oxygen and possibly carbon during adult growth (Barrera et al. 1990; Lohmann et al. 2001; Trevisiol et al. 2013), and *A. colbecki* growth and diet are different under annual and multiannual sea ice (Norkko et al. 2007; Cronin et al. 2020). Isotopic differences resulting from annual *versus* multiannual sea-ice duration may also be preserved in *A. colbecki* valves.

The stable oxygen isotopic composition of bivalve shells ($\delta^{18}O_{shell}$) reflects a combination of temperature and seawater isotopic composition ($\delta^{18}O_{water}$), which is correlated with salinity (Craig and Gordon, 1965). Accordingly, fluctuations in $\delta^{18}O_{shell}$ have been attributed to annual cycles in seawater temperature and salinity and used in numerous to bivalves including *A. colbecki* both to reconstruct seawater temperature and validate suspected annual formation of growth bands (e.g. Goewert and Surge, 2008; Richardson, 2001; Schöne et al., 2005; Trevisiol et al., 2013). Coastal waters surrounding mainland Antarctica have narrower temperature ranges than temperate coastal waters, but seasonal events affect salinity: sea-ice formation in autumn and winter and sea-ice breakout and influx of glacial meltwater in spring and summer. Though brine rejected by sea-ice formation increases the salinity of the surrounding seawater, the oxygen isotope fractionation between sea ice and the seawater from which it freezes is negligible and the overall water volume is small, therefore sea-ice breakout has little effect on $\delta^{18}O_{water}$ (Craig and Gordon 1965; Meredith et al. 2017). In contrast, isotopically light glacial meltwater input can make $\delta^{18}O_{water}$ more negative in nearshore Antarctica. Variation in *A. colbecki* $\delta^{18}O_{shell}$ is attributed to glacial meltwater input in Explorers Cove (EC) (Barrera et al. 1990; Berkman 1994), a site on western McMurdo Sound that maintains year-round temperatures near the freezing point of seawater. In seasonally warmer Terra Nova Bay, $\delta^{18}O_{shell}$ instead reflects summer seawater temperature, and winter minima were used to validate X-ray growth bands as annual growth markers in *A. colbecki* (Heilmayer et al. 2003; Trevisiol et al. 2013).

Carbon isotopes in marine bivalve shells ($\delta^{13}C_{shell}$) reflect the $\delta^{13}C$ of the dissolved inorganic carbon ($\delta^{13}C_{DIC}$) of seawater and metabolic carbon, and other ecophysiological factors; the contribution from metabolic carbon increases through ontogeny (McConnaughey et al. 1997; Lorrain et al. 2004; McConnaughey and Gillikin 2008; Chauvaud et al. 2011). Sea ice dampens highly seasonal water column primary production (Arrigo et al. 1997; Norkko et al. 2007; Moline et al. 2008; Clark et al. 2015, 2017); thus sea-ice duration might be expected to affect $\delta^{13}C_{DIC}$ of the underlying seawater. When sea-ice breaks out, subsequent blooms of photosynthetic organisms preferentially consume lighter ^{12}C, enriching $\delta^{13}C_{DIC}$ in the seawater (Thomas and Papadimitriou, 2003). In contrast, persistent sea ice restricts CO_2 exchange between seawater and the atmosphere and traps oxidizing ^{13}C-depleted organic matter, resulting in depleted seawater $\delta^{13}C_{DIC}$ (Barrera et al., 1990). Respiration of buried organics in the sediment could additionally lead to light $\delta^{13}C$ in porewater (McCorkle et al. 1985). In temperate scallop species and the Antarctic clam *Laternulla elliptica*, $\delta^{13}C_{shell}$ has the opposite trend of chlorophyll-*a*, and becomes more negative as primary production increases, suggesting additional ecophysiological factors governing $\delta^{13}C_{shell}$ (Chauvaud et al. 2011; Woo et al. 2019). In areas with comparable salinity but differing sea-ice durations, multiannual sea ice lower amplitude variations in $\delta^{13}C_{shell}$. Stable isotopes of carbon have received less attention and have not been used to proxy any specific environmental parameter, but $\delta^{13}C_{shell}$ more closely matches $\delta^{13}C_{DIC}$ as valve growth slows in later ontogeny (Barrera et al. 1990, 1994; Trevisiol et al. 2013).

Stable isotopes of oxygen and carbon could help differentiate between sea-ice duration in *A. colbecki* valves and answer two additional outstanding questions regarding their growth. First, of the three ways to determine ontogenetic ages for *A. colbecki* valves, only one has been validated using $\delta^{18}O_{shell}$. X-ray bands form in winter and mostly coincide with $\delta^{18}O_{shell}$ maxima at Terra Nova Bay (Heilmayer et al. 2003). Because X-ray bands can be difficult to interpret, external annuli are also used to age *A. colbecki* and compare growth between annual and multiannual sea ice sites (Cronin et al. 2020). External annuli have not yet been validated using $\delta^{18}O_{shell}$. If growth at EC and Terra Nova Bay follows similar seasonal patterns, external annuli should coincide with $\delta^{18}O_{shell}$ maxima. Second, narrow and wide groups of striae (small commarginal ridges on valve surfaces) have been used to demarcate annual growth in EC valves (Stockton 1984; Berkman 1990) because they are hypothesized to represent fast summer growth and slow winter growth, respectively (after Stockton 1984). If striae groups represent seasonal growth differences, groups of narrow winter striae should have more positive mean $\delta^{18}O_{shell}$ than wide summer bands.

Here, we evaluate the stable isotope chemistry of *A. colbecki* valves from two sites on western McMurdo Sound that each maintain similar, stable temperatures near the freezing point of seawater but differ by sea-ice duration. Sea ice at EC persists for multiple years to decades, whereas sea ice at Bay of Sails (BOS) breaks out annually. Unless glacial meltwater input differs between EC and BOS. we hypothesize that stable isotopes of oxygen in *A. colbecki* shells will be similar at EC and BOS because temperatures are similar. If valves primarily reflect $\delta^{13}C_{DIC}$ and metabolic carbon, BOS will have seasonally heavier $\delta^{13}C_{shell}$, but if other ecophysiological factors influence $\delta^{13}C_{shell}$ more than $\delta^{13}C_{DIC}$, BOS will have seasonally lighter $\delta^{13}C_{shell}$ like *L. elliptica* (Woo et al., 2019) Shells from BOS will have In addition, we will test two hypotheses about growth lines in *A. colbecki* using stable isotopes of oxygen and carbon: first, that striae groups represent seasonal differences in growth (after Stockton, 1984), and second, that external annuli can be used to age *A. colbecki* similar to X-ray bands (Heilmayer et al. 2003).

Methods

Field sampling

Adult *A. colbecki* were collected live by divers in November 2008 from two sites on western McMurdo Sound, Explorers Cove (EC) and Bay of Sails (BOS) (Fig. 2.1). Samples from both sites were collected between ~8–18 m water depth. Additional juveniles (< 20 mm) were collected live by divers in 2016 at EC. Juvenile valves represent a fortuitous recruitment of *A. colbecki,* and their stable isotopes are compared with adults collected in 2008 to determine if the juveniles record similar sea water and productivity conditions as the adult valves.

Laboratory data collection

Three adult (> 70 mm) valves each from EC and BOS collected in 2008 and two juveniles from EC collected in 2016 were analyzed for stable isotopes of carbon and oxygen. Valves were manually cleaned of epibionts and sediment.

80 µg powder samples for stable isotope analysis were collected by hand-drilling shallow trenches from the external surface of valves using a low-speed hand drill. Trenches were drilled perpendicular to growth direction along the axis of maximum growth.

Ontogenetic ages for two valves each from EC and BOS were determined by counting external annuli (after Cronin et al. 2020). For these valves, annuli guided sample placement so that they could be aligned with $\delta^{18}O_{shell}$ values. Samples were drilled on annuli and between annuli, though fewer samples were collected per growth year as annuli became more closely spaced in later ontogeny.

On the juvenile valves and the valves that were aged using annuli, narrow and wide striae groups were identified (after Stockton 1984). Striae group types (narrow or wide) were assigned to stable isotope samples where possible to compare $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ between periods of putative summer and putative winter growth. Striae were abraded or strial grouping was unclear on some areas of valves; isotope data collected from these areas are excluded from calculations based on striae groups.

Stable isotope ratios of oxygen ($\delta^{18}O_{shell}$) and carbon ($\delta^{13}C_{shell}$) were analyzed at Union College, New York, USA, on a Thermo Gas Bench II connected to a Thermo Delta Advantage mass spectrometer in continuous flow mode. Samples were run over 10 analytical sessions in July, August, and November 2019 and January 2020. All isotopic results are expressed in parts per mil (‰) relative to the Vienna Pee Dee Belemnite (VPDB) standard. Reference standards (LSVEC, NBS-18, and NBS-19) were used for isotopic corrections. Mean analytical uncertainty for $\delta^{13}C$ was ± 0.045‰ (VPDB) and ± 0.055‰ (VPDB) for $\delta^{18}O$, based on repeated NBS-19 standards over the 10 analytical sessions. A total of 651 samples were collected over the 8 valves (Table 4.1).

Data analysis

Stable isotopes over ontogeny

$\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ were examined over ontogeny using the stable isotope profiles from the valves aged with annuli: Explorers Cove Valves #1 and #2, Explorers Cove juvenile Valves #1 and #2, and Bay of Sails Valves #1 and #2. Annuli were evaluated as suitable annual growth markers by comparing their coincidence with local maxima and minima of and $\delta^{18}O_{shell}$.

Because $\delta^{13}C_{shell}$ decreased over ontogeny in adult valves from EC and BOS, $\delta^{13}C_{shell}$ values were detrended following the methods of Chauvaud et al. (2011) for valves aged with annuli; both undetrended $\delta^{13}C_{shell}$ and detrended $\delta^{13}C_{shell}$ are presented in the results. Detrending of $\delta^{13}C_{shell}$ was performed for two reasons. First, both seasonal variation in $\delta^{13}C_{shell}$ and comparison between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ are clearer after $\delta^{13}C_{shell}$ is detrended (Chauvaud et al. 2011). Second, ontogenetic detrending allows for environmental comparison in $\delta^{13}C_{shell}$ without the influence of ontogeny (Chauvaud et al. 2011), in this case the annual and multiannual sea ice site are compared to discover differences that could be attributed to sea-ice duration. Linear regressions were calculated for each adult using least-squares regression; the residuals are referred to here as $\delta^{13}C_{shell\ det}$.

To compare the relationship between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ under annual and multiannual sea ice, Pearson correlations and linear regressions between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ were calculated for each year in ontogeny for adult valves for valves aged with annuli.

$\delta^{18}O_{shell}$ was additionally used along with $\delta^{18}O_{water}$ from EC and BOS (-0.2 ‰ at 9 m depth; -0.5 ‰ at 18 m depth) to calculate expected seawater temperature. The Kim and O'Neil (1969) equation, as modified by Shackleton (1974)

(1) $T = (16.9 - 4.0(\partial^{18}O_{shell} - \partial^{18}O_{water}))$

where T = seawater temperature

was used for comparison with previous EC studies and because it predicts temperature better at low temperatures (~0 °C).

Possible inclusion of aragonite into powder samples renders the results of this equation estimates that should be treated with caution.

Stable isotopes under annual and multiannual sea ice

Stable isotopic differences between the multiannual and annual sea ice sites were evaluated in two ways. First, the differences in $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ between the annual and multiannual sea ice sites were compared using bootstrapped means and 95% confidence intervals of $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ from all adult valves, including the valves for which annuli were not evaluated. Second, to evaluate striae group types as seasonal indicators and to determine possible seasonal stable isotopic differences under annual and multiannual sea ice, the bootstrapped mean and 95% confidence intervals of $\delta^{13}C_{shell\ det}$ and $\delta^{18}O_{shell}$ samples that could be assigned to a striae group type were compared. $\delta^{13}C_{shell\ det}$ instead of $\delta^{13}C_{shell}$ was used to compare striae groups to minimize the impact of metabolic carbon incorporated into the shell on the intended environmental comparisons between sites and seasons (Chauvaud et al. 2011).

Results

Annuli and ontogenetic trends in $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ in adult valves

External annuli coincide with both $\delta^{18}O_{shell}$ local maxima and minima in valves from both BOS and EC (gray lines; Fig. 4.2A–B). Annuli on EC Valves (Fig. 4.2A) coincide slightly more often with maxima than minima. EC Valve #1 has 7 annuli on maxima and 5 on minima (Fig. 4.2A), and EC Valve #2 has 5 annuli on maxima, and 5 on minima. Annuli in BOS valves primarily coincide with $\delta^{18}O_{shell}$ minima (Fig. 4.2B). BOS Valve #1 annuli exclusively coincide with maxima, whereas on BOS Valve #2, 5 annuli coincide with minima and 3 coincide with maxima.

Clear cycles in $\delta^{18}O_{shell}$ are inconsistent or absent in valves from both sites. $\delta^{18}O_{shell}$ in EC Valve #2 has cycles between ~1996 and 2001 (years calculated with annuli), and EC Valve #1 has cycles before 2002. Neither BOS valve has consecutive years of cyclical behavior in $\delta^{18}O_{shell}$. Additionally, $\delta^{18}O_{shell}$ patterns indicate high inter-individual variability in valves from EC and BOS. Growth in both EC valves span 2002 (arrow, Fig. 4.2A), when sea ice broke out in EC. EC Valve #1 has a large negative excursion in $\delta^{18}O_{shell}$ in 2002, but EC Valve #2 does not. There are few years of coincident growth where both valves from the same site have similar patterns in $\delta^{18}O_{shell}$, and fewer at EC than at BOS. At EC, 1998 has similar patterns in $\delta^{18}O_{shell}$; at BOS, 2000, 2003, and 2004 has similar $\delta^{18}O_{shell}$ patterns in both valves (Fig. 4.2A–B).

Both $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ become progressively less positive through ontogeny in adult valves from EC and BOS that were aged with annuli. $\delta^{18}O_{shell}$ displays a small but statistically significant decrease over ontogeny (Table 4.2; Fig. 4.2A–B). The ontogenetic decline in $\delta^{13}C_{shell}$ is also statistically significant with a more negative slope than in $\delta^{18}O_{shell}$ for all valves (Table 4.2, Appendix 3).

The strength of the correlation between $\delta^{18}O_{shell}$ and ontogeny is variable within sites. EC correlations are as high as 0.81 and as low as 0.40. Similarly, BOS correlations are as high as 0.84 and as low as 0.59 (Table 4.2). Moreover, the slope of $\delta^{18}O_{shell}$ over ontogeny in EC Valve #1 is more than triple that of EC Valve #2, and the slope of $\delta^{18}O_{shell}$ over ontogeny in BOS Valve #1 is double that of BOS Valve #2 (Table 4.2).

Correlation strength between $\delta^{13}C_{shell}$ and ontogeny is strong in EC valves (r = 0.83 and 0.83) but differs between the valves from BOS (r = 0.30 and 0.75).Three of the four adult valves aged with annuli share a common pattern in $\delta^{13}C_{shell\ det}$ before age 5. Large negative excursions and large intra-annual variation are evident on EC Valve #1 between ages 4 and 7 (Fig. 4.3A) and on EC Valve #2 between ages 1 and 3 (Fig. 4.3B), and between ages 3 and 4 in BOS Valve #1 (Fig. 4.3C). BOS Valve #2 has high intra-annual variation in $\delta^{13}C_{shell\ det}$ in year 3 but lacks the large negative excursions, which may have occurred in earlier growth that was not sampled.

2016 Juveniles

Stable oxygen and carbon isotopes are more similar in the 2016 juveniles over concurrent growth than adults from EC and BOS, but patterns and values of $\delta^{18}O_{shell}$ are less similar than $\delta^{13}C_{shell}$. $\delta^{18}O_{shell}$ begins between 3.9 and 4.1‰ near the first striae, then become more negative, with minima ~3.9 and 3.7‰ (Fig. 4.4A). $\delta^{18}O_{shell}$ then becomes more positive, albeit with different patterns and timing for each valve, to maxima between 4.0 and 4.1‰, and finally become more negative at the end of shell growth, with minima ~4.0 and 3.9‰ near valve margins. $\delta^{13}C_{shell}$ was not detrended over ontogeny for the 2016 juveniles. Detrending carbon is intended to remove influence of increasingly light metabolic carbon over the lifetime of adult scallops, and therefore was not performed on the juvenile valves. Patterns in undetrended $\delta^{13}C_{shell}$ are similar between the 2016 juveniles. $\delta^{13}C_{shell}$ begins at ~2.5 and 2.7‰ near the first striae, become more positive and reach maxima > 3.0‰, then become steadily more negative and reach minima < 2.4‰ near valve margins (Fig. 4.4B). The 2016 juveniles do not exhibit large negative excursions in $\delta^{13}C_{shells}$ evident in adult valves (Fig. 4.3); possibly this carbon pattern begins later in ontogeny than is captured by the juvenile shells, which likely spawned in 2014 or 2015, and thus likely represent < 2 years of growth.

Carbon vs Oxygen correlations

When all of valve growth is considered, undetrended $\delta^{13}C_{shell}$ is positively correlated with $\delta^{18}O_{shell}$ in adult valves from both EC and BOS (Fig. 4.5; Table 4.3). In contrast, juvenile valves from EC have weak negative correlations between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$. Juvenile growth in adult valves from both EC and BOS also have negative correlations between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$, but the correlations become positive later in ontogeny at EC than at BOS. At EC, $\delta^{13}C_{shell}$ is negatively correlated with $\delta^{18}O_{shell}$ through year 5, and positively correlated beginning at year 6. Conversely, at BOS, the correlation is negative only though year 3 and positive correlation begins at year 4 (for correlations for all years, see Appendix C). Correlations are mostly robust to differencing to account for non-independence of samples. Correlation for Explorers Cove Valve #2 is somewhat stronger after differencing, whereas whole-valve correlations of Explorers Cove Valve #3 and Bay of Sails Valves #2 and #3 weaken but remain positive and statistically significant. Correlations for Explorers Cove Valve #1 and Bay of Sails Valve #1 are not statistically significant from 0 after differencing.

Mean $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ under annual and multiannual sea ice

$\delta^{18}O_{shell}$ from EC and BOS valves are essentially identical between the annual and multiannual sea ice site. Mean $\delta^{18}O_{shell}$ for all 3 adult valves from EC is 4.25‰; mean $\delta^{18}O_{shell}$ for all 3 adult valves from BOS is 4.27‰ (Fig. 4.6A). 95% confidence intervals on the means overlap (see Appendix 3 for all means and confidence intervals), and difference between the means is within analytical uncertainty. Additionally, the amplitude of $\delta^{18}O_{shell}$ is identical at both sites (1.18‰), with the lowest valves ~3.60‰ and the highest values ~4.78‰ (Fig. 4.6A).

Mean $\delta^{18}O_{shell}$ of the 2016 juveniles from EC is more negative than means for adults from either site (Fig. 4.6A; 2016 Juv: 3.99‰). Even when $\delta^{18}O_{shell}$ of EC valves is analyzed only over the juvenile growth portion of the adult valves (< 6 years), $\delta^{18}O_{shell}$ of the 2016 juveniles is still nearly 0.5‰ more negative. Mean $\delta^{18}O_{shell}$ of juvenile growth of adult valves is 4.42‰. The difference in means between 2016 juveniles and the juvenile growth of adults is outside of analytical uncertainty and confidence intervals do not overlap.

Temperature estimates using $\delta^{18}O_{shell}$ and $\delta^{18}O_{water}$ of either -0.5 or -0.2 ‰ range from -4.22–1.7 °C at EC and -4.22–1.66 °C at BOS over the lifetimes of adult valves. If $\delta^{18}O_{water}$ was similar in 2018 to the collection date in 2008, temperature estimates over the lifetime of 2016 juveniles range from -1.54–1. 4 °C.

Contrary to expectations, mean $\delta^{13}C_{shell}$ (undetrended) is more positive in adult valves from EC than BOS (Fig. 4.6B; EC: 2.19‰; BOS: 2.03‰). The amplitude of $\delta^{13}C_{shell}$ is lower at EC than BOS (EC: 2.46‰; BOS: 2.66‰; Fig. 4.6A). However, when analysis is restricted to ages ≥ 6 years to exclude large $\delta^{13}C_{shell}$ variations in juvenile growth (Fig. 4.4A–D), the difference between the sites disappears. During growth at ages ≥ 6 years, mean $\delta^{13}C_{shell}$, is essentially identical under annual and multiannual sea ice and the difference is within analytical error (EC: 1.86‰; BOS 1.85‰).

$\delta^{13}C_{shell}$ of 2016 juveniles is somewhat more negative than juvenile growth (< 6 years) of adult EC valves, and 95% confidence intervals overlap (2016 Juv: 2.67‰; EC adults age < 6 years: 2.79‰). Mean $\delta^{13}C_{shell}$ of the 2016 juveniles from EC is more positive than adults from either site (Fig. 4.6B) 2016 Juv: 2.67‰).

$\delta^{18}O_{shell}$ has similar mean values in narrow and wide striae groups in EC and BOS adults, but $\delta^{13}C_{shell\ det}$ is more positive in wide striae groups at BOS (Fig. 4.7A). In adult valves from EC mean $\delta^{18}O_{shell}$ of narrow striae groups is slightly more positive than for wide striae groups (Fig. 4.8A; EC narrow: 4.37‰; EC wide: 4.33‰) but overlapping confidence intervals indicate that means were indistinguishable (Appendix 3); Similarly, BOS narrow groups have slightly more positive $\delta^{18}O_{shell}$ than wide groups (BOS narrow: 4.36‰; BOS wide: 4.30‰) with overlapping 95% confidence intervals.

Unlike $\delta^{18}O_{shell}$, $\delta^{13}C_{shell\ det}$ varies between narrow and wide striae for BOS, but not EC (Fig. 4.7B). Narrow and wide striae group means are nearly identical in adult EC valves (EC narrow: 0.01‰; EC wide: 0.01‰); confidence intervals overlap and the difference in means is within analytical error.   In contrast to EC adults, the mean $\delta^{13}C_{shell\ det}$ at BOS is over 1‰ more positive in wide striae groups than narrow, (BOS narrow: -0.224‰; BOS wide: 0.264‰).

Like adult valves from both sites, there is also no statistically significant difference between narrow and wide striae groups in $\delta^{18}O_{shell}$ of 2016 juveniles (Fig. 4.8A). Narrow groups have slightly higher $\delta^{18}O_{shell}$ than wide groups (Fig. 4.8A; 2016 Juv. narrow: 4.01‰, 2016 Juv. wide: 3.96‰), bur 95% confidence intervals overlap.

The 2016 juveniles have more positive $\delta^{13}C_{shell}$ in wide striae groups than narrow (Fig. 4.8B). The difference in means was larger than the analytical precision for $\delta^{13}C_{shell}$, and 95% confidence intervals suggest that the difference is statistically significant (2016 Juv. narrow: 2.46‰; 2016 Juv. wide: 2.80‰).

Discussion

The Antarctic scallop *Adamussium colbecki* is a potentially important proxy for sea-ice persistence along the Antarctic coast. Stable isotopes of oxygen do not meaningfully differ under annual and multiannual sea ice but may reveal disparities in growth patterns between Antarctic sites with seasonally warmer water and sites with stable, frigid water temperatures. Stable isotopes of carbon have received less attention than oxygen in *A. colbecki*; nevertheless, we report more positive $\delta^{13}C_{shell}$ maximum values than have been found in previous studies. Moreover, after detrending for ontogenetic effects, $\delta^{13}C_{shell}$ potentially reflects seasonal differences in $\delta^{13}C_{DIC}$ under annual sea ice.

$\delta^{18}O_{shell}$ and annuli in the coldest waters on Earth

Distinct cycles in $\delta^{18}O_{shell}$ like those described from *A. colbecki* in Terra Nova Bay (Heilmayer et al. 2003; Trevisiol et al. 2013) and in *Laternula elliptica* from King George's Island on the Antarctic Peninsula (Woo et al. 2019) are mostly absent from the valves in this study, especially from BOS valves. Despite the absence of clear cycles, annuli mostly occurred at or near local $\delta^{18}O_{shell}$ maxima or minima. At BOS, annuli predominantly occurred on or near local minima, but only BOS Valve #2 had exclusive co-incidence between local $\delta^{18}O_{shell}$ minima and annuli. At EC, more annuli occurred at or near $\delta^{18}O_{shell}$ maxima, but several annuli also occurred near $\delta^{18}O_{shell}$ minima. This is in contrast to *A. colbecki* at Terra Nova Bay, where annual X-ray bands coincide most closely with $\delta^{18}O_{shell}$ maxima and are interpreted to be formed in winter (Heilmayer et al. 2003; Trevisiol et al. 2013).

Even within the same bivalve species, the timing of growth band deposition sometimes occurs during different parts of the year if populations live at different latitudes or are subject to different seasonal environmental stressors (Jones and Quitmyer 1996; Schöne 2008), and there are two possible explanations for the discrepancy. First. Terra Nova Bay $\delta^{18}O_{shell}$ maxima coincide with X-ray bands, rather than external annuli, which were noted by Heilmayer et al. (2003) to occur in similar numbers, but often at different locations on the same valve. It may be that X-ray bands coincide with maxima in these valves, but the valves were not X-rayed, so this cannot be confirmed here. Second, it is possible that seasonally warmer temperatures at Terra Nova Bay (up to +1 or +2 °C in summer (Jacobs and Giulivi 1999; Heilmayer and Brey 2003)) provide a stronger driver on growth. Terra Nova Bay *A. colbecki* mostly grow during summer as adults (Trevisiol et al. 2013). Annual temperature amplitudes are < 1.5 °C at both EC, where temperatures do not exceed ~ -0.5 °C; (P. Cziko, personal communication), and BOS, which had recorded seawater temperatures near -1.97 °C in austral summer when these valves were collected (Hancock et al. 2015). Annuli can form during disturbances (Merrill et al. 1966) and weaker temperature control on growth could heighten the effects of other potential causes of growth line formation, like seasonal glacial meltwater influxes.

We posit that at least some of the variation in $\delta^{18}O_{shell}$ results from glacial meltwater input into EC and BOS and positive excursions in $\delta^{18}O_{water}$ during austral winter, rather than temperature variation, as others have suggested for EC *A. colbecki* (Barrera et al. 1990; Berkman 1994; Lohmann et al. 2001). $\delta^{18}O_{shell}$-to-temperature conversions result in temperature estimates that are 2 °C higher than the highest previously recorded temperature for EC and ~3.5 °C higher than recorded temperatures at BOS during austral summer. Moreover, $\delta^{18}O_{water}$ must be more positive in austral winter at both EC and BOS. The freezing temperature of seawater is ~ -2 °C, but the most positive $\delta^{18}O_{shell}$ samples paired with summer $\delta^{18}O_{water}$ measured at -0.5 ‰ estimate winter seawater temperatures < - 4 °C at both EC and BOS.

If $\delta^{18}O_{shell}$ variations are driven by glacial meltwater, rather than temperature, this would also explain the high inter-individual variability in $\delta^{18}O_{shell}$ patterns during concurrent growth at both sites and the lower intra-annual variability in BOS valves than EC valves (Fig. 4.2). Rather than a site-wide temperature signal governing $\delta^{18}O_{shell}$, we suggest that shells record intra-site differences in mixing of less dense and isotopically lighter freshwater into more dense seawater. BOS has less annual glacial meltwater input than EC (Radford et al. 2014), and though site-wide $\delta^{18}O_{shell}$ ranges are essentially identical, intra-individual variations are mostly smaller in BOS valves than EC valve, which could be explained by less overall input of glacial meltwater into BOS every year.

Site-wide ranges of $\delta^{18}O_{shell}$ at EC and BOS from this study fall within previously recorded ranges from in *A. colbecki* from EC and Terra Nova Bay (Table 4.4). Barrera et al. (1990) was the first to sample along a 41 mm profile from the margin to roughly the middle of the valve and found a range of $\delta^{18}O_{shell}$ from 3.85–4.75‰. They also found no discernable annual cycles but did not tie the transect spacing to any growth line. Bulk samples from adult shell margins resulted in a range of $\delta^{18}O_{shell}$ from 3.56–4.08‰ that increased with depth of collection. Finally, in sequentially micromilled samples from the last 35 mm of a putatively 100-year old valve, Lohman et al. (2001) found a range from 2.75–4.55‰. Large overlap in $\delta^{18}O_{shell}$ ranges among valves that grew over the last 4+

decades suggests little change in seawater conditions over that time. The 2016 juveniles had lighter mean oxygen isotopes than juvenile growth of EC adults from this study, possibly indicating more glacial meltwater input during their lifetimes than during the mid-1990s, but the range of $\delta^{18}O_{shell}$ in the 2016 juveniles falls within the ranges reported by this study and other authors for shell growth over the past several decades. In contrast, Terra Nova Bay ranges of sequentially sampled valves collected over the last ~3 decades have a maximum of 4.4‰, but minima range from ~0.5 to 1.2‰ below than the least positive $\delta^{18}O_{shell}$ in this study. The difference in minima can be partially, but not entirely, accounted for by the ~1.5 °C temperature difference between maximum temperatures at EC and Terra Nova Bay. A difference in $\delta^{18}O_{shell}$ of 1.2‰ results in a temperature difference of 4.8 °C using the Shackleton low-temperature equation. Some of the difference in $\delta^{18}O_{shell}$ between EC and BOS and Terra Nova Bay must be a result of $\delta^{18}O_{water}$.

Carbon isotopes over A. colbecki *ontogeny*

Carbon isotopes have received less attention in *A. colbecki* than oxygen and have never been described over early juvenile ontogeny. Results from this study suggest an interplay between metabolic and environmental influences on $\delta^{13}C_{shell}$ in *A. colbecki*, with distinct and likely metabolic features in juvenile growth. After detrending for ontogenetic influence on $\delta^{13}C_{shell}$, juvenile growth of adult valves from both sites contained a distinctive pattern in $\delta^{13}C_{shell\ det}$: high-amplitude negative excursions (~1–2‰ $\delta^{13}C_{shell\ det}$; Fig. 4.3) are present before age 5 in EC valves and before age 4 in BOS valves. After age 5 in EC and 4 in BOS, valves from both sites have total variation in $\delta^{13}C_{shell\ det} < 1$‰, intra-annual variation in $\delta^{13}C_{shell\ det} < \sim 0.5$‰. This pattern is absent from the 2016 juveniles, which likely represent < 2 years of growth. It may be that the large swings in carbon characterize late juvenile ontogeny. The end of the large variation in juvenile growth coincides with two other features in undetrended carbon over ontogeny: the beginning of steadily more negative $\delta^{13}C_{shell}$ values attributed to increasing incorporation of metabolic carbon into valves (Appendix C; Chauvaud et al., 2011) and the shift in the direction of correlation between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ from negative in early ontogeny to positive for the rest of valve growth (Fig. 4.5). The shift between large variation in early growth to steadily more negative $\delta^{13}C_{shell}$ values has been attributed to the onset of sexual maturation in *Tridacna maxima* (Romanek and Grossman 1989). Similarly, we speculate that the correlation shift and the decrease in intra-annual variability in $\delta^{13}C_{shell\ det}$ reflect kinetic effects on carbon incorporated into valves is associated with sexual maturation, which occurs at approximately year 5 in *A. colbecki* from Terra Nova Bay (Cattaneo-Vietti et al. 1997).

We predicted that $\delta^{13}C_{shell}$ would be more negative under persistent sea-ice conditions than under multiannual sea-ice conditions if $\delta^{13}C_{shell}$ primarily reflects $\delta^{13}C_{DIC}$. Under multiannual sea ice, decomposition of ^{13}C-depleted organic matter and reduced exchange between seawater and the atmosphere should result in more negative $\delta^{13}C_{DIC}$ under multiannual sea ice (after Barrera et al., 1990) and seasonal phytoplankton blooms under annual sea ice should result in seasonally more positive $\delta^{13}C_{DIC}$ under annual sea ice. However mean $\delta^{13}C_{shell}$ was more positive at EC than BOS, which may indicate additional ecophysiological controls on $\delta^{13}C_{shell}$ (Chauvaud et al. 2011; Woo et al. 2019), but here seems to be largely driven by ontogenetic patterns. Higher $\delta^{13}C_{shell}$ seems to be entirely driven by the high-amplitude variations in early valve ontogeny that occur in valves at both sites. When juvenile growth (age < 6) is excluded, mean $\delta^{13}C_{shell}$ is identical at EC and BOS during adult growth.

Carbon isotopes from this study have more positive means and maximum values than previously reported carbon isotopes from EC and Terra Nova Bay, though the minima from BOS is similar to previous reports from Terra Nova Bay and EC (Table 4.4). Undetrended $\delta^{13}C_{shell}$ is compared here because $\delta^{13}C_{shell}$ was not detrended for other studies (Table 4.4). Et EC, Barrera et al. (1994, 1990) found $\delta^{13}C_{shell}$ ranged from 0.09–2.5‰ and that juvenile growth of adult valves had higher mean $\delta^{13}C_{shell}$ than adult growth near the margins, which is consistent with a decrease in $\delta^{13}C_{shell}$ over ontogeny. Trevisiol et al. (2013) reported a range of 0.6–2.0‰ in valves from Terra Nova Bay. Barrera et al. (1994, 1990) collected 2 samples from juvenile growth and 20 samples from adult growth that are comparable to our isotope profiles over the two studies. Trevisiol et al. (2013) sampled less than 3 years of adult growth. In contrast, we sample at least 1.5 years of juvenile growth in the 2016 juveniles and up to ~11 years of growth in our adults. Because $\delta^{13}C_{shell}$ varies with ontogeny, our higher means and maximum values may be explained by the larger number of samples over a wider ontogenetic range collected for this study.

Striae groups under annual and multiannual sea ice

Isotopic compositions of striae groups provide some evidence for Stockton's (1984) hypothesis that narrow striae groups reflect winter growth and wide striae groups reflect summer growth. If Stockton's hypothesis is correct, narrow striae groups at both sites should have higher mean $\delta^{18}O_{shell}$ and wide striae groups at the annual sea ice site should have higher mean $\delta^{13}C_{shell}$ after detrending over ontogeny. Mean $\delta^{18}O_{shell}$ does not differ statistically between wide and narrow striae groups. Though mean $\delta^{18}O_{shell}$ is slightly higher in narrow striae groups than wide striae groups in both adult valves from both sites and 2016 juveniles, the differences in means are small and not statistically significant. Similar $\delta^{18}O_{shell}$ means are inconsistent with Stockton's hypothesis about striae, but consistent with our conclusions that $\delta^{18}O_{shell}$ variation is influenced by local variability in meltwater mixing rather than temperature at EC and BOS and that in the absence of strong temperature control on growth, other factors may affect interstrial growth increments.

In contrast to $\delta^{18}O_{shell}$, mean $\delta^{13}C_{shell\ det}$ is substantially more positive in wide striae groups than narrow striae groups under annual sea ice and in the 2016 juveniles, but not in EC adults. Seasonally more positive $\delta^{13}C_{shell\ det}$ is consistent with increased $\delta^{13}C_{DIC}$ due to uptake of ^{12}C by phytoplankton during annual sea-ice breakout at BOS. Similar means in $\delta^{13}C_{shell\ det}$ under annual sea ice are consistent with limited annual fluctuations in $\delta^{13}C_{DIC}$ under multiannual sea ice. The large difference (statistically significantly different means, despite a small sample size) between narrow and wide groups in the 2016 juveniles from the multiannual sea ice site may reflect fortuitous environmental conditions that enabled a rare recruitment event. Sea ice broke out at EC in austral summer 2015/2016. The 2016 juveniles may have carbon isotopes that resemble annual sea ice adults because they spent a significant portion of their life under annual-like sea-ice conditions. The difference in $\delta^{13}C_{shell\ det}$ between wide and narrow striae groups may provide a stable isotope proxy for both sea-ice duration and $\delta^{13}C_{DIC.}$ in *A. colbecki* valves.

Conclusions

Stable isotopes of carbon sampled from narrow and wide striae groups in valves of the Antarctic scallop *A. colbecki* are promising proxies for sea-ice duration in Antarctica. After detrending over ontogeny, wide striae groups under annual sea-ice conditions had more positive $\delta^{13}C$ than narrow striae groups but scallops that lived under multiannual sea ice did not, which conforms to expectations about seasonal differences in $\delta^{13}C_{DIC}$ under annual but not multiannual sea ice.

There is no difference under annual and multiannual sea ice in $\delta^{18}O_{shell}$ from either different striae groups or whole valves. However, EC and BOS have narrower annual temperature fluctuations than other sites where *A. colbecki* is well-studied, and scallop growth may differ between Antarctic sites with seasonally warmer water and sites with stable, frigid water temperatures.

Tables

Table 4.1: Valves sampled for stable isotopes of oxygen and carbon

Site	Valve	*n* stable isotopic samples	Age at death (yrs)
Explorers Cove	EC Valve #1	89	14
	EC Valve #2	130	11
	EC Valve #3	161	NA
	EC Valve (Juv) #1	9	<2
	EC Valve (Juv) #2	12	<2
Bay of Sails	BOS Valve #1	77	11
	BOS Valve #2	88	14
	BOS Valve #3	95	NA

Table 4.2: Linear regressions of $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ over ontogeny

		$\delta^{18}O_{shell}$ over ontogeny			$\delta^{13}C_{shell}$ over ontogeny		
Site	Valve	Slope	Adjusted R^2 (r)	*p*-value	Slope	Adjusted R^2 (r)	*p*-value
Explorers Cove	#1	-0.10	0.67 (-0.81)	<<0.001	-0.16	0.68 (-0.82)	<<0.001
	#2	-0.03	0.16 (-0.40)	<<0.001	-0.15	0.69 (-0.83)	<<0.001
Bay of Sails	#1	-0.06	0.70 (-0.84)	<<0.001	-0.06	0.09 (-0.30)	0.005
	#2	-0.03	0.35 (-0.59)	<<0.001	-0.07	0.57 (-0.75)	<<0.001

Table 4.3: Pearson correlations between $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ and differenced $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ for all valves. Statistically significant correlations (p < 0.05) are bolded

		$\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$			Differenced $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$		
Site	Valve	r	95% CI	*p*	r	95% CI	*p*
Explorers Cove	Valve 1	**0.85**	**0.78–0.90**	**<<0.001**	0.21	-0.02–0.42	0.07
	Valve 2	**0.31**	**0.14–0.46**	**<<0.001**	**0.37**	**0.20–0.51**	**<<0.001**
	Valve 3	**0.39**	**0.25–0.52**	**<<0.001**	**0.28**	**0.13–0.42**	**<<0.001**
	Juv. Valve 1	-0.52	-0.88–0.21	0.15			
	Juv. Valve 2	**-0.62**	**-0.88–-0.07**	**0.03**			
Bay of Sails	Valve 1	**0.38**	**0.17–0.56**	**<<0.001**	-0.22	-0.42–0.01	0.06
	Valve 2	**0.64**	**0.51–0.75**	**<<0.001**	**0.41**	**0.23–0.57**	**<<0.001**
	Valve 3	**0.73**	**0.62–0.81**	**<<0.001**	**0.23**	**0.03–0.42**	**0.03**

Table 4.4: Stable isotopes of oxygen and carbon in *Adamussium colbecki*. All isotopes standardized to VPDB, except Barrera et al., 1990, and Heilmayer et al., 2003, which were standardized to PDB.

	$\delta^{18}O_{shell}$		$\delta^{13}C_{shell}$				
Site	Mean (‰)	Range (‰)	Mean (‰)	Range (‰)	Sample position	Year collected	Reference
TNB	——	3.04– 3.92	——	——	Adult and juvenile growth	1999/2000	Heilmayer et al. (2003)
TNB	——	2.4–4.4 (most)	——	0.6–2.0	2 years of adult growth	2005–2007	Trevisiol et al. (2013)
EC	3.78	3.85–4.75	1.7	0.09–2.5	Adult: 1–41 mm from margin	1986	Barrera et al. (1990)
EC	3.43	2.96–3.76	1.12	0.98–1.24	Adult: 3–6 mm from margin	1987	Barrera et al. (1994) (right valve)
EC	3.75	3.74, 3.76	1.73	1.62,1.83	Juvenile: 46 and 50 mm from margin	1987	Barrera et al. (1994) (right valve)
EC	——	3.56–4.08	——	——	Bulk samples of margins	1986/1987	Berkman et al. (1994)
EC	——	~2.75–4.55	——	——	Adult:0–45 mm from margin	1986; 1998	Lohmann et al. (2001)
EC	4.25	3.60–4. 78	2.19	1.02–3.48	Adult and juvenile growth	2008	*This study*
EC	3.99	3.70–4.11	2.67	2.25–3.08	Juvenile growth	2016	*This study*
BOS	4.27	3.61–4.79	2.03	0.87–3.52	Adult and juvenile growth	2008	*This study*

Figures

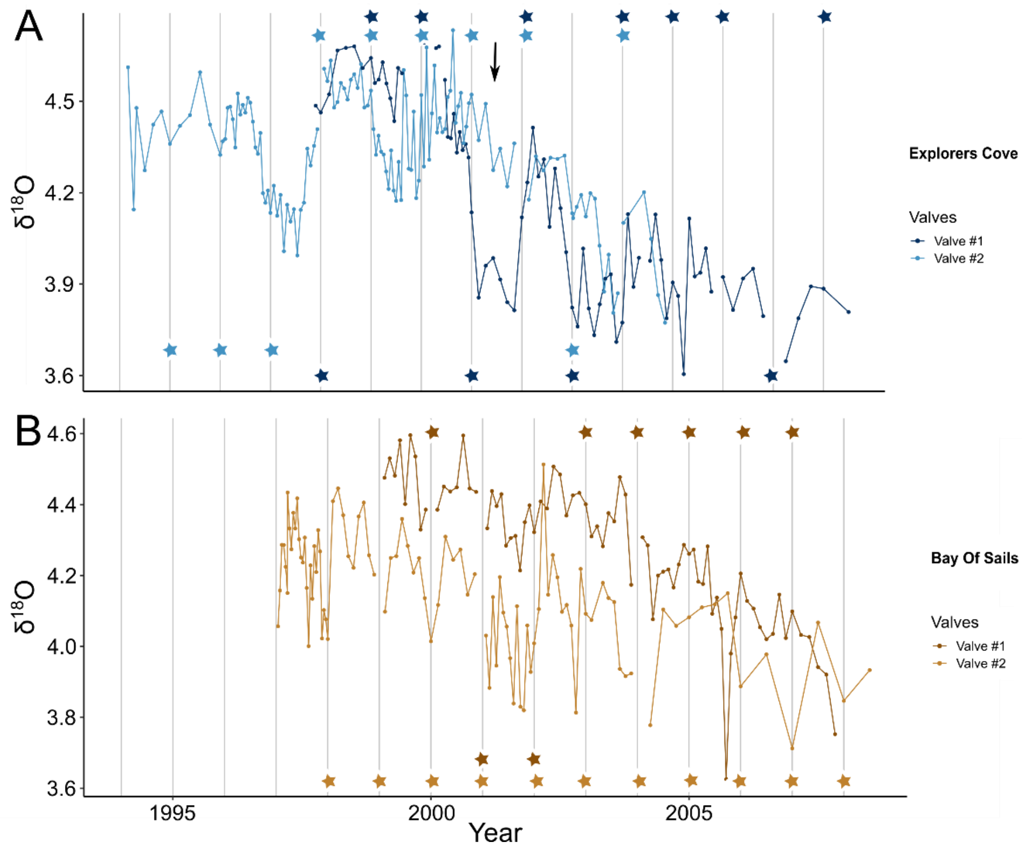


Fig. 4.2: Stable isotopes of oxygen and carbon over time for adult valves from EC and BOS. (A) $\delta^{18}O_{shell}$ for adult valves and (B) $\delta\,^{13}C_{shell}$ for adult valves. Carbon trend lines were calculated for each individual valve using least squares regression according to the methods of Chavaud et al (2011). The x-axis shows time in years to highlight common trends in stable isotopes over time within each site. The black arrow indicates 2002, when sea ice broke out at EC. Stars indicate the position of the annuli relative to local maxima or minima of $\delta^{18}O_{shell}$; stars above the $\delta^{18}O_{shell}$ line indicate occurrence of annuli on a local oxygen maxima, and stars below the $\delta^{18}O_{shell}$ line indicate occurrence of annuli on a local oxygen minima.

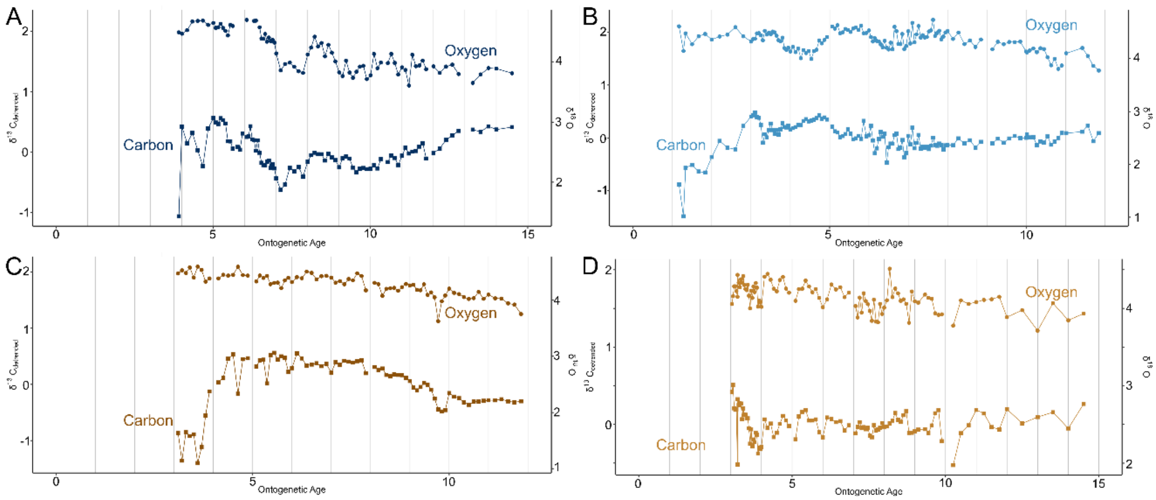


Fig. 4.3: $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell\ det}$ plotted over ontogeny for adult valves: (A) EC Valve #1, (B) EC Valve #2, (C) BOS Valve #1, and (D) BOS Valve #2. The x-axis shows time over ontogeny, or the age of the shell to highlight common ontogenetic patterns. Vertical gray lines indicate annuli position on the valves.

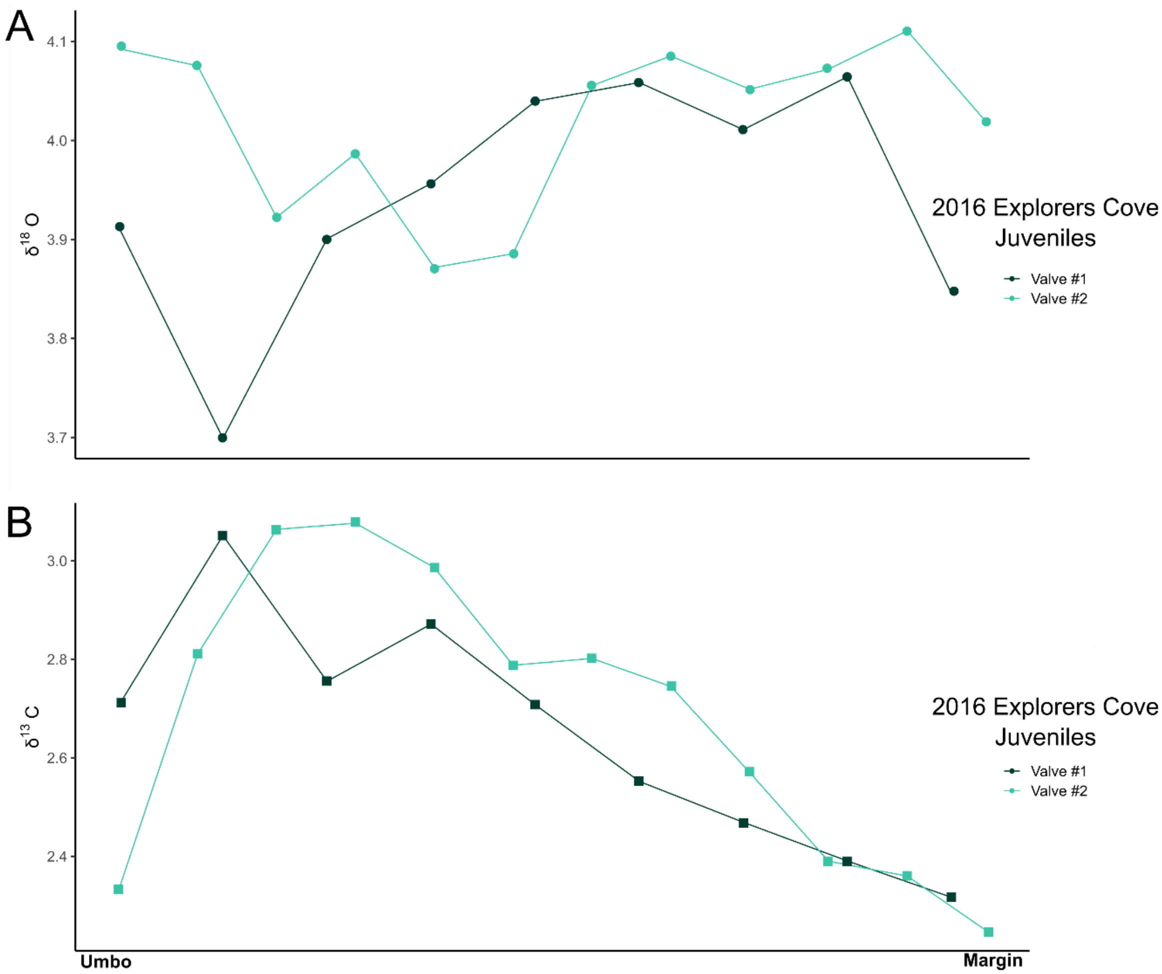


Fig. 4.4: $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ over ontogeny for 2016 juvenile valves from EC. (A) $\delta^{18}O_{shell}$ (B) $\delta^{13}C_{shell}$.

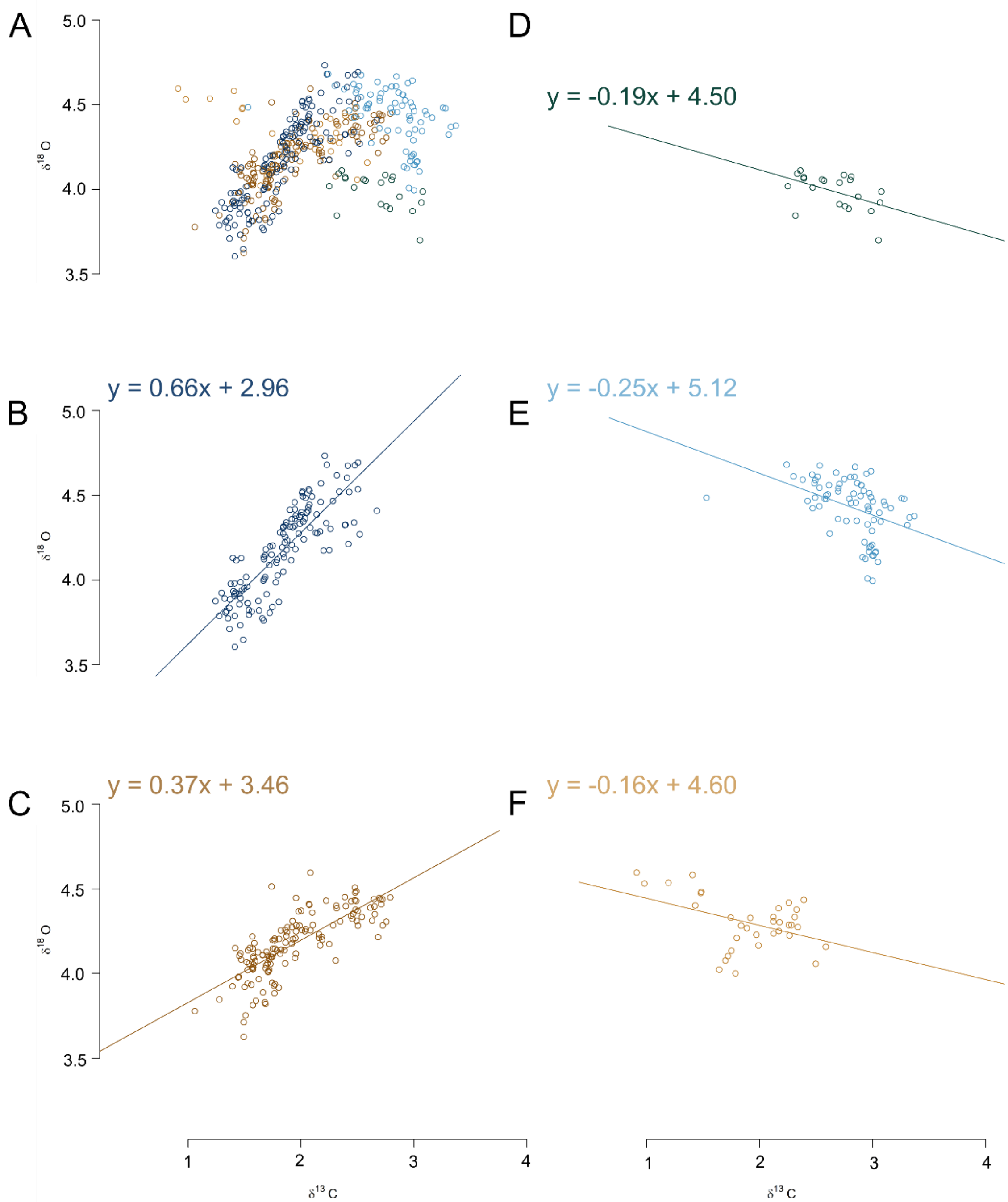


Fig. 4.5: Correlation between $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$. (A) All correlations (B) Explorers Cove adult growth, age ≥ 6 years (C) Bay of Sails adult growth, age ≥ 4 years (D) Explorers Cove 2016 Juveniles (E) Explorers Cove adult growth, age < 6 years (F) Bay of Sails juvenile growth, age < 4 years.

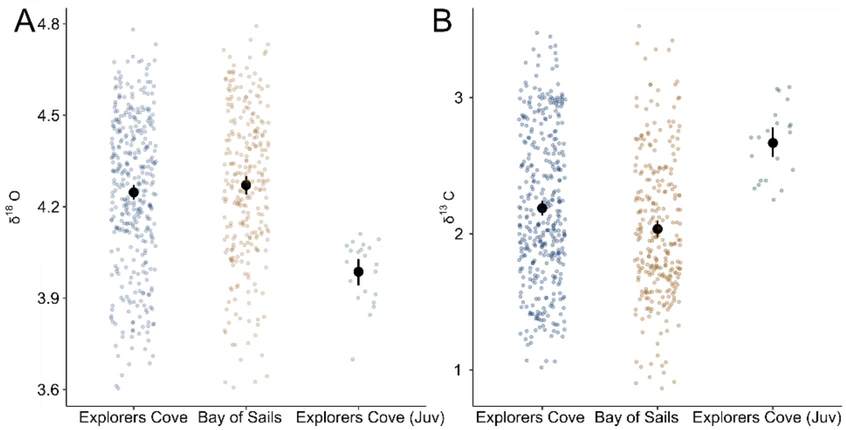


Fig. 4.6: Total variability in $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ in all valves. (A) $\delta^{18}O_{shell}$ (B) $\delta^{13}C_{shell}$. Black dots indicate mean values, bars span 95% CIs.

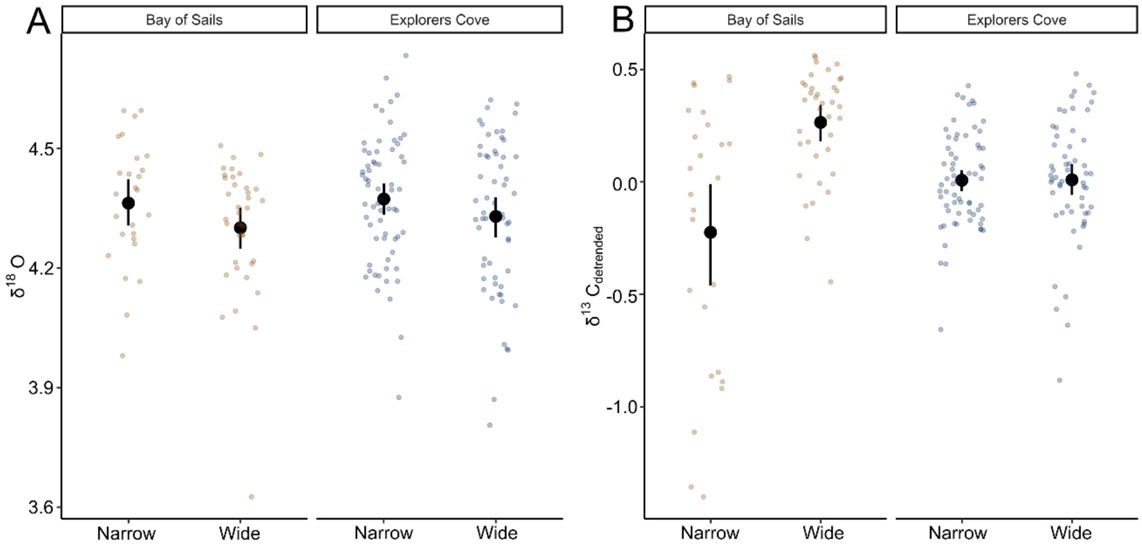


Fig. 4.7: $\delta^{18}O_{shell}$, $\delta^{13}C_{shell\ det}$ in narrow and wide striae groups in EC and BOS adult valves (A) $\delta^{18}O_{shell}$ (B) $\delta^{13}C_{shell}$. Black dots indicate mean values, bars span 95% CIs.

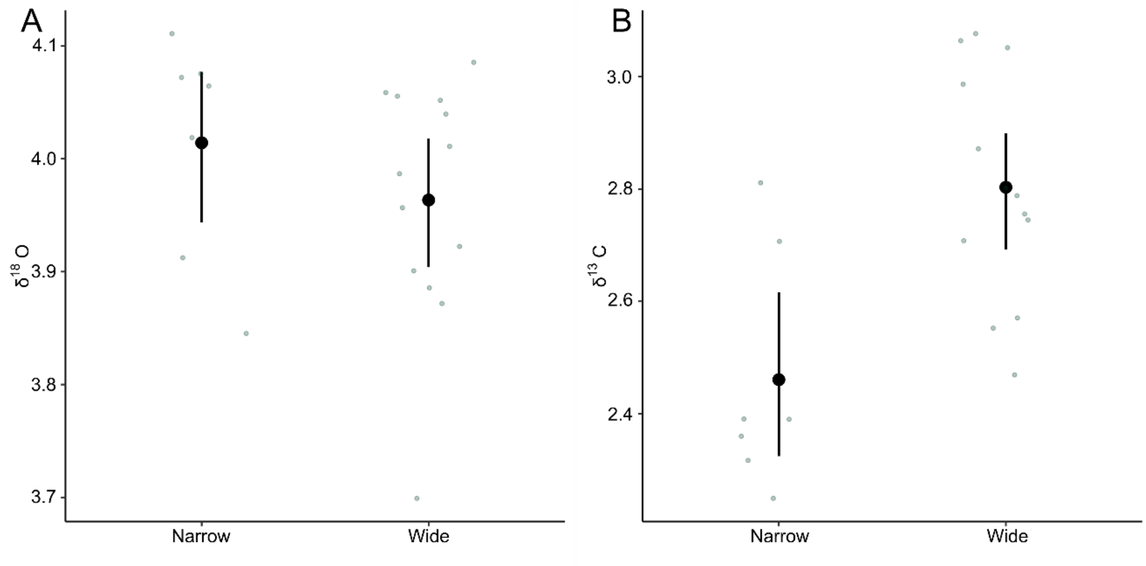


Fig. 4.8: $\delta^{18}O_{shell}$ and $\delta^{13}C_{shell}$ in narrow and wide striae groups of 2016 juveniles. (A) $\delta^{18}O_{shell}$ (B) $\delta^{13}C_{shell}$. Black dots indicate mean values, bars span 95% CIs.

CHAPTER 5

TRACE ELEMENTS IN THE ANTARCTIC SCALLOP *ADAMUSSIUM COLBECKI* UNDER ANNUAL AND MULTIANNUAL SEA ICE [4]

[4] Cronin, K. E. and others, To be submitted to Palaeogeography, Palaeoclimatology, Palaeoecology

Abstract

Sea ice is a critical environmental factor structuring Antarctic benthic ecosystems and the global climate and sea-ice persistence and extent are in decline in the Southern Ocean after decades of increases. Proxies for sea ice must be developed to understand its variability around coastal Antarctica prior to satellite data. The Antarctic scallop *Adamussium colbecki* is a promising proxy for sea-ice duration in Antarctica. It lives under both annual and multiannual sea ice, its growth and diet are affected by sea-ice persistence, and it is an ecologically important bivalve with large geographic and temporal ranges. Crucially, the concentrations of several trace elements in *A. colbecki* valves may respond to sea-ice breakout, primary productivity, or growth rate and metabolism, though these elements have been analyzed only over several weeks of juvenile growth in a single valve. Here, we compare trace elements in *A. colbecki* modern and subfossil valves from two sites in McMurdo Sound: Explorers Cove, which maintains multiannual sea ice, and Bay of Sails, where sea-ice breaks out annually. Li, Mg, Mn, Ba, and Pb were sampled from subannual growth increments over *A. colbecki* ontogeny using LA-ICP-MS and the relationships among trace elements and between each trace element and growth were evaluated. Trace element concentrations, especially Li/Ca, Mg/Ca, Mn/Ca, and Ba/Ca, form distinct cycles in valves from the annual sea ice site, but not the multiannual sea ice site. Additionally, wavelet coherence among trace elements and between trace elements and growth were stronger and persisted longer through ontogeny in valves from the annual sea ice site. Mn/Ca and Pb/Ca are supported as sea ice proxies, whereas Li/Ca and Mg/Ca may be strongly affected by physiological processes. Together, these results support the use of trace elements in *A. colbecki* valves

as proxies for sea-ice persistence in Antarctica. Trace elements from subfossil valves suggest that Bay of Sails might have maintained multiannual sea ice in the past.

Introduction

For the last several decades, sea ice remained relatively stable in the Southern Ocean, but recent data reveal precipitous declines in both extent and duration (Parkinson 2019). Sea ice is a critical factor structuring marine benthic communities in Antarctica (Dayton 1990; Eicken 1992; Moline et al. 2008; Clark et al. 2017) and regulating global climate (Dieckmann et al. 2010). Sea ice attenuates light penetration into the water column and primary productivity is restricted where it persists for several years (multiannual sea ice) compared with areas with annual breakout (annual sea ice; Arrigo et al. 1997, 2012; Norkko et al. 2007; Clark et al. 2015), and a shift to less persistent sea ice will have wide-ranging effects for the unique benthic ecosystems of coastal Antarctica (Clark et al. 2015; Gutt et al. 2015; Dayton et al. 2019; Kim et al. 2019). Given the ongoing changes in sea-ice dynamics around Antarctica, it is vital to understand past variability in sea-ice duration in the Southern Ocean.

Satellite images can be used to understand sea ice changes only over the last few decades; proxies are required to understand dynamics prior to the 1970s. Bivalve shells are widely-used proxies for past marine conditions. Growth and chemical composition of their shells can provide diverse environmental insights and reconstruct various aspects of past seawater conditions (Rhoads and Lutz 1980; Schöne et al. 2002; Stott et al. 2010; Schöne and Gillikin 2013; Butler and Schöne 2017; Tanabe et al. 2017). Changes in sea-ice persistence affect bivalve biology, particularly growth and diet (Norkko et al. 2007;

Sejr et al. 2009; Cronin et al. 2020) and trace elements in bivalve shells are promising proxies of sea-ice dynamics (Lartaud et al. 2010; Wing et al. 2020) .

The Antarctic scallop *Adamussium colbecki* already shows promise as a proxy for sea-ice conditions. The effects of sea ice on the growth and possibly trace element composition of the Antarctic scallop *Adamussium colbecki* make it a promising proxy for sea-ice duration. Valve growth is slower and consumption of resuspended detritus is higher under multiannual sea ice, whereas growth is faster (Cronin et al. 2020) and more phytoplankton is consumed under annual sea ice (Norkko et al. 2007). Though *A. colbecki* can be accurately aged using annual shell bands (Heilmayer et al. 2003; Trevisiol et al. 2013; Cronin et al. 2020), high-temporal resolution for trace element sampling may be possible using striae. Striae are small, commarginal ridges on the surface of valves that form fortnightly during juvenile growth but intermittently and irregularly during late adult growth (Berkman et al. 2004; Lartaud et al. 2010) . Growth increments between striae (interstrial growth increments, ISI) are thought to reflect seasonal variation in growth rate, with wider growth increments indicating faster summer growth and narrower growth increments reflecting slower winter growth (Stockton 1984; Berkman 1990; Lartaud et al. 2010), therefore ISI may themselves indicate seasonal growth differences.

Moreover, several trace elements were identified as suspected proxies for sea-ice breakout, phytoplankton blooms, and growth rate in a study that used LA-ICP-MS to sample a juvenile *A. colbecki* valve (Lartaud et al. 2010). Manganese (Mn), magnesium (Mg), and lead (Pb) were suspected proxies for sea-ice breakout because increases in their concentrations coincided with sea-ice breakout. Barium (Ba) increased subsequent to sea-ice breakout and was interpreted to respond to post-breakout increases in primary productivity. Magnesium (Mg) increased both during sea-ice breakout and when laser spots coincided striae, and was interpreted to respond to sea ice melt, valve growth rate (assuming valve growth slows to form striae), or both (Lartaud et al. 2010). Though Lithium (Li) showed no apparent relationship to sea ice melt in Lartaud et al. (2010)'s study, Li/Ca is connected to primary productivity and growth rate in *Pecten maximus* (Thébault and Chauvaud 2013) and to magnesium concentrations in a study that included several bivalve species including *A. colbecki* (Dellinger et al. 2018). Li/Ca, Mg/Ca, Ba/Ca, and Pb/Ca were also different under annual and multiannual sea ice regimes in the burrowing Antarctic clam *Laternula elliptica* (Wing et al. 2020). Thus far, work to explore trace elements in *A. colbecki* valves as environmental proxies used either bulk shell samples of valve margins or sequentially sampled only a few weeks of growth in juveniles (Berkman 1994*a*; Lartaud et al. 2010). Because *A. colbecki* can live for approximately two decades (Heilmayer et al. 2003; Cronin et al. 2020), yearly variation in trace element concentrations in valves should be explored to confirm its potential to proxy sea-ice duration.

Ecological importance and geographic and temporal distribution enhance *A. colbecki's* relevance as a potential Antarctic environmental proxy. *Adamussium colbecki* is an ecosystem engineer, vital for benthic-pelagic nutrient coupling, with valves that host a diverse array of epibionts and increase species diversity in areas with otherwise soft sediment (Berkman 1994*b*; Cattaneo-Vietti et al. 1997; Cummings et al. 2006; Norkko et al. 2007; Cerrano et al. 2009; Radford et al. 2014). Populations are widely, though patchily, distributed around coastal Antarctica (Schiaparelli and Linse 2006), and they are found under both annual and multiannual sea ice. The species *A. colbecki* has a history starting in the Plio–Pleistocene, and coastal terrace deposits contain early Holocene subfossils (Berkman 1992; Berkman and Prentice 1996; Berkman et al. 2004). The genus *Adamussium* has a fossil record in the Southern Ocean to the Oligocene (Quaglio et al. 2010; Beu and Taviani 2014), thus *A. colbecki* could be a proxy for annual vs. multiannual sea-ice conditions throughout much of the Cenozoic.

Here, we compare trace elements from *A. colbecki* valves from two sites on western McMurdo Sound with similar seawater temperatures but disparate sea-ice persistence: Explorers Cove (EC) maintains sea ice cover for several years to decades, whereas sea ice at Bay of Sails (BOS) breaks out annually. We use LA-ICP-MS over the entire ontogeny of adult valves to sample a suite of trace elements previously connected to sea ice (Mg, Mn, Pb), productivity (Li, Ba), or growth rate (Li, Mg) in *A. colbecki* or other bivalve species. Trace elements are sampled from ISIs to understand both the relationship of trace element growth rate and the potential for ISIs as seasonal/environmental proxies. Finally, we sample one Holocene subfossil valve collected from terraces above each site to test whether trace elements can be retrieved from subfossil shells and if so, whether EC and BOS have maintained similar sea-ice conditions over time.

Methods

Study sites and sample preparation

Scallops were collected live in 2008 from ~12–18 m depth at two sites on western McMurdo Sound at opposite end members of sea-ice duration, but with otherwise similar environmental conditions (Fig. 3.1). Explorers Cove (EC) has multiannual sea ice; partial breakouts occurred in 2002 and 1999, but otherwise remained intact during the lifetime of the live-collected scallops. In contrast, sea-ice breaks out annually at Bay of Sails (BOS). Both sites maintain similar, frigid seawater temperatures year-round (-1.97 °C measured in austral summer at collection depth). Additionally, both sites have gently sloping topography and negligible water currents, with tidal flow ranging from ~1.0 to 2.6 cm sec^{-1} (Barry & Dayton 1988, Hancock *et al.* 2015). Both sites are considered oligotrophic: current flow under the Ross Ice Shelf keeps diatom fluxes two orders of magnitude lower than in eastern McMurdo Sound (Dayton and Oliver 1977; Leventer and Dunbar 1987). Subfossil *A. colbecki* valves were collected from coastal terraces at EC and BOS.

Two live-collected lower (right) valves and one subfossil lower valve from each site were analyzed for this study. Live collected scallops were all adult-sized (> 80 mm shell height; after Cattaneo-Vietti et al 1997). The subfossil valve from BOS was a juvenile (39 mm shell height), while the EC subfossil valve was an adult (78 mm shell height). Valves were cleaned of epibionts, sonicated in distilled water, and dried for ≥ 12 hours before laser ablation.

LA-ICP-MS Analysis

The trace elements, ^{7}Li, ^{26}Mg, ^{55}Mn, ^{137}Ba, and ^{208}Pb were sampled via LA-ICP-MS in a profile over the central axis from umbo to margin on each valve. Spots (50 µm diameter) were ablated between each stria on the interstrial growth increments (ISIs). A series of 50 µm spots were also ablated between the first striae and the umbo to characterize trace elements over earliest ontogeny. LA-ICP-MS sampling was performed at Union College using an Agilent 8700 Quadrupole ICP-MS connected to a CETAC

LSX-213 frequency quintupled Nd:YAG laser ($\lambda = 213$ nm). All element concentrations were standardized to ^{43}Ca. Element/Ca intensity values were calibrated using the United States Geological Survey MACS-3 carbonate standard and calibrations and machine drift were checked using the NIST 612 glass standard. MACS-3 and NIST612 were ablated after every ~25–35 shell spots. NIST 612 trace element concentrations had relative standard deviations averaging 1.7 % for Li/Ca, 3.4% for Mg/Ca, 1.6% for Mn/Ca, 1.6% for Ba/Ca, and 2.3% for Pb/Ca (Appendix D; 301 samples over 10 days days). Trace element data were reduced using LADR standard procedure to calculate detection limits (Norris and Danyushevsky 2020).

Data Processing

Subsequent to laser ablation, valves were digitally photographed. Each laser spot was located and annotated, each stria was counted, each ISI was measured, and laser spots were matched with the appropriate ISI using ObjectJ in the image processing software FIJI (Schindelin et al. 2012).

Statistical Analyses

Relationships among trace elements and patterns over ontogeny were first assessed qualitatively using plots of trace element concentrations throughout growth. Additionally, estimates of the mean concentrations of each trace element for each valve and the 95% confidence intervals (CIs) on each mean were calculated using bootstrap resampling.

The strength of the relationships among element concentrations, between the concentration of each trace element and ontogeny (represented by striae count beginning with the first striae), and between trace element concentrations and growth rate (ISIs) were evaluated quantitatively in two ways. Pearson correlations were used to assess the direction and strength of the relationships; however, the data points are not independent of one another because they represent a time series in which environmental conditions at one time are correlating with preceding conditions. Accordingly, wavelet coherence was also used to assess the strength of the relationship between each pair of trace elements and each trace element and ISI. Wavelet coherence accommodates non-stationary time series and reveals any changes in the relationship over time (Torrence and Compo 1988). Traditional wavelet analysis requires regularly sampled, continuous data sequences, which is not always possible with LA-ICP-MS because misplaced laser spots and discarded outliers break the regular spacing and continuity of the time series. We use the complex-valued wavelet lifting method, developed to perform wavelet analysis on irregularly sampled time series (Hamilton et al. 2018), to assess the wavelet coherence of each pair of time series using the CNLTtsa package in R (R Core Team 2017; Hamilton et al. 2018). The following assumptions were made for the time series: First, we use Lartaud et al.'s (2010) finding that striae form approximately fortnightly in juvenile *A. colbecki*. Second, external annual bands have a shingled appearance in late ontogeny that likely represents actual growth cessation (Cronin et al. 2020), which would break the continuity of the time series. We therefore assess wavelet coherence on the sequence of striae from the first striae to the first obvious growth cessation (shingled annuli or repair scar). The strength of the relationship is expressed in terms of wavelet power (wavelet amplitude^2), and higher wavelet power corresponds to stronger coherence. For the sake of clarity wavelet power is discussed here as stronger or weaker wavelet coherence

Results

Mean trace element concentrations

Modern EC valves have higher mean concentrations and larger ranges for most trace elements than modern BOS valves (Table 5.1). Mean concentrations of Mg/Ca, Mn/Ca, Ba/Ca, and Pb/Ca are higher in modern EC valves, though BOS valve #3 have a higher concentration of Li/Ca than both EC valves. Mean concentrations of Li/Ca, Mg/Ca, and Ba/Ca, have similar mean values for both valves within a site, whereas mean concentrations of Mn/Ca and Pb/Ca can vary by up to twice the amount between the valves within a site.

Concentrations of some trace elements in subfossil valves differ substantially from modern valves from the same site. For instance, though mean Li/Ca is similar among modern and subfossil valves from EC, Li/Ca is significantly higher in the BOS subfossil valve than either of the modern valves from BOS (Table 5.1). Likewise, mean Mn/Ca, Mg/Ca, Ba/Ca, and Pb/Ca are significantly higher in the BOS subfossil than BOS modern valves. For EC, mean Mg/Ca is significantly lower in the subfossil than modern valves, whereas Mn/Ca and Ba/Ca concentrations are significantly higher in the EC subfossil. However, mean Pb/Ca is similar between the EC subfossil and EC modern valves.

Trace elements over ontogeny

Cyclical patterns in trace elements are clear throughout ontogeny in the modern valves from the annual sea ice site (Fig. 5.2) but cycles are absent, dampened, or inconsistent in modern valves from EC, and annuli do not consistently coincide with maxima or minima for any trace element (Fig. 5.3).

Mn/Ca

The suspected sea ice proxy Mn/Ca has particularly clear cycles in the BOS valves and annuli coincide frequently, but not exclusively, with local Mn/Ca minima (Fig. 5.2). In contrast, cycles in Mn/Ca concentrations in EC valves are dampened and inconsistent and annuli do not consistently coincide local minima or maxima (Fig. 5.3). Maximum Mn/Ca values are much higher at EC, but the differences in y-axes are not concealing regular cycles in the EC valves (Appendix D).

Pb/Ca

Pb/Ca, a second suspected sea-ice proxy exhibits weaker cycles compared with the other trace elements in modern BOS valves (Fig. 5.2). Modern EC valves have different ontogenetic patterns in Pb/Ca, but share a period of steady, low variation concentration between approximately stria 50 and stria 200, then an increase in concentration in late ontogeny, after approximately stria 350 (Fig. 5.3).

Mg/Ca

The suspected sea ice or valve growth proxy Mg/Ca has clear cyclical patterns, with maxima frequently but not exclusively coinciding with annuli in BOS valves (Fig. 5.2). In contrast, EC Mg/Ca concentrations vary very little between approximately stria 50 and 200 variation for large portions of valve growth, but the stability is punctuated by areas of large variations in trace element concentrations between approximately stria 30 and the last few years of growth (Fig. 5.3). Near the valve margin, Mg/Ca concentration increases to its highest levels.

Mg/Ca forms a distinctive U-shaped pattern during earliest ontogeny (Fig. 5.2, 5.3). The pattern is common to all sampled valves regardless of sea-ice persistence or modern/subfossil status. Mg/Ca begins at a maximum in earliest growth near the umbo, concentrations decrease to a minimum near the first stria, then rise again and follow the patterns typical to annual or multiannual sea ice before approximately stria 50.

<u>Li/Ca</u>

The suspected primary production or valve growth rate proxy Li/Ca has clear cycles in the BOS valves with maxima that coincide frequently, but not exclusively, with annuli (Fig. 5.2). In contrast, Li/Ca has a common pattern in EC valves, of a long rise to a local maximum approximately stria 100, and a long decline to a relatively steady concentration (Fig. 5.3).

<u>Ba/Ca</u>

The suspected productivity proxy Ba/Ca has similar cyclical patterns in the BOS valves, but maxima only sometimes coincide with annuli (Fig. 5.2). Ba/Ca cycles are irregular and noisy in EC valves, but the pattern in early ontogeny in EC Valve #1 mirrors the U-shaped pattern in Mg/Ca (Fig. 5.3).

Both modern EC valves capture a period of known sea-ice breakout at EC in 2002 (Fig. 5.3). Suspected valve growth and productivity proxies (Mg/Ca and Ba/Ca) have slightly elevated concentrations in 2002 valve growth in EC Valve #1, but the increases are small compared with the increases after striae ~400. In EC Valve #2, suspected sea ice proxies (Mn/Ca, and Pb/Ca), the suspected productivity proxy (Ba/Ca), and the suspected growth rate or sea ice proxy (Mg/Ca) increase during 2002 compared with the previous year of valve growth. However, Mg/Ca concentration continues to rise after 2002 until the valve margin and Ba/Ca, Mn/Ca, and Pb/Ca continue to increase through 2003/2004, despite no sea-ice breakout at EC in those years.

The BOS subfossil valve includes only juvenile growth and the concentrations of all five trace elements are higher in the BOS subfossil. Nevertheless, trace element concentrations do not form the prominent cycles seen in the modern valves (Fig. 5.4A). After high variability in concentrations in earliest ontogeny, all five trace elements form two small local maxima near striae #45 and #80. Annuli occur between the trace element maxima.

The pattern in trace elements over ontogeny in the EC subfossil valve shares more in common with the modern valves that lived under multiannual sea ice than those from the annual sea ice site (Fig. 5.4B). After a period of high concentrations and variation in early ontogeny, trace element concentrations of Mg/Ca, Ba/Ca, Mn/Ca, and Pb/Ca stabilize near striae #100 and remain stable for the rest of valve growth. Mn/Ca reaches a peak between approximately striae #50 and ~ #100. Li/Ca increases to a maximum at ~ striae #125 then declines thereafter until approximately striae #200, most similar to the pattern seen in modern EC valve #4. There is no evidence of cyclical patterns in trace element concentrations in the EC subfossil valve and the annuli do not predominantly coincide with maxima or minima of any trace element.

Correlations between trace elements and ISIs and among trace elements

Pearson correlations between individual trace elements and ISIs are negative but weak ($R^2 < 0.20$) for all modern valves (Tables 5.2–5.5). Correlations are slightly stronger between individual trace elements and ISIs in the modern BOS valves than in the modern EC valves but still weak overall.

Correlations among individual trace elements are mostly positive. In modern Bay of Sails valves, only 2 trace element pairs correlate reasonably strongly ($R^2 > 0.50$).

These are between two suspected sea ice proxies (Mn/Ca and Pb/Ca) in Valve #2 (Table 5.2) and between the suspected sea ice/ growth rate proxy and the suspected productivity proxy (Mg/Ca and Ba/Ca) in valve #4 (Table 5.3). In contrast suspected growth rate/productivity proxy (Li/Ca) and the suspected sea ice proxy (Mn/Ca) are weakly negatively correlated in both modern BOS valves. In modern EC valves, only the suspected growth rate/sea ice proxy (Mg/Ca) and the suspected productivity proxy (Ba/Ca) have reasonably strong coefficients of determination ($R^2 > 0.50$), and only in Valve #2 (Table 5.5).

In the BOS subfossil valve, correlations between ISI and individual elements are positive, but weak (Table 5.6). Like modern valves from both sites, the EC subfossil has weak, negative correlations between trace elements and ISI (Table 5.7). The BOS subfossil has particularly high ($R^2 > 0.80$) coefficients of determination between the suspected productivity proxy (Ba/Ca), the suspected sea ice proxy (Mn/Ca), and the suspected sea ice/growth rate proxy (Mg/Ca; Table 5.6). In the EC subfossil, the suspected sea ice proxy (Mn/Ca) and the suspected sea ice/growth rate proxy (Mg/Ca) are also strongly correlated ($R^2 = 0.69$) and the suspected productivity proxy (Ba/Ca) is moderately strongly correlated ($R^2 > 0.35$) with the suspected sea ice proxy (Mn/Ca) and the suspected sea ice/growth rate proxy (Mn/Mg; Table 5.7).

Wavelet coherence between trace elements and ISIs and among trace elements

Wavelet coherence describes the strength of the relationship between time series (ISI or trace elements) over time (ontogeny of a valve) at various periods (number of striae in a repeating cycle). Results reported here and in in Figs 5.5–5.7 display coherence between periods of 4–64. If hypotheses about fortnightly striae formation in yearly cycles of wide and narrow striae are accurate (after Stockton 1984; Berkman 1990; Lartaud et al. 2010), periods between ~4–64 striae represent cycles (of ISI and trace element concentrations) repeating on subannual timeframes and at time frames up to approximately 2 years of striae.

In contrast to weak Pearson correlations, wavelet coherence results suggest strong relationships between ISI and both suspected productivity and valve growth proxies (Li/Ca, Mg/Ca,and Ba/Ca) that persist from the first striae to approximately stria 100–300 in modern BOS valves (Fig. 5.5) In EC valves, coherence between ISI and trace elements are mostly weaker, do not start on the first stria, and last for only short sequences of striae (~25–50 striae; Fig. 5.6). The exception to this pattern is the coherence between ISI and the productivity/growth proxy (Li/Ca) and the sea ice/growth proxy (Mg/Ca) in EC Valve #2, which is relatively strong and persists through the entire ontogeny of the valve.

Wavelet coherence among trace elements follows a general site-wide pattern in modern valves. In BOS valves, wavelet coherence tends to be stronger, begin early in ontogeny (near the first stria), and persist over large parts of ontogeny that represent several years of growth (sequences > 150 striae, Fig. 5.5). In contrast, coherence between trace elements in modern EC valves tends to be weaker and sporadic throughout ontogeny, beginning after the first stria and persisting for shorter sections of ontogeny that represent < 2 years of growth (~25–50 striae; Fig. 5.6).

At BOS, coherence between the suspected sea ice/growth proxy (Mg/Ca) and the suspected productivity/growth proxy (Li/Ca) is particularly strong (Fig. 5.5). Coherence is also strong in BOS valves between the suspected productivity proxy (Ba/Ca) and suspected productivity/growth (Li/Ca) and suspected sea ice/growth (Mg/Ca) proxies.

The suspected sea ice proxies Mn/Ca and Pb/Ca show weaker and coherence that is short-lived over ontogeny with other trace elements, especially in BOS Valve #2 (Fig. 5.5A), but Pb/Ca coherence with other trace elements is stronger in BOS Valve #1 (Fig. 5.5B)

At EC, the strongest coherence is between suspected productivity/growth proxy (Li/Ca) and suspected sea ice/growth proxy (Mg/Ca), especially in EC Valve #1 (Fig. 5.6A). The suspected sea ice proxy (Pb/Ca) has poor coherence in both valves, The suspected sea ice proxy (Mn/Ca) instead coheres with the suspected growth/productivity proxy (Li/Ca) and the growth/sea ice proxy (Mg/Ca) for short (< ~50 striae) sections of ontogeny throughout growth in EC Valve #1, but not EC valve #4.

The BOS subfossil has strong coherence throughout its ontogeny between ISI and the suspected productivity proxy (Ba/Ca; Fig. 5.7A). Strong coherence between ISI and the suspected sea ice, growth, and productivity proxies (Li/Ca, Mg/Ca, and Mn/Ca) start after ~40 striae. There is also strong coherence between the suspected sea ice proxy (Mn/Ca) and the suspected growth/sea ice proxy (Mg/Ca). In the EC subfossil, ISI coheres only weakly with trace elements (Fig. 5.7B). The strongest coherence is between the suspected sea ice proxy (Mn/Ca), the suspected growth/sea ice proxy (Mg/Ca), and the suspected productivity proxy (Ba.Ca), but only for the final ~100 striae of growth. The suspected sea ice proxy Pb/Ca does not cohere with any of the other trace elements in either subfossil valve.

Discussion

Clear differences exist in trace element composition, ontogenetic trends in those elements, and covariation between pairs of trace elements in *A. colbecki* valves that grew under annual sea ice at Bay of Sails and under multiannual sea ice at Explorers Cove. Trace elements that were identified as suspected proxies for sea ice (Mn/Ca, Mg/Ca, Pb/Ca), post-sea-ice breakout increases in primary productivity (Ba/Ca, Li/Ca), and valve growth rate (Mg/Ca, Li/Ca) by sampling weeks of growth in juvenile *A. colbecki* (Lartaud et al. 2010) can be used throughout ontogeny to differentiate between *A. colbecki* that lived under annual or multiannual sea ice.

Manganese and lead as sea ice proxies

Strong cyclicity in Mn/Ca evident in the valves from the annual sea ice site and the frequent coincidence of annuli with Mn minima support Mn/Ca as a direct proxy for sea-ice breakout in *A. colbecki*. Our results should be tested using *A. colbecki* from other annual sea ice sites to confirm that Mn/Ca cycles at BOS reflect sea-ice breakout rather than terrestrial sources. Annual sea ice is an important Mn source in the Antarctic coast (Grotti et al. 2005); Mn concentrations are higher in sea ice than the water column and are released into the water column when sea ice melts (Lannuzel et al. 2014), but Mn concentrations are also connected to terrestrial input (Lannuzel et al. 2011), and the timing of glacial meltwater input and sea-ice breakout at BOS is similar. Moreover, Mn/Ca is only weakly correlated with either particulate Mn or dissolved Mn^{2+} in other calcitic bivalve species (Freitas et al. 2016). However, if glacial meltwater and terrestrial Mn caused the Mn/Ca cycles in the BOS valves, Mn/Ca cycles should also be apparent in EC valves, which also experience glacial meltwater input in austral summer. Therefore, our results combined with the increase in Mn/Ca coincident with sea-ice breakout in *A. colbecki* from a different annual sea ice site (Lartaud et al. 2010), suggest that cycles in Mn/Ca reflect annual sea-ice breakout.

Our results suggest that Pb/Ca may be a proxy for sea-ice duration in *A. colbecki* valves, but not because of direct increases due to sea ice melt. Pb/Ca has the weakest cycles during valve growth in BOS valves and the weakest coherence with other trace elements or ISI in valves from both sites. Plausible sources of Pb at both sites include wind-blown dust and eroded ore-bearing rocks carried into the sites with glacial meltwater (Krause-Nehring et al., 2012). It is possible, therefore, that higher mean Pb/Ca at EC reflects differences in source rock Pb content. However, the increase in Pb/Ca over ontogeny and the high mean Pb/Ca in the BOS subfossil suggests that source rock is insufficient to explain the differences. We suggest instead that increased Pb/Ca in multiannual sea ice valves results from known increased detritus consumption under multiannual sea ice (Norkko et al. 2007). This proposed link must be investigated, but if true, Pb/Ca might be a straightforward proxy for sea-ice duration in *A. colbecki*.

Barium as a productivity proxy

Ba/Ca variations in bivalves have been attributed to salinity and indirectly to primary production via bivalve consumption of barite after diatom blooms (Vander Putten et al. 2000; Lazareth et al. 2003; Gillikin et al. 2006, 2008; Barats et al. 2009; Thébault et al. 2009). Though Ba/Ca has mostly been investigated in aragonite bivalves, Ba/Ca peaks in calcitic scallops are synchronous among individuals, suggesting a common environmental driver (Gillikin et al. 2008). In *A. colbecki* Ba/Ca was proposed as a productivity proxy because the concentration increased subsequent to the sea ice melt date (Lartaud et al. 2010). In our annual sea ice valves, Ba/Ca peaks do not consistently occur after Mn/Ca peaks, underscoring the importance of understanding trace element variation over ontogeny, or at least several years of growth, to develop trace element proxies for sea ice. Moreover, Ba/Ca coheres strongly with ISI and other all other trace elements in all valves, therefore concentrations may vary with salinity, productivity, or physiology. We cannot disambiguate possible factors using this study.

Potential physiological effects on magnesium and lithium

Shared patterns early in ontogeny in valves from annual and multiannual sea ice sites suggest that the incorporation of magnesium and lithium into valves is more strongly controlled by scallop physiology than sea ice. Moreover, wavelet coherence between Mg/Ca, Li/Ca, and ISI is strong and persistent through ontogeny under both annual and multiannual sea ice.

Though early research suggested that Mg/Ca in bivalves might proxy sea surface temperature or vary with salinity, (Dodd 1965; Klein et al. 1996), subsequent research has revealed Mg/Ca to also be influenced by growth rate, ontogeny, and other physiological factors (Freitas et al. 2005; Lartaud et al. 2010; Poulain et al. 2015; Geeza et al. 2019; Tanaka et al. 2019). We do not consider possible influence of temperature on Mg/Ca here. No influence of temperature was found on Mg/Ca in *A. colbecki* previously (Lartaud et al. 2010), and temperatures vary little EC and BOS (~1.5 °C at EC, Paul Cziko, personal communication; measured summer seawater = -1.97 °C at BOS). Mg/Ca in scallops has also been linked to calcification rate, and a strong physiological control is suspected in seasonally variable incorporation into *Pecten maximus* shells (Carré et al. 2006; Freitas et al. 2016).

Mg/Ca in *A. colbecki* is suspected to be linked to growth rate because Mg/Ca had small but consistent positive excursions when samples coincided with striae, suggesting that Mg/Ca correlates negatively with growth rate (Lartaud et al. 2010). We find only equivocal evidence for a specifically negative relationship between growth rate and Mg/Ca in *A. colbecki* valves. Our Pearson correlation results indicate a weakly negative relationship between Mg and growth rate (proxied by ISI); however, ISI is weakly negatively correlated with most trace element proxies from both sites. but Mg is associated with organics in in *A. colbecki* valves (Peréz-Huerta et al. 2020), which may explain the pattern found by Lartaud et al. (2010). We did not sample striae in this study, only the growth increments between them, and it may be that Mg/Ca increases during striae formation throughout ontogeny. Mg/Ca does not, however, appear to be strongly negatively correlated with growth rate (proxied by ISI) more generally.

The U-shaped pattern in Mg/Ca during earliest ontogeny shared by all valves under both annual and multiannual sea ice suggests a strong physiological control on Mg incorporation into valves in earliest ontogeny. The pattern begins at the umbo and continues through the first ~30–50 striae and may be related to larval recruitment and energy dynamics.

Additionally, we postulate that Li concentrations vary with growth or metabolism in *A. colbecki* valves, rather than productivity *per se*. Li/Ca and Mg/Ca are positively correlated in all sampled valves. Li/Ca and Mg/Ca also have strong wavelet coherence throughout ontogeny with each other and with ISI in all valves. The coherence is more persistent through ontogeny than for other trace elements in valves from the multiannual sea ice site. Li/Ca has been connected to growth rate and primary production in *Pecten maximus* and shown to be strongly controlled by physiology and connected to Mg/Ca in several bivalves, including *A. colbecki* (Thébault and Chauvaud 2013; Dellinger et al.

2018), and the covariance with Mg/Ca suggests stronger evidence for variation of Li/Ca with physiology than productivity in *A. colbecki*.

Mean trace element compositions

Both sea ice proxies (Mn/Ca, Pb/Ca), the suspected productivity proxy (Ba/Ca), and one growth/physiology proxy (Mg/Ca) had statistically significant and unambiguously higher mean concentrations in modern valves from the multiannual sea ice site. Increased sea-ice persistence is also associated with higher mean concentrations of some trace elements in the burrowing Antarctic clam *Laternula elliptica* in McMurdo sound (Wing et al. 2020). Absolute valve concentrations should not be compared between calcitic *A. colbecki* and aragonitc *L. elliptica* because of differences in trace element incorporation into calcite and aragonite, but some commonalities between results of this study and trace elements in *L. elliptica* may identify trace elements that are reliable sea ice proxies across multiple bivalve species.

Trace elements identified as conservative because their water column concentration varies with chemical properties of the water column, including Mg and Ba (Lannuzel et al. 2011), had higher concentrations in *L. elliptica* chondrophores during times of greater sea-ice persistence (Wing et al. 2020). Mg/Ca and Ba/Ca likewise have higher concentrations in *A. colbecki* valves from the multiannual sea ice site, and their concentrations should be explored in other Antarctic bivalves as sea ice proxies. Conversely, Pb is classified as a highly scavenged trace element because Pb adheres to particles and is quickly removed from the water column and, presumably, exported to the sediment. (Wing et al. 2020). Pb/Ca had higher concentrations in *L. elliptica* when sea ice was less persistent and broke out earlier in the season (Wing et al. 2020). Higher Pb/Ca concentration under less persistent sea ice in *L. elliptica*, yet lower concentrations of Pb/Ca under less persistent sea ice in *A. colbecki* may result from differences in feeding habits between *A. colbecki* and *L. elliptica*. *Laternula elliptica* is an infaunal bivalve and siphonate suspension feeder (Ahn 1993), but *A. colbecki* feeds more heavily on detritus from resuspended sediment as sea-ice duration increases (Norkko et al. 2007). Pb-bearing particles consumed along with detritus would explain the higher mean concentration of Pb/Ca under multiannual sea ice in *A. colbecki*. Pb/Ca may be a sea ice proxy in Antarctic bivalves, but it should be interpreted carefully in light of species-specific ecology.

Trace element patterns under annual and multiannual sea ice

Trace element concentrations, especially of Li/Ca, Mg/Ca, Mn/Ca, and Ba/Ca exhibited clear cycles in modern *A. colbecki* valves from the annual sea ice site. Cycles were not apparent in modern or subfossil valves from the multiannual sea ice site. The presence of strong, regular cyclicity in bivalves under less persistent sea ice but not more persistent sea ice is qualitatively supported by cyclical patterns seen in Sr concentrations in *L. elliptica* under less persistent sea ice (Wing et al. 2020).

Wavelet coherence among trace elements and between trace elements and growth rate (ISI) are also stronger under multiannual sea ice than under annual sea ice. In most cases, wavelet coherence began earlier in ontogeny, persisted longer through ontogeny and was stronger in valves from BOS. EC valves, in contrast, had shorter, discontinuous, and weaker coherence over ontogeny. We suggest that the stronger and more persistent wavelet coherence under annual sea ice is the result of annual sea-ice breakout driving trace element concentration variation at the annual sea ice site. In the absence of an annual driver of trace element concentrations, the relationship among trace elements is weaker.

Subfossil valves

Results from subfossil valves suggest that both EC and BOS maintained multiannual sea ice in the past. The EC subfossil valve shares commonalities in trace element concentration patterns over ontogeny, means, and coherence with EC modern valves, and thus it is likely that EC maintained multiannual sea ice in the past. The BOS subfossil includes only juvenile growth, but it shares some similarities with EC modern valves, nonetheless. First, though clear local maxima are present in Mn/Ca, Pb/Ca, Mg/Ca, and Ba/Ca concentrations in the BOS subfossil, trace elements lack the distinct cycles present even in early ontogeny in the modern BOS valves. Second, mean concentrations are higher in the BOS subfossil than in modern BOS valves. Though it is possible that the means would have decreased as the scallop aged, trace elements have higher maxima in the subfossil BOS valve than the modern BOS valves. Finally, coherence does not begin until near striae #20, rather than with the first striae, except between Ba/Ca and ISI. These similarities between the BOS subfossil and the EC modern valves suggest that BOS may have maintained multiannual sea ice in the past.

Conclusions

Consistent differences in trace element concentrations, patterns of trace element concentrations through ontogeny, and wavelet coherence among trace elements and between trace elements and interstrial growth increments suggest that trace elements in *A. colbecki* valves could proxy sea-ice persistence in Antarctica. Moreover, Mn/Ca and Pb/Ca may be proxies for sea ice itself, whereas Li/Ca and Mg/Ca are likely connected to growth or physiology rather than sea ice. The multiannual sea ice site has higher mean concentrations of all trace elements except Li/Ca. Valves from the annual sea ice site display clear cycles of trace elements over ontogeny that are lacking in the valves from the annual sea ice site, and moreover the relationships among trace elements and between interstrial increments and each trace element are stronger under annual sea ice than multiannual sea ice. Finally, a comparison of subfossil valves from each site to modern valves suggests that the currently annual sea ice site may have maintained multiannual sea ice in the past.

Tables

Table 5.1: Mean, 95% CIs, and ranges of trace elements in each valve.

Element	Site	Valve	Mean (ppm)	95% CI (ppm)	Range (ppm)
Li/Ca	Explorers Cove	1	0.58	0.56–0.60	0.31–1.49
		2	0.66	0.64–0.69	0.28–1.52
		Subfossil	0.62	0.60–0.64	0.31–1.10
	Bay of Sails	1	0.88	0.85–0.92	0.33–2.10
		2	0.62	0.60–0.63	0.29–1.31
		Subfossil	1.21	1.15–1.29	0.62–2.22
Mg/Ca	Explorers Cove	1	559.69	535.69–585.28	113.62–2400.18
		2	583.36	561.69–605.88	67.80–1895.85
		Subfossil	241.89	232.80–251.43	62.62–524.21
	Bay of Sails	1	374.97	362.53–387.49	113.08–874.00
		2	343.27	328.14–359.79	143.92–1336.36
		Subfossil	483.19	433.44–537.74	294.28–1466.86
Mn/Ca	Explorers Cove	1	9.82	9.27–10.39	2.60–47.91
		2	23.34	21.82–24.97	2.79–94.84
		Subfossil	114.08	106.51–122.04	6.70–482.16
	Bay of Sails	1	6.25	5.93–6.56	1.31–13.24
		2	3.13	3.02–3.23	0.63–6.75
		Subfossil	21.15	18.95–23.57	10.46–54.08
Ba/Ca	Explorers Cove	1	1.35	1.31–1.40	0.66–4.23
		2	1.35	1.33–1.39	0.66–2.98
		Subfossil	2.80	2.69–2.89	1.54–6.70
	Bay of Sails	1	1.24	1.21–01.28	0.83–2.90
		2	1.01	0.98–1.04	0.68–2.62
		Subfossil	3.21	2.85–3.60	1.70–8.60

Element	Site	Valve	Mean (ppm)	95% CI (ppm)	Range (ppm)
Pb/Ca	Explorers Cove	1	0.08	0.07–0.08	0.01–0.73
		2	0.19	0.17–0.21	0.01–0.98
		Subfossil	0.08	0.07–0.09	0.01–0.43
	Bay of Sails	1	0.08	0.08–0.09	0.04–0.42
		2	0.04	0.03–0.04	0.01–0.28
		Subfossil	0.17	0.14–0.21	0.02–0.83

Table 5.2: R^2 values from statistically significant ($p < 0.05$) correlations between interstrial growth increments, ontogeny, and trace elements from Bay of Sails Valve #1. Italics indicate negative correlations; dashes indicate non-significant correlations, which are reported in Appendix D.

	ISI	Li/Ca	Mg/Ca	Mn/Ca	Ba/Ca	Pb/Ca
ISI		*0.07*	*0.12*	*0.04*	–	*0.02*
Li/Ca			0.18	*0.05*	0.04	0.03
Mg/Ca				0.03	0.12	0.11
Mn/Ca					–	0.57
Ba/Ca						0.19

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Table 5.3: R^2 values from statistically significant ($p < 0.05$) correlations between interstrial growth increments, ontogeny, and trace elements from Bay of Sails Valve #2. Italics indicate negative correlations; dashes indicate non-significant correlations, which are reported in Appendix D.

	ISI	Li/Ca	Mg/Ca	Mn/Ca	Ba/Ca	Pb/Ca
ISI		*0.18*	*0.15*	–	*0.11*	*0.04*
Li/Ca			0.10	*0.06*	0.02	–
Mg/Ca				–	0.51	0.06
Mn/Ca					–	0.09
Ba/Ca						0.09

Table 5.4: R^2 values from statistically significant (p < 0.05) correlations between interstrial growth increments, ontogeny, and trace elements from Explorers Cove Valve #1. Italics indicate negative correlations; dashes indicate non-significant correlations, which are reported in Appendix D.

	ISI	**Li/Ca**	**Mg/Ca**	**Mn/Ca**	**Ba/Ca**	**Pb/Ca**
ISI		–	*0.03*	0.02	*0.11*	*0.03*
Li/Ca			0.33	0.23	0.17	0.11
Mg/Ca				0.08	0.55	0.13
Mn/Ca					0.07	0.08
Ba/Ca						0.17

Table 5.5: R^2 values from statistically significant (p < 0.05) correlations between interstrial growth increments, ontogeny, and trace elements from Explorers Cove Valve #2. Italics indicate negative correlations; dashes indicate non-significant correlations, which are reported in Appendix D.

	ISI	**Li/Ca**	**Mg/Ca**	**Mn/Ca**	**Ba/Ca**	**Pb/Ca**
ISI		–	–	*0.05*	*0.05*	*0.12*
Li/Ca			0.19	0.05	0.06	0.01
Mg/Ca				0.09	0.27	0.07
Mn/Ca					0.34	0.33
Ba/Ca						0.28

Table 5.6: R^2 values from statistically significant (p < 0.05) correlations between interstrial growth increments, ontogeny, and trace elements from Bay of Sails Subfossil. Italics indicate negative correlations; dashes indicate non-significant correlations, which are reported in Appendix D.

	ISI	**Li/Ca**	**Mg/Ca**	**Mn/Ca**	**Ba/Ca**	**Pb/Ca**
ISI		–	0.07	0.06	0.12	–
Li/Ca			0.20	0.14	0.12	0.12
Mg/Ca				0.84	0.89	0.09
Mn/Ca					0.87	0.15
Ba/Ca						0.12
Pb/Ca						

Table 5.7: R^2 values from statistically significant ($p < 0.05$) correlations between interstrial growth increments, ontogeny, and trace elements from Bay of Sails Subfossil. Italics indicate negative correlations; dashes indicate non-significant correlations, which are reported in Appendix D.

	ISI	**Li/Ca**	**Mg/Ca**	**Mn/Ca**	**Ba/Ca**	**Pb/Ca**
ISI		–	*0.02*	*0.03*	*0.11*	*0.09*
Li/Ca			0.14	0.05	–	0.05
Mg/Ca				0.69	0.38	0.23
Mn/Ca					0.47	0.20
Ba/Ca						0.18
Pb/Ca						

Figures

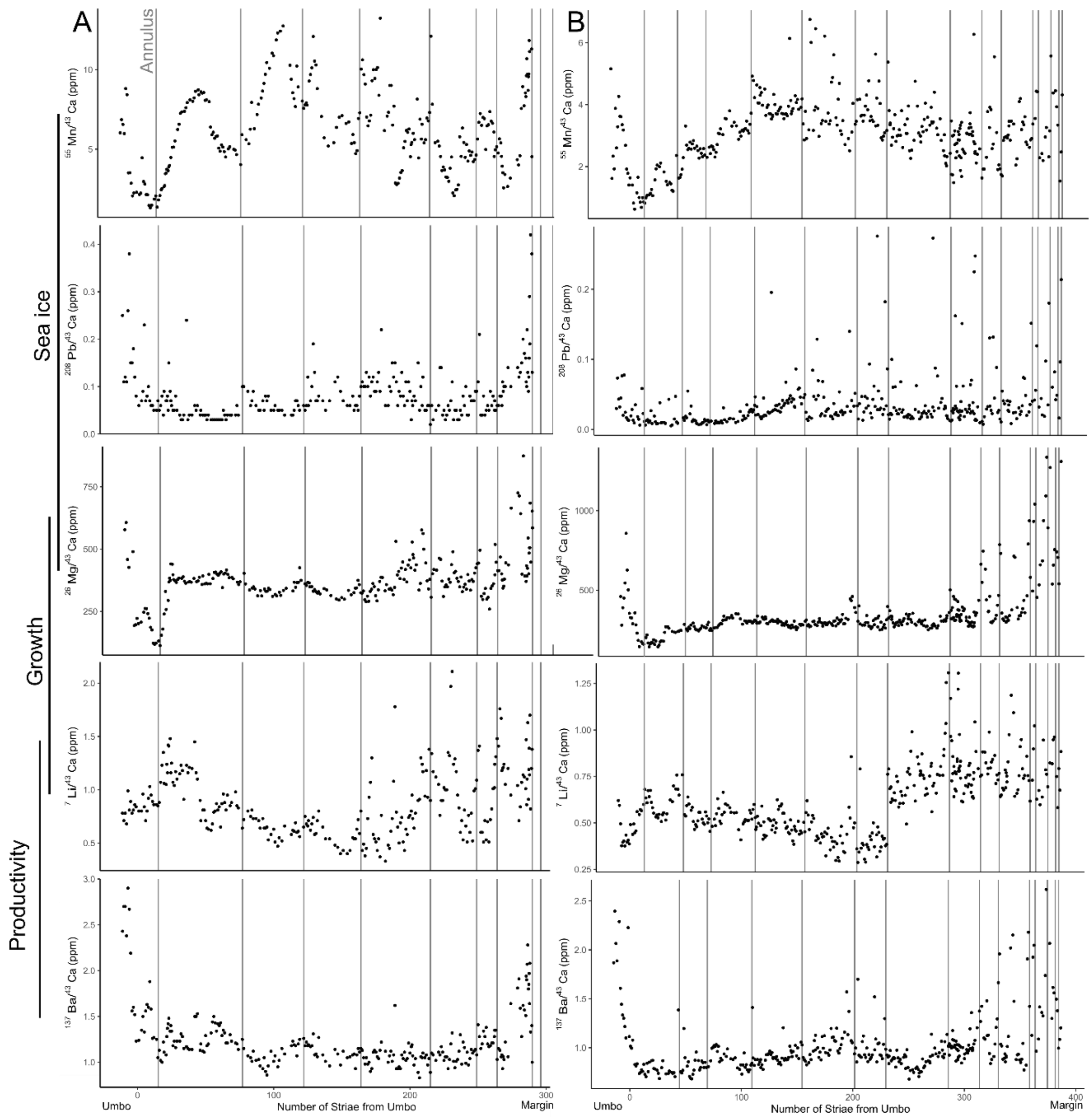

Fig. 5.2: Bay of Sails trace elements over valve ontogeny. Annual sea ice valves are characterized by cyclical concentrations. Valve annuli indicated by gray lines. (A) Modern Valve #1. (B) Modern Valve #2.

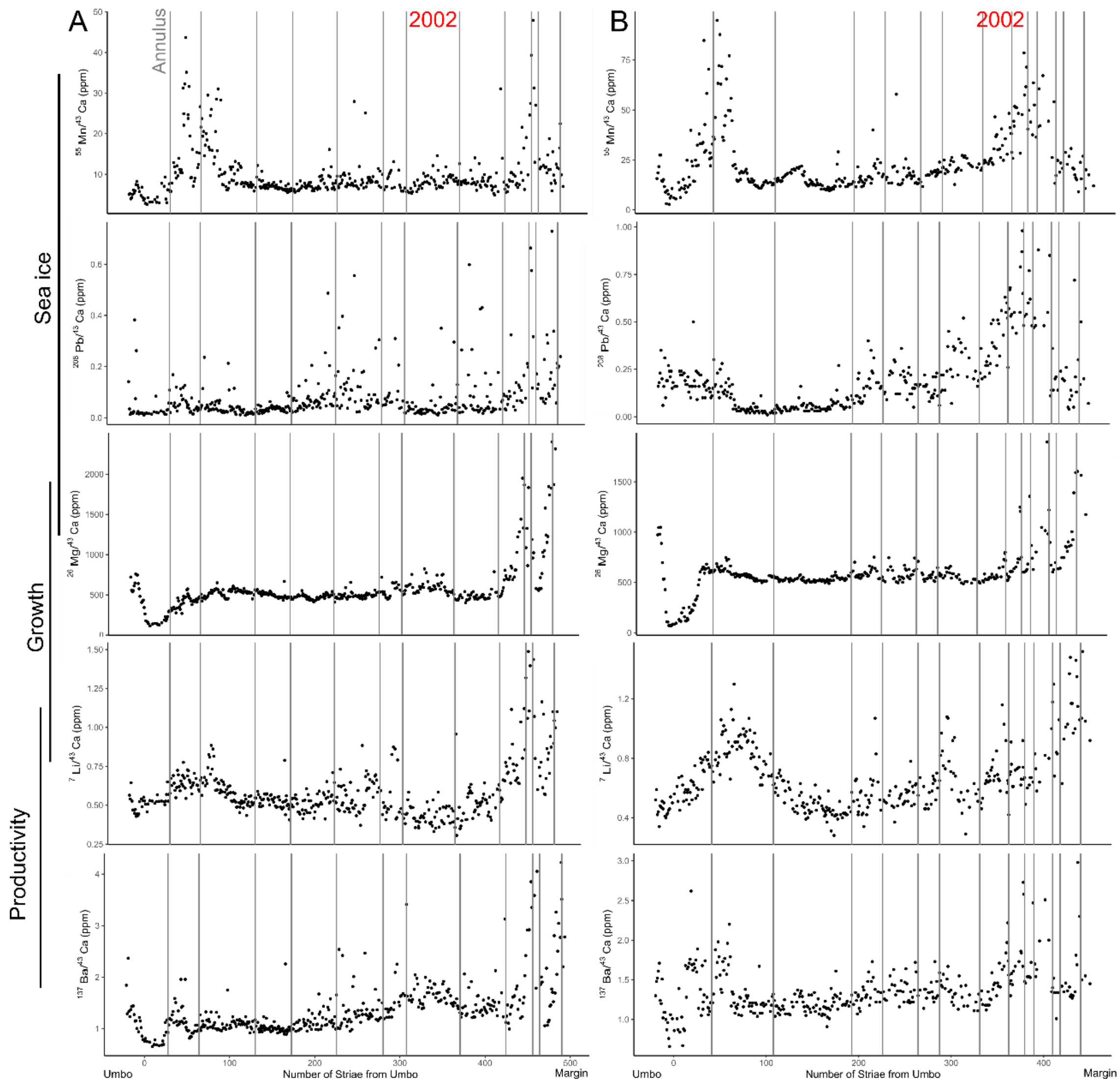

Fig. 5.3: Explorers Cove trace elements over valve ontogeny. Multiannual sea ice valves are characterized by large variation in concentrations in early and late ontogeny, and a section of middle ontogeny with otherwise stable concentrations Valve annuli indicated by gray lines. (A) Modern Valve #1. (B) Modern Valve #2.

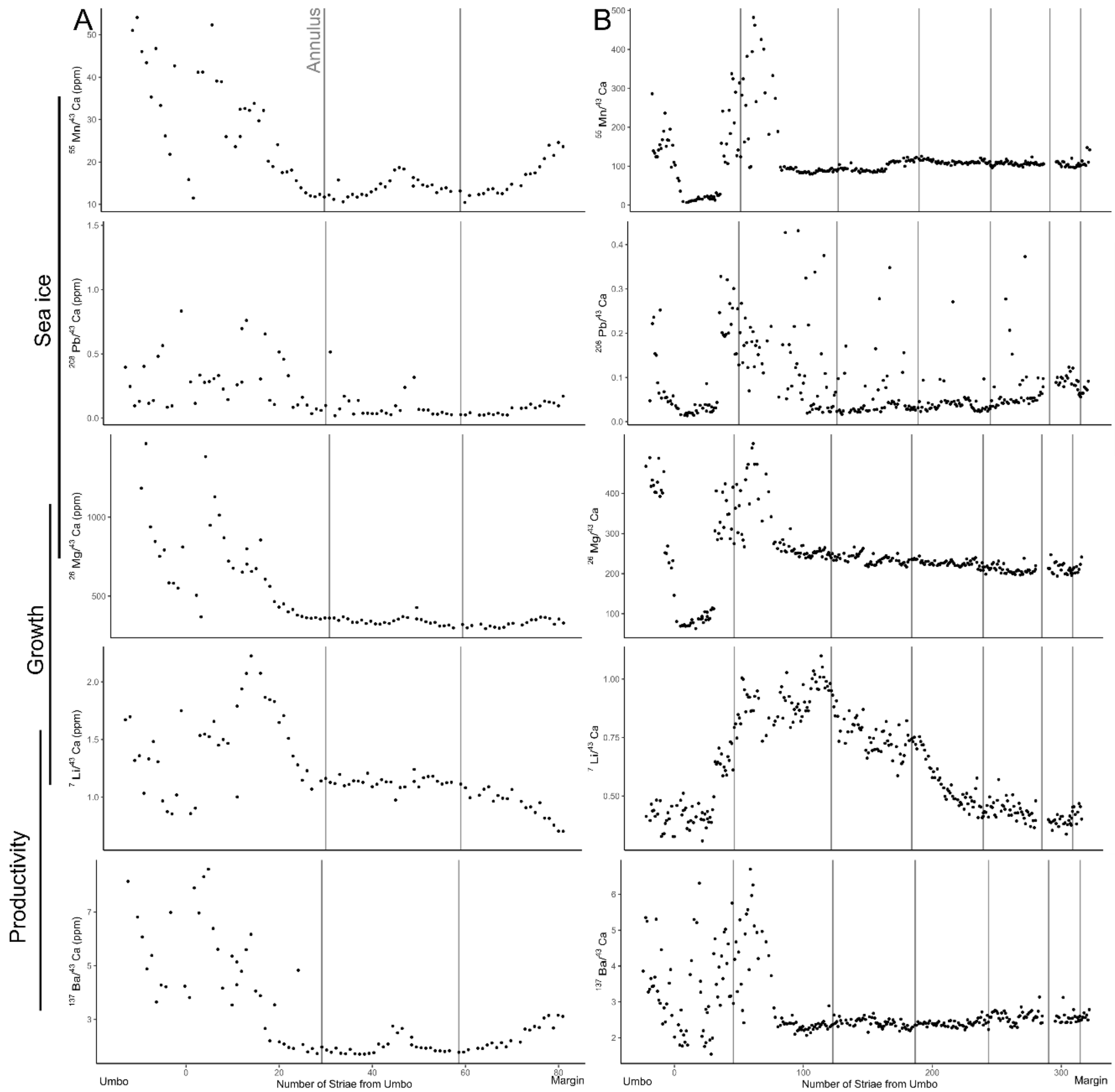

Fig. 5.4: Subfossil trace elements over valve ontogeny. Subfossil valve patterns are similar to modern valve patterns from their respective sites. Valve annuli indicated by gray lines. (A) Bay of Sails subfossil. (B) Explorers Cove subfossil.

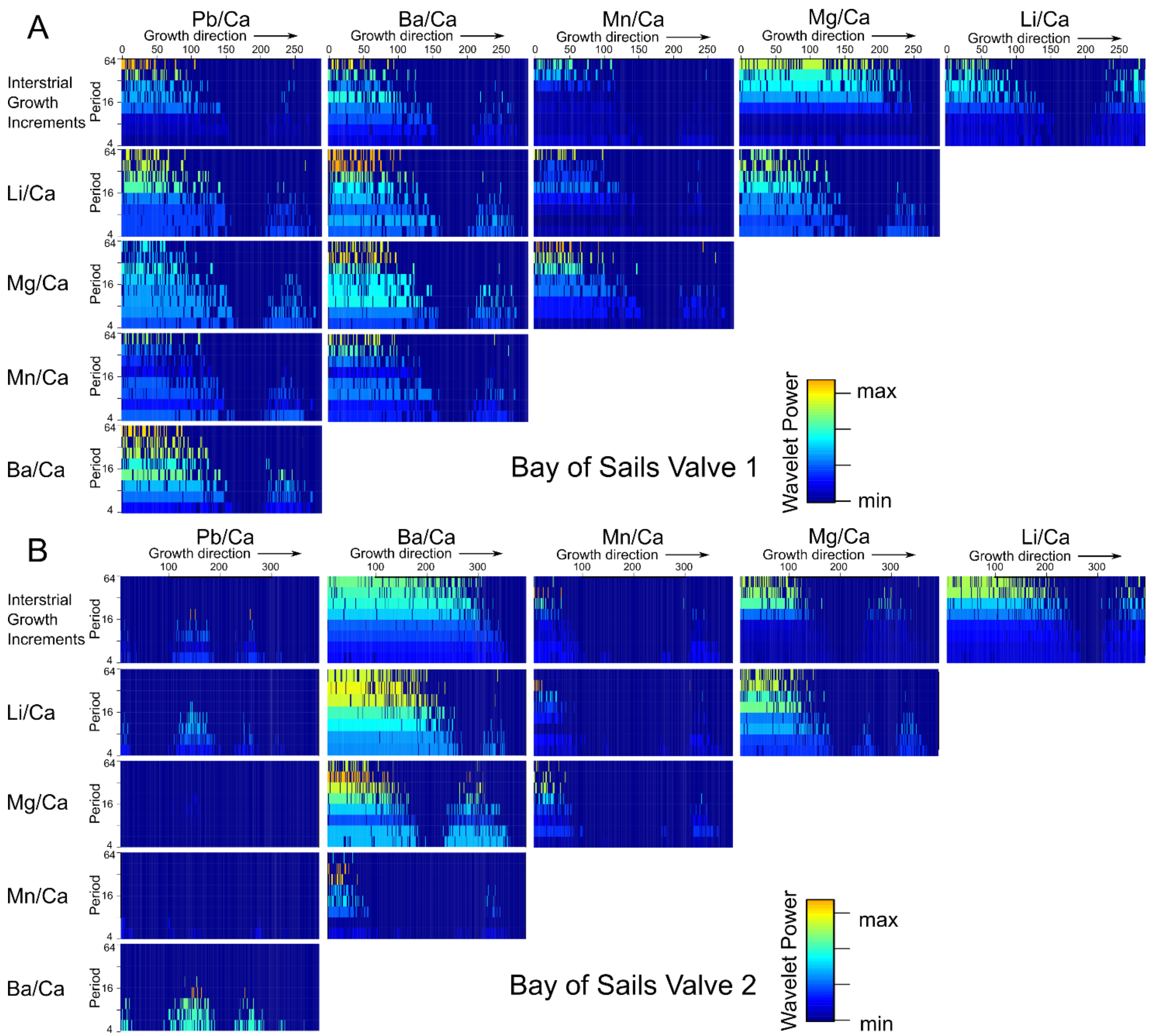

Fig. 5.5: Wavelet coherence among interstrial increments and trace elements under annual sea ice.

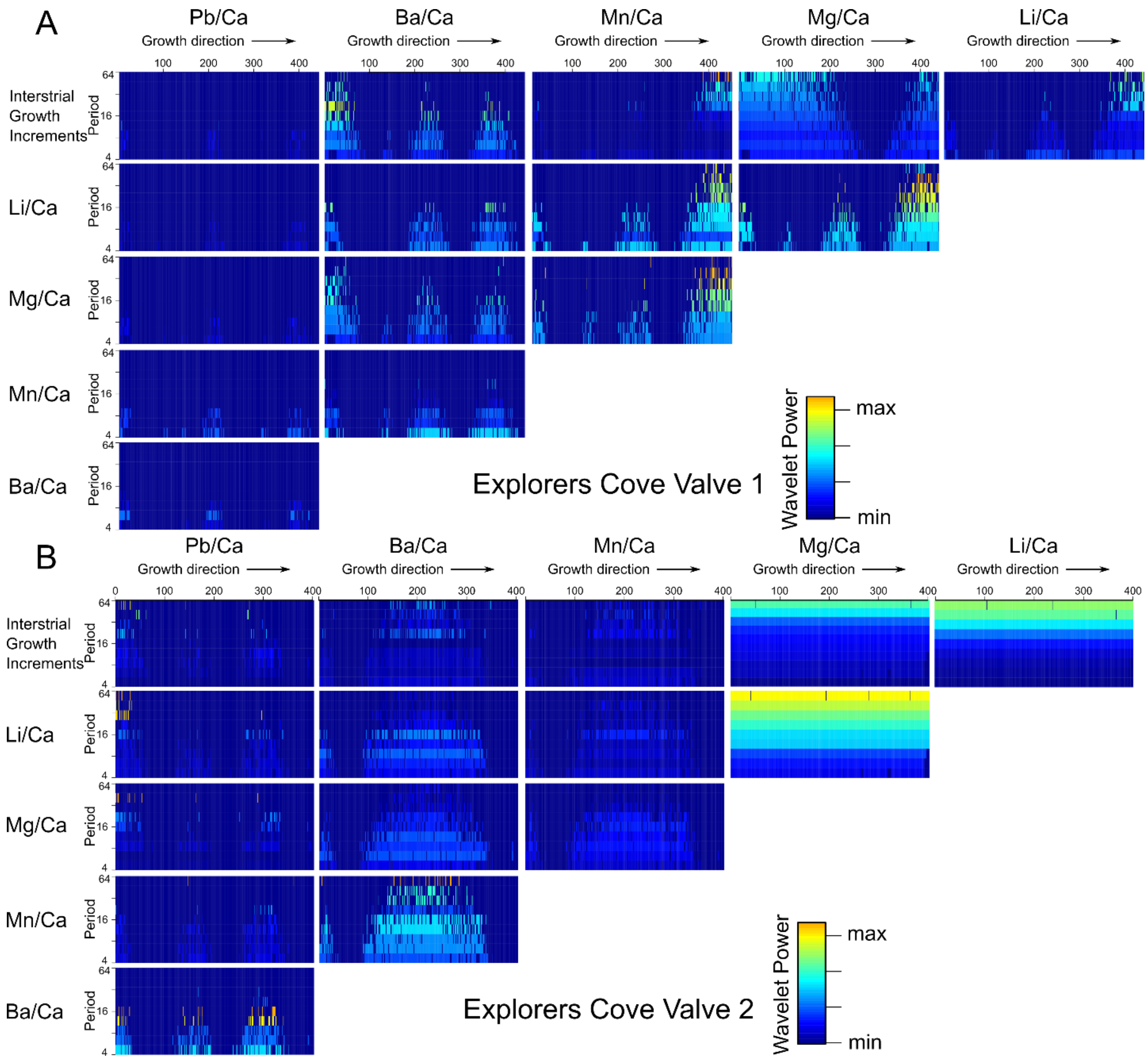

Fig. 5.6: Wavelet coherence among interstrial increments and trace elements under multiannual sea ice.

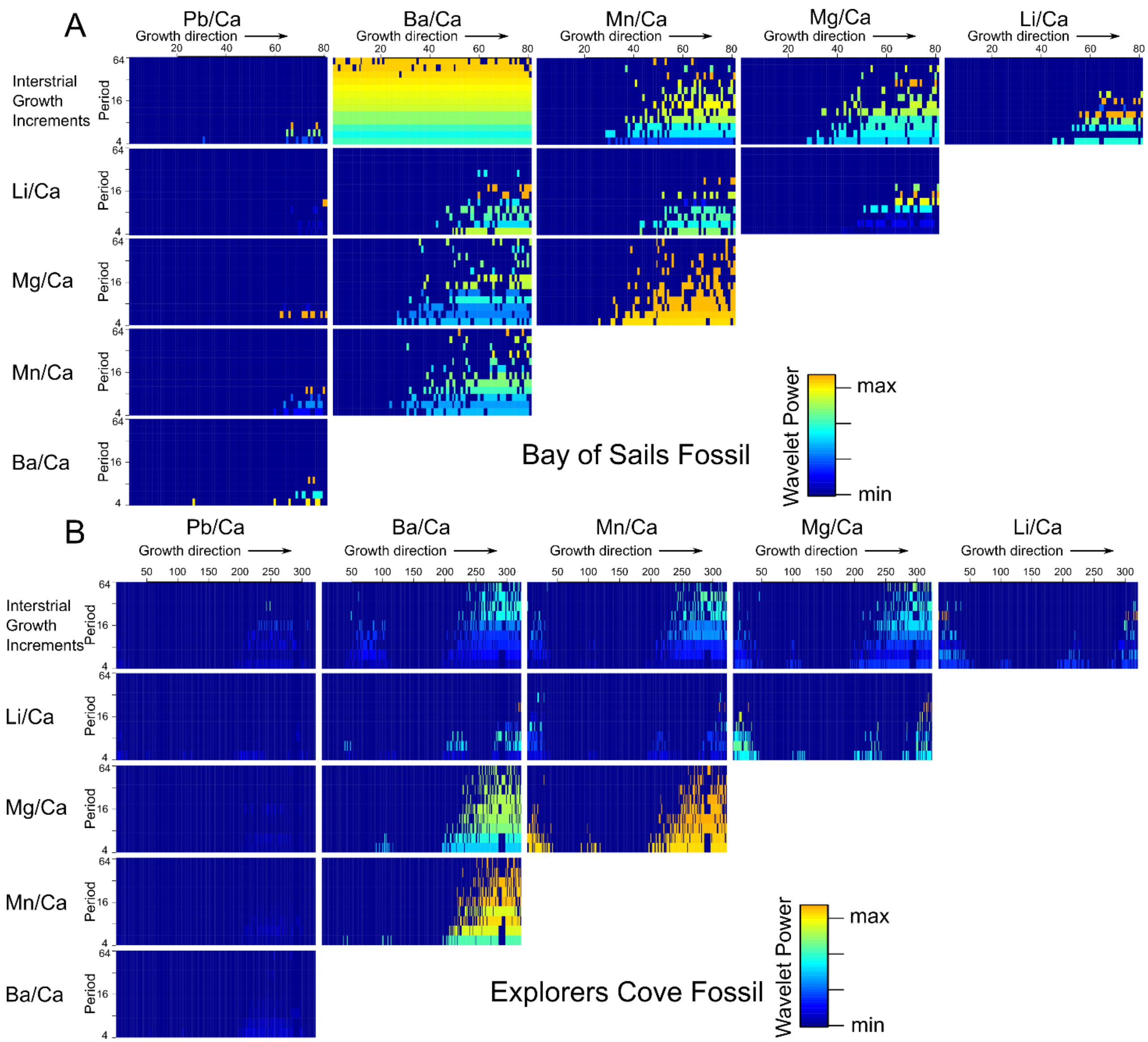

Fig. 5.7: Wavelet coherence among interstrial increments and trace elements in subfossil valves.

CHAPTER 6

CONCLUSIONS

Growth and valve chemistry differ in *Adamussium colbecki* valves under multiannual sea ice and annual sea ice. Though lifespans are indistinguishable between the sites, both annual growth rates and subannual growth rates (interstrial distances) are slower under multiannual sea ice. Growth is also more variable under multiannual sea ice at the annual scale, though at the subannual scale, no appreciable difference in the variability of growth could be detected. Though oxygen isotopes suggest negligible difference between seasons at both sites, carbon isotopes sampled from summer and winter striae groups suggest greater seasonality in carbon isotopes of seawater at the annual sea ice site. Finally, trace elements under annual sea ice exhibit clear cycles and persistent coherence between growth and trace element concentration patterns and among trace element concentration patterns. The cycles are absent or irregular under multiannual sea ice, and pattern coherence is weaker.

Future Research

Sea ice

This dissertation does not definitively establish *A. colbecki* growth or valve chemistry as an proxy for sea-ice persistence in coastal Antarctica, but the discoveries made here are promising and clarify two necessary directions for future research. First, these findings must be replicated at other Antarctic sites for which sea-ice conditions are known. *Adamussium colbecki* is relatively well-studied at Explorers Cove and Terra Nova Bay, both sites on western McMurdo Sound, and some research has also been done on the Antarctic Peninsula and Dumont D'Urville Station. To my knowledge, only presence/absence data is known from the rest of Antarctica. An obvious first step is to expand our understanding of the growth, lifespan, and shell chemistry of *A. colbecki* populations from other areas, particularly on the Indian Ocean-facing coast of Antarctica. It may be that some of the differences between EC and BOS populations are particular to EC and BOS; this is especially important for the trace element data, where concentrations may be dependent upon the bedrock geology under glacial the meltwater streams. Second, stable isotopes and trace elements should be sampled from the same valve so that they can be directly compared, especially in light of the seasonal arguments made in this dissertation. If carbon isotopes are more positive in austral summer under annual sea ice, more positive $\delta^{13}C$ shell should coincide with peaks in Mn/Ca under annual sea ice. This must be confirmed by sampling both stable isotopes and trace elements from the same individuals.

Provided *A. colbecki* is confirmed as a proxy for sea-ice persistence in coastal Antarctica with additional sites and chemical studies, it should be used to reconstruct local sea-ice persistence and variability through time. This would require a robust absolute dating protocol, using either ^{14}C or, preferably, amino acid racimerization (AAR) to establish ages in subfossil valves. Carbon reservoir data for Antarctica remains poorly constrained. AAR is tailored to each species and region and has the advantage of high temporal resolution compared with ^{14}C. Fossil *Adamussium* from terraces and cores could be dated and used to develop a chronology of sea-ice persistence.

The chronology could be used in three basic ways, beginning with local questions about ecosystems and expanding the scope to broader questions about climate history. *Adamussium colbecki* is an ecosystem engineer in part because it provides hard substrate for epibionts, thereby increasing local diversity. Slow -growing sponges and bryozoans are integral parts of the unique benthic marine ecosystems in coastal Antarctica, and they may preserve either body fossils or trace (attachment scars) fossils on *Adamussium*. The diversity of epibionts in these ecosystems could be examined over time and under different sea-ice regimes if they are tied to dated *Adamussium*. Second, aspects of Antarctic climate history could be tied to local variability in sea ice data. Precisely dated sediment cores from projects like ANDRILL yield information about a variety of past seawater conditions, including temperature, productivity, and current data. Paired with what we already know about past Antarctic and Southern Ocean climate, a chronology of sea-ice variability from around Antarctica could help refine our understanding of how broader trends in ocean temperature and chemistry interact with sea-ice variability over time. Finally, sea ice is of global importance to climate; its extent and duration affect the global albedo effect, its formation and breakout help drive global ocean currents, and it mediates gas exchange between oceans and the atmosphere. We only have precise, high-temporal resolution data about sea-ice extent and duration to pair with global climate data for the last ~40 years. An absolute-dated chronology of sea-ice variability in the Antarctic, even at fairly coarse geographic resolution, could help refine global climate models and predict both the consequences of climate change on sea ice in Antarctica, and possibly the effects of changing sea-ice duration in Antarctica on global climate.

Bivalve growth and chemical sclerochronology in narrow temperature ranges

One intersecting aspects of *A. colbecki* valves highlights knowledge gaps in bivalve growth and chemistry when temperature range is very narrow. The maximum temperature range at EC over several years of study was ~1.5 °C. The range may be even lower at BOS, but no data loggers are present to confirm. This may at least partially explain the non-coincidence of annuli and $\delta^{18}O$ maxima or minima. To my knowledge, a similar pattern has been reported for only one other scallop, the extremely well-studied *Pecten maximus*. At a collection depth where annual sweater temperatures varied <1 °C, $\delta^{18}O$ patterns did not match annuli, which were nonetheless present on valves (Chauvaud et al. 2011). Oxygen isotopes in *A. colbecki* from Terra Nova Bay, where the temperature range is approximately double that of EC, were used to validate X-ray bands as annual (Heilmayer et al. 2003). The coincidence of X-ray bands and $\delta^{18}O$ maxima were not perfect, however. Large temperature ranges in temperate environments result in reliable $\delta^{18}O_{shell}$ cycles that can be used to validate annual growth makers; in contrast, $\delta^{18}O_{shell}$ may be an unreliable method to understand annual growth in bivalves that live in narrow temperature ranges. $\delta^{18}O_{shell}$ may instead be used to understand hyperlocal and high temporal variations in $\delta^{18}O_{water}$, an under studied complication in bivalve sclerochronology. Additionally, other annually cycling chemical proxies should be explored to validate annual growth markers in the absence of reliable $\delta^{18}O$ cycles. Sites like BOS and EC have annual input of glacial meltwater and, in the case of BOS, sea ice breakout that could be employed to validate annuli. Other areas, like the deep sea, have even narrower temperature ranges and fewer truly annual fluctuations. How can we better understand growth in these organisms?

The Future of Adamussium

Adamussium colbecki is an ecosystem engineer, and a promising paleoenvironmental proxy for sea-ice persistence, yet its future in Antarctica is uncertain. Seawater temperatures are rising, especially on the Antarctic peninsula, and the highly stenothermal members of the Antarctic benthos are unlikely to adapt. The Antarctic scallop has an upper seawater temperature tolerance of ~4 °C (Bailey et al., 2005) and may become extinct like its predecessors in the Antarctic Pliocene *Chlamys* fauna (Berkman and Prentice 1996) in the changing climate.

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APPENDIX A

DATA AND R CODE FOR CHAPTER 2

Part 1: Valve age (yrs), total height (mm), and height at age (mm) for Explorers Cove and Bay of Sails valves

Site	Age	Total Valve Height	Height at Year 1	Height at Year 2	Height at Year 3	Height at Year 4	Height at Year 5	Height at Year 6	Height at Year 7
EC	11	72.62	11.13	17.9	26	40.4	47.38	54.53	61.46
EC	9	63.72	7.33	14.09	22.68	29.67	41.16	50.69	56.26
EC			10.41	21.15	26.53	32.03	39.94	48.87	57.3
EC			9.72	13.01	20.58	29.92	37.11	45.45	53.62
EC	16	78.93	10.57	17.19	24.4	31.93	40.39	47.03	53.62
EC	10	71.97	12.71	19.87	31.68	43.67	53.71	59.28	65.68
EC	14	79.09	8.9	13.49	18.98	27.06	34.88	41.49	49.51
EC	13	78.74	10.94	18.6	26.18	33.3	43.94	51.57	58.91
EC			6.86	15.17	19.49	27.55	32.36	39.01	44.61
EC	14	85.73	10.75	17.67	26.39	32.77	39.23	49.2	62.01
EC	8	63.37	10.33	16.76	25.42	37.78	44.46	53	56.86
EC	14	76.08	7.52	11.61	18.88	29.78	35.79	45.1	55.64
EC			8.22	12.82	19.31	26.78	33.34	40.96	50.78
EC	7	77.41	13.67	21.8	34.48	51.29	60.48	66.33	72.17
EC	13	78.29	9.2	15.55	26.17	42.05	49.74	57.59	63.88
EC	7	61.08	8.48	15.12	23.85	38.59	49.17	55.92	58.76
EC	14	78.08	5.44	12.53	19.59	24.94	32.18	40.9	51.77
EC	12	75.77	7.25	13.34	23.09	33.97	44.97	53.77	62.38
EC	10	75.09	7.98	13.22	23.9	34.09	50.18	58.38	65.91
EC	17	76.62	8.32	17.01	21.6	27.74	34.73	38.23	43.39
EC	18	81.11	8.87	12.11	19.7	31.46	40	47.32	55.83
EC			11.7	29.61	36.64	58.25	71.88	75.45	78.39
EC	16	85.46	9.65	15.54	21.69	32.79	44.29	56.68	65.92
EC	15	80.07	9.46	18.22	25.18	31.14	39.03	43.95	50.34
EC	10	82.21	7.68	14.92	23.76	30.71	38.09	48.53	50.69
EC	16	83.52	9.84	15.18	22.66	28.37	37.2	46.52	53.35
EC	16	84.41	8.2	13.3	21.9	29	39.83	46.74	54.18
EC	11	73.5	10.92	17.71	25.84	38.36	49.97	60.33	64.85
EC			7.37	16.8	25.5	31.75	39.25	46.36	51.2
EC	12	83.54		17.05	24.99	35.08	48.75	60.14	65.52
EC	17	80.38	7.45	16.01	27.62	38.59	46.47	54.04	61.84
EC	15	90.84	8.87	20.42	33.79	43.67	51.58	61.18	67.23
EC	12	84.02	10.55	16.36	33.84	47.77	54.19	59.81	64.68
EC	14	79.15	8.05	16.21	25.28	35.98	41.17	47.77	52.04
EC	14	80.57	8.09	21.34	29.36	39.14	45.38	51.96	58.32

Site	Age	Total Valve Height	Height at Year 1	Height at Year 2	Height at Year 3	Height at Year 4	Height at Year 5	Height at Year 6	Height at Year 7
EC	16	83.74	8.56	12.67	19.19	27.82	40.99	58.51	63.96
EC	16	83.08	8.35	21.63	37.65	48.51	56.41	63.13	67.66
EC	17	90.62	9.84	17.61	24.9	36.39	43.68	49.76	58.22
BOS	14	86.02							
BOS	15	86.15	10	17.92	24.4	37.25	50.52	61.52	67.4
BOS	9	76.52	12.86	21.83	40.52	51.93	57.33	65.59	69.41
BOS	14	95.93	10.44	19.16	31.69	51.08	69.62	74.96	79.66
BOS			7.23	14.93	23.73	30.63	37.38	44.44	50.99
BOS	7	65.1	9.08	14.16	25.25	37.33	44.24	53.63	58.94
BOS	6	64.82	10.84	20.2	30.29	39.12	56.71	61.35	
BOS	6	70.92	13.25	25.36	36.71	48.29	65.1	68.78	
BOS			10.01	19.33	42.76	49.55	58.1	64.58	70.5
BOS	10	81.8	8.83	12.75	24.02	33.36	44.05	56.94	67.73
BOS	13	78.66	10.24	18.53	31.87	48.55	56.01	62.05	66.66
BOS	13	80.23	9.06	18.57	34.61	49.05	53.97	59.4	64.57
BOS	15	83.46	7.41	15.81	30.82	43.32	52.79	60.4	65.91
BOS	15	83.09	7.77	17.88	34.72	40.43	48.58	57.39	67.21
BOS	19	80.01	6.52	12.94	23.58	37.25	43.26	48.6	53.49
BOS	16	82.09	8.14	16.41	23.39	39.26	53.03	65.56	70.02
BOS	14	89.21	7.69	14.22	30.9	48.54	62.87	69.33	77.9
BOS	15	86.57	7.46	16.28	26.7	45.77	59.59	71.28	75.12
BOS	12	80.01	8.63	14.91	27.65	45.62	58.22	64.26	67.91

Site	Age	Height at Year 8	Height at Year 9	Height at Year 10	Height at Year 11	Height at Year 12	Height at Year 13	Height at Year 14	Height at Year 15
EC	11	66.99	70.14	71.29	71.96				
EC	9	60.84	63.05						
EC		62.81	68.33	72.37	77.09	79.93	81.93		
EC		61.64	68.36						
EC	16	58.88	62	66.01	68.75	71.58	74.59	76.13	77.6
EC	10	67.85	70.04	71.48					
EC	14	60.52	64.84	68.87	71.55	73.43	75.4	77.9	
EC	13	62.68	66.98	69.67	72.27	74.98	78.08		
EC		49.69	58.78	64.67					
EC	14	66.53	70.8	73.43	79.45	82.02	84.35	85.33	
EC	8	61.89							
EC	14	61.64	71.32	72.37	73.46	74.36	75.25	75.46	
EC		59.14	68.28	72.68	74.97	76.25	77.34	77.97	78.47
EC	7								
EC	13	69.27	72.07	73.68	75.66	76.77	77.82		
EC	7								
EC	14	60.61	66.65	72.72	75.58	76.23	77.36	77.82	
EC	12	67.37	69.67	71.56	73.4	74.91			
EC	10	69.23	72.09	74.24					
EC	17	48.35	53.43	57.43	62.44	68.14	70.95	72.9	74.39
EC	18	62.22	66.39	66.88	71.15	72.54	73.39	75.56	77
EC									
EC	16	71.45	74.88	76.76	77.98	79.73	80.96	82.19	83.59
EC	15	60.52	65.27	69.26	73.04	75.63	78.26	79.26	79.99
EC	10	76.79	79.67	81.53					
EC	16	60.3	64.73	69.03	72.48	75.57	77.59	79.61	80.81
EC	16	60.02	64.45	69.51	73.53	77.57	80.13	81.6	82.57
EC	11	68.77	70.75	72.15	73.15				
EC		58.43	64.45						
EC	12	72.08	77.24	80.16	81.86	82.8			
EC	17	64.87	69.8	73.02	75.51	76.52	77.45	78.31	79.01
EC	15	76.14	79.19	81.88	85.21	87.12	88.93	90.26	90.84
EC	12	69.92	77.29	80.77	82.7	84.02			
EC	14	58.02	64.69	68.61	72.49	77.28	77.95	79.15	
EC	14	64.27	69.15	71.62	73.67	75.98	78.48	80.57	

Site	Age	Height at Year 8	Height at Year 9	Height at Year 10	Height at Year 11	Height at Year 12	Height at Year 13	Height at Year 14	Height at Year 15
EC	16	65.89	70.86	73.33	75.65	77.19	80	81.63	82.75
EC	16	71	73.91	76.79	78.12	79.17	80.25	81.59	82.34
EC	17	66.73	72.56	75.73	78.54	83.12	87.27	87.99	88.9
BOS	14								
BOS	15	70.43	72.9	75.85	78.07	80.85	83.68	84.97	85.88
BOS	9	73.31	75.67						
BOS	14	83.04	87	89.31	90.7	92.22	94.07	95.39	
BOS		61.51	66.24	70.25					
BOS	7								
BOS	6								
BOS	6								
BOS									
BOS	10	75.73	78.7	81.54					
BOS	13	70.87	73.14	74.46	75.97	76.96	78.66		
BOS	13	67.8	70.66	74.4	77.58	79.43	80.23		
BOS	15	70.71	74.2	76.96	79.71	80.9	82.12	83.12	83.46
BOS	15	72.32	74.19	76.31	77.91	79.71	81.03	82.01	83.09
BOS	19	57.46	61.49	64.01	66.89	68.79	71.28	72.95	73.2
BOS	16	72.62	74.14	76.03	78.12	79.7	80.6	81.27	81.59
BOS	14	83.41	86.15	87.15	88.32	88.87	89.14	89.21	
BOS	15	77.64	79.68	81.47	82.87	84.12	84.99	86.4	86.57
BOS	12	70.34	73.26	76.29	78.18	80.01			

Site	Age	Height at Year 16	Height at Year 17	Height at Year 18	Height at Year 19
EC	11				
EC	9				
EC					
EC					
EC	16	78.39			
EC	10				
EC	14				
EC	13				
EC					
EC	14				
EC	8				
EC	14				
EC		79.21			
EC	7				
EC	13				
EC	7				
EC	14				
EC	12				
EC	10				
EC	17	75.11	75.7		
EC	18	78.68	79.53	80.55	
EC					
EC	16	84.83			
EC	15				
EC	10				
EC	16	81.88			
EC	16	83.63			
EC	11				
EC	12				
EC	17	79.44	80.38		
EC	15				
EC	12				
EC	14				
EC	14				
EC	16	83.74			

Site	Age	Height at Year 16	Height at Year 17	Height at Year 18	Height at Year 19
EC	16	83.08			
EC	17	89.66	90.62		
BOS	14				
BOS	15				
BOS	9				
BOS	14				
BOS					
BOS	7				
BOS	6				
BOS	6				
BOS					
BOS	10				
BOS	13				
BOS	13				
BOS	15				
BOS	15				
BOS	19	76.31	78.28	79.77	80.01
BOS	16	82.09			
BOS	14				
BOS	15				
BOS	12				

Part 2: R Code to analyze data and produce figures

```
# Load required packages and scripts (bootstrap functionsxx modified
from http://strata.uga.edu/8370/lecturenotes/resampling.html)

library(ggplot2)
library(scales)
library(fishmethods)
library(FSA)
library(nlstools)

meanOfOneBootstrap <- function(x) {
                              bootstrappedSample <- sample(x,
size=length(x), replace=TRUE)
                              theMean <- mean(bootstrappedSample, na.rm
= TRUE)
                              theMean
                              }

medianOfOneBootstrap <- function(x) {
                              bootstrappedSample <- sample(x,
size=length(x), replace=TRUE)
                              theMedian <- median(bootstrappedSample,
na.rm = TRUE)
                              theMedian
                              }

k_FW <- function(slope) {
      k <- -log(slope)
      return(k)
      }

linf_FW <- function(slope, intercept) {
      linf <- intercept/(1-slope)
      return(linf)
      }

alpha = 0.05

CV <- function(x) {sd(x) / mean(x)}

# Read in data
## Age and growth data
valveSummary <- read.csv("valveSummary.csv", header = TRUE, sep = ",")
growthRateEC <- read.table("growthRatesEC.csv", header = TRUE, sep =
",")
growthRateBOS <- read.csv("growthRatesBOS.csv", header = TRUE, sep =
",")
jAGrowth <- read.table("juvenileAdultGrowthRates.csv", header = TRUE,
sep = ",")

### Von B data
allEC <- read.table("allECLengthAtAge.csv", sep = ",", header =TRUE)
allBOS <- read.table("allBOSLengthAtAge.csv", sep = ",", header =TRUE)
```

```
allValvesLengthAtAge <- read.table("allValvesLengthAtAge.csv", header =
TRUE, sep = ",")
# Note: fwSummary includes only valves where shell height is greater
than 70 mm
fwSummary <- read.csv("fordWalfordResults.csv", header = TRUE, sep =
",")
fw <- read.csv("individualFordWalfordPlots.csv", header = TRUE, sep =
",")

# Age and growth rate analysis
## Compare median valve ages
ageEC <- replicate(10000,
medianOfOneBootstrap(valveSummary$Age[valveSummary$Site == "aEC" &
valveSummary$valveType == "Bottom"]))
ageEstimateEC <- median(ageEC)
lowerAgeEC <- quantile(ageEC, alpha/2)
upperAgeEC <- quantile(ageEC, 1-alpha/2)

ageBOS <- replicate(10000,
medianOfOneBootstrap(valveSummary$Age[valveSummary$Site == "BOS" &
valveSummary$valveType == "Bottom"]))
ageEstimateBOS <- median(ageBOS)
lowerAgeBOS <- quantile(ageBOS, alpha/2)
upperAgeBOS <- quantile(ageBOS, 1-alpha/2)
ageEstimateBOS
lowerAgeBOS
upperAgeBOS

## Compare maximum valve ages
maxAgeEC <- max(valveSummary$Age[valveSummary$Site == "aEC" &
valveSummary$valveType == "Bottom"], na.rm = TRUE)
maxAgeBOS <- max(valveSummary$Age[valveSummary$Site == "BOS" &
valveSummary$valveType == "Bottom"], na.rm = TRUE)

## Plot median ages with 95% CIs (Cronin et al Fig. 5)
### Write results to table
dfAge <- list(site = c(aEC, BOS), ageEstimate = c(ageEstimateEC,
ageEstimateBOS), upperAge = c(upperAgeEC, upperAgeBOS), lowerAge =
c(lowerAgeEC, lowerAgeBOS), dummyRange = c(10, 15))
write.csv(x = as.data.frame(dfAge), file =
"bootstrapAgeEstimatesForFigure.csv")

### read table in for plot
ageSiteComparison <- read.table("bootstrapAgeEstimatesForFigure.csv",
sep = ",", header = TRUE)

### Make and save plot
ageCompPlot <- ggplot(data = ageSiteComparison, aes(x = site, y =
ageEstimate, ymin = lowerAge, ymax = upperAge))
ageCompPlot + geom_pointrange(aes(x = ageSiteComparison$site, y =
ageSiteComparison$ageEstimate, ymin = ageSiteComparison$lowerAge, ymax
= ageSiteComparison$upperAge), size = 1.15, color = c("#0072B2",
"#009E73")) + geom_point(size = 1.75, color = c("#0072B2", "#009E73"))
+ scale_x_discrete(name = NULL, labels = c("Explorers Cove", "Bay of
Sails"))+ scale_y_continuous(name = "Median Age") +
theme_classic(base_size = 16)
ggsave("ageCompPlot.pdf", width = 6, height = 6)
```

```
### Plot growth rate by year over ontogeny (Cronin et al Fig. 6A-B)
ggplot(growthRateBOS, aes(x=growthYear, y = v1)) + geom_point(shape =
1, color = "#009E73") + geom_point(aes(y=v2), shape = 1, color =
"#009E73") + geom_point(aes(y=v3), shape = 1, color = "#009E73") +
geom_point(aes(y=v4), shape = 1, color = "#009E73") +
geom_point(aes(y=v5), shape = 1, color = "#009E73") +
geom_point(aes(y=v6), shape = 1, color = "#009E73") +
geom_point(aes(y=v7), shape = 1, color = "#009E73") +
geom_point(aes(y=v8), shape = 1, color = "#009E73") +
geom_point(aes(y=v9), shape = 1, color = "#009E73") +
geom_point(aes(y=v10), shape = 1, color = "#009E73") +
geom_point(aes(y=v11), shape = 1, color = "#009E73") +
geom_point(aes(y=v12), shape = 1, color = "#009E73") +
geom_point(aes(y=v13), shape = 1, color = "#009E73") +
geom_point(aes(y=v14), shape = 1, color = "#009E73") +
scale_y_continuous(name = "Yearly Growth Rate (mm/yr)", limits = c(0,
20)) + scale_x_continuous(name = "Age (years)", limits = c(0, 20)) +
geom_line(aes(y=mean), color = "#009E73", size = 1.5) +
theme_classic(base_size = 16)
ggsave("BOS Yearly Growth Rate.pdf", width = 6, height = 6)
ggplot(growthRateEC, aes(x=growthYear, y = v1)) + geom_point(shape = 1,
color = "#0072B2") + geom_point(aes(y=v2), shape = 1, color =
"#0072B2") + geom_point(aes(y=v3), shape = 1, color = "#0072B2") +
geom_point(aes(y=v4), shape = 1, color = "#0072B2") +
geom_point(aes(y=v5), shape = 1, color = "#0072B2") +
geom_point(aes(y=v6), shape = 1, color = "#0072B2") +
geom_point(aes(y=v7), shape = 1, color = "#0072B2") +
geom_point(aes(y=v8), shape = 1, color = "#0072B2") +
geom_point(aes(y=v9), shape = 1, color = "#0072B2") +
geom_point(aes(y=v10), shape = 1, color = "#0072B2") +
geom_point(aes(y=v11), shape = 1, color = "#0072B2") +
geom_point(aes(y=v12), shape = 1, color = "#0072B2") +
geom_point(aes(y=v13), shape = 1, color = "#0072B2") +
geom_point(aes(y=v14), shape = 1, color = "#0072B2") +
scale_y_continuous(name = "Yearly Growth Rate (mm/yr)", limits = c(0,
20)) + scale_x_continuous(name = "Age (years)", limits = c(0, 20)) +
geom_line(aes(y=mean), color = "#0072B2", size = 1.5) +
theme_classic(base_size = 16)
ggsave("EC Yearly Growth Rate.pdf", width = 6, height = 6)

## Plot juvenile and adult growth rates with 95% CIs (Cronin et al Fig.
6C)
### Estimate means and confidence intervals of adult and juvenile
growth rates
juvenileGrowthRateEC <- replicate(10000,
meanOfOneBootstrap(jAGrowth$growthRate[jAGrowth$group ==
"aecjuvenile"]))
mean(juvenileGrowthRateEC)
juvenileGrowthRateEstimateEC <- mean(juvenileGrowthRateEC)
lowerJuvenileGrowthRateEC <- quantile(juvenileGrowthRateEC, alpha/2)
upperJuvenileGrowthRateEC <- quantile(juvenileGrowthRateEC, 1-alpha/2)

juvenileGrowthRateBOS <- replicate(10000,
meanOfOneBootstrap(jAGrowth$growthRate[jAGrowth$group ==
"cbosjuvenile"]))
juvenileGrowthRateEstimateBOS <- mean(juvenileGrowthRateBOS)
```

```
lowerJuvenileGrowthRateBOS <- quantile(juvenileGrowthRateBOS, alpha/2)
upperJuvenileGrowthRateBOS <- quantile(juvenileGrowthRateBOS, 1-
alpha/2)

adultGrowthRateEC <- replicate(10000,
meanOfOneBootstrap(jAGrowth$growthRate[jAGrowth$group == "becadult"]))
adultGrowthRateEstimateEC <- mean(adultGrowthRateEC)
lowerAdultGrowthRateEC <- quantile(adultGrowthRateEC, alpha/2)
upperAdultGrowthRateEC <- quantile(adultGrowthRateEC, 1-alpha/2)

adultGrowthRateBOS <- replicate(10000,
meanOfOneBootstrap(jAGrowth$growthRate[jAGrowth$group == "dbosadult"]))
adultGrowthRateEstimateBOS <- mean(adultGrowthRateBOS)
lowerAdultGrowthRateBOS <- quantile(adultGrowthRateBOS, alpha/2)
upperAdultGrowthRateBOS <- quantile(adultGrowthRateBOS, 1-alpha/2)

### Write results to table
aaJuvenile <- "aaJuvenile"
adult <- "adult"
dfGrowthRates <- list(site = c(aEC, aEC, BOS, BOS), age = c(aaJuvenile,
adult, aaJuvenile, adult), growthRateEstimate =
c(juvenileGrowthRateEstimateEC, adultGrowthRateEstimateEC,
juvenileGrowthRateEstimateBOS, adultGrowthRateEstimateBOS),
upperGrowthRate = c(upperJuvenileGrowthRateEC, upperAdultGrowthRateEC,
upperJuvenileGrowthRateBOS, upperAdultGrowthRateBOS), lowerGrowthRate =
c(lowerJuvenileGrowthRateEC, lowerAdultGrowthRateEC,
lowerJuvenileGrowthRateBOS, lowerAdultGrowthRateBOS))
write.csv(x = as.data.frame(dfGrowthRates), file =
"bootstrapGrowthRateEstimatesForFigure.csv")

### read table in for plot
growthRateSiteComparison <-
read.table("bootstrapGrowthRateEstimatesForFigure.csv", sep = ",",
header = TRUE)

### Make and save plot
growthRateCompPlot <- ggplot(data = growthRateSiteComparison, aes(x =
site, y = growthRateEstimate, ymin = lowerGrowthRate, ymax =
upperGrowthRate)) + geom_pointrange(size = 1.15, color = c("#0072B2",
"#0072B2", "#009E73", "#009E73"))
growthRateCompPlot + facet_grid(.~ growthRateSiteComparison$age) +
geom_point(size = 1.75, color = c("#0072B2", "#0072B2", "#009E73",
"#009E73")) + scale_x_discrete(name = NULL, labels = c("Explorers
Cove", "Bay of Sails", "Explorers Cove", "Bay of Sails")) +
scale_y_continuous(name = "Growth Rate (mm/yr)") +
theme_classic(base_size = 16)
ggsave("growthRateCompPlot.pdf", width = 6, height = 6)

# Von Bertalannffy analyses
## Create and plot Von B Curves
### Get starting parameters for Linf, K, t0 for all groups
allECStarts <- vbStarts(tl~age, data = allEC)
allBOSStarts <- vbStarts(tl~age, data = allBOS)

### Write in the equation (here, its important that your data is set up
correctly in the .csvs)
vbEq <- tl~Linf*(1-exp(-K*(age-t0)))
```

```
### Create the fitted equation
fitAllEC <- nls(vbEq, data = allEC, start = allECStarts)
fitAllBOS <- nls(vbEq, data = allBOS, start = allBOSStarts)

### Make the plots (Cronin et al Fig. 7)
pdf("allECVonB.pdf", height = 6, width = 6)
par(mgp = c(2, 0.4, 0))
fitPlot(fitAllEC, xlab = "Age (years)", ylab = "Total Length (mm)",
main = "All Explorers Cove", pch = 1, col.pt = "#0072B2", col.mdl =
"#0072B2", lwd = 2, xlim = c(0, 20), ylim = c(0, 100), las = 1,
cex.axis = 0.75, tck = -0.02)
text( x = 12, y = 20, labels = expression(L[t] == 94.5*(1-italic(e)^(-
0.15*(italic(t)-0.57)))), cex = 1.25)
dev.off()

pdf("allBOSVonB.pdf", height = 6, width = 6)
par(mgp = c(2, 0.4, 0))
fitPlot(fitAllBOS, xlab = "Age (years)", ylab = "Total Length (mm)",
main = "All Bay of Sails", pch = 1, col.pt = "#009E73", col.mdl =
"#009E73", lwd = 2, xlim = c(0, 20), ylim = c(0, 100), las = 1,
cex.axis = 0.75, , tck = -0.02)
text( x = 12, y = 20, labels = expression(L[t] == 89.7*(1-italic(e)^(-
0.21*(italic(t)-0.73)))), cex = 1.25)
dev.off()

# Liklihood test of Von B parameter similarities (Cronin et al Table 1)
growthlrt(len = allValvesLengthAtAge$tl, age =
allValvesLengthAtAge$age, group = allValvesLengthAtAge$site, error = 2,
select = 1, plottype = 1)

# Comparison of variation in K and Linf of individual valves (Cronin et
al Fig. 8)
# Note: calculation of individual values below, values are read in from
fwSummary for brevity
kEC <- replicate(10000, meanOfOneBootstrap(fwSummary$k[fwSummary$site
== "ec"]))
kECEstimate <- mean(kEC)
lowerKEC <- quantile(kEC, alpha/2)
upperKEC <- quantile(kEC, 1-alpha/2)

kBOS <- replicate(10000, meanOfOneBootstrap(fwSummary$k[fwSummary$site
== "bos"]))
kBOSEstimate <- mean(kBOS)
lowerKBOS <- quantile(kBOS, alpha/2)
upperKBOS <- quantile(kBOS, 1-alpha/2)

linfEC <- replicate(10000,
meanOfOneBootstrap(fwSummary$linf[fwSummary$site == "ec"]))
linfECEstimate <- mean(linfEC)
lowerLinfEC <- quantile(linfEC, alpha/2)
upperLinfEC <- quantile(linfEC, 1-alpha/2)

linfBOS <- replicate(10000,
meanOfOneBootstrap(fwSummary$linf[fwSummary$site == "bos"]))
linfBOSEstimate <- mean(linfBOS)
lowerLinfBOS <- quantile(linfBOS, alpha/2)
```

```
upperLinfBOS <- quantile(linfBOS, 1-alpha/2)

aEC <- "aEC"
BOS <- "BOS"

## Write results to table
dfFordWalford <- list(site = c(aEC, BOS), kEstimate = c(kECEstimate,
kBOSEstimate), upperK = c(upperKEC, upperKBOS), lowerK = c(lowerKEC,
lowerKBOS), linfEstimate = c(linfECEstimate, linfBOSEstimate),
upperLinf = c(upperLinfEC, upperLinfBOS), lowerLinf = c(lowerLinfEC,
lowerLinfBOS))
write.csv(x = as.data.frame(dfFordWalford), file =
"bootstrapFordWalfordEstimatesForFigure.csv")

## Read table in for plot
fordWalfordSiteComparison <-
read.table("bootstrapFordWalfordEstimatesForFigure.csv", sep = ",",
header = TRUE)

## Make and save plots
fordWalfordKCompPlot <- ggplot(data = fordWalfordSiteComparison, aes(x
= site, y = kEstimate, ymin = lowerK, ymax = upperK)) +
geom_pointrange(size = 1.15, color = c("#0072B2", "#009E73"))
fordWalfordKCompPlot + geom_point(size = 1.75, color = c("#0072B2",
"#009E73")) + scale_x_discrete(name = NULL, labels = c("Explorers
Cove", "Bay of Sails")) + scale_y_continuous(name = bquote("K ("*yr^-
1*")"), labels = scales::number_format(accuracy = 0.01)) +
theme_classic(base_size = 16)
ggsave("fordWalfordKCompPlot.pdf", width = 6, height = 6)

fordWalfordLinfCompPlot <- ggplot(data = fordWalfordSiteComparison,
aes(x = site, y = linfEstimate, ymin = lowerLinf, ymax = upperLinf)) +
geom_pointrange(size = 1.15, color = c("#0072B2", "#009E73"))
fordWalfordLinfCompPlot + geom_point(size = 1.75, color = c("#0072B2",
"#009E73")) + scale_x_discrete(name = NULL, labels = c("Explorers
Cove", "Bay of Sails")) + scale_y_continuous(name =
bquote("L"*infinity*" (mm)")) + theme_classic(base_size = 16)
ggsave("fordWalfordLinfCompPlot.pdf", width = 6, height = 6)

## Calcaulate coefficents of variation for Ks and Linfs
CV <- function(x) {sd(x) / mean(x)}
CV(fwSummary$k[fwSummary$site == "ec"])
CV(fwSummary$k[fwSummary$site == "bos"])
CV(fwSummary$linf[fwSummary$site == "ec"])
CV(fwSummary$linf[fwSummary$site == "bos"])

## Calculate K and Linf for individual valves
ec1 <- summary(lm(fw$ec1y ~ fw$ec1))
ec2 <- summary(lm(fw$ec2y ~ fw$ec2))
ec3 <- summary(lm(fw$ec3y ~ fw$ec3))
ec4 <- summary(lm(fw$ec4y ~ fw$ec4))
ec5 <- summary(lm(fw$ec5y ~ fw$ec5))
ec6 <- summary(lm(fw$ec6y ~ fw$ec6))
ec7 <- summary(lm(fw$ec7y ~ fw$ec7))
ec8 <- summary(lm(fw$ec8y ~ fw$ec8))
ec9 <- summary(lm(fw$ec9y ~ fw$ec9))
ec10 <- summary(lm(fw$ec10y ~ fw$ec10))
```

```
ec11 <- summary(lm(fw$ec11y ~ fw$ec11))
ec12 <- summary(lm(fw$ec12y ~ fw$ec12))
ec13 <- summary(lm(fw$ec13y ~ fw$ec13))
ec14 <- summary(lm(fw$ec14y ~ fw$ec14))
ec15 <- summary(lm(fw$ec15y ~ fw$ec15))
ec16 <- summary(lm(fw$ec16y ~ fw$ec16))
ec17 <- summary(lm(fw$ec17y ~ fw$ec17))
ec18 <- summary(lm(fw$ec18y ~ fw$ec18))
ec19 <- summary(lm(fw$ec19y ~ fw$ec19))
ec20 <- summary(lm(fw$ec20y ~ fw$ec20))
ec21 <- summary(lm(fw$ec21y ~ fw$ec21))
ec22 <- summary(lm(fw$ec22y ~ fw$ec22))
ec23 <- summary(lm(fw$ec23y ~ fw$ec23))
ec24 <- summary(lm(fw$ec24y ~ fw$ec24))
ec25 <- summary(lm(fw$ec25y ~ fw$ec25))
ec26 <- summary(lm(fw$ec26y ~ fw$ec26))
ec27 <- summary(lm(fw$ec27y ~ fw$ec27))
ec28 <- summary(lm(fw$ec28y ~ fw$ec28))
ec29 <- summary(lm(fw$ec29y ~ fw$ec29))
ec30 <- summary(lm(fw$ec30y ~ fw$ec30))
ec31 <- summary(lm(fw$ec31y ~ fw$ec31))
ec32 <- summary(lm(fw$ec32y ~ fw$ec32))
ec33 <- summary(lm(fw$ec33y ~ fw$ec33))
ec34 <- summary(lm(fw$ec34y ~ fw$ec34))
ec35 <- summary(lm(fw$ec35y ~ fw$ec35))
ec36 <- summary(lm(fw$ec36y ~ fw$ec36))
ec37 <- summary(lm(fw$ec37y ~ fw$ec37))
ec38 <- summary(lm(fw$ec38y ~ fw$ec38))

bos1 <- summary(lm(fw$bos1y ~ fw$bos1))
bos2 <- summary(lm(fw$bos2y ~ fw$bos2))
bos3 <- summary(lm(fw$bos3y ~ fw$bos3))
bos4 <- summary(lm(fw$bos4y ~ fw$bos4))
bos5 <- summary(lm(fw$bos5y ~ fw$bos5))
bos6 <- summary(lm(fw$bos6y ~ fw$bos6))
bos7 <- summary(lm(fw$bos7y ~ fw$bos7))
bos8 <- summary(lm(fw$bos8y ~ fw$bos8))
bos9 <- summary(lm(fw$bos9y ~ fw$bos9))
bos10 <- summary(lm(fw$bos10y ~ fw$bos10))
bos11 <- summary(lm(fw$bos11y ~ fw$bos11))
bos12 <- summary(lm(fw$bos12y ~ fw$bos12))
bos13 <- summary(lm(fw$bos13y ~ fw$bos13))
bos14 <- summary(lm(fw$bos14y ~ fw$bos14))
bos15 <- summary(lm(fw$bos15y ~ fw$bos15))
bos16 <- summary(lm(fw$bos16y ~ fw$bos16))
bos17 <- summary(lm(fw$bos17y ~ fw$bos17))
bos18 <- summary(lm(fw$bos18y ~ fw$bos18))
bos19 <- summary(lm(fw$bos19y ~ fw$bos19))

ec1K <- k_FW(coef(ec1)["fw$ec1", "Estimate"])
ec1Linf <- linf_FW(slope =  coef(ec1)["fw$ec1", "Estimate"], intercept
= coef(ec1)["(Intercept)", "Estimate"])

ec2K <- k_FW(coef(ec2)["fw$ec2", "Estimate"])
ec2Linf <- linf_FW(slope =  coef(ec2)["fw$ec2", "Estimate"], intercept
= coef(ec2)["(Intercept)", "Estimate"])
```

```
ec3K <- k_FW(coef(ec3)["fw$ec3", "Estimate"])
ec3Linf <- linf_FW(slope =  coef(ec3)["fw$ec3", "Estimate"], intercept
= coef(ec3)["(Intercept)", "Estimate"])

ec4K <- k_FW(coef(ec4)["fw$ec4", "Estimate"])
ec4Linf <- linf_FW(slope =  coef(ec4)["fw$ec4", "Estimate"], intercept
= coef(ec4)["(Intercept)", "Estimate"])

ec5K <- k_FW(coef(ec5)["fw$ec5", "Estimate"])
ec5Linf <- linf_FW(slope =  coef(ec5)["fw$ec5", "Estimate"], intercept
= coef(ec5)["(Intercept)", "Estimate"])

ec6K <- k_FW(coef(ec6)["fw$ec6", "Estimate"])
ec6Linf <- linf_FW(slope =  coef(ec6)["fw$ec6", "Estimate"], intercept
= coef(ec6)["(Intercept)", "Estimate"])

ec7K <- k_FW(coef(ec7)["fw$ec7", "Estimate"])
ec7Linf <- linf_FW(slope =  coef(ec7)["fw$ec7", "Estimate"], intercept
= coef(ec7)["(Intercept)", "Estimate"])

ec8K <- k_FW(coef(ec8)["fw$ec8", "Estimate"])
ec8Linf <- linf_FW(slope =  coef(ec8)["fw$ec8", "Estimate"], intercept
= coef(ec8)["(Intercept)", "Estimate"])

ec9K <- k_FW(coef(ec9)["fw$ec9", "Estimate"])
ec9Linf <- linf_FW(slope =  coef(ec9)["fw$ec9", "Estimate"], intercept
= coef(ec9)["(Intercept)", "Estimate"])

ec10K <- k_FW(coef(ec10)["fw$ec10", "Estimate"])
ec10Linf <- linf_FW(slope =  coef(ec10)["fw$ec10", "Estimate"],
intercept = coef(ec10)["(Intercept)", "Estimate"])

ec11K <- k_FW(coef(ec11)["fw$ec11", "Estimate"])
ec11Linf <- linf_FW(slope =  coef(ec11)["fw$ec11", "Estimate"],
intercept = coef(ec11)["(Intercept)", "Estimate"])

ec12K <- k_FW(coef(ec12)["fw$ec12", "Estimate"])
ec12Linf <- linf_FW(slope =  coef(ec12)["fw$ec12", "Estimate"],
intercept = coef(ec12)["(Intercept)", "Estimate"])

ec13K <- k_FW(coef(ec13)["fw$ec13", "Estimate"])
ec13Linf <- linf_FW(slope =  coef(ec13)["fw$ec13", "Estimate"],
intercept = coef(ec13)["(Intercept)", "Estimate"])

ec14K <- k_FW(coef(ec14)["fw$ec14", "Estimate"])
ec14Linf <- linf_FW(slope =  coef(ec14)["fw$ec14", "Estimate"],
intercept = coef(ec14)["(Intercept)", "Estimate"])

ec15K <- k_FW(coef(ec15)["fw$ec15", "Estimate"])
ec15Linf <- linf_FW(slope =  coef(ec15)["fw$ec15", "Estimate"],
intercept = coef(ec15)["(Intercept)", "Estimate"])

ec16K <- k_FW(coef(ec16)["fw$ec16", "Estimate"])
ec16Linf <- linf_FW(slope =  coef(ec16)["fw$ec16", "Estimate"],
intercept = coef(ec16)["(Intercept)", "Estimate"])

ec17K <- k_FW(coef(ec17)["fw$ec17", "Estimate"])
```

```
ec17Linf <- linf_FW(slope =  coef(ec17)["fw$ec17", "Estimate"],
intercept = coef(ec17)["(Intercept)", "Estimate"])

ec18K <- k_FW(coef(ec18)["fw$ec18", "Estimate"])
ec18Linf <- linf_FW(slope =  coef(ec18)["fw$ec18", "Estimate"],
intercept = coef(ec18)["(Intercept)", "Estimate"])

ec19K <- k_FW(coef(ec19)["fw$ec19", "Estimate"])
ec19Linf <- linf_FW(slope =  coef(ec19)["fw$ec19", "Estimate"],
intercept = coef(ec19)["(Intercept)", "Estimate"])

ec20K <- k_FW(coef(ec20)["fw$ec20", "Estimate"])
ec20Linf <- linf_FW(slope =  coef(ec20)["fw$ec20", "Estimate"],
intercept = coef(ec20)["(Intercept)", "Estimate"])

ec21K <- k_FW(coef(ec21)["fw$ec21", "Estimate"])
ec21Linf <- linf_FW(slope =  coef(ec21)["fw$ec21", "Estimate"],
intercept = coef(ec21)["(Intercept)", "Estimate"])

ec22K <- k_FW(coef(ec22)["fw$ec22", "Estimate"])
ec22Linf <- linf_FW(slope =  coef(ec22)["fw$ec22", "Estimate"],
intercept = coef(ec22)["(Intercept)", "Estimate"])

ec23K <- k_FW(coef(ec23)["fw$ec23", "Estimate"])
ec23Linf <- linf_FW(slope =  coef(ec23)["fw$ec23", "Estimate"],
intercept = coef(ec23)["(Intercept)", "Estimate"])

ec24K <- k_FW(coef(ec24)["fw$ec24", "Estimate"])
ec24Linf <- linf_FW(slope =  coef(ec24)["fw$ec24", "Estimate"],
intercept = coef(ec24)["(Intercept)", "Estimate"])

ec25K <- k_FW(coef(ec25)["fw$ec25", "Estimate"])
ec25Linf <- linf_FW(slope =  coef(ec25)["fw$ec25", "Estimate"],
intercept = coef(ec25)["(Intercept)", "Estimate"])

ec26K <- k_FW(coef(ec26)["fw$ec26", "Estimate"])
ec26Linf <- linf_FW(slope =  coef(ec26)["fw$ec26", "Estimate"],
intercept = coef(ec26)["(Intercept)", "Estimate"])

ec27K <- k_FW(coef(ec27)["fw$ec27", "Estimate"])
ec27Linf <- linf_FW(slope =  coef(ec27)["fw$ec27", "Estimate"],
intercept = coef(ec27)["(Intercept)", "Estimate"])

ec28K <- k_FW(coef(ec28)["fw$ec28", "Estimate"])
ec28Linf <- linf_FW(slope =  coef(ec28)["fw$ec28", "Estimate"],
intercept = coef(ec28)["(Intercept)", "Estimate"])

ec29K <- k_FW(coef(ec29)["fw$ec29", "Estimate"])
ec29Linf <- linf_FW(slope =  coef(ec29)["fw$ec29", "Estimate"],
intercept = coef(ec29)["(Intercept)", "Estimate"])

ec30K <- k_FW(coef(ec30)["fw$ec30", "Estimate"])
ec30Linf <- linf_FW(slope =  coef(ec30)["fw$ec30", "Estimate"],
intercept = coef(ec30)["(Intercept)", "Estimate"])

ec31K <- k_FW(coef(ec31)["fw$ec31", "Estimate"])
```

```
ec31Linf <- linf_FW(slope =  coef(ec31)["fw$ec31", "Estimate"],
intercept = coef(ec31)["(Intercept)", "Estimate"])

ec32K <- k_FW(coef(ec32)["fw$ec32", "Estimate"])
ec32Linf <- linf_FW(slope =  coef(ec32)["fw$ec32", "Estimate"],
intercept = coef(ec32)["(Intercept)", "Estimate"])

ec33K <- k_FW(coef(ec33)["fw$ec33", "Estimate"])
ec33Linf <- linf_FW(slope =  coef(ec33)["fw$ec33", "Estimate"],
intercept = coef(ec33)["(Intercept)", "Estimate"])

ec34K <- k_FW(coef(ec34)["fw$ec34", "Estimate"])
ec34Linf <- linf_FW(slope =  coef(ec34)["fw$ec34", "Estimate"],
intercept = coef(ec34)["(Intercept)", "Estimate"])

ec35K <- k_FW(coef(ec35)["fw$ec35", "Estimate"])
ec35Linf <- linf_FW(slope =  coef(ec35)["fw$ec35", "Estimate"],
intercept = coef(ec35)["(Intercept)", "Estimate"])

ec36K <- k_FW(coef(ec36)["fw$ec36", "Estimate"])
ec36Linf <- linf_FW(slope =  coef(ec36)["fw$ec36", "Estimate"],
intercept = coef(ec36)["(Intercept)", "Estimate"])

ec37K <- k_FW(coef(ec37)["fw$ec37", "Estimate"])
ec37Linf <- linf_FW(slope =  coef(ec37)["fw$ec37", "Estimate"],
intercept = coef(ec37)["(Intercept)", "Estimate"])

ec38K <- k_FW(coef(ec38)["fw$ec38", "Estimate"])
ec38Linf <- linf_FW(slope =  coef(ec38)["fw$ec38", "Estimate"],
intercept = coef(ec38)["(Intercept)", "Estimate"])

bos1K <- k_FW(coef(bos1)["fw$bos1", "Estimate"])
bos1Linf <- linf_FW(slope =  coef(bos1)["fw$bos1", "Estimate"],
intercept = coef(bos1)["(Intercept)", "Estimate"])

bos2K <- k_FW(coef(bos2)["fw$bos2", "Estimate"])
bos2Linf <- linf_FW(slope =  coef(bos2)["fw$bos2", "Estimate"],
intercept = coef(bos2)["(Intercept)", "Estimate"])

bos3K <- k_FW(coef(bos3)["fw$bos3", "Estimate"])
bos3Linf <- linf_FW(slope =  coef(bos3)["fw$bos3", "Estimate"],
intercept = coef(bos3)["(Intercept)", "Estimate"])

bos4K <- k_FW(coef(bos4)["fw$bos4", "Estimate"])
bos4Linf <- linf_FW(slope =  coef(bos4)["fw$bos4", "Estimate"],
intercept = coef(bos4)["(Intercept)", "Estimate"])

bos5K <- k_FW(coef(bos5)["fw$bos5", "Estimate"])
bos5Linf <- linf_FW(slope =  coef(bos5)["fw$bos5", "Estimate"],
intercept = coef(bos5)["(Intercept)", "Estimate"])

bos6K <- k_FW(coef(bos6)["fw$bos6", "Estimate"])
bos6Linf <- linf_FW(slope =  coef(bos6)["fw$bos6", "Estimate"],
intercept = coef(bos6)["(Intercept)", "Estimate"])

bos7K <- k_FW(coef(bos7)["fw$bos7", "Estimate"])
```

```
bos7Linf <- linf_FW(slope =  coef(bos7)["fw$bos7", "Estimate"],
intercept = coef(bos7)["(Intercept)", "Estimate"])

bos8K <- k_FW(coef(bos8)["fw$bos8", "Estimate"])
bos8Linf <- linf_FW(slope =  coef(bos8)["fw$bos8", "Estimate"],
intercept = coef(bos8)["(Intercept)", "Estimate"])

bos9K <- k_FW(coef(bos9)["fw$bos9", "Estimate"])
bos9Linf <- linf_FW(slope =  coef(bos9)["fw$bos9", "Estimate"],
intercept = coef(bos9)["(Intercept)", "Estimate"])

bos10K <- k_FW(coef(bos10)["fw$bos10", "Estimate"])
bos10Linf <- linf_FW(slope =  coef(bos10)["fw$bos10", "Estimate"],
intercept = coef(bos10)["(Intercept)", "Estimate"])

bos11K <- k_FW(coef(bos11)["fw$bos11", "Estimate"])
bos11Linf <- linf_FW(slope =  coef(bos11)["fw$bos11", "Estimate"],
intercept = coef(bos11)["(Intercept)", "Estimate"])

bos12K <- k_FW(coef(bos12)["fw$bos12", "Estimate"])
bos12Linf <- linf_FW(slope =  coef(bos12)["fw$bos12", "Estimate"],
intercept = coef(bos12)["(Intercept)", "Estimate"])

bos13K <- k_FW(coef(bos13)["fw$bos13", "Estimate"])
bos13Linf <- linf_FW(slope =  coef(bos13)["fw$bos13", "Estimate"],
intercept = coef(bos13)["(Intercept)", "Estimate"])

bos14K <- k_FW(coef(bos14)["fw$bos14", "Estimate"])
bos14Linf <- linf_FW(slope =  coef(bos14)["fw$bos14", "Estimate"],
intercept = coef(bos14)["(Intercept)", "Estimate"])

bos15K <- k_FW(coef(bos15)["fw$bos15", "Estimate"])
bos15Linf <- linf_FW(slope =  coef(bos15)["fw$bos15", "Estimate"],
intercept = coef(bos15)["(Intercept)", "Estimate"])

bos16K <- k_FW(coef(bos16)["fw$bos16", "Estimate"])
bos16Linf <- linf_FW(slope =  coef(bos16)["fw$bos16", "Estimate"],
intercept = coef(bos16)["(Intercept)", "Estimate"])

bos17K <- k_FW(coef(bos17)["fw$bos17", "Estimate"])
bos17Linf <- linf_FW(slope =  coef(bos17)["fw$bos17", "Estimate"],
intercept = coef(bos17)["(Intercept)", "Estimate"])

bos18K <- k_FW(coef(bos18)["fw$bos18", "Estimate"])
bos18Linf <- linf_FW(slope =  coef(bos18)["fw$bos18", "Estimate"],
intercept = coef(bos18)["(Intercept)", "Estimate"])

bos19K <- k_FW(coef(bos19)["fw$bos19", "Estimate"])
bos19Linf <- linf_FW(slope =  coef(bos19)["fw$bos19", "Estimate"],
intercept = coef(bos19)["(Intercept)", "Estimate"])
```

APPENDIX B

DATA AND R CODE FOR CHAPTER 3

Part 1: Supplementary Data

Interstrial growth increments of all adult valves from the first visible striae to the last discernable striae or 50 mm valve height

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0.12	0.15	0.13	0.36	0.22	0.23	0.35	0.12	0.11	0.10	0.13	0.27	0.13	0.09	0.18	0.31	0.34	0.08
0.16	0.15	0.12	0.27	0.22	0.15	0.21	0.09	0.09	0.10	0.11	0.30	0.08	0.06	0.14	0.32	0.31	0.12
0.15	0.12	0.13	0.36	0.16	0.20	0.13	0.15	0.07	0.16	0.12	0.18	0.14	0.05	0.14	0.36	0.39	0.13
0.12	0.18	0.15	0.31	0.15	0.15	0.21	0.16	0.15	0.16	0.09	0.12	0.14	0.04	0.08	0.35	0.31	0.11
0.06	0.18	0.10	0.40	0.15	0.23	0.23	0.11	0.15	0.30	0.15	0.09	0.16	0.06	0.04	0.28	0.27	0.13
0.09	0.22	0.14	0.19	0.15	0.24	0.28	0.11	0.12	0.12	0.10	0.12	0.13	0.07	0.06	0.26	0.23	0.09
0.13	0.18	0.12	0.22	0.17	0.29	0.19	0.10	0.09	0.07	0.14	0.21	0.22	0.09	0.09	0.28	0.10	0.15
0.13	0.08	0.15	0.17	0.23	0.34	0.19	0.12	0.08	0.15	0.14	0.12	0.33	0.08	0.07	0.20	0.08	0.12
0.05	0.11	0.13	0.18	0.22	0.36	0.25	0.18	0.09	0.13	0.13	0.10	0.33	0.07	0.05	0.15	0.03	0.13
0.08	0.15	0.16	0.17	0.23	0.37	0.14	0.16	0.07	0.12	0.16	0.09	0.31	0.07	0.05	0.13	0.08	0.12
0.08	0.13	0.24	0.13	0.37	0.36	0.17	0.13	0.11	0.09	0.19	0.06	0.29	0.07	0.08	0.06	0.07	0.16
0.12	0.22	0.25	0.12	0.34	0.38	0.26	0.19	0.09	0.09	0.27	0.13	0.26	0.11	0.10	0.08	0.09	0.16
0.13	0.18	0.32	0.12	0.32	0.29	0.30	0.14	0.12	0.08	0.19	0.09	0.22	0.09	0.07	0.10	0.09	0.14
0.13	0.15	0.36	0.06	0.34	0.35	0.28	0.12	0.15	0.12	0.19	0.14	0.09	0.09	0.06	0.13	0.08	0.11
0.12	0.18	0.29	0.15	0.37	0.29	0.26	0.12	0.18	0.09	0.15	0.09	0.08	0.08	0.09	0.14	0.08	0.14
0.11	0.18	0.47	0.14	0.42	0.33	0.33	0.13	0.22	0.12	0.13	0.13	0.08	0.09	0.06	0.10	0.09	0.11
0.13	0.25	0.33	0.11	0.34	0.29	0.33	0.13	0.13	0.08	0.14	0.15	0.08	0.08	0.12	0.09	0.12	0.13
0.18	0.28	0.37	0.05	0.39	0.31	0.42	0.13	0.15	0.09	0.12	0.15	0.06	0.08	0.15	0.13	0.10	0.10
0.25	0.25	0.28	0.07	0.27	0.34	0.42	0.12	0.22	0.10	0.12	0.24	0.11	0.13	0.22	0.12	0.11	0.12
0.20	0.23	0.24	0.07	0.24	0.31	0.44	0.24	0.22	0.14	0.21	0.23	0.07	0.14	0.23	0.11	0.15	0.09
0.18	0.25	0.16	0.08	0.20	0.29	0.33	0.27	0.16	0.20	0.21	0.40	0.09	0.09	0.38	0.13	0.15	0.11
0.15	0.17	0.22	0.07	0.23	0.20	0.39	0.18	0.11	0.21	0.39	0.14	0.13	0.09	0.37	0.15	0.15	0.10
0.16	0.16	0.17	0.14	0.21	0.30	0.52	0.09	0.11	0.27	0.24	0.16	0.18	0.11	0.23	0.10	0.14	0.15
0.18	0.19	0.16	0.06	0.24	0.25	0.28	0.06	0.22	0.13	0.24	0.21	0.10	0.04	0.30	0.12	0.18	0.14
0.15	0.19	0.14	0.07	0.17	0.28	0.25	0.05	0.22	0.12	0.16	0.29	0.16	0.10	0.22	0.17	0.17	0.17
0.18	0.14	0.14	0.13	0.19	0.13	0.28	0.07	0.22	0.24	0.23	0.16	0.16	0.08	0.17	0.22	0.14	0.16

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0.20	0.15	0.18	0.07	0.22	0.25	0.35	0.09	0.24	0.22	0.21	0.15	0.18	0.14	0.13	0.19	0.08	0.11
0.24	0.13	0.18	0.12	0.14	0.20	0.38	0.14	0.23	0.26	0.35	0.26	0.13	0.12	0.12	0.27	0.08	0.06
0.39	0.16	0.12	0.04	0.19	0.14	0.25	0.11	0.24	0.20	0.04	0.33	0.21	0.10	0.11	0.23	0.10	0.19
0.13	0.13	0.10	0.11	0.09	0.12	0.23	0.09	0.23	0.15	0.10	0.32	0.25	0.12	0.14	0.18	0.12	0.14
0.23	0.12	0.10	0.09	0.14	0.18	0.26	0.11	0.28	0.21	0.12	0.32	0.28	0.10	0.12	0.19	0.17	0.21
0.19	0.14	0.14	0.16	0.13	0.17	0.23	0.09	0.27	0.29	0.16	0.31	0.30	0.12	0.17	0.19	0.21	0.14
0.22	0.19	0.57	0.27	0.13	0.23	0.33	0.09	0.25	0.29	0.15	0.31	0.28	0.16	0.16	0.23	0.27	0.17
0.22	0.19	0.17	0.36	0.17	0.36	0.35	0.09	0.22	0.38	0.16	0.38	0.41	0.16	0.11	0.15	0.30	0.14
0.26	0.14	0.27	0.31	0.22	0.41	0.27	0.16	0.25	0.38	0.16	0.28	0.34	0.18	0.09	0.20	0.30	0.13
0.29	0.22	0.23	0.30	0.22	0.29	0.35	0.16	0.26	0.40	0.20	0.30	0.31	0.17	0.08	0.23	0.35	0.12
0.26	0.17	0.28	0.35	0.22	0.32	0.42	0.21	0.27	0.42	0.09	0.27	0.38	0.17	0.07	0.29	0.46	0.14
0.43	0.19	0.22	0.34	0.32	0.19	0.42	0.14	0.24	0.43	0.21	0.22	0.37	0.14	0.08	0.28	0.35	0.13
0.30	0.31	0.19	0.17	0.23	0.40	0.44	0.15	0.15	0.38	0.36	0.36	0.34	0.15	0.14	0.28	0.37	0.07
0.21	0.22	0.20	0.13	0.20	0.37	0.41	0.16	0.16	0.11	0.33	0.28	0.36	0.14	0.20	0.25	0.31	0.06
0.15	0.15	0.25	0.34	0.29	0.25	0.23	0.15	0.19	0.12	0.28	0.22	0.26	0.16	0.13	0.16	0.32	0.09
0.20	0.22	0.25	0.22	0.21	0.48	0.43	0.15	0.15	0.19	0.19	0.22	0.31	0.22	0.15	0.32	0.26	0.10
0.22	0.18	0.22	0.15	0.20	0.30	0.90	0.13	0.15	0.22	0.24	0.20	0.23	0.28	0.21	0.32	0.25	0.10
0.26	0.25	0.16	0.45	0.23	0.32	0.33	0.16	0.15	0.16	0.42	0.18	0.21	0.31	0.22	0.34	0.27	0.10
0.27	0.28	0.23	0.43	0.26	0.52	0.87	0.12	0.13	0.13	0.36	0.15	0.19	0.29	0.21	0.41	0.28	0.08
0.16	0.39	0.24	0.42	0.21	0.42	0.50	0.19	0.15	0.26	0.21	0.22	0.22	0.35	0.15	0.42	0.25	0.12
0.24	0.33	0.18	0.35	0.20	0.51	0.62	0.24	0.13	0.19	0.17	0.06	0.23	0.40	0.15	0.41	0.23	0.12
0.25	0.21	0.36	0.27	0.14	0.59		0.23	0.13	0.21	0.27	0.12	0.21	0.35	0.12	0.32	0.21	0.12
0.24	0.21	0.32	0.30	0.13	0.43		0.27	0.11	0.28	0.23	0.13	0.09	0.32	0.09	0.28	0.23	0.11
0.15	0.21	0.31	0.30	0.27	0.41		0.36	0.12	0.12	0.21	0.15	0.18	0.33	0.13	0.26	0.21	0.09
0.15	0.29		0.24	0.26	0.39		0.36	0.15	0.26	0.19	0.14	0.14	0.24	0.23	0.19	0.24	0.05
0.17	0.32		0.41	0.28	0.38		0.30	0.18	0.22	0.21	0.16	0.17	0.20	0.33	0.16	0.26	0.07

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0.25	0.16		0.38	0.28	0.42		0.25	0.18	0.21	0.22	0.17	0.18	0.19	0.36	0.13	0.27	0.05
0.21	0.15		0.24	0.31	0.36		0.17	0.18	0.14	0.20	0.18	0.19	0.25	0.35	0.15	0.20	0.07
0.22	0.18		0.27	0.27	0.32		0.26	0.21	0.19	0.23	0.14	0.22	0.16	0.28	0.13	0.20	0.10
0.19	0.15		0.17	0.37	0.29		0.22	0.25	0.23	0.20	0.17	0.22	0.16	0.22	0.14	0.22	0.12
0.15	0.13		0.20	0.27	0.32		0.22	0.29	0.23	0.20	0.16	0.21	0.21	0.34	0.08	0.20	0.09
0.19	0.21		0.20	0.32	0.20		0.18	0.29	0.23	0.20	0.23	0.30	0.19	0.28	0.12	0.19	0.09
0.12	0.09		0.20	0.29	0.26		0.16	0.29	0.17	0.19	0.29	0.28	0.20	0.30	0.10	0.21	0.12
0.29	0.12		0.20	0.29	0.29		0.12	0.30	0.19	0.16	0.30	0.38	0.24	0.27	0.13	0.22	0.06
0.14	0.15		0.18	0.29	0.32		0.12	0.29	0.17	0.17	0.23	0.37	0.20	0.17	0.13	0.26	0.09
0.16	0.16		0.20	0.27	0.27		0.12	0.25	0.29	0.14	0.27	0.46	0.18	0.14	0.11	0.27	0.08
0.24	0.12		0.30	0.24	0.26		0.13	0.27	0.22	0.14	0.24	0.47	0.16	0.14	0.12	0.40	0.08
0.17	0.11		0.29	0.22	0.15		0.15	0.21	0.24	0.18	0.12	0.54	0.18	0.13	0.11	0.33	0.16
0.22	0.12		0.33	0.24	0.16		0.10	0.16	0.23	0.17	0.15	0.44	0.17	0.13	0.10	0.23	0.19
0.17	0.13		0.48	0.16	0.35		0.09	0.18	0.22	0.18	0.33	0.47	0.14	0.12	0.16	0.21	0.20
0.30	0.11		0.48	0.16	0.48		0.09	0.16	0.20	0.14	0.26	0.55	0.13	0.18	0.15	0.41	0.26
0.19	0.11		0.56	0.21	0.52		0.12	0.18	0.42	0.25	0.21	0.42	0.12	0.18	0.18	0.37	0.30
0.22	0.09		0.53	0.16	0.35		0.11	0.19	0.31	0.20	0.22	0.49	0.16	0.21	0.21	0.46	0.30
0.43	0.12		0.29	0.13	0.45		0.10	0.23	0.25	0.24	0.09	0.48	0.21	0.17	0.22	0.43	0.29
0.39	0.16		0.29	0.21	0.45		0.10	0.25	0.27	0.28	0.10	0.34	0.23	0.16	0.25	0.33	0.41
0.25	0.14		0.29	0.15	0.74		0.11	0.25	0.19	0.28	0.20	0.32	0.25	0.14	0.22	0.38	0.50
0.18	0.16		0.28	0.20	0.59		0.09	0.20	0.14	0.42	0.25	0.28	0.20	0.10	0.20	0.36	0.36
0.31	0.15		0.24	0.12	0.43		0.12	0.22	0.21	0.33	0.21	0.38	0.26	0.14	0.22	0.26	0.31
0.31	0.06		0.27	0.18	0.63		0.18	0.21	0.19	0.27	0.24	0.36	0.26	0.17	0.16	0.20	0.31
0.29	0.13		0.39	0.16	0.29		0.18	0.19	0.35	0.24	0.24	0.19	0.28	0.20	0.23	0.25	0.22
0.28	0.13		0.29	0.21	0.17		0.19	0.22	0.36	0.14	0.19	0.28	0.31	0.26	0.14	0.33	0.26
0.40	0.19		0.38	0.16	0.51		0.15	0.22	0.19	0.19	0.27	0.34	0.31	0.24	0.15	0.30	0.24

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0.23	0.22		0.30	0.13	0.42		0.24	0.11	0.23	0.14	0.21	0.26	0.22	0.23	0.12	0.50	0.24
0.38	0.22		0.19	0.23	0.59		0.26	0.13	0.38	0.09	0.22	0.31	0.15	0.25	0.12	0.35	0.23
0.22	0.17		0.26	0.18	0.62		0.25	0.12	0.41		0.18	0.39	0.14	0.29	0.17	0.21	0.18
0.28	0.21		0.27	0.14	0.47		0.24	0.10	0.69		0.12	0.40	0.18	0.27	0.16	0.29	0.19
0.25	0.24		0.44	0.14	0.36		0.22	0.09	0.70		0.10	0.34	0.21	0.33	0.17	0.21	0.18
0.33	0.20		0.26	0.10	0.39		0.19	0.14	0.38		0.14	0.36	0.25	0.27	0.25	0.54	0.22
0.32	0.26		0.20	0.17	0.40		0.14	0.13	0.32		0.13	0.36	0.31	0.28	0.21	0.31	0.17
0.16	0.23		0.28	0.19	0.40		0.12	0.14	0.25		0.14	0.34	0.35	0.22	0.26	0.29	0.15
0.16	0.24		0.32	0.17	0.53		0.09	0.12	0.23		0.14	0.41	0.34	0.32	0.25	0.21	0.12
0.31	0.30		0.54	0.13	0.33		0.16	0.12	0.28		0.17	0.65	0.36	0.28	0.41	0.35	0.11
0.38	0.22		0.27	0.12	0.18		0.18	0.09	0.30		0.13	0.62	0.35	0.30	0.42	0.24	0.11
0.25	0.31		0.30	0.16	0.25		0.21	0.11	0.38		0.11	0.49	0.32	0.32	0.27	0.33	0.13
0.34	0.32		0.36	0.16	0.32		0.28	0.10	0.30		0.14	0.38	0.42	0.36	0.37	0.37	0.14
0.38	0.38		0.20	0.14	0.22		0.31	0.12	0.39		0.10	0.37	0.37	0.32	0.32	0.26	0.12
0.49	0.39		0.22	0.14	0.47		0.33	0.07	0.32		0.13	0.37	0.33	0.34	0.20	0.25	0.23
0.44			0.34	0.09	1.15		0.40	0.11	0.27		0.09	0.53	0.34	0.42	0.21	0.33	0.27
0.50			0.28	0.01	0.52		0.50	0.12	0.22		0.08	0.61	0.30	0.21	0.16	0.26	0.28
0.64			0.35	0.03	0.38		0.42	0.12	0.29		0.09	0.60	0.24	0.29	0.19	0.32	0.25
0.27			0.38	0.04	0.46		0.48	0.12	0.21		0.14	0.50	0.19	0.23	0.16	0.28	0.27
0.26			0.26	0.06	0.38		0.51	0.12	0.29		0.09	0.52	0.19	0.25	0.07	0.24	0.25
0.25			0.27	0.07	0.47		0.49	0.13	0.30		0.14	0.59	0.23	0.14	0.15	0.28	0.23
0.22			0.33	0.05	0.33		0.54	0.13	0.23		0.14	0.49	0.20	0.18	0.10	0.24	0.22
0.13			0.35	0.05	0.17		0.46	0.17	0.33		0.14	0.42	0.20	0.28	0.13	0.28	0.23
0.22			0.23	0.10	0.24		0.25	0.21	0.19		0.12	0.29	0.27	0.35	0.12	0.28	0.25
0.17			0.30	0.18	0.32		0.34	0.22	0.24		0.22	0.31	0.25	0.34	0.13	0.25	0.17
0.25			0.23	0.28	0.64		0.31	0.19	0.19		0.20	0.20	0.24	0.25	0.13	0.19	0.17

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0.31			0.30	0.15	0.58		0.33	0.29	0.21		0.26	0.13	0.24	0.28	0.12	0.22	0.19
0.21			0.31	0.21	0.63		0.38	0.25	0.33		0.27	0.13	0.29	0.25	0.13	0.20	0.19
0.40			0.29	0.27	0.58		0.33	0.27	0.26		0.25	0.16	0.28	0.25	0.10	0.19	0.32
0.19			0.37	0.32	0.49		0.36	0.25	0.25		0.27	0.30	0.27	0.18	0.18	0.17	0.37
0.14			0.22	0.23	0.59		0.33	0.20	0.11		0.25	0.33	0.30	0.19	0.18	0.22	0.47
0.23			0.46	0.56	0.52		0.38	0.20	0.18		0.30	0.36	0.27	0.23	0.17	0.24	0.53
0.37			0.36	0.45	0.65		0.33	0.18			0.24	0.39	0.27	0.21	0.19	0.33	0.42
0.46			0.44	0.45	0.65		0.31	0.15			0.18	0.51	0.31	0.20	0.23	0.30	0.41
0.21			0.57	0.25	0.65		0.29	0.19			0.19	0.62	0.28	0.18	0.23	0.33	0.44
0.27			0.40	0.28	0.36		0.31	0.17			0.18	0.56	0.30	0.21	0.26	0.30	0.51
0.26			0.41	0.22	0.54		0.30	0.24			0.28	0.43	0.37	0.20	0.23	0.64	0.36
0.42			0.46	0.23	0.43		0.28	0.24			0.27	0.36	0.38	0.20	0.24	0.27	0.45
0.28			0.46	0.32	0.32		0.28	0.12			0.29	0.30	0.38	0.14	0.22	0.33	0.37
0.31			0.51	0.29	0.12		0.25	0.12			0.22	0.30	0.44	0.11	0.21	0.37	0.19
0.25			0.39	0.28	0.81		0.21	0.13			0.39	0.33	0.38	0.15	0.17	0.17	0.34
0.24			0.36	0.28			0.26	0.22			0.25	0.29	0.45	0.16	0.14	0.17	0.26
0.08				0.25			0.28	0.16			0.44	0.29	0.49	0.18	0.18	0.12	0.24
0.20				0.24			0.26	0.17			0.31	0.20	0.46	0.13	0.13	0.20	0.21
0.15				0.25			0.21	0.18			0.44	0.25	0.49	0.20	0.13	0.14	0.27
0.18				0.18			0.42				0.50	0.22	0.46	0.28	0.17	0.16	0.25
0.10				0.21			0.40				0.32	0.25	0.53	0.32	0.25	0.19	0.26
0.16				0.21			0.37				0.42	0.20	0.38	0.32	0.23	0.21	0.25
0.19				0.17							0.45	0.16	0.33	0.25		0.18	0.26
0.12				0.22							0.38	0.19	0.45	0.25		0.33	0.23
				0.19							0.36	0.16	0.39	0.31		0.25	0.19
				0.14							0.34	0.20	0.38	0.28		0.20	0.17

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
			0.20							0.31	0.20	0.43	0.27		0.14	0.20	
			0.20							0.35	0.25	0.34	0.28		0.16	0.22	
			0.25							0.27	0.23	0.18	0.25		0.24	0.19	
			0.25							0.29	0.29	0.18	0.23		0.18	0.20	
			0.25							0.28	0.27	0.24	0.18		0.19	0.23	
			0.21							0.24	0.32	0.16	0.17		0.24	0.28	
			0.25							0.21	0.40	0.28	0.26		0.21	0.32	
			0.18							0.28	0.39	0.18	0.39		0.26	0.27	
			0.11							0.17	0.42	0.27	0.35		0.24	0.46	
			0.15							0.23	0.41	0.27	0.32		0.15	0.39	
			0.28							0.14	0.50	0.39	0.39		0.15	0.19	
			0.32							0.16	0.50	0.39	0.38		0.22	0.14	
			0.27							0.11	0.40	0.39	0.34		0.19	0.18	
			0.40							0.27	0.38	0.39	0.18		0.22	0.25	
			0.28							0.19	0.35	0.28	0.22		0.21	0.41	
			0.21							0.16	0.39	0.43	0.26		0.24	0.13	
			0.22							0.11	0.38	0.34	0.31		0.21	0.22	
			0.22							0.19	0.40	0.26	0.30		0.26	0.11	
			0.08							0.16		0.25	0.31		0.20	0.11	
			0.09							0.17		0.22	0.28		0.31	0.52	
			0.23							0.26		0.16	0.19		0.22	0.44	
			0.25							0.23		0.14	0.17		0.22	0.41	
			0.23							0.30		0.15	0.24		0.23	0.24	
			0.28							0.33		0.14	0.23		0.23	0.06	
			0.20							0.25		0.23	0.19		0.27	0.11	
			0.23							0.14		0.16	0.24		0.27	0.37	

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
				0.27							0.16		0.21	0.10		0.26	0.32
				0.27							0.15		0.21	0.17		0.41	0.24
				0.30							0.11		0.21	0.19		0.32	0.28
				0.18							0.23		0.24	0.19		0.30	0.26
				0.25							0.27		0.26	0.21		0.24	0.13
				0.21							0.24		0.33	0.17		0.20	0.06
				0.16							0.33		0.27	0.27		0.19	0.18
				0.19							0.50		0.33	0.31		0.11	0.21
				0.21							0.16		0.33	0.32		0.15	0.10
				0.20							0.17		0.33	0.36		0.18	0.16
				0.29							0.23		0.40	0.31		0.14	0.07
				0.41							0.28		0.38	0.29		0.16	0.15
				0.68							0.59		0.42	0.31		0.16	0.05
				0.20							0.20		0.45	0.26		0.16	0.16
				0.21							0.23		0.36	0.26		0.10	0.13
				0.12							0.21		0.26	0.24		0.17	0.18
				0.25							0.22		0.31	0.26		0.21	0.18
				0.32							0.20		0.23	0.27		0.17	0.14
				0.38							0.29		0.18	0.26		0.14	0.31
				0.15							0.31		0.20	0.16		0.09	0.17
				0.15							0.30		0.14	0.18		0.13	0.13
				0.16							0.34		0.15	0.18		0.11	0.09
				0.11							0.19		0.18	0.31		0.12	0.13
				0.20							0.18		0.17	0.29		0.16	0.17
				0.18							0.22		0.26	0.29		0.12	0.22
				0.10							0.19		0.13	0.17		0.12	0.11

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
			0.32							0.28		0.24	0.13		0.13	0.22	
			0.30							0.33		0.27	0.22		0.07	0.15	
			0.32							0.38		0.30	0.18		0.07	0.10	
			0.36							0.43		0.30	0.22		0.07	0.09	
			0.22							0.45		0.15	0.26		0.11	0.09	
			0.23							0.35		0.12	0.24		0.09	0.23	
			0.22							0.38			0.30		0.10	0.30	
													0.17			0.36	
													0.14			0.33	
													0.20			0.34	
													0.20			0.25	
													0.26			0.20	
													0.33			0.24	
													0.26			0.26	
													0.13			0.19	
													0.28			0.23	
													0.25			0.23	
													0.33			0.22	
													0.33			0.22	
																0.20	
																0.15	
																0.18	
																0.18	
																0.18	
																0.25	
																0.19	

Explorers Cove Valves											Bay of Sails						
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
																	0.14
																	0.28
																	0.15
																	0.25
																	0.21
																	0.26
																	0.10
																	0.29
																	0.38
																	0.50
																	0.48
																	0.20
																	0.17

Interstrial growth increments of all 2016 juvenile valves from margin to the first visible striae after the umbo

Explorers Cove 2016 Juveniles				
1	**2**	**3**	**4**	**5**
0.31	NA	NA	0.27	0.22
0.33	0.23	NA	0.34	0.32
0.33	0.16	NA	0.34	0.33
0.35	0.19	NA	0.31	0.35
0.33	0.16	NA	0.31	0.31
0.33	0.25	NA	0.28	0.26
0.29	0.06	0.19	0.32	0.25
0.35	0.20	0.19	0.22	0.30
0.31	0.24	0.20	0.22	0.31
0.25	0.23	0.23	0.18	0.31
0.29	0.22	0.21	0.22	0.29
0.31	0.17	0.23	0.30	0.28
0.29	0.25	0.26	0.28	0.22
0.27	0.22	0.26	0.33	0.31
0.31	0.32	0.20	0.26	0.23
0.35	0.22	0.28	0.32	0.22
0.27	0.26	0.25	0.29	0.20
0.35	0.29	0.28	0.28	0.27
0.27	0.26	0.28	0.38	0.22
0.29	0.30	0.36	0.33	0.27
0.33	0.24	0.31	0.47	0.36
0.31	0.46	0.33	0.50	0.38
0.38	0.43	0.43	0.63	0.59
0.42	0.50	0.41	0.58	0.45
0.42	0.42	0.47	0.49	0.53
0.36	0.47	0.46	0.55	0.52
0.38	0.56	0.43	0.50	0.51
0.47	0.58	0.42	0.38	0.46
0.52	0.62	0.30	0.32	0.42
0.40	0.43	0.31	0.24	0.45
0.32	0.36	0.22	0.20	0.50
0.36	0.28	0.19	0.09	0.45
0.29	0.22	0.19	0.11	0.53
0.23	0.24	0.09	0.13	0.52
0.23	0.11	0.16	0.14	0.48
0.19	0.10	0.17	0.16	0.32
0.09	0.10	0.18	0.21	0.23

1	**2**	**3**	**4**	**5**
0.13	0.12	0.19	0.18	0.23
0.21	0.17	0.12	0.15	0.27
0.13	0.14	0.13	0.15	0.38
0.15			0.14	0.32
0.17				0.26
0.19				0.32
0.25				0.32
0.19				0.36
0.17				0.35
0.13				0.40
0.19				0.43
0.23				0.38
0.25				0.33
0.29				0.27
0.25				0.29
0.24				0.29
0.19				0.33
0.27				0.26
0.23				0.25
0.23				0.35
0.28				0.36
0.32				0.43
				0.40
				0.46
				0.37
				0.42
				0.42
				0.49
				0.50
				0.50
				0.53
				0.43
				0.45
				0.45
				0.48
				0.62
				0.53
				0.63
				0.56
				0.61
				0.59
				0.55

1	2	3	4	5
				0.42
				0.45
				0.48
				0.43
				0.48
				0.45
				0.36
				0.42
				0.49
				0.48
				0.42
				0.40
				0.32
				0.38
				0.29
				0.23
				0.28
				0.20
				0.26
				0.22
				0.25
				0.23
				0.20
				0.23
				0.22
				0.20
				0.24
				0.25
				0.21
				0.20
				0.26
				0.22
				0.24
				0.21
				0.33
				0.33
				0.36
				0.42
				0.45
				0.48
				0.48
				0.44

1	2	3	4	5
				0.39
				0.42
				0.36
				0.23
				0.08
				0.09
				0.15
				0.10
				0.08
				0.12
				0.09
				0.10
				0.11
				0.10
				0.12
				0.15
				0.14
				0.11
				0.08
				0.08
				0.16

Number of striae in groups and cycles on each valve

Site	Valve	Group Type	Group Number	Striae In Group	Cycle Number	Striae In Cycle
BOS	1	narrow	1	17	1	40
BOS	1	wide	1	23		
BOS	1	narrow	2	23	2	58
BOS	1	wide	2	35		
BOS	1	narrow	3	11		
BOS	1	indeterminate	NA	24		
BOS	1	indeterminate	NA	44		
BOS	2	narrow	1	10	1	20
BOS	2	wide	1	10		
BOS	2	narrow	2	13	2	31
BOS	2	wide	2	18		
BOS	2	wide	3	12	3	19
BOS	2	narrow	3	7		
BOS	2	wide	4	20	4	26
BOS	2	narrow	4	6		
BOS	2	wide	5	12	5	42
BOS	2	narrow	5	30		
BOS	2	wide	6	3		
BOS	3	narrow	1	16	1	21
BOS	3	wide	1	5		
BOS	3	narrow	2	23	2	31
BOS	3	wide	2	9		
BOS	3	narrow	3	27	3	42
BOS	3	wide	3	15		
BOS	3	indeterminate	NA	58		
BOS	4	wide	1	11	1	33
BOS	4	narrow	1	22		
BOS	4	wide	2	21	2	30
BOS	4	narrow	2	9		
BOS	4	wide	3	7	3	13
BOS	4	narrow	3	6		
BOS	4	wide	4	5		
BOS	4	indeterminate	NA	42		
BOS	5	narrow	1	7	1	20
BOS	5	wide	1	13		
BOS	5	narrow	2	15	2	20
BOS	5	wide	2	5		
BOS	5	narrow	3	10	3	26
BOS	5	wide	3	16		
BOS	5	narrow	4	38	4	60

Site	Valve	Group Type	Group Number	Striae In Group	Cycle Number	Striae In Cycle
BOS	5	wide	4	22		
BOS	5	narrow	5	16	5	22
BOS	5	wide	5	6		
BOS	5	narrow	6	3	6	23
BOS	5	wide	6	20		
BOS	5	narrow	7	7	7	16
BOS	5	wide	7	9		
BOS	5	narrow	8	7	8	15
BOS	5	wide	8	8		
BOS	6	narrow	1	5	1	21
BOS	6	wide	1	16		
BOS	6	narrow	2	12	2	34
BOS	6	wide	2	22		
BOS	6	narrow	3	11	3	31
BOS	6	wide	3	20		
BOS	6	narrow	4	8	4	15
BOS	6	wide	4	7		
BOS	6	narrow	5	4	5	31
BOS	6	wide	5	17		
BOS	7	narrow	1	13	1	30
BOS	7	wide	1	17		
BOS	7	narrow	2	7		
EC	1	narrow	1	13	1	39
EC	1	wide	1	26		
EC	1	narrow	2	16	2	26
EC	1	wide	2	10		
EC	1	narrow	3	5	3	15
EC	1	wide	3	10		
EC	1	narrow	4	22	4	35
EC	1	wide	4	13		
EC	1	narrow	5	6		
EC	1	indeterminate	NA	9		
EC	1	indeterminate	NA	9		
EC	1	wide	5	11		
EC	1	narrow	6	8		
EC	1	wide	6	16		
EC	1	narrow	7	18		
EC	1	indeterminate	NA	33		
EC	2	wide	1	22	1	36
EC	2	narrow	1	14		
EC	2	wide	2	24	2	40
EC	2	narrow	2	16		

Site	Valve	Group Type	Group Number	Striae In Group	Cycle Number	Striae In Cycle
EC	2	wide	3	10	3	16
EC	2	narrow	3	6		
EC	2	wide	4	23	4	35
EC	2	narrow	4	12		
EC	2	wide	5	22	5	37
EC	2	narrow	5	15		
EC	3	narrow	1	19	1	40
EC	3	wide	1	21		
EC	3	indeterminate	NA	38		
EC	3	narrow	2	3		
EC	3	wide	2	5		
EC	3	indeterminate	NA	9		
EC	3	narrow	2	5		
EC	3	indeterminate	NA	60		
EC	4	narrow	1	9	2	14
EC	4	wide	1	5		
EC	4	narrow	2	5	2	15
EC	4	wide	2	10		
EC	4	narrow	3	10	3	17
EC	4	wide	3	7		
EC	4	narrow	4	22	4	31
EC	4	wide	4	9		
EC	4	narrow	5	5		
EC	4	indeterminate	NA	20		
EC	4	wide	5	9		
EC	4	narrow	6	11		
EC	4	wide	6	12		
EC	4	narrow	7	14		
EC	4	wide	7	10		
EC	5	wide	1	3	1	15
EC	5	narrow	1	12		
EC	5	wide	2	6	2	9
EC	5	narrow	2	3		
EC	5	wide	3	17	3	34
EC	5	narrow	3	17		
EC	5	wide	4	10	4	15
EC	5	narrow	4	5		
EC	5	wide	5	9	5	33
EC	5	narrow	5	24		
EC	5	wide	6	7	6	11
EC	5	narrow	6	4		
EC	5	wide	7	19	7	37

Site	Valve	Group Type	Group Number	Striae In Group	Cycle Number	Striae In Cycle
EC	5	narrow	7	18		
EC	5	wide	8	5	8	13
EC	5	narrow	8	8		
EC	5	wide	9	7	9	21
EC	5	narrow	9	14		
EC	5	wide	10	7		
EC	6	wide	1	14	1	30
EC	6	narrow	1	16		
EC	6	wide	2	19	2	27
EC	6	narrow	2	8		
EC	6	wide	3	15	3	32
EC	6	narrow	3	17		
EC	6	wide	4	16	4	21
EC	6	narrow	4	5		
EC	6	wide	5	9	5	30
EC	6	narrow	5	21		
EC	6	wide	6	13		
EC	7	narrow	1	12	1	24
EC	7	wide	1	12		
EC	7	narrow	2	10	2	30
EC	7	wide	2	20		
EC	7	narrow	3	17	3	27
EC	7	wide	3	10		
EC	7	narrow	4	5	4	17
EC	7	wide	4	12		
EC	7	narrow	5	20	5	39
EC	7	wide	5	19		
EC	7	narrow	6	8	6	17
EC	7	wide	6	9		
EC	7	narrow	7	11	7	25
EC	7	wide	7	14		
EC	7	narrow	8	7		
EC	8	wide	1	3	1	16
EC	8	narrow	1	13		
EC	8	wide	2	11	2	35
EC	8	narrow	2	24		
EC	8	wide	3	10	3	24
EC	8	narrow	3	14		
EC	8	wide	4	33	4	51
EC	8	narrow	4	18		
EC	8	wide	5	27	5	21
EC	8	narrow	5	14		

Site	Valve	Group Type	Group Number	Striae In Group	Cycle Number	Striae In Cycle
EC	8	wide	6	8		
EC	8	indeterminate	NA	32		
EC	9	wide	1	10	1	25
EC	9	narrow	1	15		
EC	9	wide	2	6	2	12
EC	9	narrow	2	6		
EC	9	wide	3	15	3	34
EC	9	narrow	3	19		
EC	9	wide	4	7	4	13
EC	9	narrow	4	6		
EC	9	wide	5	15	5	27
EC	9	narrow	5	12		
EC	9	wide	6	12	6	17
EC	9	narrow	6	5		
EC	9	wide	7	6	7	12
EC	9	narrow	7	6		
EC	9	wide	8	6	8	12
EC	9	narrow	8	6		
EC	9	wide	9	10		
EC	9	indeterminate	NA	21		
EC	10	wide	1	6	1	19
EC	10	narrow	1	13		
EC	10	wide	2	4	2	11
EC	10	narrow	2	7		
EC	10	wide	3	14	3	32
EC	10	narrow	3	18		
EC	10	wide	4	11	4	15
EC	10	narrow	4	4		
EC	10	wide	5	28	5	34
EC	10	narrow	5	6		
EC	10	wide	6	10	6	17
EC	10	narrow	6	7		
EC	10	wide	7	14	7	25
EC	10	narrow	7	11		
EC	10	wide	8	25	8	42
EC	10	narrow	8	17		
EC	11	wide	1	38	1	64
EC	11	narrow	1	26		
EC	11	wide	2	12	2	30
EC	11	narrow	2	18		
EC	11	wide	3	10	3	13
EC	11	narrow	3	13		

Site	Valve	Group Type	Group Number	Striae In Group	Cycle Number	Striae In Cycle
EC	11	wide	4	15	4	31
EC	11	narrow	4	16		
EC	11	wide	5	6	5	15
EC	11	narrow	5	9		
EC	11	wide	6	12	6	40
EC	11	narrow	6	28		
EC	11	indeterminate	NA	36		

Part 2: R Code

```
# call required packages
library(ggplot2)
library(WaveletComp)
library(svglite)

# read in data
striaeInGroupsAndCycles <-
read.table("numberOfStriaeInGroupsAndCycles.csv", header = TRUE, sep =
",")
striaeGroupAndCyclePlot <- read.table("striaeGroupAndCyclePlot.csv",
header = TRUE, sep = ",")
wornFraction <- read.table("wornFraction.csv", header = TRUE, sep =
",")

allInterstrialIncrements <- read.table("allInterstrialIncrements.csv",
header = TRUE, sep = ",")
explorersCoveInterstrialIncrements <-
allInterstrialIncrements$isi[allInterstrialIncrements$site == "aEC"]
bayOfSailsInterstrialIncrements <-
allInterstrialIncrements$isi[allInterstrialIncrements$site == "BOS"]

explorersCove2016Juveniles <-
read.table("bottomBabyStriaeMeasurements.csv", header = TRUE, sep =
",")

interstrialIncrementsBOS1 <-
read.table("interstrialIncrementsBOS1.csv", header = TRUE, sep = ",")
interstrialIncrementsBOS2 <-
read.table("interstrialIncrementsBOS2.csv", header = TRUE, sep = ",")
interstrialIncrementsBOS3 <-
read.table("interstrialIncrementsBOS3.csv", header = TRUE, sep = ",")
interstrialIncrementsBOS4 <-
read.table("interstrialIncrementsBOS4.csv", header = TRUE, sep = ",")
interstrialIncrementsBOS5 <-
read.table("interstrialIncrementsBOS5.csv", header = TRUE, sep = ",")
interstrialIncrementsBOS6 <-
read.table("interstrialIncrementsBOS6.csv", header = TRUE, sep = ",")
interstrialIncrementsBOS7 <-
read.table("interstrialIncrementsBOS7.csv", header = TRUE, sep = ",")
interstrialIncrementsEC1 <- read.table("interstrialIncrementsEC1.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC2 <- read.table("interstrialIncrementsEC2.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC3 <- read.table("interstrialIncrementsEC3.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC4 <- read.table("interstrialIncrementsEC4.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC5 <- read.table("interstrialIncrementsEC5.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC6 <- read.table("interstrialIncrementsEC6.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC7 <- read.table("interstrialIncrementsEC7.csv",
header = TRUE, sep = ",")
```

```
interstrialIncrementsEC8 <- read.table("interstrialIncrementsEC8.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC9 <- read.table("interstrialIncrementsEC9.csv",
header = TRUE, sep = ",")
interstrialIncrementsEC10 <-
read.table("interstrialIncrementsEC10.csv", header = TRUE, sep = ",")
interstrialIncrementsEC11 <-
read.table("interstrialIncrementsEC11.csv", header = TRUE, sep = ",")

# Estimate median striae per group, striae per cycle; maximum liklihood
code modified from
http://strata.uga.edu/8370/lecturenotes/likelihood.html

# Observations are numbers of objects in a fixed interval of space or
time
# Will calculate the maximum likelihood estimate of the Poisson rate
parameter and the confidence interval on it
precision    <- 0.01
lowerRate    <- 1
upperRate    <- 100
confidence   <- 0.95

###############################################
# MLE striae in groups for all groups
###############################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$groupType
!= "indeterminate"]

# Calculate log-likelihoods over a range of rates
rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allGroupsMLE <- rate[which(logLikelihood == max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allGroupsConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

allGroupsMLE
allGroupsConfLimits

#################################################
# MLE striae in groups for all groups on Explorers Cove valves
#################################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$site ==
"EC" & striaeInGroupsAndCycles$groupType != "indeterminate"]

rate <- seq(lowerRate, upperRate, precision)
```

```
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allExplorersCoveGroupsMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allExplorersCoveGroupsConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

allExplorersCoveGroupsMLE
allExplorersCoveGroupsConfLimits

############################################
# MLE striae in groups for all groups on Bay of Sails valves
############################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$site ==
"BOS" & striaeInGroupsAndCycles$groupType != "indeterminate"]

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allBayOfSailsGroupsMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allBayOfSailsGroupsConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

allBayOfSailsGroupsMLE
allBayOfSailsGroupsConfLimits

############################################
# MLE striae in groups for all narrow groups on Explorers Cove valves
############################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$site ==
"EC" & striaeInGroupsAndCycles$groupType == "narrow" &
striaeInGroupsAndCycles$groupType != "indeterminate"]

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
```

```
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allExplorersCoveNarrowGroupsMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allExplorersCoveNarrowGroupsConfLimits <-
range(rate[which(logLikelihood > max(logLikelihood)-cutoff)])

allExplorersCoveNarrowGroupsMLE
allExplorersCoveNarrowGroupsConfLimits

############################################
# MLE striae in groups for all wide groups on Explorers Cove valves
############################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$site ==
"EC" & striaeInGroupsAndCycles$groupType == "wide" &
striaeInGroupsAndCycles$groupType != "indeterminate"]

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allExplorersCoveWideGroupsMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allExplorersCoveWideGroupsConfLimits <- range(rate[which(logLikelihood
> max(logLikelihood)-cutoff)])

allExplorersCoveWideGroupsMLE
allExplorersCoveWideGroupsConfLimits

############################################
# MLE striae in groups for all narrow groups on Bay of Sails valves
############################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$site ==
"BOS" & striaeInGroupsAndCycles$groupType == "narrow" &
striaeInGroupsAndCycles$groupType != "indeterminate"]

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
```

```
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allBayOfSailsNarrowGroupsMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allBayOfSailsNarrowGroupsConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

allBayOfSailsNarrowGroupsMLE
allBayOfSailsNarrowGroupsConfLimits

############################################
# MLE striae in groups for all wide groups on Bay of Sails valves
############################################
observations <-
striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$site ==
"BOS" & striaeInGroupsAndCycles$groupType == "wide" &
striaeInGroupsAndCycles$groupType != "indeterminate"]

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
allBayOfSailsWideGroupsMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allBayOfSailsWideGroupsConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

allBayOfSailsWideGroupsMLE
allBayOfSailsWideGroupsConfLimits

############################################
# MLE striae in cycles for all cycles
############################################
observations <-
na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndCycles$g
roupType != "indeterminate"])

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
```

```
}

# Maximum likelihood estimate of Poisson rate
allCyclesMLE <- rate[which(logLikelihood == max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
allCyclesConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

allCyclesMLE
allCyclesConfLimits

############################################
# MLE striae in cycles for all cycles on Explorers Cove valves
############################################
observations <-
na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndCycles$s
ite == "EC" & striaeInGroupsAndCycles$groupType != "indeterminate"])

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
explorersCoveCyclesMLE <- rate[which(logLikelihood ==
max(logLikelihood))]

# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
explorersCoveCyclesConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

explorersCoveCyclesMLE
explorersCoveCyclesConfLimits

############################################
# MLE striae in cycles for all cycles on Bay of Sails valves
############################################
observations <-
na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndCycles$s
ite == "BOS" & striaeInGroupsAndCycles$groupType != "indeterminate"])

rate <- seq(lowerRate, upperRate, precision)
logLikelihood <- 0
for (i in 1:length(rate)) {
   logLikelihood[i] <- sum(sapply(observations, FUN=dpois,
lambda=rate[i], log=TRUE))
}

# Maximum likelihood estimate of Poisson rate
bayOfSailsCyclesMLE <- rate[which(logLikelihood == max(logLikelihood))]
```

```
# Confidence interval on Poisson rate
df <- 1
cutoff <- qchisq(confidence, df) / 2
bayOfSailsCyclesConfLimits <- range(rate[which(logLikelihood >
max(logLikelihood)-cutoff)])

bayOfSailsCyclesMLE
bayOfSailsCyclesConfLimits

# How many groups are more or less consistent with fortnightly striae
(i.e. how many groups range from 10-16)
length(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$st
riaeInGroup >= 10 & striaeInGroupsAndCycles$striaeInGroup <= 16 &
striaeInGroupsAndCycles$groupType !=
"indeterminate"])/length(striaeInGroupsAndCycles$striaeInGroup[striaeIn
GroupsAndCycles$groupType != "indeterminate"])
length(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$si
te == "EC" & striaeInGroupsAndCycles$groupType != "indeterminate"])
length(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$si
te == "BOS" & striaeInGroupsAndCycles$groupType != "indeterminate"])
length(na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndC
ycles$site == "EC" & striaeInGroupsAndCycles$groupType !=
"indeterminate"]))
length(na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndC
ycles$site == "BOS" & striaeInGroupsAndCycles$groupType !=
"indeterminate"]))

# How many cycles are more or less consistent with fortnightly striae
(i.e. how many groups range from 20-32)
length(na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndC
ycles$striaeInCycle >= 20 & striaeInGroupsAndCycles$striaeInCycle <= 32
& striaeInGroupsAndCycles$groupType !=
"indeterminate"]))/length(na.omit(striaeInGroupsAndCycles$striaeInCycle
[striaeInGroupsAndCycles$striaeInCycle >= 0]))

# Estimate worn fraction of valves at EC and BOS
meanOfOneBootstrap <- function(x) {
                              bootstrappedSample <- sample(x,
size=length(x), replace=TRUE)
                              theMean <- mean(bootstrappedSample, na.rm
= TRUE)
                              theMean
                              }
alpha = 0.05

wornEC <- replicate(10000,
meanOfOneBootstrap(wornFraction$explorersCove))
wornEstimateEC <- mean(wornEC, na.rm = TRUE)
lowerWornEC <- quantile(wornEC, alpha/2, na.rm = TRUE)
upperWornEC <- quantile(wornEC, 1-alpha/2, na.rm = TRUE)

wornBOS <- replicate(10000,
meanOfOneBootstrap(wornFraction$bayOfSails))
wornEstimateBOS <- mean(wornBOS, na.rm = TRUE)
lowerWornBOS <- quantile(wornBOS, alpha/2, na.rm = TRUE)
upperWornBOS <- quantile(wornBOS, 1-alpha/2, na.rm = TRUE)
```

```
wornEstimateEC
lowerWornEC
upperWornEC

wornEstimateBOS
lowerWornBOS
upperWornBOS

# Estimatemean ISI (mm) at EC and BOS
isiEC <- replicate(10000,
meanOfOneBootstrap(explorersCoveInterstrialIncrements))
isiEstimateEC <- mean(isiEC, na.rm = TRUE)
lowerIsiEC <- quantile(isiEC, alpha/2, na.rm = TRUE)
upperIsiEC <- quantile(isiEC, 1-alpha/2, na.rm = TRUE)

isiBOS <- replicate(10000,
meanOfOneBootstrap(bayOfSailsInterstrialIncrements))
isiEstimateBOS <- mean(isiBOS, na.rm = TRUE)
lowerIsiBOS <- quantile(isiBOS, alpha/2, na.rm = TRUE)
upperIsiBOS <- quantile(isiBOS, 1-alpha/2, na.rm = TRUE)

isiEstimateEC
lowerIsiEC
upperIsiEC

isiEstimateBOS
lowerIsiBOS
upperIsiBOS

# Calculate ranges of striae per group and striae per cycle
rangeAllGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$gro
upType != "indeterminate"])
rangeAllExplorersCoveGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$sit
e == "EC" & striaeInGroupsAndCycles$groupType != "indeterminate"])
rangeAllBayOfSailsGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$sit
e == "BOS" & striaeInGroupsAndCycles$groupType != "indeterminate"])
rangeAllExplorersCoveNarrowGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$sit
e == "EC" & striaeInGroupsAndCycles$groupType == "narrow" &
striaeInGroupsAndCycles$groupType != "indeterminate"])
rangeAllExplorersCoveWideGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$sit
e == "EC" & striaeInGroupsAndCycles$groupType == "wide" &
striaeInGroupsAndCycles$groupType != "indeterminate"])
rangeAllBayOfSailsNarrowGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$sit
e == "BOS" & striaeInGroupsAndCycles$groupType == "narrow" &
striaeInGroupsAndCycles$groupType != "indeterminate"])
rangeAllBayOfSailsWideGroups <-
range(striaeInGroupsAndCycles$striaeInGroup[striaeInGroupsAndCycles$sit
e == "BOS" & striaeInGroupsAndCycles$groupType == "wide" &
striaeInGroupsAndCycles$groupType != "indeterminate"])
```

```
rangeAllCycles <-
range(na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndCy
cles$groupType != "indeterminate"]))
rangeExplorersCoveCycles <-
range(na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndCy
cles$site == "EC" & striaeInGroupsAndCycles$groupType !=
"indeterminate"]))
rangeBayOfSailsCycles <-
range(na.omit(striaeInGroupsAndCycles$striaeInCycle[striaeInGroupsAndCy
cles$site == "BOS" & striaeInGroupsAndCycles$groupType !=
"indeterminate"]))

rangeAllGroups
rangeAllExplorersCoveGroups
rangeAllBayOfSailsGroups
rangeAllExplorersCoveNarrowGroups
rangeAllExplorersCoveWideGroups
rangeAllBayOfSailsNarrowGroups
rangeAllBayOfSailsNarrowGroups
rangeAllCycles
rangeExplorersCoveCycles
rangeBayOfSailsCycles

# Plots

## Striae per group and cycle by site
groupPlot <- ggplot(data = striaeGroupAndCyclePlot, aes(x = site, y =
allGroups, ymin = rangeLowAllGroups, ymax = rangeHighAllGroups))
groupPlot + geom_linerange(aes(x = site, ymin = rangeLowAllGroups, ymax
= rangeHighAllGroups), size = 1, color = "gray69") +
geom_errorbar(aes(x = site, ymin = low95AllGroups, ymax =
high95AllGroups), color = "gray47", size = 1.4, width = .3) +
geom_point(color = "gray7", size = 2) + scale_x_discrete(name = NULL,
labels = c("Explorers Cove", "Bay of Sails", "Both sites"))+
scale_y_continuous(name = "Number of Striae Per Group") +
theme_classic(base_size = 16)
ggsave("Fig3A.svg", device = "svg", units = "in", width = 6, height =
6)

cyclePlot <- ggplot(data = striaeGroupAndCyclePlot, aes(x = site, y =
allCycles, ymin = rangeLowAllCycles, ymax = rangeHighAllCycles))
cyclePlot + geom_linerange(aes(x = site, ymin = rangeLowAllCycles, ymax
= rangeHighAllCycles), size = 1, color = "gray69") +
geom_errorbar(aes(x = site, ymin = low95AllCycles, ymax =
high95AllCycles), color = "gray47", size = 1.4, width = .3) +
geom_point(color = "gray7", size = 2) + scale_x_discrete(name = NULL,
labels = c("Explorers Cove", "Bay of Sails", "Both sites"))+
scale_y_continuous(name = "Number of Striae Per Cycle") +
theme_classic(base_size = 16)
ggsave("Fig3B.svg", device = "svg", units = "in", width = 6, height =
6)

# Analyze and plot periodicity of ISI for each valve using wavelets

### Includes on the first (beginning after the umbo) continious
(unbroken by abrasion) striae sequence for each valve.
```

```
###### Grayscale with blue ridges for internet and dissertation

#explorersCoveValve1
EC1 <- analyze.wavelet(my.data = interstrialIncrementsEC1, my.series =
"explorersCoveValve1", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC1blue.svg", width = 6, height = 6)
wt.image(EC1, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #1")
dev.off()

#explorersCoveValve2
EC2 <- analyze.wavelet(my.data = interstrialIncrementsEC2, my.series =
"explorersCoveValve2", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC2blue.svg", width = 6, height = 6)
wt.image(EC2, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #2")
dev.off()

#explorersCoveValve3
EC3 <- analyze.wavelet(my.data = interstrialIncrementsEC3, my.series =
"explorersCoveValve3", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC3blue.svg", width = 6, height = 6)
wt.image(EC3, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #3")
dev.off()

#explorersCoveValve4
EC4 <- analyze.wavelet(my.data = interstrialIncrementsEC4, my.series =
"explorersCoveValve4", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC4blue.svg", width = 6, height = 6)
wt.image(EC4, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #4")
dev.off()

#explorersCoveValve5
EC5 <- analyze.wavelet(my.data = interstrialIncrementsEC5, my.series =
"explorersCoveValve5", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC5blue.svg", width = 6, height = 6)
wt.image(EC5, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #5")
dev.off()

#explorersCoveValve6
EC6 <- analyze.wavelet(my.data = interstrialIncrementsEC6, my.series =
"explorersCoveValve6", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC6blue.svg", width = 6, height = 6)
```

```
wt.image(EC6, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #6")
dev.off()

#explorersCoveValve7
EC7 <- analyze.wavelet(my.data = interstrialIncrementsEC7, my.series =
"explorersCoveValve7", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC7blue.svg", width = 6, height = 6)
wt.image(EC7, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #7")
dev.off()

#explorersCoveValve8
EC8 <- analyze.wavelet(my.data = interstrialIncrementsEC8, my.series =
"explorersCoveValve8", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC8blue.svg", width = 6, height = 6)
wt.image(EC8, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #8")
dev.off()

#explorersCoveValve9 (Double check this one)
EC9 <- analyze.wavelet(my.data = interstrialIncrementsEC9, my.series =
"explorersCoveValve9", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC9blue.svg", width = 6, height = 6)
wt.image(EC9, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #9")
dev.off()

#explorersCoveValve10
EC10 <- analyze.wavelet(my.data = interstrialIncrementsEC10, my.series
= "explorersCoveValve10", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC10blue.svg", width = 6, height = 6)
wt.image(EC10, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #10")
dev.off()

#explorersCoveValve11
EC11 <- analyze.wavelet(my.data = interstrialIncrementsEC11, my.series
= "explorersCoveValve11", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC11blue.svg", width = 6, height = 6)
wt.image(EC11, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #11")
dev.off()

#bayOfSailsValve1
```

```
BOS1 <- analyze.wavelet(my.data = interstrialIncrementsBOS1, my.series
= "bayOfSailsValve1", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS1blue.svg", width = 6, height = 6)
wt.image(BOS1, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #1")
dev.off()

#bayOfSailsValve2
BOS2 <- analyze.wavelet(my.data = interstrialIncrementsBOS2, my.series
= "bayOfSailsValve2", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS2blue.svg", width = 6, height = 6)
wt.image(BOS2, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #2")
dev.off()

#bayOfSailsValve3
BOS3 <- analyze.wavelet(my.data = interstrialIncrementsBOS3, my.series
= "bayOfSailsValve3", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS3blue.svg", width = 6, height = 6)
wt.image(BOS3, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #3")
dev.off()

#bayOfSailsValve4
BOS4 <- analyze.wavelet(my.data = interstrialIncrementsBOS4, my.series
= "bayOfSailsValve4", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS4blue.svg", width = 6, height = 6)
wt.image(BOS4, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #4")
dev.off()

#bayOfSailsValve5
BOS5 <- analyze.wavelet(my.data = interstrialIncrementsBOS5, my.series
= "bayOfSailsValve5", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS5blue.svg", width = 6, height = 6)
wt.image(BOS5, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #5")
dev.off()

#bayOfSailsValve6
BOS6 <- analyze.wavelet(my.data = interstrialIncrementsBOS6, my.series
= "bayOfSailsValve6", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS6blue.svg", width = 6, height = 6)
wt.image(BOS6, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #6")
```

```
dev.off()

#bayOfSailsValve7
BOS7 <- analyze.wavelet(my.data = interstrialIncrementsBOS7, my.series
= "bayOfSailsValve7", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS7blue.svg", width = 6, height = 6)
wt.image(BOS7, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "blue", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #7")
dev.off()

###### Grayscale with black color ridge for print

#explorersCoveValve1
EC1 <- analyze.wavelet(my.data = interstrialIncrementsEC1, my.series =
"explorersCoveValve1", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC1grayscale.svg", width = 6, height = 6)
wt.image(EC1, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #1")
dev.off()

#explorersCoveValve2
EC2 <- analyze.wavelet(my.data = interstrialIncrementsEC2, my.series =
"explorersCoveValve2", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC2grayscale.svg", width = 6, height = 6)
wt.image(EC2, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #2")
dev.off()

#explorersCoveValve3
EC3 <- analyze.wavelet(my.data = interstrialIncrementsEC3, my.series =
"explorersCoveValve3", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC3grayscale.svg", width = 6, height = 6)
wt.image(EC3, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #3")
dev.off()

#explorersCoveValve4
EC4 <- analyze.wavelet(my.data = interstrialIncrementsEC4, my.series =
"explorersCoveValve4", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC4grayscale.svg", width = 6, height = 6)
wt.image(EC4, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #4")
dev.off()

#explorersCoveValve5
```

```
EC5 <- analyze.wavelet(my.data = interstrialIncrementsEC5, my.series =
"explorersCoveValve5", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC5grayscale.svg", width = 6, height = 6)
wt.image(EC5, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #5")
dev.off()

#explorersCoveValve6
EC6 <- analyze.wavelet(my.data = interstrialIncrementsEC6, my.series =
"explorersCoveValve6", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC6grayscale.svg", width = 6, height = 6)
wt.image(EC6, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #6")
dev.off()

#explorersCoveValve7
EC7 <- analyze.wavelet(my.data = interstrialIncrementsEC7, my.series =
"explorersCoveValve7", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC7grayscale.svg", width = 6, height = 6)
wt.image(EC7, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #7")
dev.off()

#explorersCoveValve8
EC8 <- analyze.wavelet(my.data = interstrialIncrementsEC8, my.series =
"explorersCoveValve8", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC8grayscale.svg", width = 6, height = 6)
wt.image(EC8, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #8")
dev.off()

#explorersCoveValve9 (Double check this one)
EC9 <- analyze.wavelet(my.data = interstrialIncrementsEC9, my.series =
"explorersCoveValve9", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC9grayscale.svg", width = 6, height = 6)
wt.image(EC9, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #9")
dev.off()

#explorersCoveValve10
EC10 <- analyze.wavelet(my.data = interstrialIncrementsEC10, my.series
= "explorersCoveValve10", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC10grayscale.svg", width = 6, height = 6)
wt.image(EC10, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #10")
```

```
dev.off()

#explorersCoveValve11
EC11 <- analyze.wavelet(my.data = interstrialIncrementsEC11, my.series
= "explorersCoveValve11", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("EC11grayscale.svg", width = 6, height = 6)
wt.image(EC11, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Explorers Cove Valve #11")
dev.off()

#bayOfSailsValve1
BOS1 <- analyze.wavelet(my.data = interstrialIncrementsBOS1, my.series
= "bayOfSailsValve1", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS1grayscale.svg", width = 6, height = 6)
wt.image(BOS1, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #1")
dev.off()

#bayOfSailsValve2
BOS2 <- analyze.wavelet(my.data = interstrialIncrementsBOS2, my.series
= "bayOfSailsValve2", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS2grayscale.svg", width = 6, height = 6)
wt.image(BOS2, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #2")
dev.off()

#bayOfSailsValve3
BOS3 <- analyze.wavelet(my.data = interstrialIncrementsBOS3, my.series
= "bayOfSailsValve3", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS3grayscale.svg", width = 6, height = 6)
wt.image(BOS3, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #3")
dev.off()

#bayOfSailsValve4
BOS4 <- analyze.wavelet(my.data = interstrialIncrementsBOS4, my.series
= "bayOfSailsValve4", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS4grayscale.svg", width = 6, height = 6)
wt.image(BOS4, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #4")
dev.off()

#bayOfSailsValve5
BOS5 <- analyze.wavelet(my.data = interstrialIncrementsBOS5, my.series
= "bayOfSailsValve5", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS5grayscale.svg", width = 6, height = 6)
```

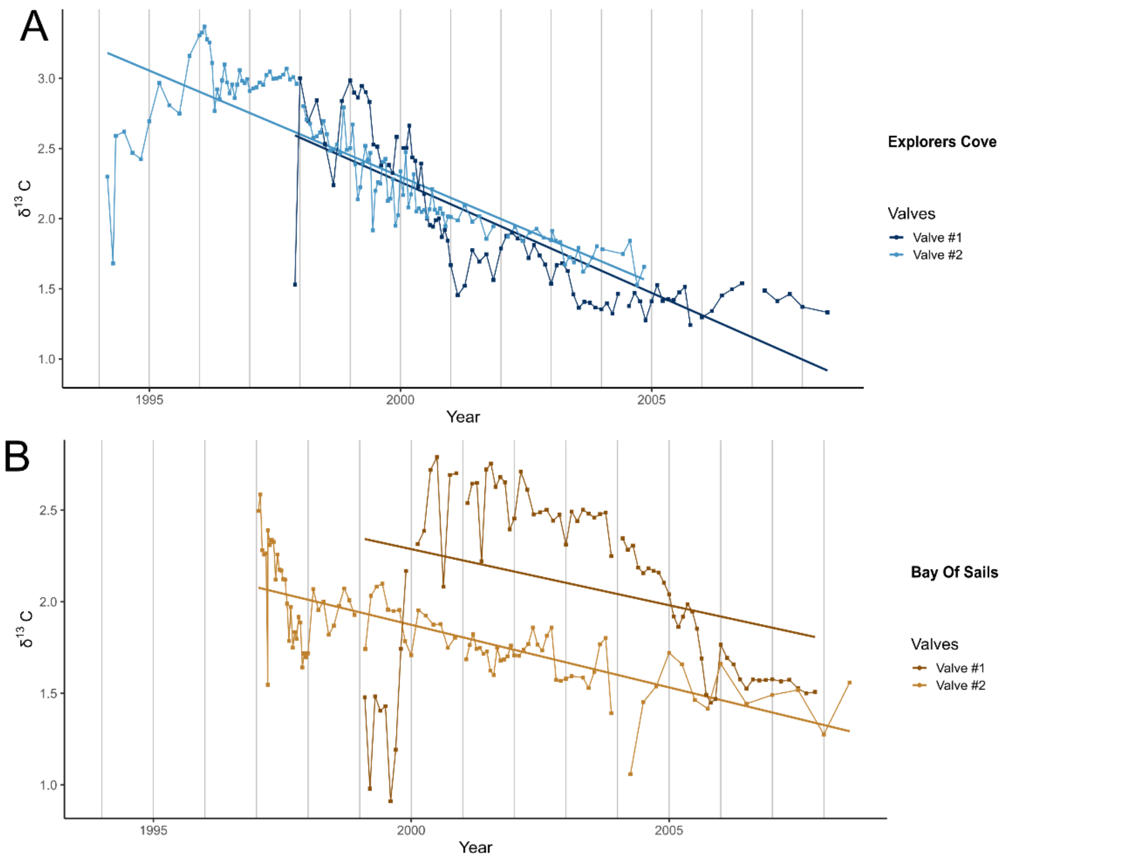
```
wt.image(BOS5, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #5")
dev.off()

#bayOfSailsValve6
BOS6 <- analyze.wavelet(my.data = interstrialIncrementsBOS6, my.series
= "bayOfSailsValve6", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS6grayscale.svg", width = 6, height = 6)
wt.image(BOS6, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #6")
dev.off()

#bayOfSailsValve7
BOS7 <- analyze.wavelet(my.data = interstrialIncrementsBOS7, my.series
= "bayOfSailsValve7", loess.span = 0, dt = 1, upperPeriod = 64,
make.pval = TRUE, method = "white.noise", n.sim = 500)
svg("BOS7grayscale.svg", width = 6, height = 6)
wt.image(BOS7, color.palette = "gray((n.levels):1/n.levels)", col.ridge
= "black", timelab = "growth (striae count from umbo)", periodlab =
"period (striae)", main = "Bay of Sails Valve #7")
dev.off()

# Plot Juvenile valve concurrent growth
myColorsJuvenilesGrayscale <- c("#252525", "#525252", "#737373",
"#969696", "#BDBDBD")
myColorsJuvenile <- c("#1B9E77", "#D95F02", "#7570B3", "#E7298A",
"#66A61E")

concurrentJuvenileGrowth <- ggplot(data = explorersCove2016Juveniles,
aes(x = striaeNumberFromMargin, y = interStrialIncrement, color =
valve))
concurrentJuvenilePlot <- concurrentJuvenileGrowth + geom_line(size =
1)+ scale_x_continuous(name = "Number of Striae from Margin")+
scale_y_continuous(name = "Interstrial Increment (mm)") +
scale_color_manual(values = myColorsJuvenilesGrayscale, name =
"Valves", breaks = c("EC2016JuvenileBottom001",
"EC2016JuvenileBottom002", "EC2016JuvenileBottom003",
"EC2016JuvenileBottom004", "EC2016JuvenileBottom005"), labels =
c("Explorers Cove (Juv) #1", "Explorers Cove (Juv) #2", "Explorers Cove
(Juv) #3", "Explorers Cove (Juv) #4", "Explorers Cove (Juv) #5")) +
theme_classic(base_size = 16)
ggsave("JuvenilesGrayScale.svg", device = "svg", units = "in", width =
10, height = 4)

concurrentJuvenileGrowth <- ggplot(data = explorersCove2016Juveniles,
aes(x = striaeNumberFromMargin, y = interStrialIncrement, color =
valve))
concurrentJuvenilePlot <- concurrentJuvenileGrowth + geom_line(size =
1)+ scale_x_continuous(name = "Number of Striae from Margin")+
scale_y_continuous(name = "Interstrial Increment (mm)") +
scale_color_manual(values = myColorsJuvenile, name = "Valves", breaks =
c("EC2016JuvenileBottom001", "EC2016JuvenileBottom002",
"EC2016JuvenileBottom003", "EC2016JuvenileBottom004",
"EC2016JuvenileBottom005"), labels = c("Explorers Cove (Juv) #1",
```

```
"Explorers Cove (Juv) #2", "Explorers Cove (Juv) #3", "Explorers Cove
(Juv) #4", "Explorers Cove (Juv) #5")) + theme_classic(base_size = 16)
ggsave("JuvenilesColors.svg", device = "svg", units = "in", width = 10,
height = 4)

# Extract values for periodicity in ISI
write.csv(x = EC1$Period, file = "Period.csv")

write.csv(x = EC1$Power.pval, file = "EC1Powerpval.csv")
write.csv(x = EC2$Power.pval, file = "EC2Powerpval.csv")
write.csv(x = EC3$Power.pval, file = "EC3Powerpval.csv")
write.csv(x = EC4$Power.pval, file = "EC4Powerpval.csv")
write.csv(x = EC5$Power.pval, file = "EC5Powerpval.csv")
write.csv(x = EC6$Power.pval, file = "EC6Powerpval.csv")
write.csv(x = EC7$Power.pval, file = "EC7Powerpval.csv")
write.csv(x = EC8$Power.pval, file = "EC8Powerpval.csv")
write.csv(x = EC9$Power.pval, file = "EC9Powerpval.csv")
write.csv(x = EC10$Power.pval, file = "EC10Powerpval.csv")
write.csv(x = EC11$Power.pval, file = "EC11Powerpval.csv")

write.csv(x = BOS1$Power.pval, file = "BOS1Powerpval.csv")
write.csv(x = BOS2$Power.pval, file = "BOS2Powerpval.csv")
write.csv(x = BOS3$Power.pval, file = "BOS3Powerpval.csv")
write.csv(x = BOS4$Power.pval, file = "BOS4Powerpval.csv")
write.csv(x = BOS5$Power.pval, file = "BOS5Powerpval.csv")
write.csv(x = BOS6$Power.pval, file = "BOS6Powerpval.csv")
write.csv(x = BOS7$Power.pval, file = "BOS7Powerpval.csv")

write.csv(x = EC1$Ridge, file = "EC1Ridge.csv")
write.csv(x = EC2$Ridge, file = "EC2Ridge.csv")
write.csv(x = EC3$Ridge, file = "EC3Ridge.csv")
write.csv(x = EC4$Ridge, file = "EC4Ridge.csv")
write.csv(x = EC5$Ridge, file = "EC5Ridge.csv")
write.csv(x = EC6$Ridge, file = "EC6Ridge.csv")
write.csv(x = EC7$Ridge, file = "EC7Ridge.csv")
write.csv(x = EC8$Ridge, file = "EC8Ridge.csv")
write.csv(x = EC9$Ridge, file = "EC9Ridge.csv")
write.csv(x = EC10$Ridge, file = "EC10Ridge.csv")
write.csv(x = EC11$Ridge, file = "EC11Ridge.csv")

write.csv(x = BOS1$Ridge, file = "BOS1Ridge.csv")
write.csv(x = BOS2$Ridge, file = "BOS2Ridge.csv")
write.csv(x = BOS3$Ridge, file = "BOS3Ridge.csv")
write.csv(x = BOS4$Ridge, file = "BOS4Ridge.csv")
write.csv(x = BOS5$Ridge, file = "BOS5Ridge.csv")
write.csv(x = BOS6$Ridge, file = "BOS6Ridge.csv")
write.csv(x = BOS7$Ridge, file = "BOS7Ridge.csv")
```

APPENDIX C

SUPPLEMENTAL FIGURES, DATA AND R CODE FOR CHAPTER 4

Part 1:



Supplementary Fig. 1: Undetrended stable isotopes of carbon over time for adult valves from EC and BOS. (A) EC (B) BOS Trend lines were calculated for each individual valve using least squares regression and residuals were labeled $\delta\,^{13}C_{shell\ det}$ according to the methods of Chauvaud et al. (2011).

Part 2: Stable isotopes of carbon and oxygen in sampled *A. colbecki* valves

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#1	BS_B1_1A	2007	2007.83	11.83	NA	1.51	-0.30	3.75
BOS	#1	BS_B1_2A	2007	2007.66	11.66	NA	1.50	-0.32	3.92
BOS	#1	BS_B1_3A	2007	2007.5	11.5	NA	1.53	-0.30	3.94
BOS	#1	BS_B1_4A	2007	2007.33	11.33	NA	1.57	-0.26	4.03
BOS	#1	BS_B1_5A	2007	2007.17	11.17	NA	1.57	-0.28	4.03
BOS	#1	BS_B1_6A	2007	2007	11	NA	1.58	-0.28	4.10
BOS	#1	BS_B1_1B	2006	2006.875	10.875	NA	1.57	-0.29	4.02
BOS	#1	BS_B1_2B	2006	2006.75	10.75	NA	1.57	-0.30	4.15
BOS	#1	BS_B1_3B	2006	2006.625	10.625	NA	1.58	-0.31	4.04
BOS	#1	BS_B1_4B	2006	2006.5	10.5	NA	1.53	-0.36	4.02
BOS	#1	BS_B1_5B	2006	2006.375	10.375	NA	1.58	-0.32	4.05
BOS	#1	BS_B1_6B	2006	2006.25	10.25	NA	1.66	-0.25	4.11
BOS	#1	BS_B1_7B	2006	2006.125	10.125	NA	1.69	-0.22	4.13
BOS	#1	BS_B1_8B	2006	2006	10	NA	1.77	-0.15	4.21
BOS	#1	BS_B1_1C	2005	2005.9	9.9	narrow	1.47	-0.46	4.08
BOS	#1	BS_B1_2C	2005	2005.81	9.81	narrow	1.45	-0.48	3.98
BOS	#1	BS_B1_3C	2005	2005.72	9.72	wide	1.49	-0.44	3.63
BOS	#1	BS_B1_4C	2005	2005.63	9.63	wide	1.69	-0.25	4.05
BOS	#1	BS_B1_5C	2005	2005.54	9.54	wide	1.85	-0.10	4.14
BOS	#1	BS_B1_6C	2005	2005.45	9.45	wide	1.95	-0.01	4.09
BOS	#1	BS_B1_7C	2005	2005.36	9.36	wide	1.99	0.03	4.28
BOS	#1	BS_B1_8C	2005	2005.27	9.27	wide	1.92	-0.05	4.18
BOS	#1	BS_B1_9C	2005	2005.18	9.18	wide	1.86	-0.11	4.18
BOS	#1	BS_B1_10C	2005	2005.09	9.09	narrow	1.92	-0.06	4.27
BOS	#1	BS_B1_1D	2005	2005	9	narrow	2.04	0.06	4.26
BOS	#1	BS_B1_2D	2004	2004.9	8.9	narrow	2.10	0.12	4.29
BOS	#1	BS_B1_3D	2004	2004.8	8.8	narrow	2.16	0.17	4.23

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#1	BS_B1_4D	2004	2004.7	8.7	narrow	2.17	0.17	4.17
BOS	#1	BS_B1_5D	2004	2004.6	8.6	wide	2.18	0.18	4.22
BOS	#1	BS_B1_6D	2004	2004.5	8.5	wide	2.16	0.14	4.21
BOS	#1	BS_B1_7D	2004	2004.4	8.4	wide	2.19	0.17	4.20
BOS	#1	BS_B1_8D	2004	2004.3	8.3	wide	2.31	0.28	4.08
BOS	#1	BS_B1_9D	2004	2004.2	8.2	narrow	2.28	0.25	4.28
BOS	#1	BS_B1_10D	2004	2004.1	8.1	narrow	2.35	0.31	4.31
BOS	#1	NA	2004	2004	8	NA	NA	NA	NA
BOS	#1	BS_B1_1E	2003	2003.88	7.88	narrow	2.25	0.20	4.17
BOS	#1	BS_B1_2E	2003	2003.77	7.77	wide	2.49	0.43	4.43
BOS	#1	BS_B1_3E	2003	2003.66	7.66	wide	2.48	0.42	4.48
BOS	#1	BS_B1_4E	2003	2003.55	7.55	wide	2.46	0.39	4.35
BOS	#1	BS_B1_5E	2003	2003.44	7.44	wide	2.48	0.40	4.38
BOS	#1	BS_B1_6E	2003	2003.33	7.33	wide	2.50	0.42	4.28
BOS	#1	BS_B1_7E	2003	2003.22	7.22	wide	2.44	0.35	4.34
BOS	#1	BS_B1_8E	2003	2003.11	7.11	wide	2.49	0.40	4.31
BOS	#1	BS_B1_1F	2003	2003	7	wide	2.31	0.21	4.40
BOS	#1	BS_B1_2F	2002	2002.875	6.875	wide	2.48	0.36	4.43
BOS	#1	BS_B1_3F	2002	2002.75	6.75	wide	2.44	0.32	4.43
BOS	#1	BS_B1_4F	2002	2002.625	6.625	wide	2.50	0.38	4.37
BOS	#1	BS_B1_5F	2002	2002.5	6.5	wide	2.49	0.35	4.48
BOS	#1	BS_B1_6F	2002	2002.375	6.375	wide	2.48	0.33	4.51
BOS	#1	BS_B1_7F	2002	2002.25	6.25	wide	2.61	0.46	4.39
BOS	#1	BS_B1_8F	2002	2002.125	6.125	wide	2.71	0.55	4.41
BOS	#1	BS_B1_9F	2002	2002	6	wide	2.45	0.29	4.32
BOS	#1	BS_B1_1G	2001	2001.909	5.909091	wide	2.40	0.22	4.40
BOS	#1	BS_B1_2G	2001	2001.818	5.818182	wide	2.65	0.48	4.35

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#1	BS_B1_3G	2001	2001.727	5.727273	wide	2.68	0.50	4.21
BOS	#1	BS_B1_4G	2001	2001.636	5.636364	wide	2.63	0.44	4.31
BOS	#1	BS_B1_5G	2001	2001.545	5.545455	wide	2.75	0.56	4.31
BOS	#1	BS_B1_6G	2001	2001.455	5.454545	wide	2.72	0.52	4.28
BOS	#1	BS_B1_7G	2001	2001.364	5.363636	narrow	2.22	0.02	4.43
BOS	#1	BS_B1_8G	2001	2001.273	5.272727	narrow	2.65	0.44	4.40
BOS	#1	BS_B1_9G	2001	2001.182	5.181818	narrow	2.64	0.43	4.44
BOS	#1	BS_B1_10G	2001	2001.091	5.090909	narrow	2.54	0.32	4.33
BOS	#1	NA	2001	2001	5	NA	NA	NA	NA
BOS	#1	BS_B1_1H	2000	2000.875	4.875	narrow	2.70	0.47	4.44
BOS	#1	BS_B1_2H	2000	2000.75	4.75	narrow	2.69	0.45	4.45
BOS	#1	BS_B1_4H	2000	2000.625	4.625	narrow	2.08	-0.17	4.59
BOS	#1	BS_B1_5H	2000	2000.5	4.5	wide	2.79	0.53	4.45
BOS	#1	BS_B1_6H	2000	2000.375	4.375	wide	2.72	0.46	4.44
BOS	#1	BS_B1_7H	2000	2000.25	4.25	wide	2.39	0.11	4.45
BOS	#1	BS_B1_8H	2000	2000.125	4.125	wide	2.31	0.03	4.39
BOS	#1	NA	2000	2000	4	NA	NA	NA	NA
BOS	#1	BS_B1_1I	1999	1999.9	3.9	narrow	2.17	-0.13	4.39
BOS	#1	BS_B1_2I	1999	1999.8	3.8	narrow	1.74	-0.56	4.33
BOS	#1	BS_B1_3I	1999	1999.7	3.7	narrow	1.19	-1.11	4.54
BOS	#1	BS_B1_4I	1999	1999.6	3.6	narrow	0.91	-1.40	4.60
BOS	#1	BS_B1_5I	1999	1999.5	3.5	narrow	1.43	-0.89	4.40
BOS	#1	BS_B1_7I	1999	1999.4	3.4	narrow	1.41	-0.92	4.58
BOS	#1	BS_B1_8I	1999	1999.3	3.3	narrow	1.48	-0.85	4.48
BOS	#1	BS_B1_9I	1999	1999.2	3.2	narrow	0.98	-1.36	4.53
BOS	#1	BS_B1_10I	1999	1999.1	3.1	narrow	1.48	-0.86	4.48
BOS	#1	NA	1999	1999	3	NA	NA	NA	NA

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#2	BS_B2_1A	2008	2008.5	14.5	NA	1.56	0.27	3.93
BOS	#2	BS_B2_2A	2008	2008	14	NA	1.28	-0.05	3.85
BOS	#2	BS_B2_3A	2007	2007.5	13.5	NA	1.52	0.16	4.07
BOS	#2	BS_B2_4A	2007	2007	13	NA	1.49	0.10	3.71
BOS	#2	BS_B2_5A	2006	2006.5	12.5	NA	1.44	0.01	3.98
BOS	#2	BS_B2_6A	2006	2006	12	NA	1.66	0.20	3.89
BOS	#2	BS_B2_1B	2005	2005.75	11.75	NA	1.42	-0.06	4.15
BOS	#2	BS_B2_2B	2005	2005.5	11.5	NA	1.46	-0.03	4.12
BOS	#2	BS_B2_3B	2005	2005.25	11.25	NA	1.66	0.14	4.11
BOS	#2	BS_B2_4B	2005	2005	11	NA	1.72	0.19	4.08
BOS	#2	BS_B2_5B	2004	2004.75	10.75	NA	1.54	-0.01	4.06
BOS	#2	BS_B2_6B	2004	2004.5	10.5	NA	1.45	-0.11	4.10
BOS	#2	BS_B2_7B	2004	2004.25	10.25	NA	1.06	-0.53	3.78
BOS	#2	NA	2004	2004	10	NA	NA	NA	NA
BOS	#2	BS_B2_1C	2003	2003.88	9.88	NA	1.39	-0.22	3.92
BOS	#2	BS_B2_2C	2003	2003.77	9.77	NA	1.80	0.19	3.92
BOS	#2	BS_B2_3C	2003	2003.66	9.66	NA	1.77	0.14	3.94
BOS	#2	BS_B2_4C	2003	2003.55	9.55	NA	1.62	-0.01	4.13
BOS	#2	BS_B2_5C	2003	2003.44	9.44	NA	1.53	-0.11	4.14
BOS	#2	BS_B2_6C	2003	2003.33	9.33	NA	1.59	-0.06	4.18
BOS	#2	BS_B2_8C	2003	2003.11	9.11	NA	1.59	-0.07	4.07
BOS	#2	BS_B2_9C	2003	2003	9	NA	1.58	-0.09	4.09
BOS	#2	BS_B2_7C	2003	1997.22	3.22	NA	1.55	-0.52	4.15
BOS	#2	BS_B2_10C	2002	2002.9	8.9	NA	1.57	-0.11	4.22
BOS	#2	BS_B2_1D	2002	2002.81	8.81	NA	1.57	-0.11	3.81
BOS	#2	BS_B2_2D	2002	2002.72	8.72	NA	1.86	0.17	4.06
BOS	#2	BS_B2_3D	2002	2002.63	8.63	NA	1.81	0.12	4.12

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#2	BS_B2_4D	2002	2002.54	8.54	NA	1.73	0.03	4.10
BOS	#2	BS_B2_5D	2002	2002.45	8.45	NA	1.77	0.06	4.19
BOS	#2	BS_B2_6D	2002	2002.36	8.36	NA	1.86	0.15	4.26
BOS	#2	BS_B2_7D	2002	2002.27	8.27	NA	1.77	0.05	4.15
BOS	#2	BS_B2_8D	2002	2002.18	8.18	NA	1.74	0.01	4.51
BOS	#2	BS_B2_9D	2002	2002.09	8.09	NA	1.71	-0.03	4.11
BOS	#2	BS_B2_10D	2002	2002	8	NA	1.71	-0.03	4.01
BOS	#2	BS_B2_1E	2001	2001.933	7.933333	NA	1.76	0.02	3.93
BOS	#2	BS_B2_2E	2001	2001.867	7.866667	NA	1.70	-0.04	4.06
BOS	#2	BS_B2_3E	2001	2001.8	7.8	NA	1.69	-0.07	3.82
BOS	#2	BS_B2_4E	2001	2001.733	7.733333	NA	1.68	-0.08	3.83
BOS	#2	BS_B2_5E	2001	2001.667	7.666667	NA	1.75	-0.01	4.11
BOS	#2	BS_B2_6E	2001	2001.6	7.6	NA	1.60	-0.16	3.84
BOS	#2	BS_B2_7E	2001	2001.533	7.533333	NA	1.62	-0.14	3.97
BOS	#2	BS_B2_8E	2001	2001.467	7.466667	NA	1.73	-0.05	4.06
BOS	#2	BS_B2_9E	2001	2001.4	7.4	NA	1.72	-0.06	4.10
BOS	#2	BS_B2_10E	2001	2001.333	7.333333	NA	1.75	-0.03	4.20
BOS	#2	BS_B2_1F	2001	2001.267	7.266667	NA	1.74	-0.04	3.95
BOS	#2	BS_B2_2F	2001	2001.2	7.2	NA	1.82	0.03	4.14
BOS	#2	BS_B2_3F	2001	2001.133	7.133333	NA	1.76	-0.03	3.88
BOS	#2	BS_B2_4F	2001	2001.067	7.066667	NA	1.69	-0.12	4.03
BOS	#2	NA	2001	2001	7	NA	NA	NA	NA
BOS	#2	BS_B2_5F	2000	2000.85	6.85	NA	1.80	-0.01	4.20
BOS	#2	BS_B2_6F	2000	2000.71	6.71	NA	1.75	-0.08	4.15
BOS	#2	BS_B2_7F	2000	2000.57	6.57	NA	1.88	0.04	4.27
BOS	#2	BS_B2_8F	2000	2000.43	6.43	NA	1.88	0.03	4.24
BOS	#2	BS_B2_9F	2000	2000.28	6.28	NA	1.92	0.07	4.31

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#2	BS_B2_10F	2000	2000.14	6.14	NA	1.95	0.09	4.12
BOS	#2	BS_B2_1G	2000	2000	6	NA	1.71	-0.17	4.01
BOS	#2	BS_B2_2G	1999	1999.88	5.88	NA	1.79	-0.10	4.14
BOS	#2	BS_B2_4G	1999	1999.77	5.77	NA	1.96	0.06	4.25
BOS	#2	BS_B2_5G	1999	1999.66	5.66	NA	1.95	0.05	4.21
BOS	#2	BS_B2_6G	1999	1999.55	5.55	NA	1.96	0.05	4.28
BOS	#2	BS_B2_7G	1999	1999.44	5.44	NA	2.10	0.19	4.36
BOS	#2	BS_B2_8G	1999	1999.33	5.33	NA	2.08	0.16	4.25
BOS	#2	BS_B2_9G	1999	1999.22	5.22	NA	2.03	0.11	4.25
BOS	#2	BS_B2_10G	1999	1999.11	5.11	NA	1.74	-0.19	4.10
BOS	#2	NA	1999	1999	5	NA	NA	NA	NA
BOS	#2	BS_B2_1H	1998	1998.9	4.9	NA	1.93	-0.02	4.20
BOS	#2	BS_B2_2H	1998	1998.8	4.8	NA	2.01	0.05	4.26
BOS	#2	BS_B2_3H	1998	1998.7	4.7	NA	2.07	0.11	4.41
BOS	#2	BS_B2_4H	1998	1998.6	4.6	NA	1.98	0.01	4.37
BOS	#2	BS_B2_5H	1998	1998.5	4.5	NA	1.87	-0.11	4.22
BOS	#2	BS_B2_6H	1998	1998.4	4.4	NA	1.82	-0.16	4.25
BOS	#2	BS_B2_7H	1998	1998.3	4.3	NA	2.00	0.01	4.37
BOS	#2	BS_B2_8H	1998	1998.2	4.2	NA	1.96	-0.04	4.45
BOS	#2	BS_B2_9H	1998	1998.1	4.1	NA	2.07	0.06	4.41
BOS	#2	BS_B2_10H	1998	1998	4	NA	1.72	-0.29	4.02
BOS	#2	BS_B2_1I	1997	1997.963	3.962963	NA	1.70	-0.32	4.08
BOS	#2	BS_B2_2I	1997	1997.926	3.925926	NA	1.72	-0.30	4.10
BOS	#2	BS_B2_3I	1997	1997.889	3.888889	NA	1.64	-0.38	4.02
BOS	#2	BS_B2_4I	1997	1997.852	3.851852	NA	1.89	-0.13	4.27
BOS	#2	BS_B2_5I	1997	1997.815	3.814815	NA	1.92	-0.11	4.33
BOS	#2	BS_B2_6I	1997	1997.778	3.777778	NA	1.80	-0.23	4.21

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#2	BS_B2_7I	1997	1997.741	3.740741	NA	1.83	-0.19	4.28
BOS	#2	BS_B2_8I	1997	1997.704	3.703704	NA	1.75	-0.28	4.13
BOS	#2	BS_B2_9I	1997	1997.667	3.666667	NA	1.97	-0.06	4.23
BOS	#2	BS_B2_10I	1997	1997.63	3.62963	NA	1.79	-0.25	4.00
BOS	#2	BS_B2_1J	1997	1997.593	3.592592	NA	1.99	-0.05	4.16
BOS	#2	BS_B2_2J	1997	1997.556	3.555555	NA	2.12	0.08	4.31
BOS	#2	BS_B2_3J	1997	1997.519	3.518518	NA	2.12	0.08	4.24
BOS	#2	BS_B2_4J	1997	1997.481	3.481481	NA	2.17	0.12	4.25
BOS	#2	BS_B2_5J	1997	1997.444	3.444444	NA	2.18	0.13	4.30
BOS	#2	BS_B2_6J	1997	1997.407	3.407407	NA	2.26	0.21	4.42
BOS	#2	BS_B2_7J	1997	1997.37	3.37037	NA	2.12	0.07	4.33
BOS	#2	BS_B2_8J	1997	1997.333	3.333333	NA	2.33	0.27	4.38
BOS	#2	BS_B2_9J	1997	1997.296	3.296296	NA	2.34	0.28	4.27
BOS	#2	BS_B2_10J	1997	1997.259	3.259259	NA	2.31	0.25	4.33
BOS	#2	BS_B2_1K	1997	1997.222	3.222222	NA	2.39	0.33	4.43
BOS	#2	BS_B2_2K	1997	1997.185	3.185185	NA	2.26	0.20	4.22
BOS	#2	BS_B2_3K	1997	1997.148	3.148148	NA	2.26	0.19	4.29
BOS	#2	BS_B2_4K	1997	1997.111	3.111111	NA	2.28	0.21	4.29
BOS	#2	BS_B2_5K	1997	1997.074	3.074074	NA	2.59	0.51	4.16
BOS	#2	BS_B2_6K	1997	1997.037	3.037037	NA	2.50	0.42	4.06
BOS	#2	NA	1997	1997	3	NA	NA	NA	NA
BOS	#3	BS_B3_1A		NA	NA	NA	1.03	NA	3.70
BOS	#3	BS_B3_2A		NA	NA	NA	1.11	NA	3.83
BOS	#3	BS_B3_3A		NA	NA	NA	1.04	NA	3.62
BOS	#3	BS_B3_4A		NA	NA	NA	0.95	NA	3.79
BOS	#3	BS_B3_5A		NA	NA	NA	0.87	NA	3.64
BOS	#3	BS_B3_6A		NA	NA	NA	1.45	NA	3.75

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#3	BS_B3_2B		NA	NA	NA	1.29	NA	3.90
BOS	#3	BS_B3_3B		NA	NA	NA	0.90	NA	3.83
BOS	#3	BS_B3_4B		NA	NA	NA	1.02	NA	3.75
BOS	#3	BS_B3_5B		NA	NA	NA	1.06	NA	3.79
BOS	#3	BS_B3_6B		NA	NA	NA	1.27	NA	3.86
BOS	#3	BS_B3_7B		NA	NA	NA	1.37	NA	4.22
BOS	#3	BS_B3_1C		NA	NA	NA	1.33	NA	4.28
BOS	#3	BS_B3_2C		NA	NA	NA	1.50	NA	4.23
BOS	#3	BS_B3_3C		NA	NA	NA	1.53	NA	4.31
BOS	#3	BS_B3_4C		NA	NA	NA	1.36	NA	4.04
BOS	#3	BS_B3_5C		NA	NA	NA	1.63	NA	4.37
BOS	#3	BS_B3_6C		NA	NA	NA	1.80	NA	4.41
BOS	#3	BS_B3_7C		NA	NA	NA	1.83	NA	4.43
BOS	#3	BS_B3_8C		NA	NA	NA	1.76	NA	4.34
BOS	#3	BS_B3_9C		NA	NA	NA	1.70	NA	4.47
BOS	#3	BS_B3_1D		NA	NA	NA	1.67	NA	4.23
BOS	#3	BS_B3_2D		NA	NA	NA	1.75	NA	4.23
BOS	#3	BS_B3_3D		NA	NA	NA	1.68	NA	4.06
BOS	#3	BS_B3_4D		NA	NA	NA	1.64	NA	4.32
BOS	#3	BS_B3_5D		NA	NA	NA	1.75	NA	4.06
BOS	#3	BS_B3_6D		NA	NA	NA	1.79	NA	4.26
BOS	#3	BS_B3_7D		NA	NA	NA	1.68	NA	4.31
BOS	#3	BS_B3_8D		NA	NA	NA	1.81	NA	4.39
BOS	#3	BS_B3_9D		NA	NA	NA	1.77	NA	4.35
BOS	#3	BS_B3_10D		NA	NA	NA	1.97	NA	4.48
BOS	#3	BS_B3_1E		NA	NA	NA	1.81	NA	4.39
BOS	#3	BS_B3_2E		NA	NA	NA	1.90	NA	4.49

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#3	BS_B3_3E		NA	NA	NA	1.99	NA	4.64
BOS	#3	BS_B3_4E		NA	NA	NA	1.93	NA	4.55
BOS	#3	BS_B3_5E		NA	NA	NA	2.09	NA	4.75
BOS	#3	BS_B3_6E		NA	NA	NA	2.08	NA	4.71
BOS	#3	BS_B3_7E		NA	NA	NA	2.03	NA	4.70
BOS	#3	BS_B3_8E		NA	NA	NA	2.05	NA	4.64
BOS	#3	BS_B3_9E		NA	NA	NA	1.97	NA	4.52
BOS	#3	BS_B3_10E		NA	NA	NA	2.01	NA	4.53
BOS	#3	BS_B3_1F		NA	NA	NA	2.10	NA	4.47
BOS	#3	BS_B3_2F		NA	NA	NA	2.17	NA	4.60
BOS	#3	BS_B3_3F		NA	NA	NA	2.18	NA	4.56
BOS	#3	BS_B3_4F		NA	NA	NA	2.26	NA	4.59
BOS	#3	BS_B3_5F		NA	NA	NA	2.25	NA	4.66
BOS	#3	BS_B3_6F		NA	NA	NA	2.22	NA	4.56
BOS	#3	BS_B3_7F		NA	NA	NA	2.30	NA	4.53
BOS	#3	BS_B3_1G		NA	NA	NA	2.23	NA	4.44
BOS	#3	BS_B3_2G		NA	NA	NA	2.25	NA	4.51
BOS	#3	BS_B3_3F_uncertain		NA	NA	NA	2.28	NA	4.46
BOS	#3	BS_B3_4G		NA	NA	NA	2.36	NA	4.42
BOS	#3	BS_B3_5G		NA	NA	NA	2.36	NA	4.45
BOS	#3	BS_B3_6G		NA	NA	NA	2.44	NA	4.55
BOS	#3	BS_B3_7G		NA	NA	NA	2.40	NA	4.55
BOS	#3	BS_B3_8G		NA	NA	NA	2.36	NA	4.62
BOS	#3	BS_B3_9G		NA	NA	NA	2.46	NA	4.62
BOS	#3	BS_B3_1H		NA	NA	NA	2.46	NA	4.49
BOS	#3	BS_B3_2H		NA	NA	NA	2.28	NA	4.53

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#3	BS_B3_3H		NA	NA	NA	2.56	NA	4.62
BOS	#3	BS_B3_4H		NA	NA	NA	2.62	NA	4.64
BOS	#3	BS_B3_5H		NA	NA	NA	2.70	NA	4.73
BOS	#3	BS_B3_6H		NA	NA	NA	2.66	NA	4.61
BOS	#3	BS_B3_7H		NA	NA	NA	2.73	NA	4.69
BOS	#3	BS_B3_8H		NA	NA	NA	2.68	NA	4.57
BOS	#3	BS_B3_3I_uncertain		NA	NA	NA	NA	NA	NA
BOS	#3	BS_B3_1I		NA	NA	NA	2.74	NA	4.66
BOS	#3	BS_B3_2I		NA	NA	NA	2.80	NA	4.69
BOS	#3	BS_B3_3I		NA	NA	NA	2.76	NA	4.63
BOS	#3	BS_B3_4I		NA	NA	NA	2.70	NA	4.58
BOS	#3	BS_B3_5I		NA	NA	NA	2.82	NA	4.63
BOS	#3	BS_B3_6I		NA	NA	NA	2.82	NA	4.71
BOS	#3	BS_B3_1J		NA	NA	NA	2.79	NA	4.54
BOS	#3	BS_B3_2J		NA	NA	NA	2.94	NA	4.50
BOS	#3	BS_B3_3J		NA	NA	NA	3.00	NA	4.40
BOS	#3	BS_B3_4J		NA	NA	NA	3.09	NA	4.49
BOS	#3	BS_B3_5J		NA	NA	NA	3.10	NA	4.56
BOS	#3	BS_B3_6J		NA	NA	NA	3.09	NA	4.58
BOS	#3	BS_B3_7J		NA	NA	NA	2.95	NA	4.64
BOS	#3	BS_B3_8J		NA	NA	NA	3.00	NA	4.54
BOS	#3	BS_B3_9J		NA	NA	NA	2.98	NA	4.59
BOS	#3	BS_B3_1K		NA	NA	NA	3.00	NA	4.59
BOS	#3	BS_B3_2K		NA	NA	NA	3.05	NA	4.55
BOS	#3	BS_B3_3K		NA	NA	NA	3.12	NA	4.59
BOS	#3	BS_B3_4K		NA	NA	NA	3.35	NA	4.62

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
BOS	#3	BS_B3_5K		NA	NA	NA	3.35	NA	4.44
BOS	#3	BS_B3_6K		NA	NA	NA	3.40	NA	4.48
BOS	#3	BS_B3_7K		NA	NA	NA	3.42	NA	4.34
BOS	#3	BS_B3_8K		NA	NA	NA	3.52	NA	4.34
BOS	#3	BS_B3_9K		NA	NA	NA	3.29	NA	4.28
BOS	#3	BS_B3_10K		NA	NA	NA	2.92	NA	4.56
BOS	#3	BS_B3_1L		NA	NA	NA	2.82	NA	4.64
BOS	#3	BS_B3_2L		NA	NA	NA	2.69	NA	4.60
BOS	#3	BS_B3_3L		NA	NA	NA	2.93	NA	4.79
EC	#1	EC_B1_1A	2008	2008.5	14.5	NA	1.33	0.42	3.81
EC	#1	EC_B1_2A	2008	2008	14	NA	1.37	0.38	3.88
EC	#1	EC_B1_3A	2007	2007.75	13.75	NA	1.46	0.43	3.89
EC	#1	EC_B1_4A	2007	2007.5	13.5	NA	1.41	0.34	3.79
EC	#1	EC_B1_5A	2007	2007.25	13.25	NA	1.49	0.37	3.65
EC	#1	NA	2007	2007	13	NA	NA	NA	NA
EC	#1	EC_B1_6A	2006	2006.8	12.8	NA	1.54	0.35	3.79
EC	#1	EC_B1_7A	2006	2006.6	12.6	NA	1.50	0.28	3.95
EC	#1	EC_B1_8A	2006	2006.4	12.4	NA	1.45	0.20	3.92
EC	#1	EC_B1_9A	2006	2006.2	12.2	NA	1.34	0.06	3.82
EC	#1	EC_B1_10A	2006	2006	12	NA	1.30	-0.02	3.92
EC	#1	EC_B1_1B	2005	2005.88	11.88	NA	NA	NA	NA
EC	#1	EC_B1_2B	2005	2005.77	11.77	NA	1.24	-0.11	3.87
EC	#1	EC_B1_4B	2005	2005.66	11.66	NA	1.51	0.15	4.02
EC	#1	EC_B1_5B	2005	2005.55	11.55	NA	1.47	0.09	3.94
EC	#1	EC_B1_6B	2005	2005.44	11.44	NA	1.42	0.02	3.93
EC	#1	EC_B1_7B	2005	2005.33	11.33	NA	1.43	0.01	4.12
EC	#1	EC_B1_8B	2005	2005.22	11.22	NA	1.41	-0.02	3.60

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#1	EC_B1_9B	2005	2005.11	11.11	NA	1.53	0.07	3.86
EC	#1	EC_B1_10B	2005	2005	11	NA	1.41	-0.06	3.90
EC	#1	EC_B1_1C	2004	2004.88	10.88	NA	1.28	-0.21	3.79
EC	#1	EC_B1_2C	2004	2004.77	10.77	NA	1.41	-0.10	3.98
EC	#1	EC_B1_3C	2004	2004.66	10.66	NA	1.47	-0.05	4.13
EC	#1	EC_B1_4C	2004	2004.55	10.55	NA	1.38	-0.16	3.98
EC	#1	EC_B1_5C	2004	2004.44	10.44	NA	NA	NA	NA
EC	#1	EC_B1_6C	2004	2004.33	10.33	NA	1.46	-0.11	3.99
EC	#1	EC_B1_7C	2004	2004.22	10.22	NA	1.32	-0.27	3.89
EC	#1	EC_B1_8C	2004	2004.11	10.11	NA	1.40	-0.22	4.13
EC	#1	EC_B1_1D	2003	2004	10	NA	1.35	-0.27	3.77
EC	#1	EC_B1_2D	2003	2003.88	9.88	NA	1.37	-0.28	3.71
EC	#1	EC_B1_3D	2003	2003.77	9.77	NA	1.40	-0.26	3.93
EC	#1	EC_B1_4D	2003	2003.66	9.66	NA	1.41	-0.27	3.92
EC	#1	EC_B1_5D	2003	2003.55	9.55	NA	1.37	-0.33	3.83
EC	#1	EC_B1_6D	2003	2003.44	9.44	NA	1.46	-0.26	3.73
EC	#1	EC_B1_7D	2003	2003.33	9.33	NA	1.63	-0.11	3.82
EC	#1	EC_B1_8D	2003	2003.22	9.22	NA	1.68	-0.07	4.02
EC	#1	EC_B1_9D	2003	2003.11	9.11	NA	1.67	-0.10	3.76
EC	#1	EC_B1_10D	2003	2003	9	NA	1.54	-0.25	3.82
EC	#1	EC_B1_1E	2002	2002.88	8.88	NA	1.67	-0.13	4.00
EC	#1	EC_B1_2E	2002	2002.77	8.77	NA	1.74	-0.09	4.15
EC	#1	EC_B1_3E	2002	2002.66	8.66	NA	1.81	-0.03	4.28
EC	#1	EC_B1_4E	2002	2002.55	8.55	NA	1.72	-0.14	4.09
EC	#1	EC_B1_5E	2002	2002.44	8.44	NA	1.84	-0.03	4.31
EC	#1	EC_B1_6E	2002	2002.33	8.33	NA	1.86	-0.03	4.25
EC	#1	EC_B1_7E	2002	2002.22	8.22	NA	1.90	-0.01	4.41

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#1	EC_B1_8E	2002	2002.11	8.11	NA	1.88	-0.05	4.23
EC	#1	EC_B1_9E	2002	2002	8	NA	1.79	-0.16	4.12
EC	#1	EC_B1_1F	2001	2001.85	7.85	NA	1.56	-0.41	3.81
EC	#1	EC_B1_2F	2001	2001.71	7.71	NA	1.75	-0.24	3.84
EC	#1	EC_B1_3F	2001	2001.57	7.57	NA	1.69	-0.32	3.92
EC	#1	EC_B1_4F	2001	2001.43	7.43	NA	1.78	-0.26	3.99
EC	#1	EC_B1_5F	2001	2001.28	7.28	NA	1.52	-0.54	3.96
EC	#1	EC_B1_6F	2001	2001.14	7.14	NA	1.45	-0.63	3.86
EC	#1	EC_B1_1G	2001	2001	7	NA	1.67	-0.43	4.14
EC	#1	EC_B1_2G	2000	2000.941	6.941176	NA	1.84	-0.27	4.32
EC	#1	EC_B1_3G	2000	2000.882	6.882353	NA	1.92	-0.20	4.36
EC	#1	EC_B1_4G	2000	2000.824	6.823529	NA	1.87	-0.26	4.34
EC	#1	EC_B1_5G	2000	2000.765	6.764706	NA	2.00	-0.14	4.40
EC	#1	EC_B1_6G	2000	2000.706	6.705882	NA	1.99	-0.16	4.33
EC	#1	EC_B1_7G	2000	2000.647	6.647059	NA	1.94	-0.22	4.46
EC	#1	EC_B1_8G	2000	2000.588	6.588235	NA	1.95	-0.21	4.38
EC	#1	EC_B1_9G	2000	2000.529	6.529412	NA	2.00	-0.18	4.38
EC	#1	EC_B1_1H	2000	2000.471	6.470588	NA	2.18	-0.01	4.57
EC	#1	EC_B1_2H	2000	2000.412	6.411765	NA	2.39	0.20	NA
EC	#1	EC_B1_3H	2000	2000.353	6.352941	NA	2.23	0.02	4.68
EC	#1	EC_B1_4H	2000	2000.294	6.294118	NA	2.41	0.20	4.67
EC	#1	EC_B1_5H	2000	2000.235	6.235294	NA	2.44	0.21	NA
EC	#1	EC_B1_6H	2000	2000.176	6.176471	NA	2.66	0.43	NA
EC	#1	EC_B1_7H	2000	2000.118	6.117647	NA	2.50	0.26	NA
EC	#1	EC_B1_8H	2000	2000.059	6.058824	NA	2.50	0.25	4.69
EC	#1	NA	2000	2000	6	NA	NA	NA	NA
EC	#1	EC_B1_1I	1999	1999.923	5.923077	NA	2.58	0.31	NA

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#1	EC_B1_2I	1999	1999.846	5.846154	NA	2.32	0.04	NA
EC	#1	EC_B1_3I	1999	1999.769	5.769231	NA	2.38	0.08	NA
EC	#1	EC_B1_4I	1999	1999.692	5.692308	NA	NA	NA	NA
EC	#1	EC_B1_5I	1999	1999.615	5.615385	NA	2.38	0.06	4.59
EC	#1	EC_B1_6I	1999	1999.538	5.538462	NA	2.51	0.18	4.61
EC	#1	EC_B1_7I	1999	1999.462	5.461538	NA	2.53	0.18	4.43
EC	#1	EC_B1_8I	1999	1999.385	5.384615	NA	2.83	0.47	4.51
EC	#1	EC_B1_9I	1999	1999.308	5.307692	NA	2.90	0.53	4.56
EC	#1	EC_B1_10I	1999	1999.231	5.230769	NA	2.95	0.56	4.63
EC	#1	EC_B1_1J	1999	1999.154	5.153846	NA	2.86	0.47	4.57
EC	#1	EC_B1_2J	1999	1999.077	5.076923	NA	2.90	0.49	4.56
EC	#1	EC_B1_3J	1999	1999	5	NA	2.99	0.57	4.64
EC	#1	EC_B1_4J	1998	1998.833	4.833333	NA	2.84	0.39	4.61
EC	#1	EC_B1_5J	1998	1998.667	4.666667	NA	2.24	-0.23	4.68
EC	#1	EC_B1_6J	1998	1998.5	4.5	NA	2.53	0.03	4.68
EC	#1	EC_B1_7J	1998	1998.333	4.333333	NA	2.84	0.32	4.67
EC	#1	EC_B1_8J	1998	1998.167	4.166667	NA	2.70	0.14	4.52
EC	#1	EC_B1_9J	1998	1998	4	NA	3.00	0.42	4.46
EC	#1	EC_B1_10J	1997	1997.9	3.9	NA	1.53	-1.06	4.49
EC	#2	EC_B2_1A	2004	2004.85	11.85	NA	1.66	0.09	3.77
EC	#2	EC_B2_2A	2004	2004.71	11.71	NA	1.53	-0.06	3.86
EC	#2	EC_B2_3A	2004	2004.57	11.57	NA	1.84	0.23	4.05
EC	#2	EC_B2_4A	2004	2004.43	11.43	NA	1.75	0.12	4.20
EC	#2	EC_B2_6A	2004	2004.02	11.02	NA	1.78	0.09	4.10
EC	#2	EC_B2_7A	2004	2004	11	NA	NA	NA	NA
EC	#2	EC_B2_5A	2004	1994.28	1.28	NA	1.68	-1.48	4.15
EC	#2	EC_B2_1B	2003	2003.909	10.90909	wide	1.80	0.09	3.87

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#2	EC_B2_2B	2003	2003.818	10.81818	wide	1.72	0.00	3.81
EC	#2	EC_B2_3B	2003	2003.727	10.72727	wide	1.67	-0.07	4.00
EC	#2	EC_B2_4B	2003	2003.636	10.63636	narrow	1.62	-0.13	3.88
EC	#2	EC_B2_5B	2003	2003.545	10.54545	narrow	1.79	0.03	4.03
EC	#2	EC_B2_6B	2003	2003.455	10.45455	narrow	1.69	-0.09	4.18
EC	#2	EC_B2_7B	2003	2003.364	10.36364	narrow	1.72	-0.07	4.20
EC	#2	EC_B2_8B	2003	2003.273	10.27273	narrow	1.67	-0.13	4.12
EC	#2	EC_B2_1C	2003	2003.182	10.18182	narrow	1.83	0.01	4.19
EC	#2	EC_B2_2C	2003	2003.091	10.09091	wide	1.84	0.01	4.15
EC	#2	EC_B2_3C	2003	2003.02	10.02	wide	1.91	0.07	4.12
EC	#2	EC_B2_4C	2003	2003	10	wide	1.85	0.00	4.13
EC	#2	EC_B2_5C	2002	2002.85	9.85	wide	1.86	0.00	4.32
EC	#2	EC_B2_6C	2002	2002.71	9.71	wide	1.93	0.04	4.31
EC	#2	EC_B2_7C	2002	2002.57	9.57	wide	1.90	-0.01	4.31
EC	#2	EC_B2_8C	2002	2002.43	9.43	narrow	1.84	-0.09	4.27
EC	#2	EC_B2_9C	2002	2002.28	9.28	narrow	1.94	-0.01	4.32
EC	#2	EC_B2_10C	2002	2002.14	9.14	narrow	1.87	-0.10	4.18
EC	#2	NA	2002	2002	9	NA	NA	NA	NA
EC	#2	EC_B2_1D	2001	2001.85	8.85	narrow	1.94	-0.08	4.36
EC	#2	EC_B2_2D	2001	2001.71	8.71	narrow	1.86	-0.19	4.22
EC	#2	EC_B2_3D	2001	2001.57	8.57	narrow	2.02	-0.04	4.34
EC	#2	EC_B2_4D	2001	2001.43	8.43	narrow	1.98	-0.11	4.27
EC	#2	EC_B2_5D	2001	2001.28	8.28	narrow	2.10	-0.01	4.49
EC	#2	EC_B2_6D	2001	2001.14	8.14	narrow	1.99	-0.14	4.37
EC	#2	EC_B2_1E	2001	2001	8	wide	2.01	-0.14	4.52
EC	#2	EC_B2_2E	2000	2000.947	7.947368	wide	2.02	-0.14	4.49
EC	#2	EC_B2_3E	2000	2000.895	7.894737	wide	1.95	-0.22	4.42

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#2	EC_B2_4E	2000	2000.842	7.842105	wide	2.04	-0.14	4.36
EC	#2	EC_B2_5E	2000	2000.789	7.789474	wide	2.07	-0.11	4.53
EC	#2	EC_B2_6E	2000	2000.737	7.736842	wide	2.04	-0.15	4.48
EC	#2	EC_B2_7E	2000	2000.684	7.684211	wide	2.06	-0.13	4.43
EC	#2	EC_B2_8E	2000	2000.632	7.631579	narrow	2.21	0.00	4.73
EC	#2	EC_B2_9E	2000	2000.579	7.578947	narrow	2.07	-0.15	4.53
EC	#2	EC_B2_10E	2000	2000.526	7.526316	narrow	2.01	-0.21	4.51
EC	#2	EC_B2_1F	2000	2000.474	7.473684	narrow	2.06	-0.17	4.41
EC	#2	EC_B2_2F	2000	2000.421	7.421053	narrow	2.05	-0.19	4.40
EC	#2	EC_B2_3F	2000	2000.368	7.368421	narrow	2.07	-0.17	4.44
EC	#2	EC_B2_4F	2000	2000.316	7.315789	narrow	2.05	-0.20	4.40
EC	#2	EC_B2_5F	2000	2000.263	7.263158	narrow	2.32	0.06	4.62
EC	#2	EC_B2_6F	2000	2000.211	7.210526	narrow	2.17	-0.09	4.46
EC	#2	EC_B2_7F	2000	2000.158	7.157895	narrow	2.08	-0.20	4.31
EC	#2	EC_B2_8F	2000	2000.105	7.105263	narrow	2.48	0.19	4.68
EC	#2	EC_B2_9F	2000	2000.053	7.052632	narrow	2.17	-0.12	4.29
EC	#2	EC_B2_10F	2000	2000	7	narrow	2.34	0.04	4.52
EC	#2	EC_B2_1G	1999	1999.95	6.95	narrow	2.02	-0.28	4.24
EC	#2	EC_B2_2G	1999	1999.9	6.9	narrow	1.95	-0.37	4.18
EC	#2	EC_B2_3G	1999	1999.85	6.85	narrow	2.28	-0.04	4.47
EC	#2	EC_B2_4G	1999	1999.8	6.8	narrow	2.14	-0.19	4.27
EC	#2	EC_B2_5G	1999	1999.75	6.75	narrow	2.13	-0.21	4.28
EC	#2	EC_B2_6G	1999	1999.7	6.7	narrow	2.43	0.08	4.52
EC	#2	EC_B2_7G	1999	1999.65	6.65	wide	2.41	0.05	4.60
EC	#2	EC_B2_8G	1999	1999.6	6.6	wide	2.25	-0.11	4.18
EC	#2	EC_B2_9G	1999	1999.55	6.55	wide	2.26	-0.11	4.30
EC	#2	EC_B2_10G	1999	1999.5	6.5	wide	2.20	-0.18	4.17

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#2	EC_B2_1H	1999	1999.45	6.45	wide	1.92	-0.47	4.21
EC	#2	EC_B2_2H	1999	1999.4	6.4	wide	2.47	0.08	4.34
EC	#2	EC_B2_3H	1999	1999.35	6.35	wide	2.42	0.02	4.21
EC	#2	EC_B2_4H	1999	1999.3	6.3	wide	2.52	0.11	4.27
EC	#2	EC_B2_5H	1999	1999.25	6.25	wide	2.39	-0.02	4.33
EC	#2	EC_B2_6H	1999	1999.2	6.2	wide	2.22	-0.20	4.33
EC	#2	EC_B2_7H	1999	1999.15	6.15	wide	2.14	-0.29	4.39
EC	#2	EC_B2_8H	1999	1999.1	6.1	wide	2.39	-0.05	4.32
EC	#2	EC_B2_9H	1999	1999.05	6.05	wide	2.67	0.23	4.41
EC	#2	EC_B2_1I	1999	1999	6	wide	2.50	0.05	4.54
EC	#2	EC_B2_2I	1998	1998.933	5.933333	wide	2.49	0.03	4.49
EC	#2	EC_B2_3I	1998	1998.867	5.866667	wide	2.79	0.32	4.48
EC	#2	EC_B2_4I	1998	1998.8	5.8	wide	2.46	-0.02	4.62
EC	#2	EC_B2_5I	1998	1998.733	5.733333	wide	2.53	0.04	4.54
EC	#2	EC_B2_6I	1998	1998.667	5.666667	wide	2.49	-0.01	4.59
EC	#2	EC_B2_7I	1998	1998.6	5.6	wide	2.48	-0.03	4.57
EC	#2	EC_B2_8I	1998	1998.533	5.533333	wide	2.60	0.08	4.51
EC	#2	EC_B2_9I	1998	1998.467	5.466667	wide	2.70	0.16	4.54
EC	#2	EC_B2_10I	1998	1998.4	5.4	wide	2.61	0.07	4.56
EC	#2	EC_B2_1J	1998	1998.333	5.333333	narrow	2.59	0.04	4.50
EC	#2	EC_B2_2J	1998	1998.267	5.266667	narrow	2.58	0.01	4.48
EC	#2	EC_B2_3J	1998	1998.2	5.2	narrow	2.68	0.11	4.63
EC	#2	EC_B2_4J	1998	1998.133	5.133333	narrow	2.71	0.12	4.57
EC	#2	EC_B2_5J	1998	1998.067	5.066667	narrow	2.80	0.21	4.61
EC	#2	NA	1998	1998	5	NA	NA	NA	NA
EC	#2	EC_B2_6J	1997	1997.933	4.933333	narrow	2.96	0.35	4.41
EC	#2	EC_B2_7J	1997	1997.867	4.866667	narrow	3.01	0.39	4.35

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#2	EC_B2_8J	1997	1997.8	4.8	narrow	2.99	0.36	4.29
EC	#2	EC_B2_9J	1997	1997.733	4.733333	narrow	3.07	0.43	4.34
EC	#2	EC_B2_10J	1997	1997.667	4.666667	narrow	3.03	0.37	4.17
EC	#2	EC_B2_1K	1997	1997.6	4.6	narrow	3.01	0.34	4.14
EC	#2	EC_B2_2K	1997	1997.533	4.533333	wide	3.00	0.33	3.99
EC	#2	EC_B2_3K	1997	1997.467	4.466667	wide	3.00	0.31	4.15
EC	#2	EC_B2_4K	1997	1997.4	4.4	wide	3.05	0.35	4.11
EC	#2	EC_B2_5K	1997	1997.333	4.333333	wide	3.02	0.32	4.16
EC	#2	EC_B2_6K	1997	1997.267	4.266667	wide	2.95	0.24	4.01
EC	#2	EC_B2_7K	1997	1997.2	4.2	wide	2.97	0.25	4.19
EC	#2	EC_B2_8K	1997	1997.133	4.133333	wide	2.94	0.20	4.12
EC	#2	EC_B2_9K	1997	1997.067	4.066667	wide	2.93	0.19	4.22
EC	#2	EC_B2_10K	1997	1997	4	wide	2.91	0.16	4.13
EC	#2	EC_B2_1L	1996	1996.95	3.95	narrow	2.99	0.23	4.21
EC	#2	EC_B2_2L	1996	1996.9	3.9	narrow	2.97	0.20	4.17
EC	#2	EC_B2_3L	1996	1996.85	3.85	narrow	2.98	0.21	4.20
EC	#2	EC_B2_4L	1996	1996.8	3.8	narrow	3.06	0.28	4.40
EC	#2	EC_B2_5L	1996	1996.75	3.75	narrow	2.96	0.16	4.33
EC	#2	EC_B2_6L	1996	1996.7	3.7	narrow	2.86	0.06	4.35
EC	#2	EC_B2_7L	1996	1996.65	3.65	narrow	2.96	0.15	4.43
EC	#2	EC_B2_8L	1996	1996.6	3.6	narrow	2.89	0.08	4.50
EC	#2	EC_B2_9L	1996	1996.55	3.55	narrow	2.97	0.15	4.51
EC	#2	EC_B2_10L	1996	1996.5	3.5	narrow	3.10	0.27	4.46
EC	#2	EC_B2_1M	1996	1996.45	3.45	narrow	2.99	0.15	4.49
EC	#2	EC_B2_2M	1996	1996.4	3.4	narrow	2.85	0.01	4.46
EC	#2	EC_B2_3M	1996	1996.35	3.35	narrow	2.92	0.07	4.53
EC	#2	EC_B2_4M	1996	1996.3	3.3	narrow	2.77	-0.09	4.35

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#2	EC_B2_5M	1996	1996.25	3.25	narrow	3.11	0.24	4.44
EC	#2	EC_B2_6M	1996	1996.2	3.2	wide	3.26	0.38	4.48
EC	#2	EC_B2_7M	1996	1996.15	3.15	wide	3.28	0.40	4.48
EC	#2	EC_B2_8M	1996	1996.1	3.1	wide	3.37	0.48	4.38
EC	#2	EC_B2_9M	1996	1996.05	3.05	wide	3.33	0.43	4.37
EC	#2	EC_B2_10M	1996	1996	3	wide	3.31	0.40	4.32
EC	#2	EC_B2_1N	1995	1995.8	2.8	narrow	3.16	0.23	4.42
EC	#2	EC_B2_2N	1995	1995.6	2.6	narrow	2.75	-0.22	4.60
EC	#2	EC_B2_3N	1995	1995.4	2.4	wide	2.81	-0.19	4.45
EC	#2	EC_B2_4N	1995	1995.2	2.2	narrow	2.97	-0.06	4.42
EC	#2	EC_B2_5N	1995	1995	2	narrow	2.69	-0.36	4.36
EC	#2	EC_B2_6N	1994	1994.833	1.833333	narrow	2.42	-0.66	4.47
EC	#2	EC_B2_7N	1994	1994.667	1.666667	wide	2.47	-0.64	4.42
EC	#2	EC_B2_8N	1994	1994.5	1.5	wide	2.62	-0.51	4.27
EC	#2	EC_B2_9N	1994	1994.333	1.333333	wide	2.59	-0.57	4.48
EC	#2	EC_B2_10N	1994	1994.167	1.166667	wide	2.30	-0.88	4.61
EC	#3	EC_B_3_1A		NA	NA	NA	1.18	NA	3.71
EC	#3	EC_B_3_2A		NA	NA	NA	1.06	NA	3.61
EC	#3	EC_B_3_3A		NA	NA	NA	1.64	NA	3.91
EC	#3	EC_B_3_4A		NA	NA	NA	2.16	NA	4.25
EC	#3	EC_B_3_5A		NA	NA	NA	1.28	NA	3.95
EC	#3	EC_B3_6A		NA	NA	NA	1.07	NA	3.74
EC	#3	EC_B3_1B		NA	NA	NA	1.23	NA	3.74
EC	#3	EC_B3_2B		NA	NA	NA	1.07	NA	3.88
EC	#3	EC_B3_3B		NA	NA	NA	1.20	NA	3.97
EC	#3	EC_B3_4B		NA	NA	NA	1.02	NA	3.69
EC	#3	EC_B3_5B		NA	NA	NA	1.27	NA	3.78

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#3	EC_B3_6B		NA	NA	NA	1.24	NA	3.82
EC	#3	EC_B3_7B		NA	NA	NA	1.43	NA	4.06
EC	#3	EC_B3_8B		NA	NA	NA	1.64	NA	4.00
EC	#3	EC_B3_9B		NA	NA	NA	1.56	NA	3.91
EC	#3	EC_B3_10B		NA	NA	NA	1.60	NA	4.14
EC	#3	EC_B3_11B		NA	NA	NA	1.61	NA	3.98
EC	#3	EC_B3_1C		NA	NA	NA	1.29	NA	3.82
EC	#3	EC_B3_2C		NA	NA	NA	1.40	NA	3.84
EC	#3	EC_B3_3C		NA	NA	NA	1.31	NA	3.90
EC	#3	EC_B3_4C		NA	NA	NA	1.33	NA	3.82
EC	#3	EC_B3_5C		NA	NA	NA	1.25	NA	4.13
EC	#3	EC_B3_6C		NA	NA	NA	1.64	NA	4.11
EC	#3	EC_B3_7C		NA	NA	NA	1.86	NA	4.20
EC	#3	EC_B3_8C		NA	NA	NA	1.93	NA	4.19
EC	#3	EC_B3_9C		NA	NA	NA	1.80	NA	4.12
EC	#3	EC_B3_10C		NA	NA	NA	1.86	NA	4.13
EC	#3	EC_B3_11C		NA	NA	NA	1.89	NA	4.18
EC	#3	EC_B3_12C		NA	NA	NA	1.65	NA	3.99
EC	#3	EC_B3_13C		NA	NA	NA	1.79	NA	4.00
EC	#3	EC_B3_1D		NA	NA	NA	1.85	NA	3.89
EC	#3	EC_B3_2D		NA	NA	NA	1.74	NA	3.68
EC	#3	EC_B3_3D		NA	NA	NA	1.92	NA	3.98
EC	#3	EC_B3_4D		NA	NA	NA	1.97	NA	4.16
EC	#3	EC_B3_5D		NA	NA	NA	1.99	NA	4.21
EC	#3	EC_B3_6D		NA	NA	NA	2.00	NA	4.14
EC	#3	EC_B3_7D		NA	NA	NA	1.29	NA	4.12
EC	#3	EC_B3_8D		NA	NA	NA	1.69	NA	4.29

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#3	EC_B3_9D		NA	NA	NA	1.78	NA	4.03
EC	#3	EC_B3_10D		NA	NA	NA	1.82	NA	4.16
EC	#3	EC_B3_1E		NA	NA	NA	1.99	NA	4.04
EC	#3	EC_B3_2E		NA	NA	NA	1.89	NA	3.79
EC	#3	EC_B3_3E		NA	NA	NA	1.99	NA	4.21
EC	#3	EC_B3_4E		NA	NA	NA	1.92	NA	3.86
EC	#3	EC_B3_5E		NA	NA	NA	1.89	NA	4.21
EC	#3	EC_B3_6E		NA	NA	NA	2.02	NA	4.28
EC	#3	EC_B3_7E		NA	NA	NA	1.38	NA	4.10
EC	#3	EC_B3_8E		NA	NA	NA	1.89	NA	4.12
EC	#3	EC_B3_9E		NA	NA	NA	1.81	NA	4.22
EC	#3	EC_B3_10E		NA	NA	NA	1.52	NA	4.13
EC	#3	EC_B3_1F		NA	NA	NA	1.72	NA	3.89
EC	#3	EC_B3_2F		NA	NA	NA	1.83	NA	4.07
EC	#3	EC_B3_3F		NA	NA	NA	1.41	NA	3.85
EC	#3	EC_B3_4F		NA	NA	NA	1.70	NA	4.25
EC	#3	EC_B3_5F		NA	NA	NA	1.86	NA	4.08
EC	#3	EC_B3_6F		NA	NA	NA	1.84	NA	4.34
EC	#3	EC_B3_1G		NA	NA	NA	1.94	NA	4.19
EC	#3	EC_B3_2G		NA	NA	NA	1.91	NA	4.19
EC	#3	EC_B3_3G		NA	NA	NA	1.92	NA	4.22
EC	#3	EC_B3_4G		NA	NA	NA	1.97	NA	4.33
EC	#3	EC_B3_5G		NA	NA	NA	1.95	NA	4.36
EC	#3	EC_B3_6G		NA	NA	NA	1.95	NA	4.45
EC	#3	EC_B3_7G		NA	NA	NA	1.96	NA	4.40
EC	#3	EC_B3_8G		NA	NA	NA	2.08	NA	4.28
EC	#3	EC_B3_9G		NA	NA	NA	2.04	NA	4.39

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#3	EC_B3_10G		NA	NA	NA	2.03	NA	4.31
EC	#3	EC_B3_1H		NA	NA	NA	1.97	NA	4.19
EC	#3	EC_B3_2H		NA	NA	NA	2.06	NA	4.31
EC	#3	EC_B3_3H		NA	NA	NA	2.03	NA	4.25
EC	#3	EC_B3_4H		NA	NA	NA	1.88	NA	4.18
EC	#3	EC_B3_5H		NA	NA	NA	2.25	NA	4.22
EC	#3	EC_B3_6H		NA	NA	NA	1.57	NA	4.16
EC	#3	EC_B3_7H		NA	NA	NA	2.11	NA	4.09
EC	#3	EC_B3_8H		NA	NA	NA	2.06	NA	4.34
EC	#3	EC_B3_9H		NA	NA	NA	2.06	NA	4.32
EC	#3	EC_B3_10H		NA	NA	NA	2.13	NA	4.50
EC	#3	EC_B3_1I		NA	NA	NA	2.08	NA	4.38
EC	#3	EC_B3_2I		NA	NA	NA	2.12	NA	4.28
EC	#3	EC_B3_3I		NA	NA	NA	2.19	NA	4.45
EC	#3	EC_B3_4I		NA	NA	NA	2.13	NA	4.36
EC	#3	EC_B3_5I		NA	NA	NA	2.12	NA	4.42
EC	#3	EC_B3_6I		NA	NA	NA	2.24	NA	4.58
EC	#3	EC_B3_7I		NA	NA	NA	2.23	NA	4.45
EC	#3	EC_B3_8I		NA	NA	NA	2.28	NA	4.41
EC	#3	EC_B3_9I		NA	NA	NA	2.38	NA	4.65
EC	#3	EC_B3_10I		NA	NA	NA	2.33	NA	4.33
EC	#3	EC_B3_11I		NA	NA	NA	2.31	NA	4.45
EC	#3	EC_B3_12I		NA	NA	NA	1.52	NA	4.17
EC	#3	EC_B3_13I		NA	NA	NA	1.98	NA	4.18
EC	#3	EC_B3_14I		NA	NA	NA	2.08	NA	4.59
EC	#3	EC_B3_15I		NA	NA	NA	2.07	NA	NA
EC	#3	EC_B3_16I		NA	NA	NA	2.27	NA	4.52

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#3	EC_B3_1J		NA	NA	NA	2.23	NA	4.45
EC	#3	EC_B3_2J		NA	NA	NA	2.20	NA	4.45
EC	#3	EC_B3_3J		NA	NA	NA	2.24	NA	4.51
EC	#3	EC_B3_4J		NA	NA	NA	2.18	NA	4.49
EC	#3	EC_B3_5J		NA	NA	NA	2.23	NA	4.47
EC	#3	EC_B3_6J		NA	NA	NA	2.30	NA	4.51
EC	#3	EC_B3_7J		NA	NA	NA	2.25	NA	4.50
EC	#3	EC_B3_8J		NA	NA	NA	2.02	NA	NA
EC	#3	EC_B3_9J		NA	NA	NA	2.50	NA	4.52
EC	#3	EC_B3_10J		NA	NA	NA	2.26	NA	4.51
EC	#3	EC_B3_11J		NA	NA	NA	2.43	NA	4.60
EC	#3	EC_B3_1K		NA	NA	NA	2.29	NA	4.45
EC	#3	EC_B3_2K		NA	NA	NA	2.11	NA	NA
EC	#3	EC_B3_3K		NA	NA	NA	2.41	NA	4.45
EC	#3	EC_B3_4K		NA	NA	NA	2.27	NA	4.78
EC	#3	EC_B3_5K		NA	NA	NA	2.50	NA	4.49
EC	#3	EC_B3_6K		NA	NA	NA	2.55	NA	4.59
EC	#3	EC_B3_7K		NA	NA	NA	1.29	NA	NA
EC	#3	EC_B3_8K		NA	NA	NA	2.47	NA	4.57
EC	#3	EC_B3_1L		NA	NA	NA	2.34	NA	4.29
EC	#3	EC_B3_2L		NA	NA	NA	2.54	NA	4.52
EC	#3	EC_B3_3L		NA	NA	NA	2.48	NA	4.40
EC	#3	EC_B3_4L		NA	NA	NA	2.59	NA	4.56
EC	#3	EC_B3_5L		NA	NA	NA	2.67	NA	4.53
EC	#3	EC_B3_6L		NA	NA	NA	2.65	NA	4.48
EC	#3	EC_B3_7L		NA	NA	NA	2.75	NA	4.37
EC	#3	EC_B3_8L		NA	NA	NA	2.65	NA	4.21

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#3	EC_B3_9L		NA	NA	NA	2.84	NA	4.23
EC	#3	EC_B3_10L		NA	NA	NA	2.75	NA	4.20
EC	#3	EC_B3_11L		NA	NA	NA	2.96	NA	4.25
EC	#3	EC_B3_12L		NA	NA	NA	2.74	NA	4.22
EC	#3	EC_B3_13L		NA	NA	NA	3.02	NA	4.25
EC	#3	EC_B3_1M		NA	NA	NA	3.09	NA	4.30
EC	#3	EC_B3_2M		NA	NA	NA	2.98	NA	4.31
EC	#3	EC_B3_3M		NA	NA	NA	2.88	NA	4.30
EC	#3	EC_B3_4M		NA	NA	NA	2.03	NA	4.46
EC	#3	EC_B3_5M		NA	NA	NA	3.00	NA	4.39
EC	#3	EC_B3_6M		NA	NA	NA	2.86	NA	4.39
EC	#3	EC_B3_7M		NA	NA	NA	2.86	NA	4.38
EC	#3	EC_B3_8M		NA	NA	NA	2.66	NA	4.35
EC	#3	EC_B3_9M		NA	NA	NA	2.72	NA	4.39
EC	#3	EC_B3_1N		NA	NA	NA	2.63	NA	4.32
EC	#3	EC_B3_2N		NA	NA	NA	2.72	NA	4.38
EC	#3	EC_B3_3N		NA	NA	NA	2.91	NA	4.32
EC	#3	EC_B3_4N		NA	NA	NA	2.70	NA	4.26
EC	#3	EC_B3_5N		NA	NA	NA	2.72	NA	4.24
EC	#3	EC_B3_6N		NA	NA	NA	2.81	NA	4.07
EC	#3	EC_B3_7N		NA	NA	NA	2.98	NA	4.37
EC	#3	EC_B3_8N		NA	NA	NA	2.82	NA	4.42
EC	#3	EC_B3_1O		NA	NA	NA	2.87	NA	4.23
EC	#3	EC_B3_2O		NA	NA	NA	2.93	NA	4.28
EC	#3	EC_B3_3O		NA	NA	NA	2.99	NA	4.35
EC	#3	EC_B3_4O		NA	NA	NA	3.05	NA	4.20
EC	#3	EC_B3_5O		NA	NA	NA	3.21	NA	4.13

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC	#3	EC_B3_6O		NA	NA	NA	3.24	NA	4.19
EC	#3	EC_B3_7O		NA	NA	NA	3.35	NA	4.06
EC	#3	EC_B3_8O		NA	NA	NA	3.38	NA	4.05
EC	#3	EC_B3_9O		NA	NA	NA	3.48	NA	4.14
EC	#3	EC_B3_10O		NA	NA	NA	3.45	NA	4.11
EC	#3	EC_B3_1P		NA	NA	NA	3.23	NA	4.17
EC	#3	EC_B3_2P		NA	NA	NA	2.85	NA	4.21
EC	#3	EC_B3_3P		NA	NA	NA	2.63	NA	4.16
EC	#3	EC_B3_4P		NA	NA	NA	2.47	NA	4.12
EC	#3	EC_B3_5P		NA	NA	NA	2.60	NA	4.06
EC	#3	EC_B3_6P		NA	NA	NA	2.88	NA	4.10
EC	#3	EC_B3_7P		NA	NA	NA	3.00	NA	4.20
EC	#3	EC_B3_8P		NA	NA	NA	2.63	NA	4.27
EC	#3	EC_B3_9P		NA	NA	NA	1.93	NA	4.24
EC	#3	EC_B3_10P		NA	NA	NA	1.96	NA	4.33
EC (Juv)	#1	EC_bby1_A1			NA	narrow	2.32	NA	3.85
EC (Juv)	#1	EC_bby1_A2			NA	narrow	2.39	NA	4.06
EC (Juv)	#1	EC_bby1_B1			NA	wide	2.47	NA	4.01
EC (Juv)	#1	EC_bby1_B2			NA	wide	2.55	NA	4.06
EC (Juv)	#1	EC_bby1_B3			NA	wide	2.71	NA	4.04
EC (Juv)	#1	EC_bby1_B4			NA	wide	2.87	NA	3.96
EC (Juv)	#1	EC_bby1_B5			NA	wide	2.76	NA	3.90
EC (Juv)	#1	EC_bby1_C1			NA	wide	3.05	NA	3.70

Site	Valve	Sample ID	Year	Year Plot	Ontogeny	Striae Type	$\delta^{13}C_{shell}$	$\delta^{13}C_{Detrended}$	$\delta^{18}O_{shell}$
EC (Juv)	#1	EC_bby1_C2			NA	narrow	2.71	NA	3.91
EC (Juv)	#2	EC_bby3_A1			NA	narrow	2.25	NA	4.02
EC (Juv)	#2	EC_bby3_A2			NA	narrow	2.36	NA	4.11
EC (Juv)	#2	EC_bby3_A3			NA	narrow	2.39	NA	4.07
EC (Juv)	#2	EC_bby3_B1			NA	wide	2.57	NA	4.05
EC (Juv)	#2	EC_bby3_B2			NA	wide	2.74	NA	4.09
EC (Juv)	#2	EC_bby3_B3			NA	wide	2.80	NA	4.06
EC (Juv)	#2	EC_bby3_B4			NA	wide	2.79	NA	3.89
EC (Juv)	#2	EC_bby3_B5			NA	wide	2.99	NA	3.87
EC (Juv)	#2	EC_bby3_C1			NA	wide	3.08	NA	3.99
EC (Juv)	#2	EC_bby3_C2			NA	wide	3.06	NA	3.92
EC (Juv)	#2	EC_bby3_D1			NA	narrow	2.81	NA	4.08
EC (Juv)	#2	EC_bby3_D2			NA	NA	2.33	NA	4.09

Part 3: R Code

```
# Load required packages
library(ggplot2)

# Load data
isotopes <- read.table("adamussiumStableIsotopesOfOxygenAndCarbon.csv",
header = TRUE, sep = ",")

# Detrend carbon and save the residuals as .csvs

## create linear regressions over ontogeny
regressionExplorersCove001 <- summary(lm(isotopes$d13C[isotopes$valve
==
"2008ExplorersCove001"]~isotopes$ontogenyCalendarCronin[isotopes$valve
== "2008ExplorersCove001"]))
regressionExplorersCove002 <- summary(lm(isotopes$d13C[isotopes$valve
==
"2008ExplorersCove002"]~isotopes$ontogenyCalendarCronin[isotopes$valve
== "2008ExplorersCove002"]))
regressionExplorersCove003 <- summary(lm(isotopes$d13C[isotopes$valve
==
"2008ExplorersCove003"]~isotopes$ontogenyCalendarCronin[isotopes$valve
== "2008ExplorersCove003"]))
regressionBayOfSails001 <- summary(lm(isotopes$d13C[isotopes$valve ==
"2008BayOfSails001"]~isotopes$ontogenyCalendarCronin[isotopes$valve ==
"2008BayOfSails001"]))
regressionBayOfSails002 <- summary(lm(isotopes$d13C[isotopes$valve ==
"2008BayOfSails002"]~isotopes$ontogenyCalendarCronin[isotopes$valve ==
"2008BayOfSails002"]))
regressionBayOfSails003 <- summary(lm(isotopes$d13C[isotopes$valve ==
"2008BayOfSails003"]~isotopes$ontogenyCalendarCronin[isotopes$valve ==
"2008BayOfSails003"]))

## save residuals
detrendedExplorersCove001 <- regressionExplorersCove001$residuals
detrendedExplorersCove002<- regressionExplorersCove002$residuals
detrendedExplorersCove003<- regressionExplorersCove003$residuals

detrendedBayOfSails001 <- regressionBayOfSails001$residuals
detrendedBayOfSails002 <- regressionBayOfSails002$residuals
detrendedBayOfSails003 <- regressionBayOfSails003$residuals

## write tables with just the residuals (dont include this in paper
code, just add to master csv)
write.table(x = detrendedExplorersCove001, file =
"detrendedCarbonExplorersCove001.csv", col.names =
"detrendedExplorersCove001", row.names = FALSE, na = "NA", sep = ",")
write.table(x = detrendedExplorersCove002, file =
"detrendedCarbonExplorersCove002.csv", col.names =
"detrendedExplorersCove002", row.names = FALSE, na = "NA", sep = ",")
```

```
write.table(x = detrendedExplorersCove003, file =
"detrendedCarbonExplorersCove003.csv", col.names =
"detrendedExplorersCove003", row.names = FALSE, na = "NA", sep = ",")

write.table(x = detrendedBayOfSails001, file =
"detrendedCarbonBayOfSails001.csv", col.names =
"detrendedBayOfSails001", row.names = FALSE, na = "NA", sep = ",")
write.table(x = detrendedBayOfSails002, file =
"detrendedCarbonBayOfSails002.csv", col.names =
"detrendedBayOfSails002", row.names = FALSE, na = "NA", sep = ",")
write.table(x = detrendedBayOfSails003, file =
"detrendedCarbonBayOfSails003.csv", col.names =
"detrendedBayOfSails003", row.names = FALSE, na = "NA", sep = ",")

# Bootstrap function from
http://strata.uga.edu/8370/lecturenotes/resampling.html
meanOfOneBootstrap <- function(x) {
bootstrappedSample <- sample(x, size=length(x), replace=TRUE)
theMean <- mean(bootstrappedSample, na.rm = TRUE)
theMean
}
alpha = 0.05

# Code shapes and colors for figures
myShapesOxygenIsotopesOverOntogeny <- 16
myShapesCarbonIsotopesOverOntogeny <- 15
myColorsIsotopesOverOntogeny <- c("#053061", "#4393C3", "#8C510A",
"#BF812D")
myColorsIsotopesExplorersCoveOverOntogeny <- c("#053061", "#4393C3")
myColorsIsotopesBayOfSailsOverOntogeny <- c("#8C510A", "#BF812D")
myColorsIsotopesExplorersCoveJuveniles <- c("#003C30", "#3AC2A7")
shapeCarbonExplorersCove <- 5
shapeOxygenExplorersCove <- 16
shapeCarbonBayOfSails <- 18
shapeOxygenBayOfSails <- 19
colorEC001 <- "#053061"
colorEC002 <- "#4393C3"
colorBOS001 <- "#8C510A"
colorBOS002 <- "#BF812D"
myVariabilityColors <- c("#8C510A", "#053061", "#003C30")
myVariabilityColorsNoBabies <- c("#8C510A", "#053061")
myVariabilityColorsDetrended <- c("#8C510A", "#053061")
myVariabilityColorsStriae <- c("#8C510A", "#053061")
myVariabilityColorsExplorersCoveJuveniles <- c("#003C30", "#003C30")
myFacetLabels <- c("Explorers Cove", "Bay of Sails")
names(myFacetLabels) <- c("explorersCove", "bayOfSails")

# Plot d18O over ontogeny
oxygenOverOntogenyExplorersCoveAdults <- ggplot(data = subset(isotopes,
site == "explorersCove" & valve != "2008ExplorersCove003"), aes(x =
ontogenyCalendarCronin, y = d18O, shape = site, color = valve))
oxygenOverOntogenyExplorersCoveAdultsPlot <-
oxygenOverOntogenyExplorersCoveAdults + geom_line() + geom_point() +
theme_classic(base_size = 16) + scale_color_manual(values =
myColorsIsotopesExplorersCoveOverOntogeny, name = "Valves", breaks =
c("2008ExplorersCove001", "2008ExplorersCove002"), labels = c("Valve
#1", "Valve #2")) + scale_shape_manual(values =
```

```
myShapesOxygenIsotopesOverOntogeny, name = "Explorers Cove", breaks =
c("explorersCove"), labels = "") + labs (x = "Year", y =
bquote(delta^18~"O"))

oxygenOverOntogenyExplorersCoveJuveniles <- ggplot(data =
subset(isotopes, site == "explorersCoveBaby"), aes(x =
ontogenyCalendarCronin, y = d18O, shape = site, color = valve))
oxygenOverOntogenyExplorersCoveJuvenilesPlot <-
oxygenOverOntogenyExplorersCoveJuveniles + geom_line() + geom_point() +
theme_classic(base_size = 16) + scale_color_manual(values =
myColorsIsotopesExplorersCoveJuveniles, name = "Valves", breaks =
c("2016ExplorersCoveBaby001", "2016ExplorersCoveBaby003"), labels =
c("Valve #1", "Valve #2")) + scale_shape_manual(values =
myShapesOxygenIsotopesOverOntogeny, name = "", labels = c("")) + labs
(x = "Year", y = bquote(delta^18~"O")) + scale_x_continuous(breaks =
2016.45, labels = NULL)

oxygenOverOntogenyBayOfSailsAdults <- ggplot(data = subset(isotopes,
site == "bayOfSails" & valve != "2008BayOfSails003"), aes(x =
ontogenyCalendarCronin, y = d18O, shape = site, color = valve))
oxygenOverOntogenyBayOfSailsAdultsPlot <-
oxygenOverOntogenyBayOfSailsAdults + geom_line() + geom_point() +
theme_classic(base_size = 16) + scale_color_manual(values =
myColorsIsotopesBayOfSailsOverOntogeny, name = "Valves", breaks =
c("2008BayOfSails001", "2008BayOfSails002"), labels = c("Valve #1",
"Valve #2")) + scale_shape_manual(values =
myShapesOxygenIsotopesOverOntogeny, name = "Bay Of Sails", breaks =
c("bayOfSails"), labels = c("")) + labs (x = "Year", y =
bquote(delta^18~"O"))

# Plot d13C over ontogeny with ontogenetic trendlines for each valve
carbonOverOntogenyExplorersCoveAdults <- ggplot(data = subset(isotopes,
site == "explorersCove" & valve != "2008ExplorersCove003"), aes(x =
ontogenyCalendarCronin, y = d13C, shape = site, color = valve))
carbonOverOntogenyExplorersCoveAdultsPlot <-
carbonOverOntogenyExplorersCoveAdults + geom_smooth(method = "lm", se =
FALSE) + geom_line() + geom_point() + theme_classic(base_size = 16) +
scale_color_manual(values = myColorsIsotopesExplorersCoveOverOntogeny,
name = "Valves", breaks = c("2008ExplorersCove001",
"2008ExplorersCove002"), labels = c("Valve #1", "Valve #2")) +
scale_shape_manual(values = myShapesCarbonIsotopesOverOntogeny, name =
"Explorers Cove", breaks = c("explorersCove"), labels = "") + labs (x =
"Year", y = bquote(delta^13~"C"))

carbonOverOntogenyExplorersCoveJuveniles <- ggplot(data =
subset(isotopes, site == "explorersCoveBaby"), aes(x =
ontogenyCalendarCronin, y = d13C, shape = site, color = valve))
carbonOverOntogenyExplorersCoveJuvenilesPlot <-
carbonOverOntogenyExplorersCoveJuveniles + geom_line() + geom_point() +
theme_classic(base_size = 16) + scale_color_manual(values =
myColorsIsotopesExplorersCoveJuveniles, name = "Valves", breaks =
c("2016ExplorersCoveBaby001", "2016ExplorersCoveBaby003"), labels =
c("Valve #1", "Valve #2")) + scale_shape_manual(values =
myShapesCarbonIsotopesOverOntogeny, name = "", labels = c("")) + labs
(x = "Year", y = bquote(delta^13~"C")) + scale_x_continuous(breaks =
2016.45, labels = NULL)
```

```
carbonOverOntogenyBayOfSailsAdults <- ggplot(data = subset(isotopes,
site == "bayOfSails" & valve != "2008BayOfSails003"), aes(x =
ontogenyCalendarCronin, y = d13C, shape = site, color = valve))
carbonOverOntogenyBayOfSailsAdultsPlot <-
carbonOverOntogenyBayOfSailsAdults + geom_smooth(method = "lm", se =
FALSE) + geom_line() + geom_point() + theme_classic(base_size = 16) +
scale_color_manual(values = myColorsIsotopesBayOfSailsOverOntogeny,
name = "Valves", breaks = c("2008BayOfSails001", "2008BayOfSails002"),
labels = c("Valve #1", "Valve #2")) + scale_shape_manual(values =
myShapesCarbonIsotopesOverOntogeny, name = "Bay Of Sails", breaks =
c("bayOfSails"), labels = c("")) + labs (x = "Year", y =
bquote(delta^13~"C"))

# Plot detrended d13C detrended over ontogeny
detrendedCarbonOverOntogenyExplorersCoveAdults <- ggplot(data =
subset(isotopes, site == "explorersCove" & valve !=
"2008ExplorersCove003"), aes(x = ontogenyCalendarCronin, y =
d13CDetrended, shape = site, color = valve))
detrendedCarbonOverOntogenyExplorersCoveAdultsPlot <-
detrendedCarbonOverOntogenyExplorersCoveAdults + geom_vline(xintercept
= seq(from = 1994, to =2008, by = 1), linetype = 1, color = "gray") +
geom_line() + geom_point() + theme_classic(base_size = 16) +
scale_color_manual(values = myColorsIsotopesExplorersCoveOverOntogeny,
name = "Valves", breaks = c("2008ExplorersCove001",
"2008ExplorersCove002"), labels = c("Valve #1", "Valve #2")) +
scale_shape_manual(values = myShapesCarbonIsotopesOverOntogeny, name =
"Explorers Cove", breaks = c("explorersCove"), labels = "") + labs (x =
"Year", y = bquote(delta^13~C[detrended]))

detrendedCarbonOverOntogenyBayOfSailsAdults <- ggplot(data =
subset(isotopes, site == "bayOfSails" & valve != "2008BayOfSails003"),
aes(x = ontogenyCalendarCronin, y = d13CDetrended, shape = site, color
= valve))
detrendedCarbonOverOntogenyBayOfSailsAdultsPlot <-
detrendedCarbonOverOntogenyBayOfSailsAdults + geom_vline(xintercept =
seq(from = 1994, to =2008, by = 1), linetype = 1, color = "gray") +
geom_line() + geom_point() + theme_classic(base_size = 16) +
scale_color_manual(values = myColorsIsotopesBayOfSailsOverOntogeny,
name = "Valves", breaks = c("2008BayOfSails001", "2008BayOfSails002"),
labels = c("Valve #1", "Valve #2")) + scale_shape_manual(values =
myShapesCarbonIsotopesOverOntogeny, name = "Bay Of Sails", breaks =
c("bayOfSails"), labels = c("")) + labs (x = "Year", y =
bquote(delta^13~C[detrended]))

# Plot d18O and detrended d13C together (double y axis) by valve

# EC001
EC001 <- ggplot(data = subset(isotopes, valve ==
"2008ExplorersCove001"), aes(x = ontogeneticPosition, color = valve))
EC001 <- EC001 + geom_vline(xintercept = seq(from = 1, to = 15, by =
1), linetype = 1, color = "gray") + geom_point(aes(y = d13CDetrended,
shape = "d13CDetrended", size = valve)) + geom_line(aes(y =
d13CDetrended))
EC001 <- EC001 + geom_point(aes(y = d18O - 2.5, shape = "d18O", size =
valve)) + geom_line(aes(y = d18O - 2.5))
```

```
EC001 <- EC001 + scale_y_continuous(name =
bquote(delta^13~"C"[detrended]), sec.axis = sec_axis(~.+2.5, name =
bquote(delta^18~"O")))
detrendedCarbonAndOxygenExplorersCove001 <- EC001 +
scale_color_manual(values = colorEC001) + scale_shape_manual(values =
c(myShapesCarbonIsotopesOverOntogeny,
myShapesOxygenIsotopesOverOntogeny)) + scale_size_manual(values = 3) +
theme_classic(base_size = 16) + scale_x_continuous(name = "Ontogenetic
Age", breaks = c(0, 5, 10, 15), labels = c(0, 5, 10, 15), limits = c(0,
15)) + guides(color = FALSE, shape = FALSE, size = FALSE)

# EC002
EC002 <- ggplot(data = subset(isotopes, valve ==
"2008ExplorersCove002"), aes(x = ontogeneticPosition, color = valve))
EC002 <- EC002 + geom_vline(xintercept = seq(from = 1, to = 12, by =
1), linetype = 1, color = "gray") + geom_point(aes(y = d13CDetrended,
shape = "d13CDetrended", size = valve)) + geom_line(aes(y =
d13CDetrended))
EC002 <- EC002 + geom_point(aes(y = d18O - 2.5, shape = "d18O", size =
valve)) + geom_line(aes(y = d18O - 2.5))
EC002 <- EC002 + scale_y_continuous(name =
bquote(delta^13~"C"[detrended]), sec.axis = sec_axis(~.+2.5, name =
bquote(delta^18~"O")))
detrendedCarbonAndOxygenExplorersCove002 <- EC002 +
scale_color_manual(values = colorEC002) + scale_shape_manual(values =
c(myShapesCarbonIsotopesOverOntogeny,
myShapesOxygenIsotopesOverOntogeny)) + scale_size_manual(values = 3) +
theme_classic(base_size = 16) + scale_x_continuous(name = "Ontogenetic
Age", breaks = c(0, 5, 10), labels = c(0, 5, 10), limits = c(0, 12)) +
guides(color = FALSE, shape = FALSE, size = FALSE)

# BOS001
BOS001 <- ggplot(data = subset(isotopes, valve == "2008BayOfSails001"),
aes(x = ontogeneticPosition, color = valve))
BOS001 <- BOS001 + geom_vline(xintercept = seq(from = 1, to = 15, by =
1), linetype = 1, color = "gray") + geom_point(aes(y = d13CDetrended,
shape = "d13CDetrended", size = valve)) + geom_line(aes(y =
d13CDetrended))
BOS001 <- BOS001 + geom_point(aes(y = d18O - 2.5, shape = "d18O", size
= valve)) + geom_line(aes(y = d18O - 2.5))
BOS001 <- BOS001 + scale_y_continuous(name =
bquote(delta^13~"C"[detrended]), sec.axis = sec_axis(~.+2.5, name =
bquote(delta^18~"O")))
detrendedCarbonAndOxygenBayOfSails001 <- BOS001 +
scale_color_manual(values = colorBOS001) + scale_shape_manual(values =
c(myShapesCarbonIsotopesOverOntogeny,
myShapesOxygenIsotopesOverOntogeny)) + scale_size_manual(values = 3) +
theme_classic(base_size = 16) + scale_x_continuous(name = "Ontogenetic
Age", breaks = c(0, 5, 10), labels = c(0, 5, 10), limits = c(0, 12)) +
guides(color = FALSE, shape = FALSE, size = FALSE)

# BOS002
BOS002 <- ggplot(data = subset(isotopes, valve == "2008BayOfSails002"),
aes(x = ontogeneticPosition, color = valve))
BOS002 <- BOS002 + geom_vline(xintercept = seq(from = 1, to = 15, by =
1), linetype = 1, color = "gray") + geom_point(aes(y = d13CDetrended,
```

```
shape = "d13CDetrended", size = valve)) + geom_line(aes(y =
d13CDetrended))
BOS002 <- BOS002 + geom_point(aes(y = d18O - 2.5, shape = "d18O", size
= valve)) + geom_line(aes(y = d18O - 2.5))
BOS002 <- BOS002 + scale_y_continuous(name =
bquote(delta^13~"C"[detrended]), sec.axis = sec_axis(~.+2.5, name =
bquote(delta^18~"O")))
detrendedCarbonAndOxygenBayOfSails002 <- BOS002 +
scale_color_manual(values = colorBOS002) + scale_shape_manual(values =
c(myShapesCarbonIsotopesOverOntogeny,
myShapesOxygenIsotopesOverOntogeny)) + scale_size_manual(values = 3) +
theme_classic(base_size = 16) + scale_x_continuous(name = "Ontogenetic
Age", breaks = c(0, 5, 10, 15), labels = c(0, 5, 10, 15), limits = c(0,
15)) + guides(color = FALSE, shape = FALSE, size = FALSE)

# EC Juvenile 1
ECJuvenile1 <- ggplot(data = subset(isotopes, valve ==
"2016ExplorersCoveBaby001"), aes(x = ontogenyCalendarCronin, color =
valve))
ECJuvenile1 <- ECJuvenile1 + geom_point(aes(y = d13C, shape = "d13C",
size = valve)) + geom_line(aes(y = d13C))
ECJuvenile1 <- ECJuvenile1 + geom_point(aes(y = d18O - 1, shape =
"d18O", size = valve)) + geom_line(aes(y = d18O - 1))
ECJuvenile1 <- ECJuvenile1 + scale_y_continuous(name =
bquote(delta^13~"C"), sec.axis = sec_axis(~.+1, name =
bquote(delta^18~"O")))
detrendedCarbonAndOxygenExplorersCoveJuvenile001 <- ECJuvenile1 +
scale_color_manual(values = myColorsIsotopesExplorersCoveJuveniles) +
scale_shape_manual(values = c(myShapesCarbonIsotopesOverOntogeny,
myShapesOxygenIsotopesOverOntogeny)) + scale_size_manual(values = 3) +
theme_classic(base_size = 16) + scale_x_continuous(name = "Ontogenetic
Age", breaks = 2016.45, labels = "") + guides(color = FALSE, shape =
FALSE, size = FALSE)

# EC Juvenile 2
ECJuvenile2 <- ggplot(data = subset(isotopes, valve ==
"2016ExplorersCoveBaby003"), aes(x = ontogenyCalendarCronin, color =
valve))
ECJuvenile2 <- ECJuvenile2 + geom_point(aes(y = d13C, shape = "d13C",
size = valve)) + geom_line(aes(y = d13C))
ECJuvenile2 <- ECJuvenile2 + geom_point(aes(y = d18O - 1, shape =
"d18O", size = valve)) + geom_line(aes(y = d18O - 1))
ECJuvenile2 <- ECJuvenile2 + scale_y_continuous(name =
bquote(delta^13~"C"), sec.axis = sec_axis(~.+1, name =
bquote(delta^18~"O")))
detrendedCarbonAndOxygenExplorersCoveJuvenile002 <- ECJuvenile2 +
scale_color_manual(values = myColorsIsotopesExplorersCoveJuveniles) +
scale_shape_manual(values = c(myShapesCarbonIsotopesOverOntogeny,
myShapesOxygenIsotopesOverOntogeny)) + scale_size_manual(values = 3) +
theme_classic(base_size = 16) + scale_x_continuous(name = "Ontogenetic
Age", breaks = 2016.45, labels = "") + guides(color = FALSE, shape =
FALSE, size = FALSE)

# save plots
ggsave(filename = "oxygenOverOntogenyExplorersCoveAdults.svg", plot =
oxygenOverOntogenyExplorersCoveAdultsPlot, device = "svg", units =
"in", width = 14, height = 6)
```

```
ggsave(filename = "oxygenOverOntogenyExplorersCoveJuveniles.svg", plot
= oxygenOverOntogenyExplorersCoveJuvenilesPlot, device = "svg", units =
"in", width = 14, height = 6)
ggsave(filename = "oxygenOverOntogenyBayOfSailsAdults.svg", plot =
oxygenOverOntogenyBayOfSailsAdultsPlot, device = "svg", units = "in",
width = 14, height = 6)
ggsave(filename = "carbonOverOntogenyExplorersCoveAdults.svg", plot =
carbonOverOntogenyExplorersCoveAdultsPlot, device = "svg", units =
"in", width = 14, height = 6)
ggsave(filename = "carbonOverOntogenyExplorersCoveJuveniles.svg", plot
= carbonOverOntogenyExplorersCoveJuvenilesPlot, device = "svg", units =
"in", width = 14, height = 6)
ggsave(filename = "carbonOverOntogenyBayOfSailsAdults.svg", plot =
carbonOverOntogenyBayOfSailsAdultsPlot, device = "svg", units = "in",
width = 14, height = 6)
ggsave(filename = "detrendedCarbonOverOntogenyExplorersCoveAdults.svg",
plot = detrendedCarbonOverOntogenyExplorersCoveAdultsPlot, device =
"svg", units = "in", width = 14, height = 6)
ggsave(filename = "detrendedCarbonOverOntogenyBayOfSailsAdults.svg",
plot = detrendedCarbonOverOntogenyBayOfSailsAdultsPlot, device = "svg",
units = "in", width = 14, height = 6)
ggsave(filename = "detrendedCarbonAndOxygenExplorersCove001.svg", plot
= detrendedCarbonAndOxygenExplorersCove001, device = "svg", units =
"in", width = 14, height = 6)
ggsave(filename = "detrendedCarbonAndOxygenExplorersCove002.svg", plot
= detrendedCarbonAndOxygenExplorersCove002, device = "svg", units =
"in", width = 14, height = 6)
ggsave(filename = "detrendedCarbonAndOxygenBayOfSails001.svg", plot =
detrendedCarbonAndOxygenBayOfSails001, device = "svg", units = "in",
width = 14, height = 6)
ggsave(filename = "detrendedCarbonAndOxygenBayOfSails002.svg", plot =
detrendedCarbonAndOxygenBayOfSails002, device = "svg", units = "in",
width = 14, height = 6)
ggsave(filename =
"detrendedCarbonAndOxygenExplorersCoveJuvenile001.svg", plot =
detrendedCarbonAndOxygenExplorersCoveJuvenile001, device = "svg", units
= "in", width = 14, height = 6)
ggsave(filename =
"detrendedCarbonAndOxygenExplorersCoveJuvenile002.svg", plot =
detrendedCarbonAndOxygenExplorersCoveJuvenile002, device = "svg", units
= "in", width = 14, height = 6)

# Correlations between d18O and d13C
attach(isotopes)

## Explorers Cove Valve #1

### Whole valve
summary(lm(d13C[valve == "2008ExplorersCove001"] ~ d18O[valve ==
"2008ExplorersCove001"]))
cor.test(d18O[valve == "2008ExplorersCove001"], d13C[valve ==
"2008ExplorersCove001"])

### Adult Growth
summary(lm(d13C[valve == "2008ExplorersCove001" & ontogenyYearCronin <=
14 & ontogenyYearCronin >= 6] ~ d18O[valve == "2008ExplorersCove001" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 6]))
```

```
cor.test(d18O[valve == "2008ExplorersCove001" & ontogenyYearCronin <=
14 & ontogenyYearCronin >= 6], d13C[valve == "2008ExplorersCove001" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 6])

### Juvenile Growth
summary(lm(d13C[valve == "2008ExplorersCove001" & ontogenyYearCronin <=
5] ~ d18O[valve == "2008ExplorersCove001" & ontogenyYearCronin <= 5]))
cor.test(d18O[valve == "2008ExplorersCove001" & ontogenyYearCronin <=
5], d13C[valve == "2008ExplorersCove001" & ontogenyYearCronin <= 5])

## Explorers Cove Valve #2

### Whole Valve
summary(lm(d13C[valve == "2008ExplorersCove002"] ~ d18O[valve ==
"2008ExplorersCove002"]))
cor.test(d18O[valve == "2008ExplorersCove002"], d13C[valve ==
"2008ExplorersCove002"])

### Adult Growth
summary(lm(d13C[valve == "2008ExplorersCove002" & ontogenyYearCronin <=
14 & ontogenyYearCronin >= 6] ~ d18O[valve == "2008ExplorersCove002" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 6]))
cor.test(d18O[valve == "2008ExplorersCove002" & ontogenyYearCronin <=
14 & ontogenyYearCronin >= 6], d13C[valve == "2008ExplorersCove002" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 6])

### Juvenile Growth
summary(lm(d13C[valve == "2008ExplorersCove002" & ontogenyYearCronin <=
5] ~ d18O[valve == "2008ExplorersCove002" & ontogenyYearCronin <= 5]))
cor.test(d18O[valve == "2008ExplorersCove002" & ontogenyYearCronin <=
5], d13C[valve == "2008ExplorersCove002" & ontogenyYearCronin <= 5])

## Explorers Cove Valve #3

### Whole valve
summary(lm(d13C[valve == "2008ExplorersCove003"] ~ d18O[valve ==
"2008ExplorersCove003"]))
cor.test(d18O[valve == "2008ExplorersCove003"], d13C[valve ==
"2008ExplorersCove003"])

### Not aged with annuli, so not correlated with adult/juvenile growth

## Explorers Cove Juvenile Valve #1
summary(lm(d13C[valve == "2016ExplorersCoveBaby001"] ~ d18O[valve ==
"2016ExplorersCoveBaby001"]))
cor.test(d18O[valve == "2016ExplorersCoveBaby001"], d13C[valve ==
"2016ExplorersCoveBaby001"])

## Explorers Cove Juvenile Valve #1
summary(lm(d13C[valve == "2016ExplorersCoveBaby003"] ~ d18O[valve ==
"2016ExplorersCoveBaby003"]))
cor.test(d18O[valve == "2016ExplorersCoveBaby003"], d13C[valve ==
"2016ExplorersCoveBaby003"])

## Bay of Sails Valve #1

### Whole Valve
```

```
summary(lm(d13C[valve == "2008BayOfSails001"] ~ d18O[valve ==
"2008BayOfSails001"]))
cor.test(d18O[valve == "2008BayOfSails001"], d13C[valve ==
"2008BayOfSails001"])

### Adult Growth
summary(lm(d13C[valve == "2008BayOfSails001" & ontogenyYearCronin <= 14
& ontogenyYearCronin >= 4] ~ d18O[valve == "2008BayOfSails001" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 4]))
cor.test(d18O[valve == "2008BayOfSails001" & ontogenyYearCronin <= 14 &
ontogenyYearCronin >= 4], d13C[valve == "2008BayOfSails001" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 4])

### Juvenile Growth
summary(lm(d13C[valve == "2008BayOfSails001" & ontogenyYearCronin <= 3]
~ d18O[valve == "2008BayOfSails001" & ontogenyYearCronin <= 3]))
cor.test(d18O[valve == "2008BayOfSails001" & ontogenyYearCronin <= 3],
d13C[valve == "2008BayOfSails001" & ontogenyYearCronin <= 3])

## Bay of Sails Valve #2

### Whole Valve
summary(lm(d13C[valve == "2008BayOfSails002"] ~ d18O[valve ==
"2008BayOfSails002"]))
cor.test(d18O[valve == "2008BayOfSails002"], d13C[valve ==
"2008BayOfSails002"])

### Adult Growth
summary(lm(d13C[valve == "2008BayOfSails002" & ontogenyYearCronin <= 14
& ontogenyYearCronin >= 4] ~ d18O[valve == "2008BayOfSails002" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 4]))
cor.test(d18O[valve == "2008BayOfSails002" & ontogenyYearCronin <= 14 &
ontogenyYearCronin >= 4], d13C[valve == "2008BayOfSails002" &
ontogenyYearCronin <= 14 & ontogenyYearCronin >= 4])

### Juvenile Growth
summary(lm(d13C[valve == "2008BayOfSails002" & ontogenyYearCronin <= 3]
~ d18O[valve == "2008BayOfSails002" & ontogenyYearCronin <= 3]))
cor.test(d18O[valve == "2008BayOfSails002" & ontogenyYearCronin <= 3],
d13C[valve == "2008BayOfSails002" & ontogenyYearCronin <= 3])

## Bay of Sails Valve #3

### Whole valve
summary(lm(d13C[valve == "2008BayOfSails003"] ~ d18O[valve ==
"2008BayOfSails003"]))
cor.test(d18O[valve == "2008BayOfSails003"], d13C[valve ==
"2008BayOfSails003"])

## Bay of Sails Valve #3

### Not aged with annuli, cannot be detrended

# PLot correlations for both sites
png("isotopeCorrelations.png", height = 7, width = 7, unit = "in", res
= 600)
```

```
plot(NULL, axes = FALSE, xlim = c(min(isotopes$d13C[isotopes$site ==
"bayOfSails"] - .5, na.rm = TRUE), max(isotopes$d13C[isotopes$site ==
"bayOfSails"] + .5, na.rm = TRUE)), ylim =
c(min(isotopes$d18O[isotopes$site == "bayOfSails"] - .5, na.rm = TRUE),
max(isotopes$d18O[isotopes$site == "bayOfSails"] + .5, na.rm = TRUE)),
xlab = bquote(delta^13~"C"), ylab = bquote(delta ^18~"O"), main = "")
axis(side = 1)
axis(side = 2, las = 2)

points(x = isotopes$d13C[isotopes$ontogenyYearCronin >= 4 &
isotopes$site == "bayOfSails"], y =
isotopes$d18O[isotopes$ontogenyYearCronin >= 4 & isotopes$site ==
"bayOfSails"], pch = 1, col = colorBOS001)
abline(lm(isotopes$d18O[isotopes$ontogenyYearCronin >= 4 &
isotopes$site == "bayOfSails"] ~
isotopes$d13C[isotopes$ontogenyYearCronin >= 4 & isotopes$site ==
"bayOfSails"]), col = colorBOS001)

points(x = isotopes$d13C[isotopes$ontogenyYearCronin <= 3  &
isotopes$site == "bayOfSails"], y =
isotopes$d18O[isotopes$ontogenyYearCronin <= 3  & isotopes$site ==
"bayOfSails"], pch = 1, col = colorBOS002)
abline(lm(isotopes$d18O[isotopes$ontogenyYearCronin <= 3  &
isotopes$site == "bayOfSails"] ~
isotopes$d13C[isotopes$ontogenyYearCronin <= 3  & isotopes$site ==
"bayOfSails"]), col = colorBOS002)

points(x = isotopes$d13C[isotopes$ontogenyYearCronin >= 6 &
isotopes$site == "explorersCove"], y =
isotopes$d18O[isotopes$ontogenyYearCronin >= 6 & isotopes$site ==
"explorersCove"], pch = 1, col = colorEC001)
abline(lm(isotopes$d18O[isotopes$ontogenyYearCronin >= 6 &
isotopes$site == "explorersCove"] ~
isotopes$d13C[isotopes$ontogenyYearCronin >= 6 & isotopes$site ==
"explorersCove"]), col = colorEC001)

points(x = isotopes$d13C[isotopes$ontogenyYearCronin < 6 &
isotopes$site == "explorersCove"], y =
isotopes$d18O[isotopes$ontogenyYearCronin < 6 & isotopes$site ==
"explorersCove"], pch = 1, col = colorEC002)
summary(lm(isotopes$d18O[isotopes$ontogenyYearCronin < 6 &
isotopes$site == "explorersCove"] ~
isotopes$d13C[isotopes$ontogenyYearCronin < 6 & isotopes$site ==
"explorersCove"]), col = colorEC002)

points(x = isotopes$d13C[isotopes$ontogenyYearCronin <= 5 &
isotopes$site == "explorersCoveBaby"], y =
isotopes$d18O[isotopes$ontogenyYearCronin <= 5 & isotopes$site ==
"explorersCoveBaby"], pch = 1, col = "#003C30")
summary(lm(isotopes$d18O[isotopes$ontogenyYearCronin <= 5 &
isotopes$site == "explorersCoveBaby"] ~
isotopes$d13C[isotopes$ontogenyYearCronin <= 5 & isotopes$site ==
"explorersCoveBaby"]), col = "#003C30")

dev.off()

# Correlations between differenced d18O and differenced d13C
```

```
## difference the data
dCarbonEC001 <- diff(x = d13C[valve == "2008ExplorersCove001"], lag =
1)
dOxygenEC001 <- diff(x = d18O[valve == "2008ExplorersCove001"], lag =
1)
dCarbonEC002 <- diff(x = d13C[valve == "2008ExplorersCove002"], lag =
1)
dOxygenEC002 <- diff(x = d18O[valve == "2008ExplorersCove002"], lag =
1)
dCarbonEC003 <- diff(x = d13C[valve == "2008ExplorersCove003"], lag =
1)
dOxygenEC003 <- diff(x = d18O[valve == "2008ExplorersCove003"], lag =
1)
dOxygenECJuv001 <- diff(x = d18O[valve == "2016ExplorersCoveBaby001"],
lag = 1)
dCarbonECJuv001 <- diff(x = d13C[valve == "2016ExplorersCoveBaby001"],
lag = 1)
dOxygenECJuv002 <- diff(x = d18O[valve == "2016ExplorersCoveBaby003"],
lag = 1)
dCarbonECJuv002 <- diff(x = d13C[valve == "2016ExplorersCoveBaby003"],
lag = 1)

dCarbonBOS001 <- diff(x = d13C[valve == "2008BayOfSails001"], lag = 1)
dOxygenBOS001 <- diff(x = d18O[valve == "2008BayOfSails001"], lag = 1)
dCarbonBOS002 <- diff(x = d13C[valve == "2008BayOfSails002"], lag = 1)
dOxygenBOS002 <- diff(x = d18O[valve == "2008BayOfSails002"], lag = 1)
dCarbonBOS003 <- diff(x = d13C[valve == "2008BayOfSails003"], lag = 1)
dOxygenBOS003 <- diff(x = d18O[valve == "2008BayOfSails003"], lag = 1)

## Explorers Cove Valves
summary(lm(dCarbonEC001 ~ dOxygenEC001))
cor.test(dOxygenEC001, dCarbonEC001)
summary(lm(dCarbonEC002 ~ dOxygenEC002))
cor.test(dOxygenEC002, dCarbonEC002)
summary(lm(dCarbonEC003 ~ dOxygenEC003))
cor.test(dOxygenEC003, dCarbonEC003)
summary(lm(dCarbonECJuv001 ~ dOxygenECJuv001))
cor.test(dOxygenECJuv001, dCarbonECJuv001)
summary(lm(dCarbonECJuv002 ~ dOxygenECJuv002))
cor.test(dOxygenECJuv002, dCarbonECJuv002)

## Bay of Sails Valves
summary(lm(dCarbonBOS001 ~ dOxygenBOS001))
cor.test(dOxygenBOS001, dCarbonBOS001)
summary(lm(dCarbonBOS002 ~ dOxygenBOS002))
cor.test(dOxygenBOS002, dCarbonBOS002)
summary(lm(dCarbonBOS003 ~ dOxygenBOS003))
cor.test(dOxygenBOS003, dCarbonBOS003)

detach(isotopes)

# Calculate min, max, bootstrapped estimate of mean and 95% Confidence
intervals on d18O and d13C for all valves

oxygenMinimumExplorersCove <- min(isotopes$d18O[isotopes$site ==
"explorersCove"], na.rm = TRUE)
```

```
oxygenMaximumExplorersCove <- max(isotopes$d18O[isotopes$site ==
"explorersCove"], na.rm = TRUE)
oxygenEC <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "explorersCove"]))
oxygenMeanExplorersCove <- mean(oxygenEC, na.rm = TRUE)
oxygenLower95ExplorersCove <- quantile(oxygenEC, alpha/2, na.rm = TRUE)
oxygenUpper95ExplorersCove <- quantile(oxygenEC, 1-alpha/2, na.rm =
TRUE)
oxygenMeanExplorersCove
oxygenLower95ExplorersCove
oxygenUpper95ExplorersCove

oxygenMinimumExplorersCoveAdultAgeUnder6 <-
min(isotopes$d18O[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition < 6], na.rm = TRUE)
oxygenMaximumExplorersCoveAdultAgeUnder6 <-
max(isotopes$d18O[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition < 6], na.rm = TRUE)
oxygenECAdultAgeUnder6 <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition < 6]))
oxygenMeanExplorersCoveAdultAgeUnder6 <- mean(oxygenECAdultAgeUnder6,
na.rm = TRUE)
oxygenLower95ExplorersCoveAdultAgeUnder6 <-
quantile(oxygenECAdultAgeUnder6, alpha/2, na.rm = TRUE)
oxygenUpper95ExplorersCoveAdultAgeUnder6 <-
quantile(oxygenECAdultAgeUnder6, 1-alpha/2, na.rm = TRUE)
oxygenMeanExplorersCoveAdultAgeUnder6
oxygenLower95ExplorersCoveAdultAgeUnder6
oxygenUpper95ExplorersCoveAdultAgeUnder6

oxygenMinimumExplorersCoveBabies <- min(isotopes$d18O[isotopes$valve ==
"explorersCoveBaby"], na.rm = TRUE)
oxygenMinimumExplorersCoveBabies <- max(isotopes$d18O[isotopes$site ==
"explorersCoveBaby"], na.rm = TRUE)
oxygenECBabies <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site ==
"explorersCoveBaby"]))
oxygenMeanExplorersCoveBabies <- mean(oxygenECBabies, na.rm = TRUE)
oxygenLower95ExplorersCoveBabies <- quantile(oxygenECBabies, alpha/2,
na.rm = TRUE)
oxygenUpper95ExplorersCoveBabies <- quantile(oxygenECBabies, 1-alpha/2,
na.rm = TRUE)
oxygenMeanExplorersCoveBabies
oxygenLower95ExplorersCoveBabies
oxygenUpper95ExplorersCoveBabies

oxygenMinimumExplorersCoveBaby001 <- min(isotopes$d18O[isotopes$valve
== "2016ExplorersCoveBaby001"], na.rm = TRUE)
oxygenMaximumExplorersCoveBaby001 <- max(isotopes$d18O[isotopes$site ==
"2016ExplorersCoveBaby001"], na.rm = TRUE)
oxygenECBaby001 <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$valve ==
"2016ExplorersCoveBaby001"]))
oxygenMeanExplorersCoveBaby001 <- mean(oxygenECBaby001, na.rm = TRUE)
oxygenLower95ExplorersCoveBaby001 <- quantile(oxygenECBaby001, alpha/2,
na.rm = TRUE)
```

```
oxygenUpper95ExplorersCoveBaby001 <- quantile(oxygenECBaby001, 1-
alpha/2, na.rm = TRUE)
oxygenMeanExplorersCoveBaby001
oxygenLower95ExplorersCoveBaby001
oxygenUpper95ExplorersCoveBaby001

oxygenMinimumExplorersCoveBaby003 <- min(isotopes$d18O[isotopes$valve
== "2016ExplorersCoveBaby003"], na.rm = TRUE)
oxygenMaximumExplorersCoveBaby003 <- max(isotopes$d18O[isotopes$site ==
"2016ExplorersCoveBaby003"], na.rm = TRUE)
oxygenECBaby003 <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$valve ==
"2016ExplorersCoveBaby003"]))
oxygenMeanExplorersCoveBaby003 <- mean(oxygenECBaby003, na.rm = TRUE)
oxygenLower95ExplorersCoveBaby003 <- quantile(oxygenECBaby003, alpha/2,
na.rm = TRUE)
oxygenUpper95ExplorersCoveBaby003 <- quantile(oxygenECBaby003, 1-
alpha/2, na.rm = TRUE)
oxygenMeanExplorersCoveBaby003
oxygenLower95ExplorersCoveBaby003
oxygenUpper95ExplorersCoveBaby003

carbonMinimumExplorersCoveBaby001 <- min(isotopes$d13C[isotopes$valve
== "2016ExplorersCoveBaby001"], na.rm = TRUE)
carbonMaximumExplorersCoveBaby001 <- max(isotopes$d13C[isotopes$site ==
"2016ExplorersCoveBaby001"], na.rm = TRUE)
carbonECBaby001 <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$valve ==
"2016ExplorersCoveBaby001"]))
carbonMeanExplorersCoveBaby001 <- mean(carbonECBaby001, na.rm = TRUE)
carbonLower95ExplorersCoveBaby001 <- quantile(carbonECBaby001, alpha/2,
na.rm = TRUE)
carbonUpper95ExplorersCoveBaby001 <- quantile(carbonECBaby001, 1-
alpha/2, na.rm = TRUE)
carbonMeanExplorersCoveBaby001
carbonLower95ExplorersCoveBaby001
carbonUpper95ExplorersCoveBaby001

carbonMinimumExplorersCoveBaby003 <- min(isotopes$d13C[isotopes$valve
== "2016ExplorersCoveBaby003"], na.rm = TRUE)
carbonMaximumExplorersCoveBaby003 <- max(isotopes$d13C[isotopes$site ==
"2016ExplorersCoveBaby003"], na.rm = TRUE)
carbonECBaby003 <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$valve ==
"2016ExplorersCoveBaby003"]))
carbonMeanExplorersCoveBaby003 <- mean(carbonECBaby003, na.rm = TRUE)
carbonLower95ExplorersCoveBaby003 <- quantile(carbonECBaby003, alpha/2,
na.rm = TRUE)
carbonUpper95ExplorersCoveBaby003 <- quantile(carbonECBaby003, 1-
alpha/2, na.rm = TRUE)
carbonMeanExplorersCoveBaby003
carbonLower95ExplorersCoveBaby003
carbonUpper95ExplorersCoveBaby003

oxygenMinimumBayOfSails <- min(isotopes$d18O[isotopes$site ==
"bayOfSails"], na.rm = TRUE)
```

```
oxygenMaximumBayOfSails <- max(isotopes$d18O[isotopes$site ==
"bayOfSails"], na.rm = TRUE)
oxygenBOS <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "bayOfSails"]))
oxygenMeanBayOfSails <- mean(oxygenBOS, na.rm = TRUE)
oxygenLower95BayOfSails <- quantile(oxygenBOS, alpha/2, na.rm = TRUE)
oxygenUpper95BayOfSails <- quantile(oxygenBOS, 1-alpha/2, na.rm = TRUE)
oxygenMeanBayOfSails
oxygenLower95BayOfSails
oxygenUpper95BayOfSails

carbonMinimumExplorersCove <- min(isotopes$d13C[isotopes$site ==
"explorersCove"], na.rm = TRUE)
carbonMaximumExplorersCove <- max(isotopes$d13C[isotopes$site ==
"explorersCove"], na.rm = TRUE)
carbonEC <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "explorersCove"]))
carbonMeanExplorersCove <- mean(carbonEC, na.rm = TRUE)
carbonLower95ExplorersCove <- quantile(carbonEC, alpha/2, na.rm = TRUE)
carbonUpper95ExplorersCove <- quantile(carbonEC, 1-alpha/2, na.rm =
TRUE)
carbonMeanExplorersCove
carbonLower95ExplorersCove
carbonUpper95ExplorersCove

carbonMinimumExplorersCoveAdult <- min(isotopes$d13C[isotopes$site ==
"explorersCove" & isotopes$ontogeneticPosition >= 6], na.rm = TRUE)
carbonMaximumExplorersCoveAdult <- max(isotopes$d13C[isotopes$site ==
"explorersCove" & isotopes$ontogeneticPosition >= 6], na.rm = TRUE)
carbonECAdult <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition >= 6]))
carbonMeanExplorersCoveAdult <- mean(carbonECAdult, na.rm = TRUE)
carbonLower95ExplorersCoveAdult <- quantile(carbonECAdult, alpha/2,
na.rm = TRUE)
carbonUpper95ExplorersCoveAdult <- quantile(carbonECAdult, 1-alpha/2,
na.rm = TRUE)
carbonMeanExplorersCoveAdult
carbonLower95ExplorersCoveAdult
carbonUpper95ExplorersCoveAdult

carbonMinimumExplorersCoveAdultAgeUnder6 <-
min(isotopes$d13C[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition < 6], na.rm = TRUE)
carbonMaximumExplorersCoveAdultAgeUnder6 <-
max(isotopes$d13C[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition < 6], na.rm = TRUE)
carbonECAdultAgeUnder6 <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "explorersCove" &
isotopes$ontogeneticPosition < 6]))
carbonMeanExplorersCoveAdultAgeUnder6 <- mean(carbonECAdultAgeUnder6,
na.rm = TRUE)
carbonLower95ExplorersCoveAdultAgeUnder6 <-
quantile(carbonECAdultAgeUnder6, alpha/2, na.rm = TRUE)
carbonUpper95ExplorersCoveAdultAgeUnder6 <-
quantile(carbonECAdultAgeUnder6, 1-alpha/2, na.rm = TRUE)
carbonMeanExplorersCoveAdultAgeUnder6
```

```
carbonLower95ExplorersCoveAdultAgeUnder6
carbonUpper95ExplorersCoveAdultAgeUnder6

carbonMinimumExplorersCoveBaby <- min(isotopes$d13C[isotopes$site ==
"explorersCoveBaby"], na.rm = TRUE)
carbonMaximumExplorersCoveBaby <- max(isotopes$d13C[isotopes$site ==
"explorersCoveBaby"], na.rm = TRUE)
carbonECBaby <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site ==
"explorersCoveBaby"]))
carbonMeanExplorersCoveBaby <- mean(carbonECBaby, na.rm = TRUE)
carbonLower95ExplorersCoveBaby <- quantile(carbonECBaby, alpha/2, na.rm
= TRUE)
carbonUpper95ExplorersCoveBaby <- quantile(carbonECBaby, 1-alpha/2,
na.rm = TRUE)
carbonMeanExplorersCoveBaby
carbonLower95ExplorersCoveBaby
carbonUpper95ExplorersCoveBaby

carbonMinimumBayOfSails <- min(isotopes$d13C[isotopes$site ==
"bayOfSails"], na.rm = TRUE)
carbonMaximumBayOfSails <- max(isotopes$d13C[isotopes$site ==
"bayOfSails"], na.rm = TRUE)
carbonBOS <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "bayOfSails"]))
carbonMeanBayOfSails <- mean(carbonBOS, na.rm = TRUE)
carbonLower95BayOfSails <- quantile(carbonBOS, alpha/2, na.rm = TRUE)
carbonUpper95BayOfSails <- quantile(carbonBOS, 1-alpha/2, na.rm = TRUE)
carbonMeanBayOfSails
carbonLower95BayOfSails
carbonUpper95BayOfSails

carbonMinimumBayOfSailsAdult <- min(isotopes$d13C[isotopes$site ==
"bayOfSails" & isotopes$ontogeneticPosition >= 6], na.rm = TRUE)
carbonMaximumBayOfSailsAdult <- max(isotopes$d13C[isotopes$site ==
"bayOfSails" & isotopes$ontogeneticPosition >= 6], na.rm = TRUE)
carbonBOSAdult <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "bayOfSails" &
isotopes$ontogeneticPosition >= 6]))
carbonMeanBayOfSailsAdult <- mean(carbonBOSAdult, na.rm = TRUE)
carbonLower95BayOfSailsAdult <- quantile(carbonBOSAdult, alpha/2, na.rm
= TRUE)
carbonUpper95BayOfSailsAdult <- quantile(carbonBOSAdult, 1-alpha/2,
na.rm = TRUE)
carbonMeanBayOfSailsAdult
carbonLower95BayOfSailsAdult
carbonUpper95BayOfSailsAdult

carbonMinimumBayOfSailsAdultAgeUnder6 <-
min(isotopes$d13C[isotopes$site == "bayOfSails" &
isotopes$ontogeneticPosition < 6], na.rm = TRUE)
carbonMaximumBayOfSailsAdultAgeUnder6 <-
max(isotopes$d13C[isotopes$site == "bayOfSails" &
isotopes$ontogeneticPosition < 6], na.rm = TRUE)
carbonBOSAdultAgeUnder6 <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "bayOfSails" &
isotopes$ontogeneticPosition < 6]))
```

```
carbonMeanBayOfSailsAdultAgeUnder6 <- mean(carbonBOSAdult, na.rm =
TRUE)
carbonLower95BayOfSailsAdultAgeUnder6 <- quantile(carbonBOSAdult,
alpha/2, na.rm = TRUE)
carbonUpper95BayOfSailsAdultAgeUnder6 <- quantile(carbonBOSAdult, 1-
alpha/2, na.rm = TRUE)
carbonMeanBayOfSailsAdultAgeUnder6
carbonLower95BayOfSailsAdultAgeUnder6
carbonUpper95BayOfSailsAdultAgeUnder6

carbonDetrendedMinimumExplorersCove <-
min(isotopes$d13CDetrended[isotopes$site == "explorersCove"], na.rm =
TRUE)
carbonDetrendedMaximumExplorersCove <-
max(isotopes$d13CDetrended[isotopes$site == "explorersCove"], na.rm =
TRUE)
carbonDetrendedEC <- replicate(10000,
meanOfOneBootstrap(isotopes$d13CDetrended[isotopes$site ==
"explorersCove"]))
carbonDetrendedMeanExplorersCove <- mean(carbonDetrendedEC, na.rm =
TRUE)
carbonDetrendedLower95ExplorersCove <- quantile(carbonDetrendedEC,
alpha/2, na.rm = TRUE)
carbonDetrendedUpper95ExplorersCove <- quantile(carbonDetrendedEC, 1-
alpha/2, na.rm = TRUE)
carbonDetrendedMeanExplorersCove
carbonDetrendedLower95ExplorersCove
carbonDetrendedUpper95ExplorersCove

carbonDetrendedMinimumBayOfSails <-
min(isotopes$d13CDetrended[isotopes$site == "bayOfSails"], na.rm =
TRUE)
carbonDetrendedMaximumBayOfSails <-
max(isotopes$d13CDetrended[isotopes$site == "bayOfSails"], na.rm =
TRUE)
carbonDetrendedBOS <- replicate(10000,
meanOfOneBootstrap(isotopes$d13CDetrended[isotopes$site ==
"bayOfSails"]))
carbonDetrendedMeanBayOfSails <- mean(carbonDetrendedBOS, na.rm = TRUE)
carbonDetrendedLower95BayOfSails <- quantile(carbonDetrendedBOS,
alpha/2, na.rm = TRUE)
carbonDetrendedUpper95BayOfSails <- quantile(carbonDetrendedBOS, 1-
alpha/2, na.rm = TRUE)
carbonDetrendedMeanBayOfSails
carbonDetrendedLower95BayOfSails
carbonDetrendedUpper95BayOfSails

carbonDetrendedMinimumExplorersCoveNarrow <-
min(isotopes$d13CDetrended[isotopes$site == "explorersCove" &
isotopes$striaeType == "narrow"], na.rm = TRUE)
carbonDetrendedMaximumExplorersCoveNarrow <-
max(isotopes$d13CDetrended[isotopes$site == "explorersCove" &
isotopes$striaeType == "narrow"], na.rm = TRUE)
carbonDetrendedECNarrow <- replicate(10000,
meanOfOneBootstrap(isotopes$d13CDetrended[isotopes$site ==
"explorersCove" & isotopes$striaeType == "narrow"]))
```

```
carbonDetrendedMeanExplorersCoveNarrow <- mean(carbonDetrendedECNarrow,
na.rm = TRUE)
carbonDetrendedLower95ExplorersCoveNarrow <-
quantile(carbonDetrendedECNarrow, alpha/2, na.rm = TRUE)
carbonDetrendedUpper95ExplorersCoveNarrow <-
quantile(carbonDetrendedECNarrow, 1-alpha/2, na.rm = TRUE)
carbonDetrendedMeanExplorersCoveNarrow
carbonDetrendedLower95ExplorersCoveNarrow
carbonDetrendedUpper95ExplorersCoveNarrow

carbonDetrendedMinimumExplorersCoveWide <-
min(isotopes$d13CDetrended[isotopes$site == "explorersCove" &
isotopes$striaeType == "wide"], na.rm = TRUE)
carbonDetrendedMaximumExplorersCoveWide <-
max(isotopes$d13CDetrended[isotopes$site == "explorersCove" &
isotopes$striaeType == "wide"], na.rm = TRUE)
carbonDetrendedECWide <- replicate(10000,
meanOfOneBootstrap(isotopes$d13CDetrended[isotopes$site ==
"explorersCove" & isotopes$striaeType == "wide"]))
carbonDetrendedMeanExplorersCoveWide <- mean(carbonDetrendedECWide,
na.rm = TRUE)
carbonDetrendedLower95ExplorersCoveWide <-
quantile(carbonDetrendedECWide, alpha/2, na.rm = TRUE)
carbonDetrendedUpper95ExplorersCoveWide <-
quantile(carbonDetrendedECWide, 1-alpha/2, na.rm = TRUE)
carbonDetrendedMeanExplorersCoveWide
carbonDetrendedLower95ExplorersCoveWide
carbonDetrendedUpper95ExplorersCoveWide

carbonMinimumExplorersCoveBabyNarrow <- min(isotopes$d13C[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "narrow"], na.rm =
TRUE)
carbonMaximumExplorersCoveBabyNarrow <- max(isotopes$d13C[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "narrow"], na.rm =
TRUE)
carbonECBabyNarrow <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "explorersCoveBaby" &
isotopes$striaeType == "narrow"]))
carbonMeanExplorersCoveBabyNarrow <- mean(carbonECBabyNarrow, na.rm =
TRUE)
carbonLower95ExplorersCoveBabyNarrow <- quantile(carbonECBabyNarrow,
alpha/2, na.rm = TRUE)
carbonUpper95ExplorersCoveBabyNarrow <- quantile(carbonECBabyNarrow, 1-
alpha/2, na.rm = TRUE)
carbonMeanExplorersCoveBabyNarrow
carbonLower95ExplorersCoveBabyNarrow
carbonUpper95ExplorersCoveBabyNarrow

carbonMinimumExplorersCoveBabyWide <- min(isotopes$d13C[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "wide"], na.rm = TRUE)
carbonMaximumExplorersCoveBabyWide <- max(isotopes$d13C[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "wide"], na.rm = TRUE)
carbonECBabyWide <- replicate(10000,
meanOfOneBootstrap(isotopes$d13C[isotopes$site == "explorersCoveBaby" &
isotopes$striaeType == "wide"]))
carbonMeanExplorersCoveBabyWide <- mean(carbonECBabyWide, na.rm = TRUE)
```

```
carbonLower95ExplorersCoveBabyWide <- quantile(carbonECBabyWide,
alpha/2, na.rm = TRUE)
carbonUpper95ExplorersCoveBabyWide <- quantile(carbonECBabyWide, 1-
alpha/2, na.rm = TRUE)
carbonMeanExplorersCoveBabyWide
carbonLower95ExplorersCoveBabyWide
carbonUpper95ExplorersCoveBabyWide

carbonDetrendedMinimumBayOfSailsNarrow <-
min(isotopes$d13CDetrended[isotopes$site == "bayOfSails" &
isotopes$striaeType == "narrow"], na.rm = TRUE)
carbonDetrendedMaximumBayOfSailsNarrow <-
max(isotopes$d13CDetrended[isotopes$site == "bayOfSails" &
isotopes$striaeType == "narrow"], na.rm = TRUE)
carbonDetrendedBOSNarrow <- replicate(10000,
meanOfOneBootstrap(isotopes$d13CDetrended[isotopes$site == "bayOfSails"
& isotopes$striaeType == "narrow"]))
carbonDetrendedMeanBayOfSailsNarrow <- mean(carbonDetrendedBOSNarrow,
na.rm = TRUE)
carbonDetrendedLower95BayOfSailsNarrow <-
quantile(carbonDetrendedBOSNarrow, alpha/2, na.rm = TRUE)
carbonDetrendedUpper95BayOfSailsNarrow <-
quantile(carbonDetrendedBOSNarrow, 1-alpha/2, na.rm = TRUE)
carbonDetrendedMeanBayOfSailsNarrow
carbonDetrendedLower95BayOfSailsNarrow
carbonDetrendedUpper95BayOfSailsNarrow

carbonDetrendedMinimumBayOfSailsWide <-
min(isotopes$d13CDetrended[isotopes$site == "bayOfSails" &
isotopes$striaeType == "wide"], na.rm = TRUE)
carbonDetrendedMaximumBayOfSailsWide <-
max(isotopes$d13CDetrended[isotopes$site == "bayOfSails" &
isotopes$striaeType == "wide"], na.rm = TRUE)
carbonDetrendedBOSWide <- replicate(10000,
meanOfOneBootstrap(isotopes$d13CDetrended[isotopes$site == "bayOfSails"
& isotopes$striaeType == "wide"]))
carbonDetrendedMeanBayOfSailsWide <- mean(carbonDetrendedBOSWide, na.rm
= TRUE)
carbonDetrendedLower95BayOfSailsWide <-
quantile(carbonDetrendedBOSWide, alpha/2, na.rm = TRUE)
carbonDetrendedUpper95BayOfSailsWide <-
quantile(carbonDetrendedBOSWide, 1-alpha/2, na.rm = TRUE)
carbonDetrendedMeanBayOfSailsWide
carbonDetrendedLower95BayOfSailsWide
carbonDetrendedUpper95BayOfSailsWide

oxygenMinimumExplorersCoveNarrow <- min(isotopes$d18O[isotopes$site ==
"explorersCove" & isotopes$striaeType == "narrow"], na.rm = TRUE)
oxygenMaximumExplorersCoveNarrow <- max(isotopes$d18O[isotopes$site ==
"explorersCove" & isotopes$striaeType == "narrow"], na.rm = TRUE)
oxygenECNarrow <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "explorersCove" &
isotopes$striaeType == "narrow"]))
oxygenMeanExplorersCoveNarrow <- mean(oxygenECNarrow, na.rm = TRUE)
oxygenLower95ExplorersCoveNarrow <- quantile(oxygenECNarrow, alpha/2,
na.rm = TRUE)
```

```
oxygenUpper95ExplorersCoveNarrow <- quantile(oxygenECNarrow, 1-alpha/2,
na.rm = TRUE)
oxygenMeanExplorersCoveNarrow
oxygenLower95ExplorersCoveNarrow
oxygenUpper95ExplorersCoveNarrow

oxygenMinimumExplorersCoveWide <- min(isotopes$d18O[isotopes$site ==
"explorersCove" & isotopes$striaeType == "wide"], na.rm = TRUE)
oxygenMaximumExplorersCoveWide <- max(isotopes$d18O[isotopes$site ==
"explorersCove" & isotopes$striaeType == "wide"], na.rm = TRUE)
oxygenECWide <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "explorersCove" &
isotopes$striaeType == "wide"]))
oxygenMeanExplorersCoveWide <- mean(oxygenECWide, na.rm = TRUE)
oxygenLower95ExplorersCoveWide <- quantile(oxygenECWide, alpha/2, na.rm
= TRUE)
oxygenUpper95ExplorersCoveWide <- quantile(oxygenECWide, 1-alpha/2,
na.rm = TRUE)
oxygenMeanExplorersCoveWide
oxygenLower95ExplorersCoveWide
oxygenUpper95ExplorersCoveWide

oxygenMinimumExplorersCoveBabyNarrow <- min(isotopes$d18O[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "narrow"], na.rm =
TRUE)
oxygenMaximumExplorersCoveBabyNarrow <- max(isotopes$d18O[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "narrow"], na.rm =
TRUE)
oxygenECBabyNarrow <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "explorersCoveBaby" &
isotopes$striaeType == "narrow"]))
oxygenMeanExplorersCoveBabyNarrow <- mean(oxygenECBabyNarrow, na.rm =
TRUE)
oxygenLower95ExplorersCoveBabyNarrow <- quantile(oxygenECBabyNarrow,
alpha/2, na.rm = TRUE)
oxygenUpper95ExplorersCoveBabyNarrow <- quantile(oxygenECBabyNarrow, 1-
alpha/2, na.rm = TRUE)
oxygenMeanExplorersCoveBabyNarrow
oxygenLower95ExplorersCoveBabyNarrow
oxygenUpper95ExplorersCoveBabyNarrow

oxygenMinimumExplorersCoveBabyWide <- min(isotopes$d18O[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "wide"], na.rm = TRUE)
oxygenMaximumExplorersCoveBabyWide <- max(isotopes$d18O[isotopes$site
== "explorersCoveBaby" & isotopes$striaeType == "wide"], na.rm = TRUE)
oxygenECBabyWide <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "explorersCoveBaby" &
isotopes$striaeType == "wide"]))
oxygenMeanExplorersCoveBabyWide <- mean(oxygenECBabyWide, na.rm = TRUE)
oxygenLower95ExplorersCoveBabyWide <- quantile(oxygenECBabyWide,
alpha/2, na.rm = TRUE)
oxygenUpper95ExplorersCoveBabyWide <- quantile(oxygenECBabyWide, 1-
alpha/2, na.rm = TRUE)
oxygenMeanExplorersCoveBabyWide
oxygenLower95ExplorersCoveBabyWide
oxygenUpper95ExplorersCoveBabyWide
```

```
oxygenMinimumBayOfSailsNarrow <- min(isotopes$d18O[isotopes$site ==
"bayOfSails" & isotopes$striaeType == "narrow"], na.rm = TRUE)
oxygenMaximumBayOfSailsNarrow <- max(isotopes$d18O[isotopes$site ==
"bayOfSails" & isotopes$striaeType == "narrow"], na.rm = TRUE)
oxygenBOSNarrow <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "bayOfSails" &
isotopes$striaeType == "narrow"]))
oxygenMeanBayOfSailsNarrow <- mean(oxygenBOSNarrow, na.rm = TRUE)
oxygenLower95BayOfSailsNarrow <- quantile(oxygenBOSNarrow, alpha/2,
na.rm = TRUE)
oxygenUpper95BayOfSailsNarrow <- quantile(oxygenBOSNarrow, 1-alpha/2,
na.rm = TRUE)
oxygenMeanBayOfSailsNarrow
oxygenLower95BayOfSailsNarrow
oxygenUpper95BayOfSailsNarrow

oxygenMinimumBayOfSailsWide <- min(isotopes$d18O[isotopes$site ==
"bayOfSails" & isotopes$striaeType == "wide"], na.rm = TRUE)
oxygenMaximumBayOfSailsWide <- max(isotopes$d18O[isotopes$site ==
"bayOfSails" & isotopes$striaeType == "wide"], na.rm = TRUE)
oxygenBOSWide <- replicate(10000,
meanOfOneBootstrap(isotopes$d18O[isotopes$site == "bayOfSails" &
isotopes$striaeType == "wide"]))
oxygenMeanBayOfSailsWide <- mean(oxygenBOSWide, na.rm = TRUE)
oxygenLower95BayOfSailsWide <- quantile(oxygenBOSWide, alpha/2, na.rm =
TRUE)
oxygenUpper95BayOfSailsWide <- quantile(oxygenBOSWide, 1-alpha/2, na.rm
= TRUE)
oxygenMeanBayOfSailsWide
oxygenLower95BayOfSailsWide
oxygenUpper95BayOfSailsWide

# Plot d18O and d13C variability comparison figures with all data,
means, and 95% confidence intervals

## d18O all valves
oxygenVariation <- ggplot(data = isotopes, aes(x = site, y = d18O,
group = site, color = site))
oxygenVariationPlot <- oxygenVariation + stat_summary(fun.data =
"mean_cl_boot", colour = "black", size = 1, geom = "pointrange")  +
theme_classic(base_size = 16) +
geom_point(position=position_jitterdodge(),alpha=0.2) +
scale_color_manual(values = myVariabilityColors, name = "", breaks =
c("explorersCove", "bayOfSails", "explorersCoveBaby"), labels =
c("Explorers Cove", "Bay of Sails", "Explorers Cove (Juv)")) + labs(x =
"Site", y = bquote(delta^18~"O")) + scale_x_discrete(labels =
c("Explorers Cove", "Bay of Sails", "Explorers Cove (Juv)"))

## d13C all valves
carbonVariation <- ggplot(data = isotopes, aes(x = site, y = d13C,
group = site, color = site))
carbonVariationPlot <- carbonVariation + stat_summary(fun.data =
"mean_cl_boot", colour = "black", size = 1, geom = "pointrange") +
theme_classic(base_size = 16) +
geom_point(position=position_jitterdodge(),alpha=0.3) +
scale_color_manual(values = myVariabilityColors, name = "Valve", breaks
= c("explorersCove", "bayOfSails", "explorersCoveBaby"), labels =
```

```
c("Explorers Cove", "Bay of Sails", "Explorers Cove (Juv)")) + labs(x =
"Site", y = bquote(delta^13~"C")) + scale_x_discrete(labels =
c("Explorers Cove", "Bay of Sails", "Explorers Cove (Juv)"))

## d18O by striae type
oxygenVariationByStriaeType <- ggplot(data = subset(isotopes,
striaeType != "NA" & site != "explorersCoveBaby"), aes(x = striaeType,
y = d18O, group = striaeType, color = site))
oxygenVariationByStriaeTypePlot <- oxygenVariationByStriaeType +
stat_summary(fun.data = "mean_cl_boot", colour = "black", size = 1,
geom = "pointrange")  + theme_classic(base_size = 16) +
geom_point(position=position_jitterdodge(),alpha=0.3) + facet_grid(cols
= vars(site), labeller = labeller(site = myFacetLabels)) +
scale_color_manual(values = myVariabilityColorsStriae) + labs(x = "", y
= bquote(delta^18~"O")) + scale_x_discrete(labels = c("Narrow", "Wide",
"Narrow", "Wide")) + guides(color = FALSE)

## d13CDetrended by striae type
carbonDetrendedVariationByStriaeType <- ggplot(data = subset(isotopes,
striaeType != "NA" & site != "explorersCoveBaby" & valve !=
"2008BayOfSails003", valve != "2008ExplorersCove003"), aes(x =
striaeType, y = d13CDetrended, group = striaeType, color = site))
carbonDetrendedVariationByStriaeTypePlot <-
carbonDetrendedVariationByStriaeType + stat_summary(fun.data =
"mean_cl_boot", colour = "black", size = 1, geom = "pointrange")  +
theme_classic(base_size = 16) +
geom_point(position=position_jitterdodge(),alpha=0.3) + facet_grid(cols
= vars(site), labeller = labeller(site = myFacetLabels)) +
scale_color_manual(values = myVariabilityColorsStriae) + labs(x =
"Site", y = bquote(delta^13~"C"[detrended])) + scale_x_discrete(labels
= c("Narrow", "Wide", "Narrow", "Wide")) + guides(color = FALSE)

## d18O for EC juveniles by striae type
oxygenVariationExplorersCoveJuvenilesByStriaeType <- ggplot(data =
subset(isotopes, site == "explorersCoveBaby" & striaeType != "NA"),
aes(x = striaeType, y = d18O, group = striaeType, color = site))
oxygenVariationExplorersCoveJuvenilesByStriaeTypePlot <-
oxygenVariationExplorersCoveJuvenilesByStriaeType +
stat_summary(fun.data = "mean_cl_boot", colour = "black", size = 1,
geom = "pointrange")  + theme_classic(base_size = 16) +
geom_point(position=position_jitterdodge(),alpha=0.3) +
scale_color_manual(values = myVariabilityColorsExplorersCoveJuveniles)
+ labs(x = "", y = bquote(delta^18~"O")) + scale_x_discrete(labels =
c("Narrow", "Wide")) + guides(color = FALSE)

## d13C for EC juveniles by striae type
carbonVariationExplorersCoveJuvenilesByStriaeType <- ggplot(data =
subset(isotopes, site == "explorersCoveBaby" & striaeType != "NA"),
aes(x = striaeType, y = d13C, group = striaeType, color = site))
carbonVariationExplorersCoveJuvenilesByStriaeTypePlot <-
carbonVariationExplorersCoveJuvenilesByStriaeType +
stat_summary(fun.data = "mean_cl_boot", colour = "black", size = 1,
geom = "pointrange")  + theme_classic(base_size = 16) +
geom_point(position=position_jitterdodge(),alpha=0.3) +
scale_color_manual(values = myVariabilityColorsExplorersCoveJuveniles)
+ labs(x = "", y = bquote(delta^13~"C")) + scale_x_discrete(labels =
c("Narrow", "Wide")) + guides(color = FALSE)
```

```
## Plot the figures as svgs

ggsave(filename = "oxygenIsotopeVariationBySite.svg", plot =
oxygenVariationPlot, device = "svg", units = "in", width = 9, height =
7)
ggsave(filename = "carbonIsotopeVariationBySite.svg", plot =
carbonVariationPlot, device = "svg", units = "in", width = 9, height =
7)
ggsave(filename = "oxygenVariationByStriaeType.svg", plot =
oxygenVariationByStriaeTypePlot, device = "svg", units = "in", width =
7, height = 7)
ggsave(filename = "carbonDetrendedVariationByStriaeType.svg", plot =
carbonDetrendedVariationByStriaeTypePlot, device = "svg", units = "in",
width = 7, height = 7)
ggsave(filename =
"oxygenVariationExplorersCoveJuvenilesByStriaeTypePlot.svg", plot =
oxygenVariationExplorersCoveJuvenilesByStriaeTypePlot, device = "svg",
units = "in", width = 7, height = 7)
ggsave(filename =
"carbonVariationExplorersCoveJuvenilesByStriaeType.svg", plot =
carbonVariationExplorersCoveJuvenilesByStriaeTypePlot, device = "svg",
units = "in", width = 7, height = 7)
```

APPENDIX D

SUPPLEMENTARY MATERIALS, DATA, AND R CODE FOR CHAPTER 4

Part 1: Supplementary Material

Relative standard deviations on NIST-612 standards over 10 sampling days

Date	Li7	Mg26	Mn55	Ba137	Pb208	N
Jan23	2.74	1.50	0.93	1.44	2.93	10
Jan23	0.76	1.86	0.49	0.74	1.09	3
Jan23	1.44	1.90	0.47	1.03	2.49	3
Jan23	1.44	1.67	0.56	1.39	1.50	3
Jan23	1.84	1.71	0.30	1.13	0.45	3
Jan23	0.92	2.19	0.38	0.91	2.48	3
Jan24	0.84	2.06	0.96	1.65	1.64	10
Jan24	1.50	2.19	1.10	0.31	1.19	3
Jan24	2.24	0.91	0.83	3.58	0.89	3
Jan24	1.47	0.61	0.45	0.32	1.43	3
Jan24	2.04	2.22	0.60	1.46	0.12	3
Jan24	2.66	0.51	0.63	1.30	1.94	3
Jan24	0.57	1.01	1.15	1.66	3.01	3
Jan24	1.21	1.95	0.83	0.76	2.81	3
Jan24	1.21	0.08	1.48	2.42	3.47	3
Jan25	1.67	3.97	1.39	2.12	3.83	10
Jan25	2.60	1.48	1.40	1.56	1.14	3
Jan25	1.99	1.35	0.93	1.36	2.01	3
Jan25	0.70	2.19	0.25	0.03	1.98	3
Jan25	1.29	5.58	0.69	2.76	0.78	3
Jan25	0.97	2.99	0.96	2.16	2.77	3
Jan25	0.79	7.44	0.38	1.41	0.85	3
Jan25	1.69	2.65	1.00	1.06	1.64	3
Jan26	1.54	1.62	2.61	1.47	1.81	10
Jan26	0.44	4.00	1.05	0.89	3.07	3
Jan26	1.26	18.64	1.16	1.04	2.08	3
Jan26	1.33	0.35	1.13	0.99	2.42	3
Jan26	0.14	2.45	0.59	3.31	2.55	3
Jan26	1.14	2.64	0.62	1.21	1.62	3
Jan26	2.15	2.97	2.17	1.42	2.54	3
Jan27	0.69	1.67	0.73	3.13	0.72	10

Date	Li7	Mg26	Mn55	Ba137	Pb208	N
Jan27	0.64	3.48	0.25	2.25	1.31	3
Jan27	1.51	1.03	0.72	1.29	2.05	3
Jan27	1.55	1.61	3.66	1.56	2.10	3
Jan27	2.29	0.91	0.60	0.13	3.71	3
Jan27	1.43	0.89	1.55	0.49	1.05	3
Jan27	0.86	1.90	1.21	1.56	1.34	3
Jan28	1.03	4.34	1.44	1.13	1.45	10
Jan28	0.92	2.51	1.58	1.30	1.34	3
Jan28	0.53	3.32	0.87	1.02	1.45	3
Jan28	1.14	1.30	0.52	1.68	1.02	3
Jan28	1.76	0.93	0.68	1.04	0.26	3
Jan28	0.73	1.36	1.45	2.47	2.39	3
Jan28	1.59	10.81	0.88	1.46	1.32	3
Jan28	1.36	3.24	1.65	1.39	15.21	3
Jan29	1.63	1.42	0.65	0.91	2.59	10
Jan29	0.02	1.73	0.41	0.97	1.87	3
Jan29	1.03	1.38	0.47	1.68	0.99	3
Jan29	1.65	1.95	1.49	1.03	0.36	3
Jan29	2.42	0.90	3.80	1.61	5.52	3
Jan29	1.71	2.24	0.80	0.35	0.98	3
May15	2.26	2.95	1.19	1.81	2.25	10
May15	0.45	0.66	3.28	1.98	2.25	3
May15	0.59	8.24	1.77	3.07	1.46	3
May15	1.60	3.77	2.00	0.65	0.81	3
May15	1.23	3.41	1.72	1.24	2.56	3
May15	1.64	2.33	3.10	1.16	1.49	3
May16	5.65	8.01	2.45	4.53	3.79	10
May16	2.34	6.25	2.27	3.13	1.24	3
May16	2.49	6.49	2.26	4.15	2.35	3
May16	1.20	3.03	0.83	1.20	2.47	3
May16	1.42	5.79	0.82	2.08	10.24	3
May16	1.82	3.34	2.57	2.05	3.99	3
May16	2.05	3.95	2.57	1.94	0.35	3
May16	1.82	8.99	3.54	1.97	2.91	3
May16	1.95	2.78	2.27	0.93	3.31	3
May17	2.05	4.16	1.52	2.37	2.04	10
May17	2.58	2.11	3.02	1.20	1.92	3
May17	0.56	5.83	2.84	1.25	2.42	3
May17	6.08	4.42	2.73	0.94	6.23	3
May17	3.81	8.58	3.48	0.90	4.90	3
May17	3.68	6.51	2.62	1.38	1.00	3
May17	3.64	3.78	2.40	1.80	4.28	3

May17	4.25	5.37	1.41	3.33	1.48	3
May17	2.57	3.40	1.64	2.79	1.43	3
May17	3.04	9.51	10.35	4.04	2.37	3
May17	1.01	3.49	4.11	1.03	1.33	3

Part 2: Data

Explorers Cove Valve #1 trace element concentrations, striae numbers, and interstrial distances

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4RIW3b_105	umbo	NA	0.56	NA	5.03	1.84	0.14
sect4RIW3b_104	umbo	NA	0.54	721.13	5.20	1.29	0.03
sect4RIW3b_103	umbo	NA	0.64	556.51	3.95	2.37	0.01
sect4RIW3b_102	umbo	NA	0.53	537.51	4.27	1.34	0.02
sect4RIW3b_101	umbo	NA	0.47	551.90	5.02	1.24	0.02
sect4RIW3b_100	umbo	NA	0.47	611.18	6.09	1.37	0.02
sect4RIW3b_099	umbo	NA	0.45	647.29	5.39	1.43	0.02
sect4RIW3b_098	umbo	NA	0.47	758.84	5.95	1.44	0.38
sect4RIW3b_097	umbo	NA	0.43	749.30	7.47	1.44	0.07
sect4RIW3b_096	umbo	NA	0.44	746.26	8.27	1.27	0.26
sect4RIW3b_095	umbo	NA	0.43	641.62	7.32	1.15	0.02
sect4RIW3b_094	umbo	NA	0.44	575.70	6.67	1.16	0.02
sect4RIW3b_093	umbo	NA	0.52	482.29	5.77	1.01	0.02
sect4RIW3b_092	1	0.321	0.54	406.08	4.77	0.94	0.02
sect4RIW3b_091	2	0.207	0.49	421.42	6.82	1.22	0.02
sect4RIW3b_090	3	0.2891	0.53	434.08	4.27	1.15	0.02
sect4RIW3b_089	4	0.4578	0.55	343.41	3.59	1.02	0.02
sect4RIW3b_088	5	0.2285	0.53	262.78	3.95	0.86	0.01
sect4RIW3b_087	6	0.185	0.51	177.15	2.84	0.79	0.02
	7	0.1532	NA	NA	NA	NA	NA
sect4RIW3b_086	8	0.2014	0.46	162.25	2.60	0.76	0.02
sect4RIW3b_085	9	0.1307	0.51	142.69	4.23	0.81	0.02
	10	0.0764	NA	NA	NA	NA	NA
sect4RIW3b_084	11	0.0979	0.53	113.62	3.15	0.75	0.02
	12	0.0818	NA	NA	NA	NA	NA
	13	0.0707	NA	NA	NA	NA	NA
sect4RIW3b_083	14	0.0655	0.53	137.80	3.20	0.74	0.01
	15	0.0544	NA	NA	NA	NA	NA
	16	0.0818	NA	NA	NA	NA	NA
sect4RIW3b_082	17	0.0709	0.51	144.39	3.78	0.66	0.02

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
	18	0.0816	NA	NA	NA	NA	NA
sect4RIW3b_081	19	0.1142	0.52	142.29	3.11	0.69	0.08
sect4RIW3b_080	20	0.0816	0.57	130.13	4.38	0.78	0.02
	21	0.0764	NA	NA	NA	NA	NA
sect4RIW3b_079	22	0.0985	0.52	127.45	2.98	0.69	0.02
	23	0.1034	NA	NA	NA	NA	NA
	24	0.0707	NA	NA	NA	NA	NA
sect4RIW3b_078	25	0.0764	0.53	152.51	7.77	0.67	0.03
	26	0.0707	NA	NA	NA	NA	NA
	27	0.0979	NA	NA	NA	NA	NA
sect4RIW3b_077	28	0.1035	0.52	187.82	7.04	0.68	0.02
sect4RIW3b_076	29	0.147	0.50	225.97	9.31	0.76	0.02
sect4RIW3b_075	30	0.2449	0.53	180.08	3.91	0.69	0.01
sect4RIW3b_074	31	0.3482	0.57	198.48	3.02	0.87	0.01
sect4RIW3b_073	32	0.321	0.65	230.30	6.19	1.12	0.03
sect4RIW3b_072	33	0.1905	0.53	290.29	6.12	0.93	0.03
sect4RIW3b_071	34	0.1361	0.57	299.13	7.66	1.17	0.06
sect4RIW3b_070	35	0.1034	0.58	296.51	5.69	0.93	0.11
sect4RIW3b_069	36	0.1256	0.67	331.23	5.80	1.07	0.02
sect4RIW3b_068	37	0.1307	0.63	308.22	7.83	1.19	0.06
	38	0.0931	NA	NA	NA	NA	NA
sect4RIW3b_067	39	0.1089	0.69	346.19	12.86	1.17	0.17
sect4RIW3b_066	40	0.1198	0.64	326.70	11.86	1.27	0.05
sect4RIW3b_065	41	0.1364	0.60	327.05	10.45	1.33	0.06
sect4RIW3b_064	42	0.2517	0.55	275.82	9.04	1.12	0.04
sect4RIW3b_063	43	0.1306	0.61	335.90	12.10	1.59	0.12
sect4RIW3b_062	44	0.1687	0.72	461.55	9.62	1.51	0.03
sect4RIW3b_061	45	0.1961	0.70	424.84	13.95	1.14	0.05
sect4RIW3b_060	46	0.2122	0.62	350.21	11.19	1.06	NA
sect4RIW3b_059	47	0.2885	0.59	319.20	10.47	1.35	0.05
sect4RIW3b_058	48	0.3004	0.66	381.60	11.10	1.09	0.11
sect4RIW3b_057	49	0.3591	0.64	269.04	10.40	1.14	0.09
sect4RIW3b_056	50	0.2777	0.69	438.08	31.22	1.96	0.07
sect4RIW3b_055	50.8	0.2777	0.62	397.80	24.92	1.41	0.07
sect4RIW3b_054	51	0.234	0.78	484.19	22.07	1.14	0.12
sect4RIW3b_053	52	0.1579	0.67	467.81	32.25	1.44	NA
sect4RIW3b_052	53	0.1034	0.61	468.53	43.69	1.11	0.13
sect4RIW3b_051	54	0.1415	0.54	475.69	35.13	1.20	0.07
sect4RIW3b_050	55	0.2463	NA	560.96	NA	1.96	0.06
sect4RIW3b_049	55.9	0.2463	0.73	573.53	24.66	1.13	0.04
sect4RIW3b_048	56	0.2179	0.69	512.40	23.75	1.02	0.05

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4RIW3b_047	57	0.2512	0.72	490.12	31.62	0.97	0.05
sect4RIW3b_046	58	0.245	0.66	460.38	19.43	0.96	0.04
sect4RIW3b_045	59	0.2233	0.65	453.06	9.15	0.96	0.02
sect4RIW3b_044	60	0.234	0.61	422.17	9.20	0.82	0.02
sect4RIW3b_043	61	0.2666	0.57	378.91	16.14	0.85	0.08
sect4RIW3b_042	62	0.245	0.63	417.19	7.07	0.85	0.02
sect4RIW3b_041	63	0.1795	0.64	430.04	8.26	0.92	0.01
sect4RIW3b_040	64	0.1923	0.70	417.27	9.00	0.91	0.03
	65	0.1523	NA	NA	NA	NA	NA
sect4RIW3b_039	66	0.136	0.67	446.41	15.39	0.95	0.04
sect4RIW3b_038	67	0.1799	0.63	409.75	11.65	1.07	0.04
sect4RIW3b_037	68	0.1197	0.63	445.46	12.40	0.95	0.03
sect4RIW3b_036	69	0.1088	0.60	461.19	15.23	1.07	0.04
sect4RIW3b_035	70	0.0979	0.59	476.79	26.66	0.97	0.06
sect4RIW3b_034	71	0.1034	0.66	466.29	21.63	0.99	0.03
sect4RIW3b_033	72	0.1202	0.68	507.37	23.72	1.27	0.04
sect4RIW3b_032	73	0.1579	0.56	423.68	19.36	0.96	0.05
sect4RIW3b_031	74	0.2342	0.64	465.35	20.55	1.03	0.11
sect4RIW3b_030	75	0.2394	NA	459.21	14.55	1.15	NA
sect4RIW3b_029	76	0.2779	0.68	487.15	17.18	1.08	0.24
sect4RIW3b_028	77	0.2946	0.63	449.74	20.00	1.04	0.04
sect4RIW3b_027	78	0.2612	0.66	471.59	18.46	1.06	0.04
sect4RIW3b_026	79	0.3108	0.64	469.79	29.48	1.33	0.05
sect4RIW3b_025	80	0.2502	0.74	489.67	16.71	1.16	0.04
sect4RIW3b_024	81	0.2674	0.82	517.59	16.01	1.01	0.03
sect4RIW3b_023	82	0.2231	0.81	526.32	24.44	1.18	0.03
sect4RIW3b_022	83	0.2453	0.70	525.00	26.01	1.13	0.05
sect4RIW3b_021	84	0.3214	0.88	559.22	15.89	1.03	0.03
sect4RIW3b_020	85	0.3818	0.73	519.86	NA	1.32	0.06
sect4RIW3b_019	86	0.4109	0.86	542.63	12.59	1.04	0.03
sect4RIW3b_018	87	0.464	0.81	551.72	14.25	1.01	0.03
sect4RIW3b_017	88	0.4849	0.66	566.66	20.54	1.07	0.05
sect4RIW3b_016	89	0.5121	0.60	565.21	28.50	1.12	0.06
sect4RIW3b_015	90	0.5173	0.67	575.76	15.79	1.00	0.03
sect4RIW3b_014	91	0.6108	0.60	650.05	30.98	1.32	0.07
sect4RIW3b_013	92	0.5284	0.64	565.50	9.60	0.98	0.03
sect4RIW3b_012	93	0.5132	0.64	531.54	11.23	1.00	0.06
sect4RIW3b_011	94	0.6047	0.58	529.97	28.28	1.23	0.07
sect4RIW3b_010	95	0.2019	0.60	530.33	9.96	0.98	0.03
sect4RIW3b_009	96	0.3706	0.66	505.19	7.50	0.97	0.02
sect4RIW3b_008	97	0.4581	0.59	488.11	7.38	0.96	0.02

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4RIW3b_007	98	0.4901	0.65	564.68	10.20	1.09	0.03
sect4RIW3b_006	99	0.3264	0.63	495.22	10.46	1.01	0.02
sect4RIW3b_005	100	0.3485	0.58	462.87	6.95	1.02	0.02
sect4RIW3b_004	101	0.338	0.55	447.66	6.14	1.01	0.02
sect4RIW3b_003	102	0.3264	0.60	450.26	6.16	0.99	0.02
sect4RIW3b_002	103	0.3059	0.57	443.26	6.57	1.07	0.02
sect4RIW3b_001	104	0.3482	0.62	454.94	7.94	1.75	0.21
sect3RIW3b_069	105	0.3232	0.58	547.70	11.77	NA	0.11
sect3RIW3b_068	106	0.274	0.62	564.73	11.16	1.00	0.04
sect3RIW3b_067	107	0.2938	0.58	544.88	8.56	1.07	0.03
sect3RIW3b_066	108	0.3054	0.53	542.59	11.84	1.02	0.04
sect3RIW3b_065	109	0.2794	0.52	574.82	8.42	1.13	0.03
sect3RIW3b_064	110	0.2902	0.58	606.83	10.10	1.23	0.03
sect3RIW3b_063	111	0.2508	0.53	588.06	13.17	1.15	0.12
sect3RIW3b_062	112	0.272	0.58	572.73	7.56	1.13	0.02
sect3RIW3b_061	113	0.2734	0.52	534.49	7.81	1.10	0.01
sect3RIW3b_060	114	0.262	0.49	538.72	11.06	1.04	0.04
sect1RIW3b_059	115	0.2085	0.49	578.20	12.63	1.17	0.04
	116	0.197					
sect1RIW3b_058	117	0.3178	0.52	550.04	12.01	1.09	0.04
sect1RIW3b_057	117.7	0.3178	0.45	556.78	11.66	1.16	0.03
sect1RIW3b_056	118	0.2409	0.49	544.77	7.68	1.18	0.01
sect1RIW3b_055	119	0.328	0.51	560.17	8.03	1.08	0.03
sect1RIW3b_054	120	0.2775	0.53	535.38	7.88	1.15	0.03
sect1RIW3b_053	121	0.1744	0.52	542.08	7.01	1.08	0.02
sect1RIW3b_052	122	0.1473	0.48	523.60	7.79	1.13	0.03
sect1RIW3b_051	123	0.2122	0.52	577.24	7.96	1.10	NA
sect1RIW3b_050	124	0.1708	0.56	537.98	7.70	1.08	0.01
sect1RIW3b_049	125	0.1473	0.54	542.67	7.79	1.23	0.01
sect1RIW3b_048	126	0.3546	0.43	525.39	7.26	1.09	0.02
sect1RIW3b_047	126.7	0.3546	0.50	540.56	7.03	1.03	0.01
sect1RIW3b_046	127	0.3105	0.50	519.61	6.90	1.13	0.02
sect1RIW3b_045	128	0.3502	0.52	526.72	7.40	1.11	0.02
sect1RIW3b_044	129	0.3271	0.56	533.83	7.99	1.13	0.02
sect1RIW3b_043	130	0.2674	0.49	522.25	6.79	0.92	0.02
sect1RIW3b_042	131	0.3077	0.56	528.04	7.46	1.03	0.02
sect1RIW3b_041	132	0.2837	0.52	525.86	7.33	1.00	0.02
sect1RIW3b_040	133	0.1744	0.50	449.04	5.87	1.14	0.01
sect1RIW3b_038	135	0.1431	0.52	500.51	6.76	0.93	0.02
sect1RIW3b_037	136	0.1039	0.55	563.59	9.32	1.17	0.03
sect1RIW3b_036	137	0.2775	0.55	553.75	12.17	1.05	0.02

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
	138	0.1334					
sect1RIW3b_035	139	0.147	0.59	565.36	8.66	1.12	0.05
sect1RIW3b_034	140	0.1539	0.57	525.13	6.96	0.99	0.02
sect1RIW3b_033	141	0.2512	0.49	516.96	6.61	0.93	0.03
sect1RIW3b_032	141.7	0.2512	0.51	533.99	8.30	0.99	0.03
sect1RIW3b_031	142	0.3064	0.55	528.11	10.72	1.01	0.05
sect3RIW3b_030	143	0.1252	NA	514.75	8.44	0.97	0.03
sect1RIW3b_039	143	0.137	0.49	509.51	6.82	1.06	0.03
sect3RIW3b_029	144	0.234	0.53	489.26	7.04	0.94	0.02
sect3RIW3b_028	145	0.2049	0.50	547.37	7.38	1.02	0.03
sect3RIW3b_027	145.8	0.2049	0.54	512.58	6.51	1.23	0.02
sect3RIW3b_026	146	0.1414	0.54	514.05	6.90	1.06	0.03
sect3RIW3b_025	147	0.1431	0.57	530.73	7.44	0.97	0.03
sect3RIW3b_024	148	0.1093	0.57	509.82	7.28	1.01	0.03
sect3RIW3b_023	149	0.1415	0.57	505.62	6.51	1.20	0.04
sect3RIW3b_022	150	0.131	0.57	524.13	7.82	1.00	0.03
sect3RIW3b_021	151	0.1307	0.54	517.20	7.13	0.98	0.03
sect3RIW3b_020	152	0.1579	0.53	499.24	7.01	0.99	0.04
sect3RIW3b_019	153	0.2233	0.50	512.14	7.15	1.03	0.06
sect3RIW3b_018	154	0.2829	0.56	546.34	7.47	0.94	0.04
sect3RIW3b_017	155	0.2399	0.57	530.29	7.08	1.05	0.05
sect3RIW3b_016	156	0.2291	0.54	500.64	7.99	0.96	0.04
sect3RIW3b_015	157	0.2503	0.53	506.62	7.08	1.01	0.04
sect3RIW3b_014	158	0.234	0.52	491.79	6.63	1.14	0.04
sect3RIW3b_013	159	0.2394	0.55	500.83	7.36	1.01	0.03
sect3RIW3b_012	160	0.1959	0.50	479.20	6.84	0.99	0.04
sect3RIW3b_011	161	0.2013	0.49	472.68	6.40	1.00	0.04
sect3RIW3b_010	162	0.1636	0.49	475.59	6.72	0.92	0.04
sect3RIW3b_009	163	0.1633	0.55	476.38	6.51	1.04	0.04
sect3RIW3b_008	164	0.1959	0.56	455.78	8.20	0.99	0.04
sect3RIW3b_007	165	0.1961	0.53	476.84	6.61	0.94	0.04
sect3RIW3b_006	166	0.2725	0.49	462.29	6.33	0.96	0.03
sect3RIW3b_005	167	0.197	0.48	474.17	6.19	1.00	0.03
sect3RIW3b_004	168	0.2449	0.48	468.10	6.25	1.01	0.04
sect3RIW3b_003	169	0.5006	0.52	467.30	6.24	0.94	0.02
sect3RIW3b_002	169.6	0.5006	0.49	432.70	5.97	0.90	0.03
sect3RIW3b_001	170	0.3048	NA	461.78	7.16	NA	NA
sect2RIW3b_120	171	0.414	0.79	667.21	NA	2.26	NA
sect2RIW3b_119	171.6	0.414	0.53	488.01	6.33	0.97	0.04
sect2RIW3b_118	172	0.185	0.44	479.21	5.50	0.89	0.02
sect2RIW3b_117	172.8	0.185	0.53	469.56	5.69	0.98	0.02

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2RIW3b_116	173	0.2247	0.56	468.61	7.65	0.94	0.10
sect2RIW3b_115	174	0.1197	0.50	456.68	5.77	0.97	0.04
sect2RIW3b_114	175	0.1977	0.51	462.99	6.39	1.03	0.08
sect2RIW3b_113	176.2	0.207	0.48	474.81	5.99	0.98	0.04
sect2RIW3b_112	176.6	0.207	0.41	469.02	6.43	0.96	0.03
sect2RIW3b_111	177	0.1035	0.50	462.88	6.26	1.04	0.03
sect2RIW3b_110	178	0.1307	0.49	473.02	6.32	1.01	0.03
sect2RIW3b_109	179	0.1251	0.50	470.49	5.88	1.00	0.02
sect2RIW3b_108	180	0.1364	0.54	444.99	6.22	0.99	0.07
sect2RIW3b_107	181	0.1904	0.49	445.77	5.60	1.09	0.08
	182	0.1419					
sect2RIW3b_106	183	0.1632	0.55	470.68	7.59	0.95	0.02
sect2RIW3b_105	184	0.0872	0.57	472.58	5.96	1.12	0.07
sect2RIW3b_104	185	0.1093	0.54	471.64	5.96	1.12	0.03
sect2RIW3b_103	186	0.2014	0.51	478.10	6.24	0.97	0.04
sect2RIW3b_102	187	0.1089	0.46	496.25	8.37	1.16	0.12
sect2RIW3b_101	188	0.1034	0.46	499.97	6.64	1.00	0.05
sect2RIW3b_100	189	0.1581	0.44	483.88	7.08	1.00	0.04
	190	0.0816					
	191	0.0925					
sect2RIW3b_099	192	0.169	0.47	552.96	7.79	1.18	0.06
sect2RIW3b_098	192.6	0.169	0.41	490.77	6.85	1.12	0.03
sect2RIW3b_097	193	0.2016	0.53	512.98	7.14	1.06	0.05
sect2RIW3b_096	194	0.147	0.44	486.02	6.62	1.07	0.05
sect2RIW3b_095	195	0.1251	0.53	498.25	7.04	1.09	0.15
sect2RIW3b_094	196	0.1262	0.47	475.45	7.42	0.95	0.04
sect2RIW3b_093	197	0.2231	0.61	488.43	7.89	1.16	0.08
sect2RIW3b_092	198	0.1808	0.45	446.63	7.13	1.36	0.08
sect2RIW3b_091	199	0.1578	0.57	466.36	7.99	1.04	0.05
sect2RIW3b_090	200	0.164	0.53	475.56	6.94	1.13	0.07
sect2RIW3b_089	201	0.3118	0.45	431.36	5.91	0.99	0.06
sect2RIW3b_088	202	0.169	0.53	450.91	6.44	1.29	0.20
sect2RIW3b_087	203	0.2074	0.48	437.54	5.92	1.08	0.04
	204	0.0931					
sect2RIW3b_086	205	0.1415	0.50	438.43	6.62	1.20	0.06
sect2RIW3b_085	206	0.1687	0.42	411.56	6.56	0.99	0.06
sect2RIW3b_084	207	0.1744	0.46	422.79	6.27	1.08	0.07
sect2RIW3b_083	208	0.2722	0.51	431.02	7.03	1.09	0.04
sect2RIW3b_082	209	0.2557	0.50	435.64	6.65	0.98	0.06
sect2RIW3b_081	209.7	0.2557	0.57	452.87	9.45	1.67	0.13
sect2RIW3b_080	210	0.354	0.50	467.33	6.49	1.28	0.05

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sect2RIW3b_079	211	0.2779	0.49	446.04	8.40	1.32	0.06
sect2RIW3b_078	212	0.2019	0.59	447.77	9.66	0.99	0.04
sect2RIW3b_077	213	0.1796	0.51	466.30	8.79	1.06	0.08
sect2RIW3b_076	214	0.1742	0.52	480.13	11.16	1.21	0.08
sect2RIW3b_075	215	0.087	0.51	471.68	7.73	1.44	0.09
	216	0.1089					
sect2RIW3b_074	217	0.1197	0.58	477.27	6.77	1.07	0.07
sect2RIW3b_073	218	0.1035	0.57	509.15	6.82	1.18	0.25
sect2RIW3b_072	219	0.1039	0.41	455.21	6.25	1.08	0.05
sect2RIW3b_071	220	0.1798	0.54	489.89	9.63	1.42	0.10
sect2RIW3b_070	221	0.1148	0.65	529.86	16.13	1.37	0.49
sect2RIW3b_069	222	0.1035	0.55	522.06	9.37	1.14	0.11
sect2RIW3b_068	223	0.1959	0.59	503.89	11.85	1.58	0.20
sect2RIW3b_067	224	0.1959	0.52	472.55	6.47	1.11	0.05
sect2RIW3b_066	225	0.147	0.52	479.93	7.72	1.17	0.05
sect2RIW3b_065	226	0.1687	0.56	491.02	6.86	1.04	0.05
sect2RIW3b_064	227	0.1198	0.57	499.30	6.25	1.10	0.05
sect2RIW3b_063	228	0.1558	0.71	541.59	7.85	1.23	0.08
sect2RIW3b_062	229	0.0981	0.53	500.34	8.50	0.99	0.09
sect2RIW3b_061	230	0.1088	0.65	505.17	9.56	1.66	0.16
sect2RIW3b_060	231	0.2291	0.52	409.49	7.03	1.01	0.07
sect2RIW3b_059	232	0.1414	0.52	466.22	6.70	1.01	0.05
sect2RIW3b_058	233	0.1089	0.55	473.81	7.60	2.54	0.18
sect2RIW3b_057	234	0.1144	0.47	454.59	9.46	1.00	0.35
sect2RIW3b_056	235	0.1636	0.62	455.36	7.87	1.06	0.04
sect2RIW3b_055	236	0.1523	0.47	507.92	8.57	1.11	0.12
sect2RIW3b_054	237	0.0818	0.73	450.57	9.95	2.42	0.05
sect2RIW3b_053	238	0.1527	0.62	502.31	10.36	1.45	0.40
sect2RIW3b_052	239	0.1636	0.50	470.48	9.75	1.19	0.09
sect2RIW3b_051	240	0.3051	0.51	457.86	7.01	1.18	0.13
sect2RIW3b_050	241	0.1796	0.63	497.61	6.92	1.33	0.11
sect2RIW3b_049	242	0.1148	0.46	486.67	7.71	1.05	0.11
sect2RIW3b_048	243	0.1088	0.60	513.43	7.46	1.14	0.14
sect2RIW3b_047	244	0.1419	0.57	589.41	10.08	1.36	0.04
sect2RIW3b_046	245	0.1198	0.48	463.49	8.99	1.18	0.15
sect2RIW3b_045	246	0.137	0.48	447.17	7.34	0.95	0.07
sect2RIW3b_044	247	0.1636	0.48	478.93	7.78	1.13	0.07
sect2RIW3b_043	248	0.1093	0.46	477.36	7.71	0.99	0.11
sect2RIW3b_042	249	0.1905	0.65	476.75	7.15	1.82	0.11
sect2RIW3b_041	250	0.2291	0.51	654.41	27.95	2.01	NA
sect2RIW3b_040	251	0.2177	0.53	532.94	8.32	1.33	0.19

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2RIW3b_039	252	0.1636	0.48	520.75	7.21	1.29	0.56
sect2RIW3b_038	253	0.0653	0.48	477.65	6.94	1.22	0.06
	254	0.185					
sect2RIW3b_037	255	0.0762	0.50	485.87	6.44	1.35	0.02
sect2RIW3b_036	256	0.1089	0.43	493.02	11.92	1.26	0.12
	257	0.0762					
sect2RIW3b_035	258	0.1148	0.59	478.57	7.35	1.12	0.02
sect2RIW3b_034	259	0.1208	0.46	479.04	8.71	1.35	0.12
sect2RIW3b_033	260	0.169	0.45	494.17	7.93	1.28	0.07
sect2RIW3b_032	261	0.1816	0.37	459.15	6.65	1.49	0.18
	262	0.131					
sect2RIW3b_031	263	0.1324	0.88	490.04	25.09	2.47	0.18
sect2RIW3b_030	264	0.2014	0.48	448.08	6.90	1.27	0.04
sect2RIW3b_029	265	0.2182	0.50	484.24	7.85	1.37	0.04
sect2RIW3b_028	266	0.1579	0.50	491.25	9.19	1.25	0.04
sect2RIW3b_027	267	0.136	0.68	451.04	8.48	1.19	0.07
sect2RIW3b_026	267.8	0.136	0.59	494.31	9.24	1.20	0.05
sect2RIW3b_025	268	0.1197	0.72	458.30	9.15	1.22	0.03
sect2RIW3b_024	269	0.1905	0.61	521.58	7.98	1.29	0.09
sect2RIW3b_023	270	0.0707	0.70	495.24	8.51	1.27	0.04
sect2RIW3b_022	271	0.1307	0.61	511.69	8.15	1.24	0.05
sect2RIW3b_021	272	0.131	0.66	512.05	9.41	1.36	0.07
	273	0.1144					
	274	0.0779					
sect2RIW3b_020	275	0.0818	0.65	489.59	8.08	1.76	0.09
sect2RIW3b_019	276	0.1088	0.55	475.92	8.26	1.18	0.09
sect2RIW3b_018	277	0.0979	0.64	497.73	8.01	1.37	0.27
sect2RIW3b_017	278	0.1524	0.69	489.99	11.42	1.15	0.06
sect2RIW3b_016	279	0.1034	0.70	559.32	7.13	1.55	0.07
sect2RIW3b_015	280	0.0981	0.66	495.73	10.78	1.19	0.06
sect2RIW3b_014	281	0.1686	0.58	526.89	6.74	1.21	0.31
	282	0.1089					
sect2RIW3b_013	283	0.1089	0.61	532.54	9.98	1.50	NA
	284	0.1035					
sect2RIW3b_012	285	0.1578	0.59	534.82	6.23	1.19	0.05
	286	0.0709					
sect2RIW3b_011	287	0.2122	0.44	718.76	6.93	1.38	0.05
sect2RIW3b_010	288	0.2182	0.52	539.85	6.94	1.22	0.07
sect2RIW3b_009	289	0.1142	0.49	509.59	8.98	1.38	0.05
sect2RIW3b_008	290	0.2019	0.49	537.94	9.41	1.32	0.07
sect2RIW3b_007	291	0.1415	0.41	501.74	10.14	1.22	0.08

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2RIW3b_006	292	0.1414	0.45	467.33	10.46	1.37	0.09
sect2RIW3b_005	293	0.0925	0.48	462.34	11.01	1.40	0.10
sect2RIW3b_004	294	0.1089	0.47	444.77	6.57	1.23	0.06
	295	0.0926					
sect2RIW3b_003	296	0.1093	0.58	458.33	13.13	1.37	0.06
sect2RIW3b_002	297	0.1539	0.49	486.36	6.79	1.51	NA
sect2RIW3b_001	298	0.1636	0.83	NA	NA	2.09	NA
	299	0.1061					
sect1RIW3b_158	300	0.0898	0.87	650.31	NA	2.25	0.31
	301	0.0694					
sect1RIW3b_157	302	0.0779	0.86	645.09	11.04	1.51	0.07
sect1RIW3b_156	303	0.0979	0.41	579.50	7.33	1.45	0.10
sect1RIW3b_155	304	0.0739	0.42	656.44	6.70	1.63	0.21
sect1RIW3b_154	305	0.098	0.79	588.05	5.86	1.64	0.04
	306	0.0861					
sect1RIW3b_153	307	0.0983	0.46	624.58	5.85	1.68	0.04
	308	0.0613					
sect1RIW3b_152	309	0.0939	0.48	560.99	6.63	1.64	0.07
	310	0.0939					
sect1RIW3b_151	311	0.1143	0.44	543.05	5.76	3.41	0.02
sect1RIW3b_150	312	0.0573	0.42	498.40	5.86	1.63	0.02
	313	0.0408					
sect1RIW3b_149	314	0.0816	0.38	511.55	5.46	1.56	0.06
sect1RIW3b_148	315	0.1471	0.44	554.37	5.53	1.55	0.03
sect1RIW3b_147	316	0.0858	0.45	609.61	6.49	1.64	0.04
sect1RIW3b_146	317	0.1393	0.54	607.44	5.29	1.52	0.04
sect1RIW3b_145	318	0.1061	0.58	611.48	5.75	1.57	0.03
	319	0.0654					
sect1RIW3b_144	320	0.0612	0.49	625.73	7.93	1.76	0.06
sect1RIW3b_143	321	0.0858	0.48	631.34	7.25	2.04	0.03
	322	0.0532					
sect1RIW3b_142	323	0.0734	0.49	753.81	5.75	1.98	0.02
sect1RIW3b_141	324	0.155	0.42	593.19	8.59	1.86	0.04
sect1RIW3b_140	325	0.0899	0.42	521.48	6.35	1.42	0.02
sect1RIW3b_139	326	0.1102	0.36	518.94	7.12	1.55	0.02
sect1RIW3b_138	327	0.1023	0.40	520.97	7.22	1.49	0.03
	328	0.0694					
sect1RIW3b_137	329	0.0736	0.40	537.27	6.53	1.39	0.02
sect1RIW3b_136	329.8	0.0736	0.37	548.26	7.72	1.48	0.03
sect1RIW3b_135	330	0.1183	0.35	533.73	7.66	1.47	0.02
sect1RIW3b_134	331	0.0825	0.39	530.82	10.24	1.41	0.01

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1RIW3b_133	332	0.0695	0.42	604.44	8.08	1.62	0.03
sect1RIW3b_132	333	0.0694	0.43	573.51	9.45	2.00	0.02
	334	0.0326					
sect1RIW3b_131	335	0.0736	0.43	599.01	8.14	1.70	0.02
sect1RIW3b_130	336	0.0496	0.42	632.34	9.67	1.80	0.03
sect1RIW3b_129	337	0.1553	0.45	592.19	7.82	1.70	0.03
sect1RIW3b_128	338	0.1235	0.39	822.13	7.61	1.93	0.02
	339	0.0496					
sect1RIW3b_127	340	0.1062	0.52	775.41	9.18	1.79	0.03
	341	0.0698					
sect1RIW3b_126	342	0.0695	0.47	663.45	12.15	1.67	0.07
sect1RIW3b_125	343	0.0983	0.39	583.35	8.62	1.87	0.03
sect1RIW3b_124	344	0.0816	0.38	591.91	8.18	1.86	0.13
sect1RIW3b_123	345	0.1061	0.39	548.91	7.35	1.60	0.02
sect1RIW3b_122	346	0.053	0.37	570.00	6.48	1.69	0.02
sect1RIW3b_121	347	0.1023	0.53	561.30	14.57	1.69	0.05
sect3RIW3b_120	348	0.1227	0.33	563.23	10.96	1.53	NA
sect3RIW3b_119	349	0.1347	0.42	614.61	7.05	1.70	0.01
sect3RIW3b_118	350	0.119	0.35	607.48	6.75	1.54	0.01
sect3RIW3b_117	351	0.1149	0.46	573.20	7.03	1.56	0.02
	352	0.0612					
sect3RIW3b_116	353	0.1429	0.58	744.16	6.71	1.87	0.08
sect3RIW3b_115	354	0.1186	0.36	636.55	9.50	1.92	0.35
sect3RIW3b_114	355	0.1064	0.48	613.25	7.90	1.59	0.03
	356	0.0899					
sect3RIW3b_113	357	0.0694	0.40	568.88	11.81	1.49	0.02
sect3RIW3b_112	358	0.0734	0.39	650.16	8.60	1.73	0.04
sect3RIW3b_111	359	0.151	0.49	746.69	7.90	1.71	0.02
sect3RIW3b_110	360	0.0776	0.38	754.45	9.40	1.77	0.04
	361	0.0633					
sect3RIW3b_109	362	0.0653	0.48	596.85	9.93	1.64	0.04
sect3RIW3b_108	363	0.1529	0.49	551.74	9.22	1.49	0.05
	364	0.0906					
sect3RIW3b_107	365	0.0816	0.43	526.74	9.76	1.44	0.05
sect3RIW3b_106	366	0.0906	0.49	489.88	8.66	1.51	0.05
sect3RIW3b_105	367	0.0979	0.38	539.66	8.22	1.50	0.03
	368	0.0776					
sect3RIW3b_104	369	0.0899	0.48	535.99	9.04	1.58	0.30
sect3RIW3b_103	370	0.1154	0.39	529.43	8.20	1.44	0.03
sect3RIW3b_102	371	0.0901	0.46	538.72	7.52	1.39	0.06
sect3RIW3b_101	372	0.0736	0.39	555.86	8.34	1.40	0.08

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3RIW3b_100	373	0.0816	0.36	507.18	12.59	1.31	0.13
sect3RIW3b_099	374	0.1311	0.96	452.27	8.15	1.22	0.02
sect3RIW3b_098	375	0.0946	0.31	442.12	7.47	1.29	0.04
sect3RIW3b_097	376	0.1483	0.41	438.16	8.12	1.41	0.02
	377	0.1102					
sect3RIW3b_096	378	0.0776	0.49	434.31	8.40	2.06	0.27
sect3RIW3b_095	379	0.119	0.35	454.32	7.88	1.44	0.02
sect3RIW3b_094	380	0.0942	0.37	484.69	8.54	1.26	0.05
sect3RIW3b_093	381	0.0861	0.40	499.98	7.73	1.29	0.05
	382	0.0624					
sect3RIW3b_092	383	0.0775	0.45	466.20	7.86	1.80	0.04
	384	0.082					
	385	0.0779					
sect3RIW3b_091	386	0.0858	0.41	540.88	11.02	1.91	0.17
sect1RIW3b_090	387	0.1387	0.41	402.50	7.64	1.22	0.60
sect1RIW3b_089	388	0.0938	0.55	436.40	8.91	1.32	0.09
sect1RIW3b_088	389	0.1186	0.58	434.00	7.83	1.23	0.05
sect1RIW3b_087	390	0.0983	0.61	498.46	7.99	1.22	0.27
sect1RIW3b_086	391	0.139	0.59	443.65	14.05	1.47	0.03
sect1RIW3b_085	392	0.1105	0.63	457.74	7.46	1.35	0.08
sect1RIW3b_084	393	0.0938	0.58	499.31	6.04	1.63	0.03
sect1RIW3b_083	394	0.0987	0.41	521.98	8.13	1.64	0.12
	395	0.0698					
sect1RIW3b_082	396	0.0612	0.46	540.15	12.62	1.32	0.03
sect1RIW3b_081	397	0.0901	0.47	475.12	7.28	1.35	0.04
sect1RIW3b_080	398	0.1062	0.53	449.40	6.83	1.36	0.02
sect1RIW3b_079	399	0.0899	0.51	461.32	8.32	1.26	0.03
sect1RIW3b_078	400	0.1555	0.49	497.91	9.16	1.56	0.42
sect1RIW3b_077	401	0.1429	0.44	444.36	8.31	1.41	0.04
sect1RIW3b_076	402	0.1592	0.51	455.57	9.93	1.37	0.43
sect1RIW3b_075	403	0.151	0.50	462.65	7.43	1.33	0.02
sect1RIW3b_074	404	0.2006	0.52	466.48	7.25	1.31	0.03
sect1RIW3b_073	405	0.1673	0.52	472.78	7.09	1.48	0.03
sect1RIW3b_072	406	0.1265	0.54	485.38	8.33	1.59	0.17
sect1RIW3b_071	407	0.1478	0.57	500.82	8.99	1.46	0.04
sect1RIW3b_070	408	0.053	0.64	502.04	9.28	1.38	0.08
sect1RIW3b_069	409	0.0898	0.54	464.48	9.31	1.45	0.04
sect1RIW3b_068	410	0.1265	0.53	448.26	7.20	1.35	0.04
sect1RIW3b_067	411	0.1271	0.51	453.46	6.08	1.55	0.06
sect1RIW3b_066	412	0.1797	0.43	450.87	6.83	1.44	0.13
sect1RIW3b_065	413	0.143	0.45	454.30	5.23	1.51	0.02

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1RIW3b_064	414	0.1225	0.55	459.84	4.89	2.13	0.02
sect1RIW3b_063	415	0.1224	0.42	457.51	7.04	1.37	0.04
sect1RIW3b_062	416	0.0816	0.40	504.14	10.35	1.25	0.03
	417	0.1102					
sect1RIW3b_061	418	0.1267	0.57	570.60	5.75	1.51	0.03
	419	0.0612					
	420	0.0408					
sect1RIW3b_060	421	0.0571	0.48	787.16	31.05	1.70	0.18
	422	0.0573					
sect1RIW3b_059	423	0.049	0.60	530.73	13.97	1.23	0.03
	424	0.0367					
sect1RIW3b_058	425	0.1388	0.63	531.56	8.09	3.13	0.06
sect1RIW3b_057	426	0.1518	0.60	481.12	6.37	1.12	0.07
sect1RIW3b_056	427	0.1183	0.52	472.59	5.53	1.24	0.09
sect1RIW3b_055	428	0.1186	0.55	480.98	7.35	1.46	0.09
sect1RIW3b_054	429	0.143	0.54	487.09	5.74	1.11	0.03
sect1RIW3b_053	430	0.1265	0.66	511.73	6.92	0.99	0.03
sect1RIW3b_052	431	0.0939	0.66	546.47	8.58	1.28	0.08
sect1RIW3b_051	432	0.0857	0.66	587.66	8.34	1.42	0.05
sect1RIW3b_050	433	0.0979	0.77	685.05	10.42	1.45	0.07
sect1RIW3b_049	434	0.1061	0.75	806.64	10.40	1.61	0.10
sect1RIW3b_048	435	0.1143	0.70	736.13	8.22	1.62	0.08
sect1RIW3b_047	436	0.102	0.71	701.33	9.95	1.64	0.32
	437	0.0775					
sect1RIW3b_046	438	0.1062	0.80	688.11	9.55	1.77	NA
sect1RIW3b_045	439	0.1021	0.64	693.10	7.36	1.83	0.04
sect1RIW3b_044	440	0.1149	1.12	729.75	7.75	1.38	0.10
sect1RIW3b_043	441	0.1225	0.89	857.67	6.74	NA	0.03
sect1RIW3b_042	442	0.1023	0.76	833.53	12.75	1.56	0.14
sect1RIW3b_041	443	0.1428	0.72	690.79	7.47	1.20	0.07
	444	0.0612					
sect1RIW3b_040	445	0.082	0.66	722.03	10.44	1.23	0.13
sect1RIW3b_039	446	0.0658	0.76	809.26	21.59	1.50	0.12
sect1RIW3b_038	447	0.1021	0.67	809.64	8.50	1.61	0.07
sect1RIW3b_037	448	0.0899	0.64	1028.34	16.44	2.03	0.11
sect1RIW3b_036	449	0.0698	0.64	1220.52	6.26	2.42	0.06
	450	0.0694					
sect1RIW3b_035	451	0.0817	1.04	1283.08	19.06	2.91	0.17
	452	0.0695					
sect1RIW3b_034	453	0.0734	0.80	1440.36	9.86	2.92	0.08
	454	0.0695					

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1RIW3b_033	455	0.0906	1.12	1949.31	24.59	3.85	0.21
sect1RIW3b_032	456	0.102	0.86	1331.03	27.46	3.35	0.20
sect1RIW3b_031	457	0.0899	1.32	1867.01	39.34	NA	NA
	458	0.0698					
sect1RIW3b_030	459	0.0736	1.06	1085.45	47.91	3.58	0.66
sect1RIW3b_029	460	0.2141	1.49	1325.94	31.26	NA	0.58
sect1RIW3b_028	461	0.123	1.11	862.53	12.96	1.79	0.12
sect1RIW3b_027	462	0.1183	1.40	1833.92	27.00	4.05	0.32
	463	0.082					
	464	0.0532					
	465	0.0695					
sect1RIW3b_026	466	0.1224	1.44	1188.25	13.72	1.86	0.17
sect1RIW3b_025	467	0.1224	1.07	957.78	11.35	2.00	0.11
sect1RIW3b_024	468	0.1632	0.80	1022.31	11.77	1.90	0.13
	469	0.0376					
	470	0.041					
sect1RIW3b_023	471	0.0416	0.60	578.92	12.17	1.06	0.08
	472	0.0465					
sect1RIW3b_022	473	0.1145	0.74	569.54	11.61	2.17	0.08
sect1RIW3b_021	474	0.1186	0.69	555.44	11.77	1.07	0.06
sect1RIW3b_020	475	0.123	0.78	578.21	10.37	1.13	0.23
sect1RIW3b_019	476	0.2082	1.16	713.99	14.75	1.17	0.06
sect1RIW3b_018	477	0.2204	0.61	577.74	11.11	1.44	0.07
sect1RIW3b_017	478	0.1721	1.09	765.58	18.76	1.46	0.32
sect1RIW3b_016	479	0.1919	0.57	1027.72	11.20	1.77	0.29
sect1RIW3b_015	480	0.1673	0.57	977.10	7.75	1.71	0.09
sect1RIW3b_014	481	0.1512	0.67	1051.05	5.92	1.52	0.08
sect1RIW3b_013	482	0.1061	0.86	1578.00	15.54	2.80	0.15
sect1RIW3b_012	483	0.1021	0.80	1243.01	9.82	1.69	0.18
sect1RIW3b_011	484	0.0816	0.83	1151.45	8.50	3.26	0.73
sect1RIW3b_010	485	0.0899	0.70	1225.31	7.78	2.05	0.11
sect1RIW3b_009	486	0.1073	0.94	1844.93	12.52	2.50	0.34
sect1RIW3b_008	487	0.0939	0.87	1741.15	11.71	3.04	0.13
sect1RIW3b_007	488	0.1102	NA	NA	NA	NA	NA
sect1RIW3b_006	489	0.1064	1.10	1826.03	11.37	2.77	0.06
sect1RIW3b_005	490	0.0942	0.90	2400.18	16.48	4.23	0.21
sect1RIW3b_004	490.7	0.0942	1.04	NA	22.44	3.51	0.19
	491	0.0451					
sect1RIW3b_003	492	0.0654	1.00	1871.36	9.87	2.20	0.20
	493	0.0451					
sect1RIW3b_002	494	0.0695	1.10	2313.56	7.01	2.78	0.24

Sample	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
	495	0.0912					
sect1RIW3b_001	496	0.0858	NA	NA	NA	NA	NA
	497	0.0613					

Explorers Cove Valve #2 trace element concentrations, striae numbers, and interstrial distances

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4RIW4b_075		umbo		0.52	972.67	15.65	1.3	0.16
sect4RIW4b_074		umbo		0.59	1045.24	18.55	1.48	0.18
sect4RIW4b_073		umbo		0.42	978.9	21.67	1.52	0.23
sect4RIW4b_072		umbo		0.44	1048.03	27.46	1.61	0.35
sect4RIW4b_071		umbo		0.34	888.23	27.46	1.71	0.2
sect4RIW4b_070		umbo		0.48	696.03	14.53	1.24	0.06
sect4RIW4b_069		umbo		0.47	531.97	14.23	1.2	0.16
sect4RIW4b_068		umbo		0.51	533.54	15.22	1.51	0.31
sect4RIW4b_067		umbo		0.46	428.54	11.69	1.02	0.1
sect4RIW4b_066		umbo		0.5	205.16	8.91	1.09	0.19
sect4RIW4b_065		umbo		0.41	109.26	3.11	1.09	0.19
sect4RIW4b_064		umbo		0.4	107.13	9.68	1	0.27
sect4RIW4b_063		umbo		0.42	71.35	7.87	0.87	0.24
sect4RIW4b_062		umbo		0.43	72.65	2.79	0.96	0.21
sect4RIW4b_061		umbo		0.45	67.8	5.94	0.76	0.24
sect4RIW4b_060		umbo		0.46	72.16	6.82	0.66	0.15
sect4RIW4b_059		umbo		0.54	85.05	10.67	1.06	0.18
sect4RIW4b_058		1	0.1776	0.5	85.37	6.08	1.01	0.16
		2	0.1654					
sect4RIW4b_057		3	0.0985	0.56	95.23	5.57	0.86	0.16
		4	0.1426					
		5	0.1555					
sect4RIW4b_056		6	0.0802	0.61	130.72	13.71	1.01	0.24
sect4RIW4b_055		7	0.0634	0.51	118.7	10.06	0.87	0.22
sect4RIW4b_054		8	0.0827	0.67	113.47	6.24	1.39	0.24
sect4RIW4b_053		9	0.1015	0.45	197.87	11	0.84	0.22
		10	0.1017					
sect4RIW4b_052		11	0.1078	0.68	245.91	15.29	1.03	0.23
sect4RIW4b_051		12	0.1142	0.62	158.88	10.61	0.67	0.19
sect4RIW4b_050		13	0.1142	0.51	117.41	12.15	0.88	0.17
sect4RIW4b_049		14	0.1523	0.57	116.62	8.79	0.86	0.17
sect4RIW4b_048		15	0.1269	0.59	143.86	24.87	1.68	0.21
sect4RIW4b_047		16	0.1587	0.52	130.83	11.43	1.28	0.13
sect4RIW4b_046		17	0.1903	0.57	251.86	16.37	1.64	0.16
sect4RIW4b_045		18	0.1587	0.59	194.7	12.55	1.66	0.1
sect4RIW4b_044		19	0.1269	0.49	203.54	39.81	1.71	0.16
sect4RIW4b_043		20	0.1205	0.57	230.15	24.3	1.76	0.16

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4RIW4b_042		21	0.0825	0.65	220.52	21.94	2.62	0.5
sect4RIW4b_041		22	0.1651	0.52	282.05	14.39	1.69	0.19
sect4RIW4b_040		23	0.184	0.64	270.83	14.27	1.62	0.16
sect4RIW4b_039		24	0.1651	0.62	323.64	24.94	1.7	0.24
sect4RIW4b_038		25	0.2221	0.75	336.76	22.04	1.65	0.09
sect4RIW4b_037		26	0.3811	0.53	364.36	32.4	1.75	0.23
sect4RIW4b_036		27	0.3299	0.6	475.42	22.33	1.6	0.16
sect4RIW4b_035		28	0.3235	0.55	527.16	38.04	1.89	0.22
sect4RIW4b_034		29	0.3562	0.59	605.64	33.19	1.14	0.22
		30	0.2855					
sect4RIW4b_033		31	0.2347	0.8	629.34	33.11	1.38	0.1
sect4RIW4b_032		32	0.2348	0.77	650.73	33.76	1.05	0.17
sect4RIW4b_031		33	0.1465	0.59	649.08	84.81	1.68	0.16
sect4RIW4b_030		33.75	0.1465	0.79	591.58	28.82	1.13	0.1
sect4RIW4b_029		34	0.0764	0.72	631.78	42.68	1.22	0.18
sect4RIW4b_028		35	0.1078	0.71	634.68	29.77	1.31	0.14
sect4RIW4b_027		36	0.1205	0.81	681.49	58.29	1.74	0.19
		37	0.1144					
sect4RIW4b_026		38	0.089	0.79	644.23	70.43	1.28	0.15
sect4RIW4b_025		39	0.0698	0.79	601.76	25.57	1.15	0.13
sect4RIW4b_024		39.5	0.0698	0.84	594.51	28.49	1.06	0.13
sect4RIW4b_023		40	0.0634	0.76	619.76	22.11	1.14	0.1
sect4RIW4b_022		41	0.0897	0.74	619.07	26.09	1.1	0.11
sect4RIW4b_021		42	0.1078	0.74	602.08	32.96	1.21	0.15
sect4RIW4b_020	TRUE	43	0.0952	0.75	600.72	36.62	1.22	0.3
sect4RIW4b_019		44	0.0952	0.71	610.01	35.42	1.21	0.16
sect4RIW4b_018		45	0.0888	0.64	622.69	46.28	1.32	0.17
		46	0.0888					
sect4RIW4b_017		47	0.0952	0.79	685.82	94.84	1.88	0.23
sect4RIW4b_016		48	0.0825	0.84	656.49	63.33	1.53	0.13
sect4RIW4b_015		49	0.0634	0.75	648.44	72.18	1.72	0.1
sect4RIW4b_014		50	0.0698	0.77	624.51	87.74	1.98	0.25
sect4RIW4b_013		51	0.0827	0.81	605.32	62.94	1.79	0.16
sect4RIW4b_012		52	0.127	0.69	664.04	71.8	1.56	0.28
sect4RIW4b_011		53	0.1587	1.06	616.16	36.42	1.38	0.13
sect4RIW4b_010		54	0.1651	0.96	610.73	34.76	1.34	0.12
sect4RIW4b_009		55	0.2094	0.98	631.16	42.22	1.73	0.14
sect4RIW4b_008		56	0.2031	1.02	637.65	47.09	1.62	0.18
sect4RIW4b_007		57	0.2347	0.83	745.57	65.53	1.77	0.11
sect4RIW4b_006		58	0.2287	0.99	719.31	NA	NA	0.13
sect4RIW4b_005		59	0.2418	0.81	611.18	49.75	1.57	0.2

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4RIW4b_004		60	0.2412	0.83	730.27	77.1	1.96	0.16
sect4RIW4b_003		61	0.1651	0.91	603.06	49.64	1.69	0.1
sect4RIW4b_002		62	0.2351	0.84	663.82	55.81	2.2	0.12
sect4RIW4b_001		63	0.2161	0.66	580.25	44.65	1.79	0.17
sect3RIW4b_064b		64	0.3494	1.13	577.43	22.09	1.17	0.04
sect3RIW4b_063b		65	0.2418	0.88	579.78	29.23	1.35	0.09
sect3RIW4b_062b		66	0.2921	1.06	582.8	22.8	1.32	0.06
sect3RIW4b_061b		67	0.3109	1.3	553.06	20.76	1.21	0.04
sect3RIW4b_060b		68	0.4126	0.91	588.83	14.92	1.08	0.03
sect3RIW4b_059b		69	0.4155	0.91	564.92	14.24	1.16	0.03
sect3RIW4b_058b		70	0.4659	0.86	572.56	14.62	1.14	0.05
sect3RIW4b_057b		71	0.4407	0.91	573.69	18.37	1.19	0.03
sect3RIW4b_056b		72	0.4517	0.95	555.19	15.28	1.06	0.03
sect3RIW4b_055b		73	0.4529	0.88	566.42	19.25	1.28	0.04
sect3RIW4b_054b		74	0.29	0.96	576.58	18.65	1.27	0.04
sect3RIW4b_053b		75	0.3786	0.87	574.13	18.56	1.05	0.04
		76	0.4084					
sect3RIW4b_052b		77	0.4463	1	584.38	19.38	1.16	0.03
sect3RIW4b_051b		78	0.3883	0.96	564.39	20.37	1.23	0.02
sect3RIW4b_050b		79	0.344	0.95	587.25	18.34	1.38	0.04
sect3RIW4b_049b		80	0.2952	0.98	554.6	15.35	1.3	0.03
sect3RIW4b_048b		81	0.2809	0.91	566.04	14.38	1.27	0.04
sect3RIW4b_047b		82	0.314	0.92	575.44	13.92	1.3	0.02
sect3RIW4b_046b		83	0.2817	1.07	547.74	13.99	1.17	0.05
sect3RIW4b_045b		84	0.3235	0.99	570.2	15.57	1.21	0.04
sect3RIW4b_044b		85	0.2361	0.8	554.53	13.9	1.1	0.03
sect3RIW4b_043b		86	0.2235	0.83	540.8	14.7	1.17	0.07
sect3RIW4b_042b		87	0.2369	0.91	544.99	12.53	1.21	0.02
sect3RIW4b_041b		88	0.2566	0.81	516.54	12.29	1.08	0.05
sect3RIW4b_040b		89	0.1781	0.97	514.74	11.71	1.08	0.03
sect3RIW4b_039b		90	0.2292	0.74	536.68	11.92	1.21	0.05
sect3RIW4b_038b		91	0.1777	0.87	515.53	11.18	1.19	0.03
sect3RIW4b_037b		92	0.2285	0.73	518.53	10.84	1.04	0.02
		93	0.2441					
sect3RIW4b_036b		94	0.2292	0.81	518.87	10.98	1.67	0.11
sect3RIW4b_035		95	0.2604	0.62	516.84	11.92	1.08	0.03
sect3RIW4b_034		96	0.2826	0.67	497.9	12.57	1.19	0.02
sect3RIW4b_033		97	0.2097	0.62	506.36	13.85	1.08	NA
sect3RIW4b_032		98	0.2929	0.69	514.68	13.96	1.21	0.03
sect3RIW4b_031		99	0.2503	0.78	512.34	14.56	1.17	0.02
		100	0.1804					

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sect3RIW4b_030		101	0.2065	0.76	513.57	13.5	1.19	0.01
		102	0.4381					
		103	0.4182					
sect3RIW4b_029		104	0.3777	0.68	567.16	13.87	1.23	0.02
		105	0.2128					
sect3RIW4b_028		106	0.2557	0.83	563.94	12.49	1.1	0.03
sect3RIW4b_027		107	0.2094	0.68	551.26	13.21	1.18	0.02
sect3RIW4b_026		108	0.2285	0.69	555.04	12.81	1.29	0.02
sect3RIW4b_025	TRUE	109	0.2031	0.62	564.45	15.63	1.32	0.04
sect3RIW4b_024		110	0.2608	0.63	553.98	14.7	1.24	0.02
sect3RIW4b_023		111	0.2477	0.57	545.43	14.16	1.04	0.06
sect3RIW4b_022		112	0.3114	0.6	550.24	15.85	1.17	0.05
sect3RIW4b_021		113	0.2792	0.67	546.96	14.83	1.17	0.04
sect3RIW4b_020		114	0.1713	0.55	532.68	14.59	1.08	0.04
sect3RIW4b_019		115	0.2411	0.7	507.7	14.14	1.14	0.03
sect3RIW4b_018		116	0.2918	0.72	527.96	14.49	1.06	0.02
sect3RIW4b_017		117	0.2919	0.68	524.71	16.13	1.12	0.03
		118	0.2982					
sect3RIW4b_016		119	0.1968	0.65	514.14	16.95	1.17	0.05
sect3RIW4b_015		120	0.1781	0.65	524.65	17.49	1.13	0.05
sect3RIW4b_014		121	0.2791	0.5	523.09	17.85	1.25	0.04
sect3RIW4b_013		122	0.2094	0.58	543.83	18.27	1.07	0.03
		123	0.2982					
		124	0.2601					
sect3RIW4b_012		125	0.1776	0.64	531.97	18.77	1.07	0.03
sect3RIW4b_011		126	0.2728	0.6	507.22	18.37	1.07	0.04
sect3RIW4b_010		127	0.2855	0.59	538.56	20.2	1.06	0.05
		128	0.1903					
sect3RIW4b_009		129	0.2792	0.52	520.65	20.42	1.22	0.05
sect3RIW4b_008		130	0.1459	0.46	515.96	19.84	1.16	0.04
		131	0.1776					
sect3RIW4b_007		132	0.2158	0.44	530.96	21.19	1.32	0.05
		133	0.1461					
sect3RIW4b_006		134	0.1781	0.48	536.25	20.78	1.22	0.04
sect3RIW4b_005		135	0.1781	0.43	542.63	21.58	1.37	0.1
		136	0.1841					
sect3RIW4b_004		137	0.2221	0.55	566.71	21.91	1.29	0.16
sect3RIW4b_003		138	0.3236	0.63	575.17	17.74	1.33	0.06
sect3RIW4b_002		139	0.2031	0.57	530.86	17.16	1.36	0.06
sect3RIW4b_001		140	0.2351	0.48	521.39	19.18	1.29	0.07
sect2RIW4b_064		141	0.3173	0.5	550.33	13.75	1.22	0.03

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sect2RIW4b_063		142	0.2431	0.47	513.7	13.17	1.16	0.03
sect2RIW4b_062		143	0.3099	0.43	501.68	12.63	1.1	0.05
sect2RIW4b_061		144	0.2617	0.39	498.82	11.99	1.05	0.06
sect2RIW4b_060		145	0.2381	0.49	515.99	12.33	1.17	0.03
sect2RIW4b_059		146	0.2244	0.4	518.36	15.1	1.16	0.03
sect2RIW4b_058		147	0.2379	0.45	527.84	13.3	1.31	0.07
sect2RIW4b_057		148	0.2524	0.43	506.92	14.02	1.13	0.07
sect2RIW4b_056		149	0.1761	0.54	500.77	12.45	1.09	0.04
sect2RIW4b_055		150	0.2048	0.44	505.01	12.85	1.31	0.06
		151	0.2538					
sect2RIW4b_054		152	0.1921	0.5	508.81	12.27	1.15	0.03
sect2RIW4b_053		153	0.2146	0.52	526.99	14.99	1.34	0.05
sect2RIW4b_052		154	0.2428	0.62	500.83	13.49	1.1	0.05
sect2RIW4b_051		155	0.2529	0.45	514.12	12.51	1.18	0.03
		156	0.108					
sect2RIW4b_050		157	0.5139	0.5	517.11	12.76	1.26	0.05
sect2RIW4b_049		158	0.1811	0.54	517.47	10.4	1.07	0.03
sect2RIW4b_048		159	0.1716	0.53	529.48	12.15	1.13	0.04
		160	0.1676					
sect2RIW4b_047		161	0.2288	0.48	511.73	10.49	1.05	0.04
sect2RIW4b_046		162	0.2189	0.46	528.14	10.42	1.07	0.04
sect2RIW4b_045		163	0.2348	0.45	524.9	9.95	1.16	0.04
sect2RIW4b_044		164	0.2956	0.41	518.37	10.43	1.06	0.04
sect2RIW4b_043		164.66	0.2956	0.44	498.31	9.95	1.23	0.03
sect2RIW4b_042		165	0.2953	0.42	501.34	11.37	1.15	0.04
sect2RIW4b_041		166	0.3102	0.47	507.62	11.31	1.14	0.04
sect2RIW4b_040		166.5	0.3102	0.37	515.69	9.65	0.91	0.05
sect2RIW4b_039		167	0.1618	0.45	531.19	9.54	1.03	0.04
sect2RIW4b_038		168	0.2427	0.58	510.37	10.65	1.14	0.05
sect2RIW4b_037		169	0.2241	0.46	490.5	10.22	1.01	0.04
sect2RIW4b_036		170	0.3048	0.44	526.74	11.06	1.12	0.09
sect2RIW4b_035		171	0.2766	0.31	517.2	10.42	1.39	0.06
sect2RIW4b_034		172	0.1861	0.42	562.29	11.94	1.17	0.08
sect2RIW4b_033		173	0.2026	0.45	558.89	11.74	1.27	0.07
sect2RIW4b_032		174	0.2333	0.28	521.6	14.45	1.22	0.07
sect2RIW4b_031		175	0.2007	0.41	570.89	22.9	1.31	0.07
sect2RIW4b_030		176	0.1716	0.42	601.36	29.06	1.61	0.14
sect2RIW4b_029		177	0.2476	0.42	566.91	15.41	1.29	0.08
sect2RIW4b_028		178	0.3191	0.39	548.11	11.87	1.13	0.27
		179	0.2094					
sect2RIW4b_027		180	0.1523	0.51	543.67	14.53	1.26	0.06

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sect2RIW4b_026		181	0.2191	0.42	528.92	13.9	1.33	0.06
		182	0.1713					
sect2RIW4b_025		183	0.2332	0.4	545.72	15.82	1.18	0.05
sect2RIW4b_024		184	0.4903	0.43	536.86	11.62	1.19	0.04
		185	0.1143					
sect2RIW4b_023		186	0.134	0.43	518.05	11.8	1.18	0.05
sect2RIW4b_022		187	0.1621	0.42	539.08	12.84	1.2	0.1
sect2RIW4b_021		188	0.1716	0.42	532.36	12.68	1.23	0.09
		189	0.144					
sect2RIW4b_020		190	0.1048	0.47	566.75	12.89	1.17	0.05
		191	0.0952					
sect2RIW4b_019		192	0.1904	0.44	559.21	14.06	1.22	0.11
sect2RIW4b_018	TRUE	193	0.1666	0.57	597.99	14	1.31	0.09
		194	0.138					
sect2RIW4b_017		195	0.1427	0.51	613.39	11.54	1.19	0.07
		196	0.1951					
sect2RIW4b_016		197	0.2189	0.65	700.24	21.54	1.34	0.11
sect2RIW4b_015		198	0.3093	0.66	555.33	13.89	1.24	0.11
sect2RIW4b_014		199	0.3188	0.52	566.14	16.2	1.07	0.2
sect2RIW4b_013		199.9	0.3188	0.42	555.7	16.89	1.31	0.23
sect2RIW4b_012		200	0.2998	0.44	571.07	15.01	1.29	0.08
sect2RIW4b_011		201	0.1476	0.48	549.22	11.6	1.14	0.1
sect2RIW4b_010		202	0.2001	0.57	575.46	14.01	1.1	0.07
sect2RIW4b_009		203	0.1094	0.58	540.56	12.06	1.24	0.07
sect2RIW4b_008		204	0.1427	0.42	547.26	13.32	1.26	0.08
sect2RIW4b_007		205	0.3714	0.43	579.21	15.04	1.41	0.15
sect2RIW4b_006		206	0.2051	0.34	567.6	14.98	1.37	0.11
		207	0.0761					
sect2RIW4b_005		208	0.1904	0.55	599.02	16.59	1.28	0.16
sect2RIW4b_004		209	0.2617	0.42	589.82	16.65	1.31	0.16
sect2RIW4b_003		210	0.2807	0.47	584.82	16.43	1.48	0.4
sect2RIW4b_002		211	0.2379	0.52	560.6	13.34	1.6	0.2
sect2RIW4b_001		212	0.3188	0.5	567.33	15.44	1.18	0.15
sect1RIW4b_160		213	0.2544	0.66	662.63	40.03	1.27	0.35
sect1RIW4b_159		214	0.3241	0.55	600.01	22.03	1.48	0.24
sect1RIW4b_158		215	0.2184	0.62	625.55	23.09	1.73	0.23
sect1RIW4b_157		216	0.1056	0.65	650.42	20.87	1.53	0.31
		217	0.1523					
sect1RIW4b_156		218	0.1245	1.07	751.42	25.42	1.38	NA
sect1RIW4b_155		219	0.1476	0.83	640.02	18.44	1.22	0.18
		220	0.081					

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sect1RIW4b_154		221	0.1205	0.64	612.56	23.62	1.35	0.18
		222	0.0767					
sect1RIW4b_153		223	0.118	0.52	536.22	16.63	1.22	0.15
sect1RIW4b_152		224	0.0866	0.45	538.57	17.86	1.34	0.16
		225	0.0762					
	TRUE	226	0.0511					
sect1RIW4b_151		227	0.1716	0.52	554.05	15.09	1.35	0.12
sect1RIW4b_150		228	0.1664	0.51	521.24	16.32	1.26	0.13
		229	0.0638					
sect1RIW4b_149		230	0.0922	0.5	506.61	13.41	1.24	0.09
		231	0.0666					
		232	0.1212					
sect1RIW4b_148		233	0.108	0.55	623.44	13.49	1.37	0.22
sect1RIW4b_147		234	0.0825	0.58	746.19	21.4	1.55	0.24
		235	0.0796					
sect1RIW4b_146		236	0.0543	0.48	656.37	21.89	1.44	0.23
		237	0.0539					
sect1RIW4b_145		238	0.0572	0.47	619.35	57.88	1.63	0.3
sect1RIW4b_144		239	0.2001	0.37	535.29	19.14	1.43	0.29
sect1RIW4b_143		240	0.111	0.61	541.52	12.82	1.31	0.12
		241	0.0666					
sect1RIW4b_142		242	0.0999	0.48	506.02	12.6	1.36	0.12
		243	0.0952					
sect1RIW4b_141		244	0.1427	0.53	496.93	13.29	1.16	0.12
sect1RIW4b_140		245	0.0809	0.55	558.28	14.99	1.36	0.22
sect1RIW4b_139		246	0.0809	0.56	525.43	21.02	1.49	0.36
		247	0.0856					
sect1RIW4b_138		248	0.1142	0.49	553.94	25.54	1.35	0.24
sect1RIW4b_137		249	0.1427	0.5	501.18	16.64	1.22	0.21
sect1RIW4b_136		250	0.0809	0.51	539.97	17.23	1.47	0.19
sect1RIW4b_135		251	0.1523	0.59	670.02	20.85	1.64	0.18
sect1RIW4b_134		252	0.0478	0.57	634.42	18.47	1.45	0.09
sect1RIW4b_133		253	0.0715	0.51	621.9	17.27	1.22	0.23
sect1RIW4b_132		254	0.1571	0.58	562.9	15.71	1.24	0.26
sect1RIW4b_131		255	0.1428	0.64	549.98	16.85	1.21	0.12
sect1RIW4b_130		256	0.1094	0.78	629.94	19.15	1.35	0.22
sect1RIW4b_129		257	0.0952	0.48	536.29	17.06	1.22	0.12
sect1RIW4b_128		258	0.1048	0.61	569.95	13.45	1.28	0.15
sect1RIW4b_127		259	0.0669	0.57	576.37	13.63	1.22	0.05
sect1RIW4b_126		260	0.1761	0.49	578.33	13.19	1.37	0.15
sect1RIW4b_125		261	0.1048	0.62	614.67	13.23	1.72	0.17

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1RIW4b_124		262	0.0809	0.63	742.02	15.4	1.6	0.17
		263	0.0666					
sect1RIW4b_123	TRUE	264	0.0668	0.55	633.05	14.02	1.3	0.16
		265	0.062					
sect1RIW4b_122		266	0.0619	0.67	709.29	11.68	1.37	0.17
		267	0.0809					
		268	0.0381					
		269	0.0381					
sect1RIW4b_121		270	0.1571	0.61	595.03	17.24	1.14	0.16
sect1RIW4b_120		271	0.2236	0.46	576.61	17.5	1.38	0.22
sect1RIW4b_119		272	0.1288	0.46	530.35	17.6	1.38	0.16
sect1RIW4b_118		273	0.1998	0.49	509.18	17.45	1.27	0.17
		274	0.1427					
sect1RIW4b_117		275	0.2046	0.46	535.99	19.14	1.34	0.13
sect1RIW4b_116		276	0.1571	0.57	538.96	18.35	1.34	0.08
		277	0.0953					
sect1RIW4b_115		278	0.1904	0.49	567.73	19.22	1.47	0.1
sect1RIW4b_114		279	0.1999	0.58	549.58	19.68	1.35	0.11
sect1RIW4b_113		280	0.2166	0.63	547.16	18.96	1.28	0.21
sect1RIW4b_112		280	0.2166	0.68	578.82	16.77	1.27	0.1
sect1RIW4b_111		281	0.1288	0.66	579.81	17.5	1.22	0.12
sect1RIW4b_110		282	0.1523	0.65	603	20.12	1.73	0.14
sect1RIW4b_109		283	0.1523	0.52	517.85	18.68	1.27	0.21
sect1RIW4b_108		284	0.1095	0.7	508.77	23.91	1.48	0.23
sect1RIW4b_107		285	0.0999	0.6	549.14	19.02	1.3	0.11
		286	0.1381					
sect1RIW4b_106	TRUE	287	0.1906	0.65	646.47	21.12	1.59	0.06
sect1RIW4b_105		288	0.1051	0.82	581.48	21.3	1.49	0.13
sect1RIW4b_104		289	0.1144	0.97	589.99	24.98	1.43	0.22
sect1RIW4b_103		290	0.1241	0.85	561.81	18.22	1.41	0.14
sect1RIW4b_102		291	0.1269	0.75	574.61	20.24	1.57	0.22
		292	0.1285					
sect1RIW4b_101		293	0.1668	0.73	544.26	19.16	1.39	0.14
		294	0.1761					
sect1RIW4b_100		295	0.1079	1.08	565.56	22.54	1.51	0.24
sect1RIW4b_099		296	0.1212	1.07	645.86	24.72	1.67	0.37
sect1RIW4b_098		297	0.0654	0.78	601.08	26.22	1.35	0.45
		298	0.073					
sect1RIW4b_097		299	0.054	0.71	641.57	24.12	1.37	0.25
sect1RIW4b_096		300	0.054	0.59	596.11	12.72	1.22	0.07
sect1RIW4b_095		301	0.0767	0.92	661.13	18.96	1.28	0.21

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1RIW4b_094		302	0.1333	0.7	542.95	19.99	1.18	0.37
sect1RIW4b_093		303	0.0574	0.94	587.09	20.23	1.32	0.35
sect1RIW4b_092		304	0.1174	0.68	586.98	20.92	1.33	0.36
		305	0.092					
		306	0.0571					
sect1RIW4b_091		307	0.0634	0.52	561.68	19.87	1.13	0.22
sect1RIW4b_090		308	0.0571	0.51	549.43	27.28	1.55	0.41
		309	0.1016					
sect1RIW4b_089		310	0.0606	0.57	577.1	26.36	1.42	0.39
sect1RIW4b_088		311	0.096	0.43	528.58	27.11	1.28	0.34
		312	0.1209					
sect1RIW4b_087		313	0.0952	0.52	494.94	25.85	1.17	0.52
		314	0.1054					
sect1RIW4b_086		315	0.1503	0.29	485.74	23.23	1.43	0.36
		316	0.1008					
sect1RIW4b_085		317	0.1879	0.58	509.17	22.29	1.17	0.21
		318	0.119					
sect1RIW4b_084		319	0.1853	0.47	508	21.66	1.31	0.31
		320	0.0417					
		321	0.0428					
		322	0.0571					
		323	0.0684					
sect1RIW4b_083		324	0.0809	0.63	493.83	21.21	1.11	0.2
		325	0.1428					
sect1RIW4b_082		326	0.0573	0.56	532.23	23	1.22	0.24
		327	0.0715					
sect1RIW4b_081		328	0.0953	0.51	529.93	19.89	1.11	0.16
sect1RIW4b_080		329	0.0761	0.59	529.49	20.88	1.32	0.19
	TRUE	330	0.0763					
sect1RIW4b_079		331	0.1333	0.5	501.95	23.4	1.25	0.23
sect1RIW4b_078		332	0.1761	0.46	507.3	24.88	1.36	0.36
sect1RIW4b_077		333	0.1951	0.53	493.31	23.85	1.19	0.2
		334	0.1431					
		335	0.1095					
sect1RIW4b_076		336	0.1285	0.63	516.41	23.02	1.18	0.21
sect1RIW4b_075		337	0.1618	0.65	505.43	24.34	1.12	0.27
sect1RIW4b_074		338	0.1095	0.7	583.89	25.25	1.18	0.29
sect1RIW4b_073		339	0.1523	0.64	533.17	25.74	1.35	0.27
sect1RIW4b_072		340	0.0715	0.68	528.19	23.7	1.18	0.32
sect1RIW4b_071		341	0.0909	0.65	526.26	22.73	1.26	0.23
sect1RIW4b_070		342	0.1383	0.72	527.98	30.57	1.25	0.28

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1RIW4b_069		343	0.1286	0.74	547.34	46.54	1.59	0.49
sect1RIW4b_068		344	0.1475	0.79	553.09	36.71	1.38	0.39
sect1RIW4b_067		345	0.1241	0.65	548.55	37.7	1.44	0.51
sect1RIW4b_066		346	0.1367	0.68	581.48	30.09	1.46	0.37
		347	0.0809					
sect1RIW4b_065		348	0.062	0.85	553.65	30.46	1.3	0.36
sect1RIW4b_064		349	0.0862	0.69	535.42	26.21	1.46	0.27
sect1RIW4b_063		350	0.1143	0.66	537.57	40.55	1.42	0.51
sect1RIW4b_062		351	0.1143	0.65	572.31	32.25	1.71	0.49
sect1RIW4b_061		352	0.1048	0.58	550.48	24.81	1.41	0.32
		353	0.2102					
sect1RIW4b_060		354	0.2379	1.16	644.46	35.63	1.63	0.56
		355	0.0763					
sect1RIW4b_059		356	0.1004	1.03	554.95	27.88	1.67	0.43
		357	0.0809					
sect1RIW4b_058		358	0.1571	0.92	655.83	48.31	1.84	0.63
sect1RIW4b_057		359	0.1098	0.57	728	41.15	1.97	0.55
sect1RIW4b_056		360	0.1237	0.65	788.09	38.22	2.22	0.6
sect1RIW4b_055		360.5	0.1237	0.63	799.31	38.2	1.74	0.52
sect1RIW4b_054	TRUE	361	0.081	0.42	718.01	28.81	1.56	0.26
sect1RIW4b_053		362	0.1189	0.69	582.25	25.83	1.45	0.57
sect1RIW4b_052		363	0.1189	0.71	517.86	44.38	1.3	0.67
sect1RIW4b_051		363.5	0.1189	0.91	528.5	41.91	1.49	0.68
sect1RIW4b_050		364	0.1665	0.76	560.8	51.83	1.58	0.53
sect1RIW4b_049		365	0.0968	0.61	553.7	51.39	1.44	0.54
sect1RIW4b_048		366	0.0428	0.61	608.41	51.18	1.61	0.47
		367	0.0904					
sect1RIW4b_047		368	0.1956	0.72	609.28	48.3	1.67	0.55
		369	0.1621					
sect1RIW4b_046		370	0.1621	0.73	636.92	28.34	NA	0.44
		371	0.0767					
sect1RIW4b_045		372	0.0953	0.74	654.38	47.73	1.73	NA
		373	0.1571					
sect1RIW4b_044		374	0.196	0.62	696.93	78.57	1.86	0.55
sect1RIW4b_043		374.5	0.196	0.66	734.06	57.48	1.84	0.79
		375	0.1906					
sect1RIW4b_042		376	0.1714	0.92	730.2	61.62	1.67	0.87
sect1RIW4b_041		376.6	0.1714	0.74	1247.82	71.43	2.73	0.98
sect1RIW4b_040		377	0.2427	0.66	1205.73	NA	2.58	0.65
sect1RIW4b_039	TRUE	378	0.1903	0.67	750.49	40.46	1.48	0.48
sect1RIW4b_038		379	0.1621	0.49	601.99	49.87	1.46	0.53

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
		380	0.0953					
sect1RIW4b_037		381	0.2189	0.6	601.7	43.99	1.54	0.54
		382	0.2238					
sect1RIW4b_036		383	0.1618	0.62	613.42	37.56	1.54	0.6
sect1RIW4b_035		384	0.2094	0.67	629.44	63.59	1.53	0.77
sect1RIW4b_034		385	0.1967	0.67	682.57	52.47	1.72	0.62
		386	0.1761					
sect1RIW4b_033		387	0.1098	0.64	1355.9	36.42	2.47	0.48
	TRUE	388	0.1286					
sect1RIW4b_032		389	0.062	0.83	867.32	41.61	1.7	0.47
sect1RIW4b_031		390	0.1094	0.73	740.43	60.61	1.54	0.52
sect1RIW4b_030		391	0.1858	0.58	627.96	42.19	1.63	0.48
		392	0.1476					
		393	0.2381					
sect1RIW4b_029		394	0.1523	0.64	801.14	67.18	1.99	0.88
		395	0.0745					
		396	0.1653					
		397	0.0333					
		398	0.0526					
		399	0.072					
sect1RIW4b_028		400	0.0573	0.82	1046.33	44.43	2.51	0.48
		401	0.1004					
		402	0.1047					
		403	0.1573					
sect1RIW4b_027		404	0.2193	0.8	1014.67	26.21	2	0.55
	TRUE	405	0.3831					
sect1RIW4b_026		406	0.2026	NA	1895.85	54.11	NA	0.85
sect1RIW4b_025		407	0.2257	1	982.87	13.33	1.35	0.11
sect1RIW4b_024	TRUE	408	0.2379	1.18	1218.34	17.21	1.4	0.14
sect1RIW4b_023		409	0.2191	1.3	898.06	24.86	1.52	0.36
sect1RIW4b_022		410	0.2427	0.68	671.9	24.73	1.34	0.14
		411	0.3283					
sect1RIW4b_021		412	0.3571	0.84	603.93	18.87	1.01	0.2
sect1RIW4b_020		413	0.1476	0.83	626.24	23.49	1.34	0.21
		414	0.1856					
sect1RIW4b_019		415	0.1761	1.06	696.84	20.81	1.34	0.14
	TRUE	416	0.1998					
		417	0.1809					
sect1RIW4b_018		418	0.1047	0.63	635.45	28.79	1.42	0.24
		419	0.1428					
sect1RIW4b_017		420	0.1761	0.93	641.55	22.82	1.35	0.2

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
		421	0.1714					
sect1RIW4b_016		422	0.1094	1.01	747.06	26.85	1.46	0.19
		423	0.1856					
sect1RIW4b_015		424	0.0761	1.03	746.92	30.72	1.36	0.26
		425	0.1286					
sect1RIW4b_014		426	0.1861	1.37	856.84	21.01	1.41	0.05
sect1RIW4b_013		427	0.1286	1.48	848.06	20.52	1.29	0.04
sect1RIW4b_012		428	0.1906	1.17	809.49	17.6	1.31	0.09
sect1RIW4b_011		429	0.1142	1.17	903.28	16.11	1.27	0.14
sect1RIW4b_010		430	0.1288	0.97	858.83	15.05	1.3	0.11
		431	0.134					
sect1RIW4b_009		432	0.1	1	868.81	9.04	1.35	0.05
sect1RIW4b_008		433	0.0762	1.46	1004.16	NA	1.81	0.72
sect1RIW4b_007		434	0.1051	1.35	925.19	23.81	1.69	0.21
sect1RIW4b_006		435	0.1051	1.15	1390.34	15.56	2.98	0.13
		436	0.1114					
sect1RIW4b_005		437	0.1241	1.06	1591.75	26.85	2.3	0.3
	TRUE	438	0.1049					
sect1RIW4b_004		439	0.1241	1.07	1602.93	10.75	1.5	0.17
sect1RIW4b_003		440	0.0952	1.52	NA	20.08	NA	0.5
		441	0.0767					
		442	0.138					
sect1RIW4b_002		443	0.0382	1.05	1564.2	17.54	1.55	0.2
		444	0.062					
		445	0.0856					
		446	0.0381					
		447	0.0346					
sect1RIW4b_001		448	0.0285	0.92	1174	12.06	1.45	0.07

Explorers Cove Subfossil trace element concentrations, striae numbers, and interstrial distances

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4FossilEC001_085		umbo	NA	0.41	467.53	286.04	3.86	0.05
sect4FossilEC001_084		umbo	NA	NA	NA	139.47	NA	NA
sect4FossilEC001_083		umbo	NA	NA	NA	133.39	5.35	0.22
sect4FossilEC001_082		umbo	NA	0.39	489.11	124.03	5.25	0.24
sect4FossilEC001_081		umbo	NA	0.46	417.60	124.13	3.28	0.15
sect4FossilEC001_080		umbo	NA	0.44	433.24	141.44	3.35	0.15
sect4FossilEC001_079		umbo	NA	0.44	419.93	155.09	3.65	0.09
sect4FossilEC001_078		umbo	NA	0.41	403.02	145.52	3.43	0.06
sect4FossilEC001_077		umbo	NA	0.48	402.31	167.96	3.44	0.25
sect4FossilEC001_076		umbo	NA	0.42	427.74	189.83	3.69	0.05
sect4FossilEC001_075b		umbo	NA	NA	487.51	236.23	5.31	NA
sect4FossilEC001_074b		umbo	NA	0.48	392.49	150.88	3.30	0.07
sect4FossilEC001_073b		umbo	NA	0.33	407.69	167.40	3.05	0.05
sect4FossilEC001_072b		umbo	NA	0.34	400.96	166.38	2.96	0.06
sect4FossilEC001_071b		umbo	NA	0.34	454.36	194.89	4.45	0.05
sect4FossilEC001_070		umbo	NA	0.38	251.81	97.46	2.39	NA
sect4FossilEC001_069		umbo	NA	0.40	250.28	153.68	2.83	0.05
sect4FossilEC001_068		umbo	NA	0.43	268.62	109.72	2.44	0.04
sect4FossilEC001_067		umbo	NA	0.40	227.11	102.61	2.94	0.06
sect4FossilEC001_066		1	0.3911	0.46	214.02	69.00	3.52	0.04
sect4FossilEC001_065		2	0.2915	0.33	232.20	62.38	3.90	0.03
sect4FossilEC001_064		3	0.2684	0.33	145.90	35.81	2.63	0.03
		4	0.1					
sect4FossilEC001_063		5	0.1923	0.46	80.59	9.08	2.02	0.02
		6	0.1					
		7	0.1382					
sect4FossilEC001_062		8	0.0843	0.48	68.99	6.70	2.36	0.01
sect4FossilEC001_061		9	0.1382	0.42	70.14	7.19	1.80	0.02
sect4FossilEC001_060		10	0.1612	0.51	70.86	8.88	2.20	0.02
sect4FossilEC001_059		10	0.1612	0.44	70.24	9.22	2.77	0.01
sect4FossilEC001_058		11	0.1541	0.44	72.81	9.93	1.77	0.02
sect4FossilEC001_057		12	0.1153	0.45	68.84	11.47	2.08	0.02
sect4FossilEC001_056		13	0.1457	0.36	69.43	11.20	1.88	0.02
sect4FossilEC001_055		14	0.1265	0.39	69.93	11.74	2.19	0.02
sect4FossilEC001_054		15	0.1439	0.35	70.00	11.74	1.80	0.01
sect4FossilEC001_053		16	0.1328	0.39	76.54	15.52	NA	0.04
sect4FossilEC001_052		17	0.1035	0.46	85.03	20.48	3.76	0.02

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4FossilEC001_051		18	0.115	0.39	77.47	15.98	4.15	0.02
		19	0.115					
sect4FossilEC001_050		20	0.092	0.41	62.92	15.23	5.30	0.04
		21	0.1208					
sect4FossilEC001_049		22	0.115	0.47	87.24	21.20	5.21	0.03
		23	0.1213					
sect4FossilEC001_048		24	0.1619	0.40	86.75	22.82	6.31	0.04
sect4FossilEC001_047		24.9	0.1619	0.43	93.22	18.59	3.58	0.02
sect4FossilEC001_046		25	0.1399	0.31	88.01	20.60	3.27	0.09
sect4FossilEC001_045		26	0.2933	0.40	77.93	15.30	2.04	0.04
sect4FossilEC001_044		27	0.2359	0.42	104.84	23.31	2.20	0.04
sect4FossilEC001_043		28	0.2186	0.36	84.51	15.51	1.76	0.02
sect4FossilEC001_042		29	0.2646	0.43	103.84	21.94	2.79	0.03
sect4FossilEC001_041		29	0.2646	0.40	93.04	18.08	1.87	0.02
sect4FossilEC001_040		30	0.2934	0.39	85.47	12.60	2.70	0.02
sect4FossilEC001_039		31	0.2594	0.41	88.38	31.36	2.87	0.03
sect4FossilEC001_038		32	0.2648	0.39	109.47	25.03	1.94	0.03
sect4FossilEC001_037		33	0.1841	0.44	114.26	25.22	1.54	0.04
sect4FossilEC001_036		34	0.1841	0.50	112.53	28.06	1.99	NA
sect4FossilEC001_035		35	0.2303	0.65	306.64	158.85	4.34	0.25
sect4FossilEC001_034		36	0.2016	0.64	406.18	241.37	4.76	0.33
sect4FossilEC001_033		37	0.1323	0.64	284.63	126.00	3.49	0.20
sect4FossilEC001_032		38	0.1669	0.70	299.97	110.19	3.14	0.20
sect4FossilEC001_031		39	0.0863	0.64	327.90	157.06	3.97	0.19
sect4FossilEC001_030		40	0.0922	0.68	287.22	106.40	2.91	0.20
sect4FossilEC001_029		41	0.1037	0.59	402.96	243.53	4.28	0.32
sect4FossilEC001_028		42	0.1093	0.62	314.99	183.73	3.65	0.20
sect4FossilEC001_027		43	0.115	0.61	423.87	337.60	4.95	0.27
sect4FossilEC001_026		44	0.1381	0.59	382.32	324.40	5.02	0.22
sect4FossilEC001_025		45	0.1267	0.67	347.38	210.95	4.07	0.26
sect4FossilEC001_024		46	0.1035	0.65	348.47	289.96	4.62	0.30
sect4FossilEC001_023		47	0.1094	0.73	287.09	126.81	3.15	0.15
sect4FossilEC001_022		48	0.0844	0.72	310.97	141.65	3.16	0.15
sect4FossilEC001_021		49	0.0462	0.61	415.38	313.92	5.76	0.26
sect4FossilEC001_020	TRUE	50	0.0462	0.79	274.88	123.96	2.96	0.13
sect4FossilEC001_019		51	0.0576	0.81	362.86	282.44	4.18	0.20
sect4FossilEC001_018		52	0.0729	0.75	422.33	324.39	4.67	0.27
sect4FossilEC001_017		53	0.1189	0.85	302.03	162.21	3.29	0.13
sect4FossilEC001_016		54	0.1151	0.83	369.43	256.27	4.39	0.17
sect4FossilEC001_015		55	0.1497	0.81	406.76	382.35	5.29	0.23
sect4FossilEC001_014		56	0.1227	1.01	297.77	170.05	3.49	0.18

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4FossilEC001_013		57	0.0882	1.00	283.67	96.75	2.76	0.12
sect4FossilEC001_012		58	0.1036	0.95	266.97	98.73	2.42	0.07
sect4FossilEC001_011		59	0.1076	0.86	433.88	394.37	4.89	0.21
sect4FossilEC001_010		60	0.1112	0.93	463.49	482.16	5.45	0.18
sect4FossilEC001_009		61	0.1382	0.92	472.53	462.07	5.57	0.20
sect4FossilEC001_008		62	0.1113	0.92	373.67	265.97	3.90	0.12
sect4FossilEC001_007		63	0.1189	0.86	NA	NA	6.70	0.17
sect4FossilEC001_006		64	0.1304	0.87	513.35	NA	5.97	0.18
sect4FossilEC001_005		65	0.1304	0.86	524.21	NA	6.26	0.15
sect4FossilEC001_004		66	0.1687	0.93	472.59	425.70	5.12	0.17
		67	0.0921					
sect4FossilEC001_003		68	0.1323	0.95	472.62	400.65	4.93	0.13
sect4FossilEC001_002		69	0.2013	0.92	385.80	288.46	4.21	0.11
		70	0.0748					
		71	0.127					
sect4FossilEC001_001		72	0.1152	0.73	330.96	181.80	4.96	0.18
		73	0.0865					
		74	0.1627					
sect3FossilEC001_108		75	0.2153	0.76	448.32	332.97	4.68	0.22
		76	0.2455					
sect3FossilEC001_107		77	0.2454	0.83	404.10	274.32	4.29	NA
		78	0.1612					
sect3FossilEC001_106		79	0.1919	NA	341.99	188.99	3.73	NA
		80	0.1465					
sect3FossilEC001_105		81	0.2378	0.80	274.60	97.66	2.83	0.06
sect3FossilEC001_104		82	0.1612	0.82	278.69	89.55	2.57	NA
		83	0.1459					
sect3FossilEC001_103		84	0.1382	0.84	262.31	98.87	2.31	0.17
		85	0.138					
sect3FossilEC001_102		86	0.1687	0.94	277.20	93.33	2.35	0.43
sect3FossilEC001_101		87	0.2684	0.97	255.41	94.76	2.55	0.05
sect3FossilEC001_100		88	0.3528	0.83	284.79	92.82	2.45	0.07
sect3FossilEC001_099		89	0.2685	0.92	272.83	97.07	2.38	0.17
sect3FossilEC001_098		90	0.2455	0.91	256.36	93.38	2.40	0.16
sect3FossilEC001_097		91	0.2148	1.03	253.76	92.13	2.39	0.08
		92	0.1765					
sect3FossilEC001_096		93	0.1919	0.93	267.97	97.01	2.41	0.22
sect3FossilEC001_095		94	0.2762	0.79	311.95	86.37	2.40	0.12
sect3FossilEC001_094		95	0.2224	0.90	256.51	86.43	2.63	0.13
sect3FossilEC001_093		96	0.2224	0.82	256.90	82.84	2.39	0.43
sect3FossilEC001_092		97	0.1917	0.87	260.97	84.27	2.10	0.11

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3FossilEC001_091		98	0.184	0.85	250.30	82.88	2.43	0.06
sect3FossilEC001_090		99	0.1534	0.88	250.86	83.71	2.20	0.05
sect3FossilEC001_089		100	0.1208	0.89	251.38	85.74	2.22	0.09
sect3FossilEC001_088		101	0.1093	0.87	242.18	83.51	2.29	0.10
sect3FossilEC001_087		102	0.1094	0.82	250.91	84.56	2.23	0.32
sect3FossilEC001_086		103	0.1037	0.84	269.75	85.63	2.32	0.02
sect3FossilEC001_085		104	0.0748	0.98	270.34	79.67	2.21	0.22
sect3FossilEC001_084		105	0.127	0.90	248.18	80.63	2.24	0.02
sect3FossilEC001_083		106	0.1152	0.86	238.82	79.86	2.07	0.04
sect3FossilEC001_082		107	0.138	0.88	250.41	82.55	2.23	0.03
sect3FossilEC001_081		108	0.15	0.86	240.86	82.29	2.28	0.04
sect3FossilEC001_080		109	0.1669	0.90	244.48	88.00	2.14	0.34
sect3FossilEC001_079		110	0.1672	0.96	238.54	86.82	2.35	0.03
sect3FossilEC001_078		111	0.1841	1.00	243.65	93.37	2.24	0.06
sect3FossilEC001_077		112	0.1787	1.04	252.29	89.99	2.31	0.03
sect3FossilEC001_076		113	0.15	1.02	254.96	90.76	2.37	0.03
sect3FossilEC001_075		114	0.1672	0.99	251.60	87.95	2.25	0.15
sect3FossilEC001_074		115	0.2418	0.96	254.89	87.74	2.40	0.02
sect3FossilEC001_073		116	0.2359	0.96	255.56	86.63	2.31	0.38
sect3FossilEC001_072		117	0.2991	1.01	262.85	86.76	2.36	0.11
sect3FossilEC001_071		118	0.2536	1.10	255.99	87.95	2.42	0.08
sect3FossilEC001_070		119	0.2878	1.05	241.94	88.07	2.46	0.03
sect3FossilEC001_069		120	0.2246	1.01	259.15	92.61	2.37	0.02
sect3FossilEC001_068		121	0.1955	0.96	264.71	94.60	2.33	0.02
sect3FossilEC001_067		122	0.1783	0.99	236.38	85.56	2.24	0.03
sect3FossilEC001_066		123	0.1439	0.97	247.15	90.58	2.89	0.03
sect3FossilEC001_065		124	0.1784	0.95	252.70	90.87	2.31	0.06
sect3FossilEC001_064		125	0.138	0.98	245.78	87.97	2.35	0.07
sect3FossilEC001_063	TRUE	126	0.1381	0.95	239.29	91.93	2.37	0.02
sect3FossilEC001_062		127	0.1042	0.93	249.88	104.06	2.64	0.10
sect3FossilEC001_061		128	0.1725	0.88	233.00	95.21	2.41	0.03
sect3FossilEC001_060		129	0.2416	0.84	242.62	94.53	2.45	0.02
sect3FossilEC001_059		130	0.3509	0.91	233.81	90.37	2.32	0.02
sect3FossilEC001_058		131	0.3453	0.84	240.89	95.47	2.60	0.02
sect3FossilEC001_057		132	0.3742	0.73	247.22	93.13	2.48	0.11
sect3FossilEC001_056		133	0.2991	0.78	237.71	93.37	2.40	0.17
sect3FossilEC001_055		134	0.4716	NA	NA	NA	NA	NA
		135	0.4717					
sect3FossilBOS002_053		136	0.4372	0.83	250.71	108.66	2.50	0.02
sect3FossilBOS002_052		137	0.311	0.73	232.04	87.53	2.41	0.03
		138	0.1496					

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3FossilBOS002_051		139	0.3796	0.77	229.41	90.06	2.35	0.03
sect3FossilBOS002_050		140	0.4256	0.87	243.41	93.68	2.52	0.02
		141	0.1439					
sect3FossilBOS002_049		142	0.2934	0.77	244.73	87.15	2.33	0.02
sect3FossilBOS002_048		143	0.4716	0.81	244.96	83.17	2.36	0.03
sect3FossilBOS002_047		144	0.3512	0.80	266.33	92.91	2.47	0.02
sect3FossilBOS002_046		145	0.3823	0.83	239.62	86.66	2.52	0.03
sect3FossilBOS002_045		146	0.1496	0.84	248.06	88.24	2.54	0.03
sect3FossilBOS002_044		147	0.1959	0.80	243.41	86.60	2.48	0.04
sect3FossilBOS002_043		148	0.282	0.79	249.72	89.69	2.50	0.08
sect3FossilBOS002_042		149	0.2995	0.78	254.98	88.66	2.55	0.03
sect3FossilBOS002_041		150	0.2713	0.79	258.17	88.53	2.63	0.02
sect3FossilBOS002_040		151	0.2648	0.87	262.83	86.07	2.51	0.03
39GET THIS BACK		152	0.2703					
sect3FossilEC001_023		153	0.311	0.70	220.13	84.01	2.16	NA
sect3FossilEC001_022		154	0.2885	0.66	222.73	87.49	2.58	0.05
sect3FossilEC001_021		155	0.2074	0.68	217.47	84.63	2.39	0.03
sect3FossilEC001_020		156	0.2244	0.75	223.90	84.81	2.57	0.16
sect3FossilEC001_019		157	0.2646	0.73	229.41	90.14	2.68	0.03
sect3FossilEC001_018		158	0.2186	0.69	222.41	88.37	2.55	0.07
sect3FossilEC001_017		159	0.2426	0.75	249.97	86.65	2.42	0.28
sect3FossilEC001_016		160	0.2651	0.70	220.71	93.34	2.41	0.02
sect3FossilEC001_015		161	0.2536	0.78	221.59	86.14	2.32	0.03
sect3FossilEC001_014		162	0.2934	0.70	228.53	87.43	2.38	0.09
sect3FossilEC001_013		163	0.3163	0.69	231.14	92.83	2.31	0.03
sect3FossilEC001_012		164	0.2999	NA	233.30	105.90	2.25	0.08
sect3FossilEC001_011		165	0.3108	0.69	227.47	105.02	2.32	0.10
sect3FossilEC001_010		166	0.38	0.78	237.08	109.29	2.45	0.04
sect3FossilEC001_009		167	0.334	0.78	238.60	110.92	2.37	0.35
sect3FossilEC001_008		168	0.4144	0.73	240.81	112.58	2.44	0.04
sect3FossilEC001_007		169	0.3855	0.82	244.88	114.12	2.53	0.05
sect3FossilEC001_006		170	0.4032	0.74	239.64	109.44	2.38	0.04
sect3FossilEC001_005		171	0.3573	0.72	240.29	111.63	2.38	0.04
sect3FossilEC001_004		172	0.276	0.76	230.99	112.56	2.50	0.03
sect3FossilEC001_003		173	0.2713	0.72	232.84	111.64	2.43	0.04
sect3FossilEC001_002		174	0.2646	0.65	238.51	112.49	2.33	0.05
sect3FossilEC001_001		175	0.3233	NA	NA	NA	NA	NA
		176	0.2915					
sect2FossilEC001_57		177	0.23	0.71	232.82	120.99	2.19	0.11
sect2FossilEC001_56		178	0.2608	0.59	250.37	99.79	2.52	0.16
sect2FossilEC001_055		179	0.2991	0.80	231.65	113.09	2.27	0.04

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sect2FossilEC001_054		180	0.3987	0.68	224.01	123.08	2.38	0.03
sect2FossilEC001_053		181	0.3681	0.64	221.50	115.30	2.29	0.03
sect2FossilEC001_052		182	0.3777	0.65	225.16	113.76	2.25	0.04
sect2FossilEC001_051		183	0.3224	0.67	227.79	116.39	2.35	0.03
sect2FossilEC001_050		184	0.2608	0.72	220.42	115.37	2.22	0.03
sect2FossilEC001_049		185	0.2625	0.82	216.47	111.10	2.20	0.03
sect2FossilEC001_048		186	0.3835	0.76	229.15	120.92	2.26	0.03
sect2FossilEC001_047		187	0.2765	0.74	234.54	122.93	2.30	0.03
		188	0.115					
sect2FossilEC001_046	TRUE	189	0.1457	0.74	235.68	118.65	2.36	0.03
sect2FossilEC001_045		190	0.1564	0.73	234.74	114.84	2.35	0.05
sect2FossilEC001_044		191	0.2684	0.75	237.77	125.43	2.45	0.02
sect2FossilEC001_043		192	0.2994	0.72	235.58	115.37	2.40	0.03
sect2FossilEC001_042		193	0.1229	0.70	236.04	118.76	2.41	0.09
		194	0.1612					
sect2FossilEC001_041		195	0.115	0.75	243.72	117.66	2.39	0.03
sect2FossilEC001_040		196	0.2382	0.73	227.50	120.86	2.44	0.02
sect2FossilEC001_039		197	0.184	0.72	232.64	115.65	2.41	0.04
sect2FossilEC001_038		198	0.2382	0.72	226.48	116.67	2.30	0.03
sect2FossilEC001_037		199	0.2685	0.70	222.51	111.88	2.41	0.03
sect2FossilEC001_036		200	0.2072	0.66	229.90	117.28	2.47	0.04
		201	0.1689					
sect2FossilEC001_035		202	0.184	0.67	230.64	111.12	2.40	0.03
sect2FossilEC001_034		203	0.2306	0.62	222.42	107.28	2.36	0.03
sect2FossilEC001_033		204	0.3535	0.62	224.72	112.85	2.39	0.03
sect2FossilEC001_032		205	0.207	0.58	225.71	108.07	2.34	0.04
sect2FossilEC001_031		206	0.2607	0.60	221.36	107.34	2.41	0.10
sect2FossilEC001_030		207	0.1855	0.58	232.34	112.04	2.45	0.05
		208	0.1689					
sect2FossilEC001_029		209	0.3221	0.62	220.17	106.70	2.34	0.09
sect2FossilEC001_028		210	0.4373	0.57	223.39	107.47	2.35	0.05
sect2FossilEC001_027		211	0.3617	0.58	221.87	105.18	2.41	0.04
sect2FossilEC001_026		212	0.2225	0.55	226.03	108.64	2.32	0.05
		213	0.1919					
sect2FossilEC001_025		214	0.1765	0.53	226.27	101.72	2.31	0.04
sect2FossilEC001_024		215	0.2535	0.50	228.28	113.33	2.47	0.04
sect2FossilEC001_023		216	0.1855	0.49	231.13	112.29	2.48	0.27
sect2FossilEC001_022		217	0.23	0.53	220.62	104.74	2.28	0.05
sect2FossilEC001_021		218	0.2608	0.52	225.25	109.08	2.32	0.04
sect2FossilEC001_020		219	0.2762	0.51	228.83	109.82	2.47	0.04
sect2FossilEC001_019		220	0.2454	0.55	234.87	111.70	2.29	0.05

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sect2FossilEC001_018		221	0.2388	0.50	230.13	110.81	2.26	0.04
sect2FossilEC001_017		222	0.2302	0.49	225.36	109.10	2.42	0.04
sect2FossilEC001_016		223	0.2914	0.49	220.31	105.90	2.36	0.04
		224	0.2608					
sect2FossilEC001_015		225	0.2765	0.48	220.43	108.20	2.35	0.06
sect2FossilEC001_014		226	0.2762	0.46	218.83	109.43	2.32	0.05
sect2FossilEC001_013		227	0.3305	0.47	215.78	104.67	2.22	0.05
sect2FossilEC001_012		228	0.3148	0.46	219.11	108.70	2.29	0.05
sect2FossilEC001_011		229	0.4994	0.51	223.37	108.87	2.50	0.05
sect2FossilEC001_010		230	0.3458	0.44	225.04	111.31	2.41	0.04
sect2FossilEC001_009		231	0.3777	0.49	220.44	112.23	2.43	0.03
sect2FossilEC001_008		232	0.3377	0.51	236.63	107.92	2.37	0.03
sect2FossilEC001_007		233	0.3464	0.47	226.20	108.84	2.35	0.02
sect2FossilEC001_006		234	0.3388	0.42	222.17	109.03	2.41	0.05
sect2FossilEC001_005		235	0.3305	0.49	231.79	111.48	2.44	0.02
sect2FossilEC001_004		236	0.2532	0.48	223.52	108.12	2.46	0.03
sect2FossilEC001_003		237	0.2484	0.45	236.96	121.19	2.55	0.02
sect2FossilEC001_002		238	0.2459	0.48	235.79	115.80	2.42	0.02
sect2FossilEC001_001		239	0.2608	0.53	239.63	113.96	2.57	0.03
sect1FossilEC001_079		240	0.2302	0.58	227.96	118.41	2.72	0.10
sect1FossilEC001_078		241	0.1618	0.41	211.02	108.66	2.36	0.03
sect1FossilEC001_077		242	0.2694	0.46	218.76	106.23	2.50	0.03
sect1FossilEC001_076		243	0.3297	0.45	208.18	108.82	2.41	0.02
sect1FossilEC001_075		244.1	0.4371	0.41	227.06	111.90	2.63	0.03
sect1FossilEC001_074		244.9	0.4371	0.41	216.11	102.95	2.44	0.03
sect1FossilEC001_073	TRUE	245	0.3068	0.43	208.34	100.51	2.23	0.03
sect1FossilEC001_072		246	0.4373	0.43	216.22	96.24	2.58	0.05
sect1FossilEC001_071		247	0.2147	0.43	198.64	100.46	2.58	0.03
sect1FossilEC001_070		248	0.3224	0.46	218.71	102.61	2.71	0.08
sect1FossilEC001_069		249	0.2994	0.41	214.08	110.29	2.73	0.03
sect1FossilEC001_068		250	0.2838	0.50	209.81	107.12	2.77	0.04
sect1FossilEC001_067		251	0.2378	0.45	213.22	110.07	2.75	0.04
sect1FossilEC001_066		252	0.3301	0.45	223.62	107.50	2.69	0.05
sect1FossilEC001_065		253	0.1764	0.47	227.41	112.40	2.54	0.06
sect1FossilEC001_064		254	0.0843	0.42	213.35	106.37	2.48	0.04
sect1FossilEC001_063		255	0.0923	0.41	209.00	105.52	2.69	0.04
sect1FossilEC001_062		256	0.115	0.48	223.60	110.06	2.54	0.05
sect1FossilEC001_061		257	0.1765	0.57	231.28	117.74	2.75	0.28
sect1FossilEC001_060		258	0.1236	NA	214.24	113.56	2.69	0.04
sect1FossilEC001_059		259	0.1306	0.44	201.31	105.91	2.56	0.04
sect1FossilEC001_058		260	0.2607	0.46	209.86	107.41	2.45	0.21

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1FossilEC001_057		261	0.1536	0.46	225.15	111.50	2.51	0.05
sect1FossilEC001_056		262	0.1173	0.44	200.83	103.40	2.31	0.15
sect1FossilEC001_055		263	0.1304	0.50	200.49	102.36	2.29	0.05
sect1FossilEC001_054		264	0.1382	0.48	209.92	108.52	2.43	0.04
sect1FossilEC001_053		265	0.1627	0.42	205.54	105.97	2.34	0.05
sect1FossilEC001_052		266	0.2225	0.44	204.23	102.49	2.40	0.04
sect1FossilEC001_051		267	0.2459	0.42	203.88	99.52	2.29	0.04
sect1FossilEC001_050		268	0.3167	0.51	199.73	102.28	2.58	0.08
sect1FossilEC001_049		269	0.3388	0.46	202.78	103.45	2.61	0.05
sect1FossilEC001_048		270	0.3145	0.43	197.78	97.46	2.86	0.09
sect1FossilEC001_047		271	0.3177	0.39	206.51	105.83	2.71	0.05
sect1FossilEC001_046		272	0.2625	0.43	209.58	112.97	2.55	0.37
sect1FossilEC001_045		273	0.2378	0.47	207.42	105.36	2.59	0.10
sect1FossilEC001_044		274	0.2647	0.45	196.61	108.86	2.57	0.05
sect1FossilEC001_043		275	0.2455	0.43	204.31	103.37	2.66	0.04
sect1FossilEC001_042		276	0.2306	0.42	198.33	108.89	2.70	0.05
sect1FossilEC001_041		277	0.1847	0.40	238.32	123.60	2.73	0.05
sect1FossilEC001_040		278	0.1689	0.38	205.70	107.42	2.76	0.05
sect1FossilEC001_039		279	0.184	0.44	203.65	105.21	2.49	0.05
sect1FossilEC001_038		280	0.1459	0.43	209.15	109.94	2.56	0.05
sect1FossilEC001_037		281	0.1618	0.42	208.26	104.35	2.59	0.05
sect1FossilEC001_036		282	0.2007	0.37	200.67	103.56	2.57	0.10
sect1FossilEC001_035		283	0.2229	0.43	201.19	102.48	2.74	0.06
sect1FossilEC001_034		284	0.1779	0.39	204.92	104.38	3.14	0.07
sect1FossilEC001_033		285	0.1536	0.36	205.83	103.60	2.41	0.06
sect1FossilEC001_032		285.9	0.1536	0.40	210.62	106.38	2.42	0.08
sect1FossilEC001_031		286	0.2612	0.48	219.77	105.49	2.61	0.10
		287	0.2224					
		288	0.2837					
		289	0.2465					
		290	0.184					
	TRUE	291	0.2225					
		292	0.1764					
		293	0.2535					
		294	0.1917					
		295	0.1457					
sect1FossilEC001_030		296	0.1304	0.40	213.14	111.13	2.46	0.09
sect1FossilEC001_029		297	0.161	0.39	212.62	112.44	2.61	0.10
sect1FossilEC001_028		298	0.1304	0.39	247.08	107.35	2.59	0.08
sect1FossilEC001_027		299	0.1847	0.35	202.46	105.34	2.56	0.09
sect1FossilEC001_026		300	0.1842	0.39	199.15	98.78	2.42	0.10

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1FossilEC001_025		301	0.1457	0.40	227.46	112.03	2.44	0.10
sect1FossilEC001_024		302	0.1618	0.38	229.74	110.68	3.13	0.08
sect1FossilEC001_023		303	0.2388	0.42	193.79	98.13	2.64	0.09
sect1FossilEC001_022		304	0.0767	0.37	219.99	102.60	2.43	0.10
sect1FossilEC001_021		305	0.1536	0.40	222.20	104.24	2.43	0.10
sect1FossilEC001_020		306	0.1689	0.41	209.00	97.69	2.55	0.12
sect1FossilEC001_019		307	0.1694	0.41	221.54	97.74	2.54	0.11
sect1FossilEC001_018		308	0.1627	0.38	225.32	120.28	2.42	0.09
sect1FossilEC001_017		309	0.1855	0.39	199.04	97.49	2.54	0.12
sect1FossilEC001_016		310	0.1229	0.34	199.84	96.24	2.79	0.08
sect1FossilEC001_015		311	0.1475	0.38	197.34	96.74	2.60	0.08
sect1FossilEC001_014		312	0.276	0.40	208.76	102.19	2.44	0.09
sect1FossilEC001_013		312.8	0.276	0.41	214.08	99.90	2.57	0.07
sect1FossilEC001_012		313.2	0.3382	0.38	206.37	106.91	2.55	0.09
sect1FossilEC001_011		313.8	0.3382	0.38	201.20	102.69	2.47	0.06
sect1FossilEC001_010		314.2	0.2612	0.40	195.79	100.62	2.48	0.06
sect1FossilEC001_009		314.8	0.2612	0.43	200.19	101.31	2.60	0.06
sect1FossilEC001_008	TRUE	315	0.161	0.45	210.60	102.48	2.49	0.06
sect1FossilEC001_007		316	0.1152	0.45	214.47	113.58	2.50	0.06
sect1FossilEC001_006		317	0.1265	0.42	201.61	104.40	2.57	0.06
sect1FossilEC001_005		318	0.1163	0.38	217.50	105.04	2.69	0.08
sect1FossilEC001_004		319	0.1439	0.43	202.86	101.72	2.56	0.07
sect1FossilEC001_003		320	0.1726	0.47	210.51	147.57	2.64	0.07
sect1FossilEC001_002		321	0.1438	0.45	222.98	109.93	2.50	0.09
sect1FossilEC001_001		322	0.1672	0.40	241.51	142.14	2.79	NA

Bay of Sails Valve #1 trace element concentrations, striae numbers, and interstrial distances

Source File	Annulus	Striae number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1BOS3B_005		umbo		0.78	577.9	6.03	2.43	0.25
sect1BOS3B_004		umbo		0.71	606.73	6.86	2.7	0.11
sect1BOS3B_003		umbo		0.78	458.38	6.56	2.7	0.12
sect1BOS3B_002		umbo		0.68	426.78	5.98	2.38	0.11
sect1BOS3B_001		umbo		0.99	NA	8.81	2.9	0.26
sect2BOS3B_054		umbo		0.81	NA	8.43	2.67	0.38
sect2BOS3B_053		umbo		0.89	489.92	3.51	2.19	0.15
sect2BOS3B_052		umbo		0.78	193.54	3.52	1.56	0.15
sect2BOS3B_051		umbo		0.81	196.7	2.86	1.6	0.18
sect2BOS3B_050		umbo		0.86	222.21	2.06	1.52	0.12
sect2BOS3B_049		umbo		0.84	201.18	2.25	1.23	0.08
sect2BOS3B_048		1	0.2172	0.8	206.76	2.29	1.24	0.06
		2	0.1776					
sect2BOS3B_047		3	0.2157	0.8	246.5	2.15	1.35	0.07
sect2BOS3B_046		4	0.1649	0.96	262.1	2.24	1.5	0.09
sect2BOS3B_045		5	0.2667	0.84	261.13	4.46	1.33	0.23
sect2BOS3B_044		6	0.2161	0.71	241.39	2.97	1.56	0.07
sect2BOS3B_043		7	0.2284	0.8	222.73	2.81	1.63	0.08
sect2BOS3B_042		8	0.2538	0.92	186.2	2.14	1.6	0.1
sect2BOS3B_041		9	0.3809	1.03	175.89	2.13	1.88	0.07
sect2BOS3B_040		10	0.3426	0.95	122.26	1.46	1.58	0.06
sect2BOS3B_039		11	0.3809	0.89	118.27	1.31	1.26	0.06
sect2BOS3B_038		12	0.4062	0.86	122.8	1.48	1.27	0.05
		13	0.3555					
sect2BOS3B_037		14	0.3555	0.86	131.81	1.86	1.25	0.05
sect2BOS3B_036		15	0.3069	0.85	113.08	2.06	1.05	0.07
sect2BOS3B_035		16	0.3952	0.88	154.37	1.36	1.13	0.05
sect2BOS3B_034		17	0.2414	1.07	179.25	1.81	1.02	0.06
sect2BOS3B_033		18	0.3428	1.23	239.66	2.08	1	0.08
sect2BOS3B_032		19	0.2918	1.35	330.18	2.45	1.22	0.04
sect2BOS3B_031		19.5	0.2918	1.06	257.81	2.53	1.11	0.09
		20	0.2541					
sect2BOS3B_030		21	0.3815	1.05	294.13	2.64	1.08	0.07
sect2BOS3B_029		21.5	0.3815	1.24	368.16	2.71	1.28	0.07
sect2BOS3B_028		22	0.2794	1.16	383.54	3.46	1.37	0.08
sect2BOS3B_027		22.5	0.2794	1.42	374.2	3.49	1.42	0.05
sect2BOS3B_026		23	0.3175	1.41	440.62	3.73	1.48	0.15

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2BOS3B_025		24	0.3806	1.48	439.63	3.65	1.34	0.09
sect2BOS3B_024		24.5	0.3806	1.16	397.05	3.88	1.4	0.07
sect2BOS3B_023		25	0.2664	1.25	377.73	3.98	1.34	0.06
sect2BOS3B_022		26	0.3939	1.07	372.88	4.48	1.18	0.05
sect2BOS3B_021		27	0.4568	1.04	366.67	5.12	1.23	0.05
sect2BOS3B_020		28	0.2791	1.17	378.4	5.13	1.16	0.08
sect2BOS3B_019		29	0.3682	1.1	383.87	5.52	1.23	0.05
		30	0.2803					
sect2BOS3B_018		31	0.2929	1.15	382.55	6.24	1.23	0.04
sect2BOS3B_017		32	0.4701	1.23	389.01	6.57	1.31	0.03
sect2BOS3B_016		33	0.4331	1.18	371.13	7.26	1.28	0.03
sect2BOS3B_015		34	0.2791	0.91	363.31	7.35	1.15	0.04
	TRUE	35	0.2918					
sect2BOS3B_014		36	0.3195	1.23	368.11	7.38	1.17	0.24
sect2BOS3B_013		37	0.3175	1.16	369.51	7.61	1.15	0.03
sect2BOS3B_012		38	0.1654	1.21	367.45	7.93	1.14	0.04
		39	0.1401					
sect2BOS3B_011		40	0.3299	1.2	382.24	8.11	1.14	0.04
		41	0.2921					
sect2BOS3B_010		42	0.3045	1.45	369.51	8.01	1.5	0.06
sect2BOS3B_009		43	0.2791	1.16	372.15	8.23	1.5	0.05
sect2BOS3B_008		44	0.3045	1.1	386.89	8.64	1.53	0.06
		45	0.3809					
sect2BOS3B_007		46	0.4314	0.9	358.11	8.74	1.13	0.04
sect2BOS3B_006		46.5	0.4314	0.71	392.55	8.43	1.2	0.05
		47	0.1776					
sect2BOS3B_005		48	0.2541	0.81	360.81	8.61	1.12	0.04
sect2BOS3B_004		49	0.2664	0.81	362.56	8.53	1.11	0.04
sect2BOS3B_003		50	0.2541	0.71	360.83	8.56	1.29	0.04
sect2BOS3B_002		51	0.3321	0.64	398.59	8.07	1.18	0.03
sect2BOS3B_001		52	0.2791	0.63	361.02	8.11	1.2	0.04
		53	0.3321					
sect3aBOS3B_039		54	0.3182	0.62	381.8	7.99	1.32	0.03
sect3aBOS3B_038		55	0.2791	0.68	406.51	6.39	1.44	0.03
sect3aBOS3B_037		56	0.3589	0.79	407.93	5.91	1.5	0.03
sect3aBOS3B_036		57	0.3682	0.8	399.68	6.07	1.43	0.03
sect3aBOS3B_035		58	0.2284	0.87	395.01	5.69	1.34	0.03
sect3aBOS3B_034		59	0.3195	0.81	402.81	5.8	1.42	0.03
sect3aBOS3B_033		60	0.3935	0.84	409.33	5.83	1.4	0.03
sect3aBOS3B_032		61	0.3048	0.65	345.62	5.07	1.43	0.03
sect3aBOS3B_031		62	0.2918	0.87	400.36	4.87	1.29	0.03

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3aBOS3B_030		63	0.3175	0.96	404.03	5.27	1.35	0.05
sect3aBOS3B_029		64	0.4189	0.88	416.21	5.13	1.32	0.04
sect3aBOS3B_028		65	0.3172	0.81	398.34	4.85	1.21	0.03
sect3aBOS3B_027		66	0.2918	0.95	385.19	4.51	1.21	0.04
		67	0.1903					
sect3aBOS3B_026		68	0.3935	0.85	386.57	5.02	1.3	0.04
sect3aBOS3B_025		69	0.2664	0.88	380.91	5.15	1.23	0.04
		70	0.2424					
		71	0.2921					
sect3aBOS3B_024		72	0.3809	0.98	367.65	4.99	1.21	0.04
sect3aBOS3B_023		73	0.3428	0.85	357.66	4.94	1.2	0.06
sect3aBOS3B_022		74	0.4457	0.83	368.88	4.66	1.14	0.04
		75	0.1649					
		76	0.2791					
sect3aBOS3B_021	TRUE	77	0.4189	0.64	403.11	4.03	1.25	0.1
sect3aBOS3B_020		78	0.4948	0.72	360.38	5.91	1.15	0.1
		79	0.2929					
		80	0.2929					
sect3aBOS3B_019		81	0.2411	0.8	336.08	5.6	1.07	0.09
		82	0.2667					
sect3aBOS3B_018		83	0.4189	0.75	343.93	5.34	1.05	0.06
sect3aBOS3B_017		84	0.219	0.81	348.84	6.26	1.01	0.07
sect3aBOS3B_016		85	0.3309	0.73	339.97	7.94	1.12	0.09
		86	0.3688					
sect3aBOS3B_015		87	0.3815	0.73	312.77	6.29	1.02	0.06
		88	0.4529					
sect3aBOS3B_014		89	0.3933	0.71	333.6	7.18	1.03	0.05
sect3aBOS3B_013		90	0.406	0.64	312.34	7.83	0.96	0.05
		91	0.5528					
sect3aBOS3B_012		92	0.4195	0.73	339.8	8.22	0.93	0.07
sect3aBOS3B_011		93	0.2921	0.64	330.93	8.66	1.05	0.05
sect3aBOS3B_010		94	0.2677	0.64	331.2	9.14	0.9	0.08
sect3aBOS3B_009		95	0.2791	0.65	342.87	9.71	0.86	0.07
sect3aBOS3B_008		96	0.3301	0.53	337.87	10.45	0.96	0.08
		97	0.3045					
sect3aBOS3B_007		98	0.3553	0.58	310.44	10.09	1.12	0.05
		99	0.2794					
sect3aBOS3B_006		100	0.255	0.63	318.41	11.04	1.01	0.05
sect3aBOS3B_005		101	0.3045	0.51	312.74	10.88	1.07	0.06
		102	0.3935					
sect3aBOS3B_004		103	0.1396	0.47	326.97	11.87	0.95	0.05

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3aBOS3B_003		104	0.3426	0.55	314.38	12.31	1.02	0.05
		105	0.4078					
sect3aBOS3B_002		106	0.2791	0.52	334.04	12.43	1.15	0.05
		107	0.3301					
sect3aBOS3B_001		108	0.4314	0.66	342.54	12.75	1.09	0.04
		109	0.3172					
		110	0.2668					
		111	0.2817					
		112	0.5823					
sect3bBOS3B_050		113	0.4377	0.58	332.02	10.28	1.18	0.04
sect3bBOS3B_049		114	0.2855	0.62	367.39	9.4	1.23	0.04
sect3bBOS3B_048		115	0.6516	0.61	346.74	8.55	1.19	0.05
sect3bBOS3B_047		116	0.5195	0.69	365.78	8.18	1.18	0.07
sect3bBOS3B_046		117	0.7065	0.6	366.92	7.68	1.07	0.07
sect3bBOS3B_045		118	0.5195	0.61	425.3	10.23	1.2	0.06
sect3bBOS3B_044		119	0.4256	0.56	374.68	8.92	1.25	0.05
		120	0.3241					
		121	0.3431					
sect3bBOS3B_043		122	0.3636	0.65	360.91	8.03	1.26	0.06
sect3bBOS3B_042		123	0.2692	0.75	354.15	7.57	1.18	0.05
sect3bBOS3B_041		124	0.2481	0.68	366.92	7.79	1.22	0.06
sect3bBOS3B_040		125	0.5153	0.66	364.54	7.92	1.18	0.12
sect3bBOS3B_039		125.5	0.5153	0.71	348.84	7.78	1.19	0.06
		126	0.6471					
sect3bBOS3B_038		127	0.4773	0.62	349.59	9.29	1.17	0.07
sect3bBOS3B_037		128	0.6862	0.68	330.95	9.7	1.18	0.1
sect3bBOS3B_036		129	0.5153	0.74	338.22	10.12	1.31	0.19
sect3bBOS3B_035	TRUE	130	0.4696	0.58	329.53	12.09	1.08	0.13
sect3bBOS3B_034		131	0.5335	0.59	323.95	10.54	1.09	0.07
sect3bBOS3B_033		132	0.368	0.71	329.14	10.3	1.06	0.07
sect3bBOS3B_032		133	0.3859	0.8	320.56	8.81	1.27	0.08
		134	0.3447					
		135	0.4068					
sect3bBOS3B_031		136	0.3301	0.65	341.41	7.06	1.08	0.07
		137	0.3952					
sect3bBOS3B_030		138	0.2034	0.54	336.15	5.72	1.01	0.05
		139	0.3428					
		140	0.2284					
sect3bBOS3B_029		141	0.3172	0.54	313.88	5.2	0.96	0.07
		142	0.2794					
		143	0.2414					

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
		144	0.3045					
sect3bBOS3B_028		145	0.3426	0.48	300.15	5.41	1.14	0.11
		146	0.3045					
sect3bBOS3B_027		147	0.2414	0.46	295.57	6.37	1.09	0.12
		148	0.2791					
sect3bBOS3B_026		149	0.3048	0.4	305.55	7.01	0.97	0.09
		150	0.3172					
sect3bBOS3B_025		151	0.2298	0.43	299.17	7.11	1.12	0.07
		152	0.2538					
		153	0.2538					
sect3bBOS3B_024		154	0.2677	0.4	334.43	6.62	1.05	0.06
		155	0.1046					
sect3bBOS3B_023		156	0.3048	0.43	316.96	6.72	1.06	0.06
		157	0.1015					
sect3bBOS3B_022		158	0.2414	0.55	325.28	5.36	1.08	0.08
sect3bBOS3B_021		159	0.2541	0.54	343.3	5.92	1.09	0.05
sect3bBOS3B_020		160	0.1649	0.54	344.37	5.41	0.93	0.06
sect3bBOS3B_019		161	0.2157	0.63	374.67	4.72	1.08	0.06
sect3bBOS3B_018		162	0.1907	0.72	357.51	4.91	1.15	0.05
sect3bBOS3B_017		163	0.3172	0.59	324.76	6.93	1.11	0.08
sect3bBOS3B_016	TRUE	164	0.1669	0.8	323.22	7.29	1.15	0.1
sect3bBOS3B_015		165	0.203	0.43	331.98	10.04	1.13	0.11
sect3bBOS3B_014		166	0.1907	0.49	297.02	10.62	1.05	0.1
sect3bBOS3B_013		167	0.1654	0.38	289.04	9.69	0.98	0.1
sect3bBOS3B_012		168	0.2414	0.45	311.3	9.1	1.05	0.13
sect3bBOS3B_011		169	0.2161	0.73	290.76	7.02	0.98	0.1
sect3bBOS3B_010		170	0.2538	0.93	330.34	6.47	1	0.12
sect3bBOS3B_009		171	0.1781	1.07	339.1	6.78	0.9	0.08
sect3bBOS3B_008		172	0.203	1.3	361.84	7.14	0.93	0.11
sect3bBOS3B_007		173	0.2161	0.58	349.39	9.31	1.11	0.12
sect3bBOS3B_006		174	0.1907	0.54	313.08	10	1.13	0.09
sect3bBOS3B_005		175	0.2664	0.51	292.22	9.45	1.11	0.09
sect3bBOS3B_004		176	0.255	0.43	336.85	10.01	1.06	0.11
sect3bBOS3B_003		177	0.2794	0.54	370.1	10.14	1.04	0.13
sect3bBOS3B_002		178	0.2284	0.37	387.09	8.39	1.13	0.09
sect3bBOS3B_001		179	0.2921	0.76	385.95	13.24	1.22	0.22
		180	0.2541					
sect4BOS3B_114		181	0.2414		332.69			
sect4BOS3B_113		182	0.2837	0.33	357.53	6.17	1.12	0.06
		183	0.0888					
sect4BOS3B_112		184	0.1903	0.48	339.41	7.08	1	0.06

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4BOS3B_111		185	0.3056	0.45	342.09	7.32	1.07	0.1
sect4BOS3B_110		186	0.6229	0.61	335.34	9.01	1.12	0.09
sect4BOS3B_109		187	0.8121	0.73	317.28	9.01	1.01	0.15
sect4BOS3B_108		188	0.6217	1.08	346.28	6.52	1.08	0.12
sect4BOS3B_107		189	0.2791	1.78	530.99	7.71	1.62	0.15
sect4BOS3B_106		190	0.3941	0.79	396.35	2.87	0.93	0.11
sect4BOS3B_105		191	0.3299	0.65	410.37	2.78	0.93	0.06
sect4BOS3B_104		192	0.3048	0.5	381.34	2.85	0.95	0.09
sect4BOS3B_103		193	0.3562	0.69	423.91	3.18	0.93	0.08
sect4BOS3B_102		194	0.2538	0.74	448.55	3.53	1.08	0.13
sect4BOS3B_101		195	0.1907	0.51	378.29	3.66	1.04	0.08
sect4BOS3B_100		196	0.1401	0.43	418.39	5.09	1.11	0.06
sect4BOS3B_099		197	0.1275	0.63	368.26	5.49	1.02	0.11
sect4BOS3B_098		198	0.1654	0.58	436.34	6.18	1.04	0.07
sect4BOS3B_097		199	0.1523	0.74	456.84	6.06	1.21	0.11
sect4BOS3B_096		200	0.127	0.76	424.91	6.27	1.1	0.09
sect4BOS3B_095		201	0.0954	0.8	528.51	4.53	1.17	0.03
sect4BOS3B_094		201.5	0.0954	0.95	478.15	5.29	1.19	0.07
sect4BOS3B_093		202	0.089	0.73	464.74	5.42	1.07	0.06
sect4BOS3B_092		203	0.0888	0.64	415.36	6	0.97	0.08
sect4BOS3B_091		204	0.0772	0.78	437.12	5.6	1.04	0.07
		205	0.096					
sect4BOS3B_090		206	0.0888	0.9	335.66	8.15	0.89	0.15
sect4BOS3B_089		207	0.1269	0.91	362.3	4.45	0.83	0.05
sect4BOS3B_088		208	0.1465	1.3	576.92	6.89	1.06	0.1
sect4BOS3B_087		209	0.1017	1.24	562.64	5.64	1.05	0.06
sect4BOS3B_086		209.5	0.1017	1.17	499.72	6.57	1.1	0.12
		210	0.1205					
sect4BOS3B_085		211	0.1207	0.94	444.65	5.4	1.05	0.05
sect4BOS3B_084		212	0.1015	1.18	372.61	5.6	1.08	0.05
sect4BOS3B_083		213	0.1149	0.93	340.15	6.96	0.97	0.06
sect4BOS3B_082		214	0.1714	1.38	378.87	6.78	1.04	0.06
sect4BOS3B_081	TRUE	215	0.0761	0.9	306.92	7.31	0.89	0.02
sect4BOS3B_080		216	0.2919	1.34	401.15	12.11	1.1	0.06
sect4BOS3B_079		217	0.1142	1.17	418.21	7.83	1.08	0.03
		218	0.0698					
sect4BOS3B_078		219	0.1015	1.12	415.69	5.41	1.02	0.05
		220	0.0634					
sect4BOS3B_077		221	0.1142	1.05	463.29	5.5	1.11	0.06
sect4BOS3B_075		222	0.203	0.76	458.55	5.2	1.08	0.14
sect4BOS3B_074		223	0.127	0.9	371.68	4.54	1.17	0.14

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4BOS3B_073		224	0.1587	0.9	310.06	3.66	1.11	0.04
sect4BOS3B_072		225	0.3301	1.02	348.36	3.88	1.02	0.05
sect4BOS3B_071		226	0.1649	1	356.51	3.7	1.06	0.03
sect4BOS3B_070		227	0.1465	1	348.32	3.25	1.06	0.04
sect4BOS3B_069		228	0.2224	1.35	379.55	3.22	0.93	0.06
sect4BOS3B_068		229	0.1968	1.32	367.28	2.98	1.03	0.05
sect4BOS3B_067		230	0.222	1.97	437.64	3.8	1.2	0.07
sect4BOS3B_066		231	0.1142	2.11	489.47	4.51	1.32	0.11
sect4BOS3B_065		232	0.096	1.24	405.1	2.25	1.01	0.03
sect4BOS3B_064		233	0.0634	1.29	410.84	2.07	0.94	0.05
sect4BOS3B_063		234	0.0825	1.17	383.05	2.44	1.01	0.05
sect4BOS3B_062		235	0.2988	0.95	370.33	2.47	1.03	0.03
sect4BOS3B_061		236	0.222	0.83	348.75	2.75	1.12	0.03
sect4BOS3B_060		237	0.2229	0.6	387.9	5.78	1.3	0.05
sect4BOS3B_059		238	0.2538	0.71	329.12	4.55	0.98	0.04
sect4BOS3B_058		239	0.2287	0.53	347.63	6.33	1.22	0.08
sect4BOS3B_057		240	0.2347	0.81	358.94	5.42	1.16	0.06
sect4BOS3B_056		241	0.146	0.66	339.09	4.49	0.99	0.1
sect4BOS3B_055		242	0.1777	0.51	397.92	5.29	1.11	0.04
sect4BOS3B_054		243	0.1904	0.76	371.82	4.25	0.97	0.04
sect4BOS3B_053		244	0.1275	0.6	335.34	4.89	1.04	0.08
sect4BOS3B_052		245	0.1524	0.78	377.99	4.61	1.14	0.07
sect4BOS3B_051		246	0.1459	0.52	370.49	4.82	1.1	0.07
sect4BOS3B_050		247	0.0954	0.99	404.04	4.22	1.12	0.07
sect4BOS3B_049		248	0.1149	1.01	425.08	4.35	1.14	0.09
sect4BOS3B_048	TRUE	249	0.0508	1.09	441.4	4.63	1.08	0.09
sect4BOS3B_047		250	0.1591	1.37	444.04	5.64	1.41	0.11
sect4BOS3B_046		251	0.1078	1.41	495.61	6.69	1.28	0.21
sect4BOS3B_045		252	0.203	0.6	311.07	7.24	1.15	0.04
sect4BOS3B_044		253	0.2284	0.6	297.87	6.5	1.2	0.04
sect4BOS3B_043		254	0.3046	0.51	321.79	7	1.34	0.08
sect4BOS3B_042		255	0.3172	0.71	342.11	6.92	1.28	0.04
sect4BOS3B_041		256	0.3235	0.53	299.52	4.98	1.38	0.05
sect4BOS3B_040		257	0.2798	0.7	306.58	6.47	1.2	0.06
sect4BOS3B_039		258	0.1904	0.51	259.4	6.54	1.17	0.05
sect4BOS3B_038		259	0.1714	0.72	342.46	7.36	1.18	0.09
sect4BOS3B_037		260	0.1907	0.82	352.4	6.76	1.21	0.06
sect4BOS3B_036		261	0.1591	1.01	360.96	6.63	1.21	0.08
sect4BOS3B_035		262	0.1465	1.02	396.96	6.08	1.28	0.05
sect4BOS3B_034		262.2	0.1465	1.24	518.74	4.54	1.35	0.07
sect4BOS3B_033		263	0.127	1.31	447.52	4.96	1.35	0.05

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4BOS3B_032	TRUE	264	0.0761	1.48	413.17	5.15	1.03	0.06
sect4BOS3B_031		265	0.1713	1.41	413.7	4.76	1.15	0.06
sect4BOS3B_030		266	0.1465	1.76	468.3	5.65	1.13	0.08
sect4BOS3B_029		267	0.1461	1.67	400.87	5.4	1.06	0.08
sect4BOS3B_028		267.5	0.1461	1.18	376	4.55	1.08	0.06
sect4BOS3B_027		268	0.2031	1.2	343.76	3.93	0.93	0.11
sect4BOS3B_026		268.5	0.2031	1.21	351.39	3.52	1.06	0.09
sect4BOS3B_025		269	0.1471	1.24	379.84	2.57	1.03	0.1
sect4BOS3B_024		270	0.1397	1.05	445.16	3.41	1.22	0.1
		271	0.1396					
sect4BOS3B_023		272	0.1338	1.2	436.83	2.65	1.06	0.14
		273	0.1142					
sect4BOS3B_022		274	0.108	0.95	664.75	3.18	1.64	0.1
		275	0.1017					
		276	0.0825					
		277	0.1078					
		278	0.0827					
sect4BOS3B_021		279	0.0888	1.04	725.53	4.34	1.81	0.14
sect4BOS3B_020		280	0.1144	0.71	713.72	4.01	1.91	0.12
sect4BOS3B_019		281	0.0952	0.84	642.17	4.59	1.59	0.13
sect4BOS3B_018		282	0.1149	1.07	399.66	7.56	1.28	0.15
sect4BOS3B_017		283	0.1078	1.14	874	8.94	1.62	0.2
sect4BOS3B_016		284	0.1461	1.12	392.32	7.73	1.57	0.17
sect4BOS3B_015		285	0.1903	1.01	370.38	8.54	1.51	0.16
sect4BOS3B_014		285.33	0.1903	1.47	433.09	8.31	1.94	0.11
sect4BOS3B_013		285.66	0.1903	0.86	392.19	9.62	1.9	0.1
sect4BOS3B_012		286	0.1907	1.1	423.25	10.69	2.07	0.22
sect4BOS3B_011		286.5	0.1907	1.63	544.49	9.72	2.28	0.13
sect4BOS3B_010		287	0.2287	0.91	401.2	8.7	1.8	0.09
sect4BOS3B_009		287.25	0.2287	1.19	484.2	9.56	1.85	0.12
sect4BOS3B_008		287.5	0.2287	1.39	505.74	9.73	1.97	0.16
sect4BOS3B_007		287.75	0.2287	1.14	505.81	11.84	1.64	0.29
sect4BOS3B_006		288	0.1461	1.7	684.74	11.14	2.08	0.19
sect4BOS3B_005		288.5	0.1461	0.82	447.83		1.33	0.42
sect4BOS3B_004		289.25	0.203	1.2				
sect4BOS3B_003b		289.5	0.203	1.38	652.75	11.3	1.4	0.38
sect4BOS3B_002b	TRUE	289.75	0.203	1.38	585.37	4.53	1	0.13
		290	0.1482					
		291	0.1665					
		292	0.1665					
		293	0.1523					

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
		294	0.1288					
		295	0.1146					
	TRUE	296	0.0571					
		297	0.0476					
		298	0.0571					
		299	0.0431					
		300	0.0285					
		301	0.0681					
		302	0.062					
		303	0.0384					
		304	0.0666					
	TRUE	305	0.0523					
		306	0.1158					
		307	0.0523					
		308	0.0532					
		309	0.0619					
		310	0.0763					
		311	0.0428					
		312	0.081					
		313	0.1098					
		314	0.0619					
sect4BOS3B_001		315	0.0761	1.89	853.21	8.86	1.42	0.19
		316	0.0476					
		317	0.0428					
		318	0.0381					

Bay of Sails Valve #2 trace element concentrations, striae numbers, and interstrial distances

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect5BOS4b_047		umbo		0.62	460.09	5.16	1.87	0.03
sect5BOS4b_046		umbo		0.59	280.12	1.62	2.40	0.07
sect5BOS4b_045		umbo		0.50	389.57	2.34	2.07	0.04
sect5BOS4b_044		umbo		0.38	450.45	1.92	1.89	0.03
sect5BOS4b_043		umbo		0.40	545.50	3.88	NA	0.04
sect5BOS4b_042		umbo		0.40	857.55	2.60	2.29	0.08
sect5BOS4b_041		umbo		0.38	626.59	3.28	1.61	0.02
sect5BOS4b_040		umbo		0.43	502.16	4.27	1.44	0.08
sect5BOS4b_039		umbo		0.40	354.68	3.62	1.33	0.02
sect5BOS4b_038		umbo		0.41	327.97	3.61	1.30	0.02
sect5BOS4b_037		umbo		0.39	325.75	3.35	1.22	0.01
sect5BOS4b_036		umbo		0.49	289.07	3.18	1.10	0.01
sect5BOS4b_035		1	0.3524	0.44	357.40	2.68	2.23	0.02
sect5BOS4b_034		2	0.4165	0.49	281.98	1.92	1.11	0.03
sect5BOS4b_033		3	0.2612	0.45	229.84	1.78	1.02	0.01
sect5BOS4b_032		4	0.1797	0.46	183.95	1.40	0.99	0.01
sect5BOS4b_031		5	0.3509	0.56	144.97	1.63	1.08	0.04
		6	0.0816					
sect5BOS4b_030		7	0.2956	0.54	175.57	1.40	0.83	0.02
sect5BOS4b_029		8	0.1879	0.57	164.65	0.82	0.81	0.01
sect5BOS4b_028		9	0.2274	0.57	160.04	0.63	0.84	0.01
		10	0.1184					
sect5BOS4b_027		11	0.2375	0.60	201.89	1.15	0.74	0.06
sect5BOS4b_026		12	0.225	0.68	218.81	1.65	0.75	0.02
sect5BOS4b_025		13	0.2081	0.63	167.83	1.00	0.77	0.01
sect5BOS4b_024		14	0.2704	0.61	144.25	0.85	0.76	0.01
sect5BOS4b_023		15	0.2745	0.67	162.47	0.68	0.83	0.01
sect5BOS4b_022		16	0.4124	0.64	171.60	0.99	0.73	0.01
sect5BOS4b_021		17	0.3573	0.67	169.62	0.86	0.70	0.01
sect5BOS4b_020		18	0.3678	0.61	188.54	0.82	0.84	0.01
sect5BOS4b_019		19	0.3637	0.58	158.52	0.99	0.76	0.03
sect5BOS4b_018		20	0.3721	0.55	180.22	1.07	0.85	0.01
		21	0.3144					
		22	0.1523					
sect5BOS4b_017		22	0.4	0.53	143.92	1.09	0.87	0.02
sect5BOS4b_016		23	0.2985	0.54	154.53	1.14	0.87	0.01
sect5BOS4b_015		24	0.3026	0.53	175.74	1.26	0.79	0.01

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect5BOS4b_014		25	0.327	0.55	181.70	1.06	0.78	0.01
		26	0.2576					
sect5BOS4b_013		27	0.3947	0.51	178.90	1.57	0.77	0.04
sect5BOS4b_012		28	0.4355	0.54	234.73	1.93	0.74	0.01
sect5BOS4b_011		29	0.3502	0.55	269.74	2.05	0.68	0.01
		30	0.3785					
sect5BOS4b_010		31	0.2182	0.52	269.21	1.99	0.80	0.01
sect5BOS4b_009		32	0.2355	0.55	260.75	2.11	0.87	0.01
		34	0.1485					
sect5BOS4b_008		35	0.3266	0.62	240.62	1.83	0.73	0.04
		36	0.2942					
sect5BOS4b_007		37	0.3217	0.61	235.53	1.52	0.74	0.01
sect5BOS4b_006		38	0.419	0.70	234.42	1.41	0.76	0.01
		39	0.3431					
sect5BOS4b_005		40	0.37	0.68	240.37	1.49	0.75	0.01
sect5BOS4b_004		41	0.2666	0.76	242.09	1.45	0.74	0.05
sect5BOS4b_003		42	0.2992	0.68	245.95	1.24	0.75	0.01
sect5BOS4b_002		43	0.1795	0.65	246.85	1.20	0.70	0.01
		44	0.1754					
		45	0.2295					
sect5BOS4b_001		46	0.2698	0.76	285.56	2.36	1.39	NA
	TRUE	47	0.3054					
sect4BOS4b_040		48	0.4462	0.54	256.45	1.63	0.75	0.02
sect4BOS4b_039		49	0.3163	0.54	244.55	1.64	0.74	0.01
sect4BOS4b_038		50	0.3605	0.59	267.34	1.74	0.77	0.02
sect4BOS4b_037		51	0.3725	0.64	258.29	1.92	1.20	0.02
sect4BOS4b_036		52	0.3808	0.60	281.03	2.29	0.90	0.05
		53	0.4039					
sect4BOS4b_035		54	0.3597	0.57	292.90	3.31	0.81	0.02
sect4BOS4b_034		55	0.3706	0.58	271.58	2.69	0.86	0.03
sect4BOS4b_033		56	0.3155	0.51	256.86	2.55	0.71	0.01
sect4BOS4b_032		57	0.272	0.46	250.66	2.59	0.69	0.01
sect4BOS4b_031		58	0.338	0.49	250.23	2.79	0.68	0.01
sect4BOS4b_030		59	0.2938	0.48	244.07	2.56	0.73	0.01
sect4BOS4b_029		60	0.3389	0.51	253.16	2.73	0.77	0.01
sect4BOS4b_028		61	0.4581	0.56	260.83	2.84	0.87	NA
sect4BOS4b_027		62	0.3401	0.56	276.64	2.59	0.96	0.01
		63	0.1741					
sect4BOS4b_026		64	0.3918	0.52	268.25	2.66	0.87	0.01
sect4BOS4b_025		65	0.4374	0.50	265.09	2.52	0.77	0.01
sect4BOS4b_024		66	0.3375	0.49	262.95	2.27	0.80	0.01

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect4BOS4b_023		67	0.3048	0.56	282.92	2.58	0.86	0.01
sect4BOS4b_022		68	0.3046	0.54	298.02	2.43	0.85	0.01
sect4BOS4b_021		69	0.2179	0.50	248.18	2.32	0.80	0.01
sect4BOS4b_020		70	0.3185	0.52	258.26	2.58	0.85	0.01
sect4BOS4b_019		71	0.3592	0.45	246.07	2.37	0.80	0.01
	TRUE	72	0.207					
sect4BOS4b_018		73	0.2611	0.48	262.20	2.30	0.81	0.01
		74	0.2524					
sect4BOS4b_017		75	0.2394	0.52	265.82	2.63	0.87	NA
sect4BOS4b_016		76	0.4374	0.48	265.87	2.42	0.99	0.01
sect4BOS4b_015		77	0.3271	0.55	276.87	2.66	1.00	0.01
sect4BOS4b_014		78	0.2722	0.63	284.90	2.64	1.02	0.01
sect4BOS4b_013		79	0.3266	0.58	291.76	2.55	1.01	0.01
sect4BOS4b_012		80	0.2848	0.51	288.36	2.31	1.03	0.01
sect4BOS4b_011		81	0.359	0.50	309.86	2.46	0.96	0.01
sect4BOS4b_010		82	0.4364	0.54	336.95	2.71	1.01	0.01
sect4BOS4b_009		83	0.3699	0.66	312.82	3.08	0.86	0.01
sect4BOS4b_008		84	0.2394	0.56	314.03	3.06	0.89	0.03
sect4BOS4b_007		85	0.2179	0.60	327.91	3.22	0.88	0.01
		86	0.2396					
sect4BOS4b_006		87	0.2837	0.60	325.54	3.03	0.94	0.01
		88	0.3048					
sect4BOS4b_005		89	0.3271	0.58	340.71	3.55	0.91	0.01
sect4BOS4b_004		90	0.3155	0.56	324.76	3.54	0.99	0.02
		91	0.197					
		92	0.3271					
sect4BOS4b_003		93	0.2729	0.55	352.65	3.80	0.89	0.01
		94	0.1741					
sect4BOS4b_002		95	0.3401	0.56	350.46	3.31	0.88	0.01
		96	0.3509					
sect4BOS4b_001		97	0.5062	0.46	320.05	3.43	0.90	0.01
sect3BOS4b_64		99	0.5714	0.41	286.49	3.32	0.79	0.03
		100	0.2449					
sect3BOS4b_63		101	0.3347	0.50	307.04	2.88	0.78	0.01
sect3BOS4b_62		102	0.3427	0.51	305.67	3.11	0.83	0.02
sect3BOS4b_61		103	0.4328	0.52	292.52	2.98	0.73	0.02
sect3BOS4b_60		104	0.351	0.51	304.04	3.17	0.82	0.02
sect3BOS4b_59		105	0.3591	0.51	304.35	3.15	0.95	0.04
sect3BOS4b_58		106	0.2939	0.51	305.37	3.21	0.80	0.02
sect3BOS4b_57		107	0.2623	0.57	301.03	3.22	0.83	0.02
sect3BOS4b_56		108	0.335	0.55	293.23	3.47	0.77	0.03

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3BOS4b_55		109	0.1879	0.52	301.30	3.16	0.76	0.03
sect3BOS4b_54		110	0.3835	0.57	311.89	3.08	0.78	0.02
sect3BOS4b_53		111	0.3183	0.60	306.90	3.37	0.82	0.03
sect3BOS4b_52	TRUE	112	0.5636	0.53	291.87	3.73	0.84	0.03
sect3BOS4b_51		112.5	0.5636	0.46	337.56	NA	1.41	0.05
sect3BOS4b_50		113	0.3428	0.48	296.54	4.92	0.90	0.02
sect3BOS4b_49		114	0.4407	0.54	293.08	4.78	0.82	0.03
sect3BOS4b_48		115	0.2612	0.50	299.86	4.23	0.88	0.02
		116	0.1803					
sect3BOS4b_47		117	0.4006	0.48	329.65	4.64	0.88	0.02
sect3BOS4b_46		118	0.4002	0.59	317.75	4.05	0.83	0.01
sect3BOS4b_45		119	0.3436	0.41	317.56	4.05	0.85	0.02
sect3BOS4b_44		119.8	0.3436	0.51	331.61	4.55	0.88	0.02
sect3BOS4b_43		120	0.4488	0.43	319.81	4.31	0.80	0.04
sect3BOS4b_42		121	0.3843	0.42	291.49	4.39	0.83	0.02
sect3BOS4b_41		122	0.302	0.43	289.60	3.98	0.78	0.02
		123	0.204					
sect3BOS4b_40		124	0.2366	0.52	302.60	4.50	0.87	0.02
sect3BOS4b_39		125	0.4031	0.52	307.67	3.65	0.93	0.02
sect3BOS4b_38		126	0.3266	0.51	313.42	3.91	0.93	0.02
sect3BOS4b_37		127	0.4462	0.46	303.33	3.99	0.94	0.20
sect3BOS4b_36		128	0.381	0.48	305.85	3.71	0.97	0.03
sect3BOS4b_35		129	0.3048	0.52	303.44	3.71	0.93	0.03
sect3BOS4b_34		130	0.6	0.45	302.15	3.54	0.95	0.03
sect3BOS4b_33		130.9	0.6	0.50	316.84	3.66	0.90	0.03
sect3BOS4b_32		131	0.4461	0.47	294.29	3.62	0.89	0.03
sect3BOS4b_31		132	0.5767	0.62	306.47	4.33	0.90	0.03
sect3BOS4b_030b		133	0.2505	0.57	303.54	4.00	0.89	0.03
sect3BOS4b_029b		134	0.3264	0.59	301.50	3.71	0.91	0.04
sect3BOS4b_028b		135	0.2613	0.59	280.82	3.69	0.87	0.02
sect3BOS4b_027b		136	0.3155	0.60	289.86	3.79	0.84	0.03
sect3BOS4b_026b		137	0.3918	0.55	279.80	3.86	0.85	0.04
sect3BOS4b_025b		138	0.3497	0.55	289.93	3.92	0.83	0.03
sect3BOS4b_024b		139	0.3375	0.50	302.91	3.72	0.89	0.04
sect3BOS4b_023b		140	0.1741	0.47	280.14	3.71	1.20	0.07
sect3BOS4b_022b		141	0.1527	0.48	268.06	3.55	0.87	0.04
sect3BOS4b_021b		142	0.2187	0.45	275.41	3.70	0.89	0.04
sect3BOS4b_020b		143	0.2176	0.44	261.17	3.70	0.88	0.04
sect3BOS4b_019b		144	0.2829	0.52	280.87	3.64	0.88	0.05
sect3BOS4b_018b		145	0.2632	0.46	266.25	3.95	0.90	0.04
sect3BOS4b_017b		146	0.3266	0.40	305.22	6.14	1.02	0.04

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3BOS4b_016b		147	0.5667	0.38	267.59	4.14	0.97	0.04
sect3BOS4b_015b		147.6	0.5667	0.48	270.95	3.71	0.95	0.03
sect3BOS4b_014b		148	0.3706	0.46	251.52	3.79	0.91	0.03
sect3BOS4b_013b		149	0.2308	0.46	263.96	3.87	0.96	0.09
		150	0.1306					
sect3BOS4b_012b		151	0.1088	0.51	285.66	4.29	1.02	0.06
sect3BOS4b_011b		152	0.2079	0.44	279.79	4.07	0.92	0.06
sect3BOS4b_010b		153	0.3048	0.46	283.72	4.17	1.00	0.05
sect3BOS4b_009b		154	0.1744	0.45	281.79	3.85	0.89	0.04
		155	0.2179					
sect3BOS4b_008b		156	0.1754	0.50	304.46	3.91	1.06	0.05
sect3BOS4b_007b	TRUE	157	0.2403	0.45	312.65	4.19	1.03	0.05
sect2BOD3b_088		158	0.272	0.56	276.69	3.38	0.90	0.02
sect2BOD3b_087		159	0.2231	0.62	283.18	2.86	0.88	0.01
sect2BOD3b_086		160	0.1744	0.54	270.24	3.78	0.86	0.01
sect2BOD3b_085		161	0.1795	0.46	272.66	2.91	0.83	0.02
		162	0.197					
sect2BOD3b_084		163	0.1578	0.50	302.49	3.19	0.85	0.02
sect2BOD3b_083		164	0.2122	0.54	304.80	6.75	0.93	0.08
sect2BOD3b_082		165	0.1853	0.52	285.13	6.01	0.88	0.05
		166	0.137					
sect2BOD3b_081		167	0.2122	0.40	277.44	3.17	0.97	0.04
sect2BOD3b_080		168	0.0818	0.43	297.84	3.82	1.07	0.13
sect2BOD3b_070		169	0.1907	0.42	321.32	6.45	1.13	0.07
sect2BOD3b_079		169	0.2093	0.41	305.49	3.93	0.98	0.05
		170	0.1093					
sect2BOD3b_078		171	0.0886	0.39	294.83	3.87	1.00	0.02
sect2BOD3b_077		172	0.1593	0.44	274.11	2.98	0.90	0.02
sect2BOD3b_076		173	0.2666	0.42	293.46	NA	0.96	0.07
sect2BOD3b_075		174	0.2362	0.43	296.42	3.39	0.88	0.05
sect2BOD3b_074		175	0.1796	0.45	283.26	3.49	1.11	0.02
sect2BOD3b_073		176	0.1744	0.32	284.68	NA	1.00	0.03
sect2BOD3b_072		177	0.1907	0.44	294.94	6.21	1.12	0.03
sect2BOD3b_071		178	0.1694	0.47	298.05	3.46	0.95	0.03
sect2BOD3b_069		180	0.2902	0.35	288.37	3.73	0.94	0.02
sect2BOD3b_068		181	0.2632	0.42	278.27	3.37	0.92	0.02
sect2BOD3b_067		182	0.2942	0.40	304.87	3.48	0.98	0.02
sect2BOD3b_066		183	0.2578	0.37	307.13	4.73	1.20	0.04
sect2BOD3b_065		184	0.1419	0.40	275.63	4.88	1.11	0.02
sect2BOD3b_064		185	0.1796	0.30	324.91	5.61	1.11	0.02
sect2BOD3b_063		186	0.2182	0.39	288.75	NA	1.07	0.02

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sect2BOD3b_062		187	0.2517	0.31	312.42	3.58	1.07	0.02
sect2BOD3b_061		188	0.3347	0.29	301.66	3.34	1.20	0.05
sect2BOS3b_060		189	0.2295	0.43	314.14	4.17	0.97	0.03
sect2BOS3b_059		190	0.2074	0.48	347.81	4.69	0.94	0.03
sect2BOS3b_058		191	0.1377	0.39	288.93	3.16	0.99	0.02
sect2BOS3b_057		192	0.1742	0.35	289.00	3.04	1.03	0.02
sect2BOS3b_056		193	0.2236	0.34	323.27	3.48	1.10	0.02
		194	0.1524					
sect2BOS3b_055		195	0.2396	0.44	316.36	2.71	1.16	0.03
		196	0.1593					
sect2BOS3b_054		197	0.1252	0.58	445.07	NA	1.57	0.14
sect2BOS3b_053		198	0.1742	0.53	434.13	2.91	1.13	0.03
sect2BOS3b_052		199	0.2139	0.86	460.40	2.51	1.37	0.04
		200	0.1256					
sect2BOS3b_051		201	0.0981	0.47	390.56	3.12	1.07	0.03
sect2BOS3b_050		202	0.22	0.50	360.11	4.04	1.05	0.05
		203	0.2179					
sect2BOS3b_049	TRUE	204	0.1742	0.36	304.35	3.37	0.94	0.03
sect2BOS3b_048		205	0.1744	0.29	401.20	3.46	1.00	0.01
sect2BOS3b_047		206	0.2505	0.34	288.19	4.16	0.86	0.04
sect2BOS3b_046		207	0.1687	0.79	NA	NA	1.70	NA
sect2BOS3b_045		208	0.2562	0.36	280.60	4.17	0.92	0.05
sect2BOS3b_044		209	0.2693	0.39	281.84	3.63	0.91	0.01
sect2BOS3b_043		210	0.1742	0.38	280.54	3.66	0.90	0.02
sect2BOS3b_042		211	0.1748	0.30	296.76	3.47	1.06	0.05
sect2BOS3b_041		212	0.1307	0.29	340.89	3.66	1.12	0.03
sect2BOS3b_040		213	0.2531	0.38	296.22	3.95	0.93	0.04
sect2BOS3b_039		214	0.2014	0.37	273.94	4.31	0.90	0.03
sect2BOS3b_038		215	0.2177	0.36	272.24	3.84	1.00	0.09
sect2BOS3b_037		216	0.3108	0.43	259.68	4.77	0.86	0.02
sect2BOS3b_036		217	0.3085	0.41	268.97	3.48	0.93	0.02
sect2BOS3b_035		218	0.2458	0.45	309.01	3.62	0.88	0.04
sect2BOS3b_034		219	0.2486	0.50	282.94	3.50	0.90	0.06
sect2BOS3b_033		220	0.3646	0.37	320.33	3.45	0.93	0.03
		221	0.1558					
sect2BOS3b_031		222	0.087	0.44	324.75	5.63	1.52	0.28
sect2BOS3b_032		222.1	0.087	0.32	269.02	3.31	0.98	0.03
sect2BOS4b_030		223	0.1853	0.48	337.62	4.21	1.09	0.05
sect2BOS4b_029		224	0.3649	0.45	250.71	3.33	0.86	0.03
sect2BOS4b_028		225	0.3268	0.35	298.29	4.76	1.04	0.03
sect2BOS4b_027		226	0.197	0.37	253.92	4.04	1.05	0.04

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2BOS4b_026		227	0.19	0.43	267.38	2.93	0.93	0.02
sect2BOS4b_025		228	0.17	0.41	284.13	2.86	0.92	0.03
sect2BOS4b_024		229	0.17	0.42	261.64	2.98	0.89	0.18
sect2BOS4b_023		230	0.1857	0.38	313.78	3.09	1.04	0.03
sect2BOS4b_022		231	0.2668	0.38	397.02	NA	1.30	0.09
sect2BOS4b_021	TRUE	232	0.2014	0.76	325.19	3.17	0.99	0.02
sect2BOS4b_020		233	0.321	0.79	370.87	5.37	0.93	0.01
sect2BOS4b_019		234	0.2247	0.68	336.16	3.81	0.91	0.02
sect2BOS4b_018		234.8	0.2247	0.61	316.84	3.35	0.84	0.02
sect2BOS4b_017		235	0.0979	0.69	334.91	3.41	0.91	0.10
sect2BOS4b_016		236	0.2349	0.63	295.02	2.69	0.97	0.06
sect2BOS4b_015		237	0.2285	0.62	269.47	2.95	0.87	0.03
sect2BOS4b_014		238	0.1923	0.66	283.89	3.22	0.88	0.06
sect2BOS4b_013		239	0.1904	0.62	294.97	3.68	0.90	0.03
sect2BOS4b_012		240	0.2247	0.75	298.21	2.81	0.89	0.02
sect2BOS4b_011		241	0.1686	0.72	277.67	2.99	0.80	0.02
sect2BOS4b_010		242	0.254	0.59	311.82	3.01	0.98	0.03
sect2BOS4b_009		243	0.2505	0.60	296.48	3.19	0.90	0.07
sect2BOS4b_008		244	0.2505	0.67	282.35	3.01	0.86	0.02
sect2BOS4b_007		245	0.1148	0.65	305.83	3.80	0.88	0.03
sect2BOS4b_006		246	0.2068	0.61	321.73	2.62	0.84	0.02
		247	0.1251					
sect2BOS4b_005		248	0.0818	0.65	349.85	3.35	0.90	0.02
sect2BOS4b_004		249	0.2291	0.49	288.45	3.07	0.93	0.02
sect2BOS4b_003		249.8	0.2291	0.69	320.81	3.07	0.79	0.02
sect2BOS4b_002		250	0.1796	0.77	335.90	3.54	0.91	0.02
sect2BOS4b_001		251	0.2231	0.79	348.35	3.96	0.98	0.02
sect1BOSb4_143		251.2	0.1766	NA	NA	NA	NA	NA
sect1BOSb4_142		252	0.1766	0.76	315.37	2.51	0.80	0.02
sect1BOSb4_141		253	0.2042	0.89	298.92	2.26	0.68	0.02
sect1BOSb4_140		254	0.1518	0.99	354.79	2.53	0.77	0.02
		255	0.1194					
sect1BOSb4_139		256	0.1346	0.70	287.31	2.85	0.78	0.03
sect1BOSb4_138		257	0.1877	0.62	280.42	4.75	0.75	0.06
		258	0.0872					
sect1BOSb4_137		259	0.1415	0.86	301.89	3.95	0.79	0.02
sect1BOSb4_136		260	0.1803	0.82	313.37	3.09	0.80	0.01
sect1BOSb4_135		261.3	0.2557	0.76	298.26	3.00	0.78	0.02
sect1BOSb4_134		261.7	0.2557	0.78	299.73	2.98	0.71	0.02
sect1BOSb4_133		262	0.0818	0.77	287.04	2.79	0.74	0.02
sect1BOSb4_132		263	0.1163	0.87	307.00	3.29	0.75	0.02

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sect1BOSb4_131		264	0.0939	0.76	277.12	3.13	0.75	0.03
sect1BOSb4_130		265	0.1742	0.74	313.12	3.52	0.89	0.03
sect1BOSb4_129		266	0.1419	0.65	270.72	4.05	0.80	0.02
sect1BOSb4_128		267	0.1361	0.68	274.22	3.18	0.81	0.02
sect1BOSb4_127		268	0.1581	0.66	251.00	3.59	0.86	0.03
		269	0.234					
sect1BOSb4_126		270	0.1252	0.75	260.83	3.34	0.87	0.02
sect1BOSb4_125		271.2	0.1694	0.80	261.61	3.91	0.86	0.02
sect1BOSb4_124		271.7	0.1694	0.82	279.17	3.45	0.84	0.03
sect1BOSb4_123		272	0.2124	0.56	275.42	3.40	0.91	0.27
sect1BOSb4_122		273	0.1306	0.70	287.87	3.44	1.14	0.03
sect1BOSb4_121		274	0.1581	0.71	275.63	4.40	0.92	0.09
		275	0.1088					
sect2BOD4b_120		276	0.1306	0.66	261.60	3.24	1.00	0.08
sect2BOD4b_119		277	0.1035	0.76	276.99	3.03	0.94	0.03
		278	0.1415					
sect2BOD4b_118		279	0.137	0.76	335.74	3.54	0.91	0.04
sect2BOD4b_117		280	0.2128	0.80	306.17	2.84	0.95	0.04
		281	0.169					
sect2BOD4b_116		282	0.2019	0.76	304.21	2.51	1.07	0.03
sect2BOD4b_115		282.8	0.2019	0.86	313.37	3.03	0.98	0.03
sect2BOD4b_114		283	0.0872	0.90	311.11	2.35	0.91	0.03
sect2BOD4b_113		284	0.169	0.98	306.34	2.10	0.90	0.02
sect2BOD4b_112		284.7	0.169	1.03	324.10	2.03	0.94	0.02
sect2BOD4b_111		285	0.1646	1.26	339.75	2.32	1.06	0.02
		286	0.1687					
sect2BOD4b_110		287	0.1798	1.31	359.42	NA	1.14	0.01
sect2BOD4b_109	TRUE	288	0.1862	NA	502.31	2.43	1.02	0.01
sect2BOD4b_97		289	0.1798	0.97	320.17	3.47	1.04	0.03
sect2BOD4b_108		289	0.1798	1.17	373.44	1.75	0.93	0.01
sect2BOD4b_96		290	0.1198	0.73	321.99	2.99	1.02	0.03
sect2BOD4b_107		290	0.1198	0.94	390.67	1.73	1.01	0.02
sect2BOD4b_95		291	0.1088	0.77	328.58	3.02	1.01	0.03
sect2BOD4b_106		291	0.1088	0.86	461.23	1.48	1.00	NA
sect2BOD4b_94		292	0.169	0.64	309.20	3.15	1.08	0.03
sect2BOD4b_105		292	0.169	0.80	444.15	2.71	1.18	0.16
sect2BOD4b_93		293	0.1646	0.68	311.63	2.74	1.01	0.03
sect2BOD4b_104		293	0.1646	0.78	441.09	2.28	1.08	0.06
sect2BOD4b_92		294	0.1633	0.67	334.96	2.48	1.00	0.03
sect2BOD4b_103		294	0.1633	0.76	347.15	2.76	1.03	0.03
sect2BOD4b_91		295	0.1795	0.84	428.53	3.13	1.07	0.02

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2BOD4b_102		295	0.1795	0.83	376.62	2.87	0.86	0.02
sect1BOS4b_090		295.8	0.1795	1.22	341.44	3.03	0.98	0.02
sect1BOS4b_089		296	0.1744	1.31	373.82	2.35	0.99	0.01
sect2BOD4b_101		296	0.1744	0.78	375.24	2.86	1.03	0.03
sect2BOD4b_100		296.5	0.1744	0.79	327.11	3.23	0.88	0.02
sect1BOS4b_088		297	0.11	0.98	312.63	1.87	0.90	0.04
sect2BOD4b_99		297	0.11	0.78	305.00	3.33	0.97	0.03
sect1BOS4b_087		297.5	0.11	0.81	308.77	2.28	1.03	0.03
sect1BOS4b_086		298	0.1473	0.74	346.95	1.68	0.92	0.03
sect2BOD4b_98		298	0.1473	0.83	308.57	3.43	1.02	0.15
sect1BOS4b_085		299	0.1361	0.62	393.81	2.55	1.01	0.06
sect1BOS4b_084		300	0.136	0.61	370.55	2.48	0.84	0.02
sect1BOS4b_083		301	0.1419	0.66	381.96	2.43	1.00	0.03
sect1BOS4b_082		302.6	0.2147	0.70	330.14	3.08	0.89	0.03
sect1BOS4b_081		302.7	0.2147	0.74	308.88	3.07	0.94	0.02
		303	0.0818					
sect1BOS4b_080		304.5	0.1694	0.76	299.61	3.25	0.95	0.03
sect1BOS4b_079		304.6	0.1694	0.70	272.80	3.04	0.98	0.03
sect1BOS4b_078		305.5	0.1977	0.71	278.70	3.38	0.95	0.06
sect1BOS4b_077		305.55	0.1977	0.81	330.01	3.74	0.98	0.02
sect1BOS4b_075		306.3	0.131	0.76	286.35	3.26	0.97	0.03
sect1BOS4b_076		306.4	0.131	0.82	296.67	3.04	1.03	0.07
sect1BOS4b_074		307.6	0.1093	0.66	272.73	3.00	1.19	0.03
sect1BOS4b_073		307.8	0.1093	0.70	298.89	3.13	0.99	0.04
sect1BOS4b_072		308.8	0.1655	0.64	269.53	2.80	0.99	0.02
sect1BOS4b_071		308.9	0.1655	0.64	272.76	6.27	1.36	0.22
sect1BOS4b_070		309.7	0.1523	0.63	272.44	2.73	0.97	0.01
sect1BOS4b_069		309.8	0.1523	0.74	362.88	2.43	1.00	0.25
sect1BOS4b_068		310	0.234	0.77	295.29	2.49	0.98	0.01
sect1BOS4b_067		311	0.2978	1.04	341.90	2.12	1.04	0.01
sect1BOS4b_066		312	0.1089	0.88	357.08	2.39	1.08	0.03
		313	0.1046					
sect1BOS4b_065		314	0.0979	0.79	436.43	2.57	1.20	0.01
sect1BOS4b_063	TRUE	316	0.1154	0.75	663.40	1.63	1.38	0.01
		317	0.0779					
sect1BOS4b_064		317	0.0764	0.76	549.68	1.92	1.27	0.01
sect1BOS4b_062		318	0.0502	0.88	745.79	1.92	1.42	0.02
		319	0.0709					
sect1BOS4b_061		320	0.1046	0.88	632.17	2.30	1.10	0.03
sect1BOS4b_060b		321	0.1307	0.82	439.51	3.78	1.09	0.03
sect1BOS4b_060		322.2	0.1796	NA	NA	NA	NA	NA

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1BOS4b_059		322.7	0.1796	0.76	364.21	3.26	1.48	0.13
sect1BOS4b_058		323	0.0993	0.79	367.65	3.92	1.12	0.03
sect1BOS4b_057		324	0.1364	0.99	461.45	3.84	1.13	0.03
sect1BOS4b_056		325	0.1579	0.80	298.27	2.58	0.94	0.02
sect1BOS4b_055		326	0.1089	0.83	296.06	2.73	0.84	0.13
sect1BOS4b_054		327	0.1959	0.84	305.25	5.55	0.88	0.04
		328	0.1271					
sect1BOS4b_053		329	0.1478	0.86	319.71	3.10	0.91	0.09
sect1BOS4b_052		330	0.1397	0.71	342.74	1.90	1.04	0.02
sect1BOS4b_051		331	0.2164	0.76	405.44	2.05	1.21	0.03
sect1BOS4b_050		332	0.1194	0.73	467.31	1.93	1.30	0.01
sect1BOS4b_049	TRUE	333	0.1349	0.77	786.28	1.74	1.66	0.01
sect1BOS4b_048		334	0.1311	0.64	731.29	1.69	1.96	0.05
sect1BOS4b_047		335	0.1847	0.65	356.13	2.85	1.04	0.04
sect1BOS4b_046		336	0.1551	0.69	319.49	2.94	1.02	0.04
sect1BOS4b_045		337	0.1714	0.68	309.09	2.96	0.88	NA
sect1BOS4b_044		338.5	0.1961	0.78	331.90	2.92	0.89	0.04
sect1BOS4b_043		338.9	0.1961	0.69	298.84	3.01	0.94	0.04
sect1BOS4b_042		339.3	0.2612	0.77	300.49	3.02	0.86	0.03
sect1BOS4b_041		339.9	0.2612	0.75	328.00	3.31	0.92	0.03
sect1BOS4b_040		340	0.1576	0.72	306.25	3.46	0.90	0.03
sect1BOS4b_039		341	0.1836	0.83	310.77	2.85	1.01	0.04
sect1BOS4b_038		342	0.1604	0.97	340.22	3.47	1.12	0.01
		343	0.0532					
sect1BOS4b_037		344	0.1265	1.19	376.23	3.37	2.02	0.02
		345	0.0739					
sect1BOS4b_036		346	0.0785	1.09	714.05	2.05	2.15	0.02
sect1BOS4b_035		347	0.0694	0.64	706.43	2.25	1.47	0.02
		348	0.082					
sect1BOS4b_034		349	0.2234	0.66	391.05	4.10	0.88	0.03
sect1BOS4b_033		350	0.1397	0.68	318.74	4.20	0.93	0.02
sect1BOS4b_032		351	0.1645	0.75	339.08	3.19	0.93	0.03
sect1BOS4b_031		352	0.196	0.91	340.69	3.44	0.88	0.03
sect1BOS4b_030		353	0.0983	0.95	359.60	3.35	0.85	0.07
sect1BOS4b_029		354	0.1376	0.79	384.23	3.61	0.88	0.07
sect1BOS4b_028		355	0.1023	0.74	435.79	2.79	1.04	0.05
sect1BOS4b_027		356	0.1512	0.76	358.42	2.71	0.77	0.02
		357	0.1281					
sect1BOS4b_026		358	0.053	0.86	465.00	2.62	0.82	0.02
sect1BOS4b_025		359	0.0942	0.75	790.88	2.86	1.91	0.04
sect1BOS4b_024		360	0.1308	0.73	936.93	2.91	2.18	0.15

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1BOS4b_023	TRUE	361	0.1183	0.62	580.37	3.38	1.42	0.04
		362	0.139					
sect1BOS4b_022		363	0.0776	0.73	494.41	3.55	1.13	0.04
sect1BOS4b_021		364	0.0654	0.90	932.61	4.44	1.93	0.06
sect1BOS4b_020		365	0.1265	1.02	1040.96	4.41	2.05	0.12
	TRUE	366	0.1308					
sect1BOS4b_019		367	0.0745	0.63	454.58	2.29	0.96	0.03
		368	0.0816					
sect1BOS4b_018		369	0.0698	0.67	533.63	2.42	1.09	0.04
sect1BOS4b_017		370	0.1102	0.60	659.41	2.19	1.42	0.02
		371	0.0624					
sect1BOS4b_016		372	0.0857	0.64	684.76	2.96	1.36	0.02
sect1BOS4b_015		373	0.0698	0.95	937.36	3.26	1.33	0.10
		374	0.0573					
sect1BOS4b_014		375.1	0.1852	0.79	1092.87	2.32	1.74	0.03
sect1BOS4b_013		375.9	0.1852	0.76	1336.36	3.15	2.62	0.18
		376	0.0942					
sect1BOS4b_012	TRUE	377	0.1346	0.69	892.08	5.57	NA	NA
sect1BOS4b_011		378	0.0496	NA	NA	NA	NA	NA
sect1BOS4b_010		379	0.0872	0.82	1271.12	4.38	2.07	0.06
		380	0.0734					
sect1BOS4b_009		381	0.0858	0.82	538.71	4.45	1.30	0.08
sect1BOS4b_008		382	0.1108	0.95	657.72	3.93	1.62	0.04
sect1BOS4b_007		383	0.0654	0.96	755.32	3.34	1.56	0.05
	TRUE	384	0.0861					
sect1BOS4b_006		385	0.0942	0.75	740.52	1.53	1.50	0.02
sect1BOS4b_005		386	0.0899	0.58	706.05	2.47	1.38	0.10
sect1BOS4b_004	TRUE	387	0.082	0.79	540.20	4.32	1.00	0.21
sect1BOS4b_003		388	0.0906	0.68	NA	NA	1.09	NA
sect1BOS4b_002		389	0.119	0.88	1309.13	NA	1.20	NA
sect1BOS4b_001		390	0.0912	NA	NA	NA	NA	NA

Bay of Sails Subfossil trace element concentrations, striae numbers, and interstrial distances

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect3_4FossilBOS002_023		umbo	NA	1.67	NA	NA	NA	0.40
sect3_4FossilBOS002_022		umbo	NA	1.70	NA	NA	NA	0.25
sect3_4FossilBOS002_021		umbo	NA	1.32	1183.62	51.04	8.15	0.10
sect3_4FossilBOS002_020		umbo	NA	1.36	1466.86	54.08	NA	0.13
sect3_4FossilBOS002_019		umbo	NA	1.03	938.64	46.02	6.82	0.40
sect3_4FossilBOS002_018		umbo	NA	1.33	846.15	43.42	6.07	0.12
sect3_4FossilBOS002_017		umbo	NA	1.48	752.30	35.33	4.89	0.14
sect3_4FossilBOS002_016		umbo	NA	1.31	792.40	46.76	5.39	0.48
sect3_4FossilBOS002_015		umbo	NA	0.97	583.92	33.35	3.65	0.57
sect3_4FossilBOS002_014		umbo	NA	0.88	581.69	26.17	4.28	0.09
sect3_4FossilBOS002_013		umbo	NA	0.86	550.68	21.80	4.22	0.10
sect3_4FossilBOS002_012		umbo	NA	1.02	811.33	42.66	6.99	NA
sect3_4FossilBOS002_011		umbo	NA	1.75	NA	NA	NA	0.83
sect3_4FossilBOS002_010		1	0.6599	0.86	505.26	15.86	4.24	0.28
sect3_4FossilBOS002_009		2	0.5005	0.91	368.75	11.49	3.82	0.11
sect3_4FossilBOS002_008		3	0.5338	1.53	1384.13	41.18	7.91	0.33
sect3_4FossilBOS002_007		4	0.4418	1.55	949.14	41.19	6.97	0.28
sect3_4FossilBOS002_006		5	0.4638	1.52	1129.69	NA	8.32	0.28
sect3_4FossilBOS002_005		6	0.4775	1.66	1013.27	52.32	8.60	0.31
sect3_4FossilBOS002_004		7	0.4581	1.45	870.10	39.10	6.39	0.33
sect3_4FossilBOS002_003		8	0.5434	1.50	721.46	38.93	5.61	0.23
sect3_4FossilBOS002_002		9	0.3353	1.47	676.80	25.96	4.17	0.14
		10	0.3141					
sect3_4FossilBOS002_001		11	0.5484	1.79	652.15	23.61	3.54	0.26
sect2FossilBOS002_038		11	0.5484	1.00	NA	NA	5.36	NA
sect2FossilBOS002_037		12	0.477	NA	799.87	32.45	5.14	0.28
sect2FossilBOS002_036		12	0.477	1.94	702.70	26.01	4.29	0.70
sect2FossilBOS002_035		13	0.3301	2.07	656.67	32.61	4.80	0.76
sect2FossilBOS002_034		14	0.3301	2.22	674.63	32.18	5.60	NA
sect2FossilBOS002_033		15	0.2685	NA	855.97	33.83	6.18	NA
sect2FossilBOS002_032		16	0.2918	2.07	607.07	29.70	4.06	0.31
sect2FossilBOS002_031		17	0.3068	1.87	561.75	32.14	3.88	0.66
sect2FossilBOS002_030		18	0.2994	1.85	465.71	20.18	2.67	0.14
sect2FossilBOS002_029		19	0.3557	1.83	430.25	18.93	2.20	0.11
sect2FossilBOS002_028		20	0.3611	1.65	450.95	24.08	3.54	0.52
sect2FossilBOS002_027		21	0.4006	1.71	400.54	17.52	2.17	0.46
sect2FossilBOS002_026		22	0.5228	1.51	415.23	17.68	2.09	0.33

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect2FossilBOS002_025		23	0.4458	1.36	379.70	18.10	1.96	0.08
sect2FossilBOS002_024		24	0.3911	1.28	371.38	15.60	1.92	0.10
sect2FossilBOS002_023		25	0.4556	1.15	363.14	13.92	4.84	0.16
sect2FossilBOS002_022		26	0.3605	1.23	359.69	12.74	2.06	0.10
sect2FossilBOS002_021		27	0.4067	1.07	364.21	12.02	1.79	0.03
sect2FossilBOS002_020		28	0.3144	NA	354.52	11.82	1.92	0.07
sect2FossilBOS002_019		29	0.3221	1.14	361.87	12.36	1.73	0.06
sect2FossilBOS002_018	TRUE	30	0.2607	1.16	360.95	11.73	1.97	0.10
sect2FossilBOS002_017		31	0.2841	1.13	361.53	12.21	1.86	0.52
sect2FossilBOS002_016		32	0.2762	1.12	346.73	11.20	1.78	0.02
sect2FossilBOS002_015		33	0.4985	1.20	368.79	15.77	1.93	0.07
sect2FossilBOS002_014		34	0.2991	1.10	356.36	10.61	1.74	0.17
sect2FossilBOS002_013		35	0.3071	1.11	334.27	11.79	1.72	0.13
sect2FossilBOS002_012		36	0.2377	1.14	333.37	12.36	1.88	0.03
sect2FossilBOS002_011		37	0.2685	1.14	347.99	11.72	1.72	0.14
sect2FossilBOS002_010		38	0.2914	1.13	326.69	12.37	1.70	0.04
sect2FossilBOS002_009		39	0.2608	1.21	340.90	12.14	1.71	0.04
sect2FossilBOS002_008		40	0.2159	1.09	323.96	12.98	1.74	0.04
sect2FossilBOS002_007		41	0.2541	1.11	322.65	13.57	1.76	0.04
sect2FossilBOS002_006		42	0.1764	1.15	332.80	14.86	2.08	0.06
sect2FossilBOS002_005		43	0.2454	1.13	326.51	14.15	1.98	0.04
sect2FossilBOS002_004		44	0.2377	1.13	343.66	15.57	2.09	0.03
sect2FossilBOS002_003		45	0.1919	0.97	354.22	18.12	2.75	0.10
sect2FossilBOS002_002		46	0.2737	1.08	370.36	18.69	2.50	0.06
sect2FossilBOS002_001		47	0.2819	1.09	364.28	18.35	2.66	0.24
		48	0.2271					
sect1FossilBOS002_033		49	0.5063	1.24	427.63	16.34	2.34	NA
sect1FossilBOS002_032		49	0.5063	1.14	355.18	14.33	2.05	0.32
sect1FossilBOS002_031		50	0.3235	1.09	351.17	15.80	1.97	0.07
sect1FossilBOS002_030		51	0.3102	1.17	337.65	14.60	1.95	0.06
sect1FossilBOS002_029		52	0.3224	1.18	328.77	14.27	1.93	0.06
sect1FossilBOS002_028		53	0.2777	1.18	333.16	14.62	1.94	0.03
sect1FossilBOS002_027		54	0.2306	1.14	310.17	12.79	1.83	0.03
sect1FossilBOS002_026		55	0.2153	1.11	311.62	13.70	1.83	0.05
sect1FossilBOS002_025		56	0.2147	1.13	316.62	13.91	1.80	0.03
sect1FossilBOS002_024		57	0.1689	1.13	298.94	13.07	1.83	0.03
		58	0.1					
sect1FossilBOS002_023	TRUE	59	0.1304	1.11	320.18	13.18	1.77	0.03
sect1FossilBOS002_022		60	0.2312	1.08	299.19	10.46	1.78	0.03
sect1FossilBOS002_021		61	0.3688	1.00	313.65	12.09	1.87	0.04
		62	0.3611					

Sample	Annulus	Striae Number	ISI	Li7	Mg26	Mn55	Ba137	Pb208
sect1FossilBOS002_020		63	0.3301	1.02	322.70	12.33	1.93	0.02
sect1FossilBOS002_019		64	0.4373	1.07	294.27	12.57	1.92	0.02
sect1FossilBOS002_018		65	0.4067	1.09	310.44	13.52	2.05	0.04
sect1FossilBOS002_017		66	0.5449	0.97	303.53	13.69	2.12	0.03
sect1FossilBOS002_016		67	0.6602	1.02	297.09	12.69	1.95	0.04
sect1FossilBOS002_015		68	0.4076	0.99	301.88	12.55	2.13	0.03
sect1FossilBOS002_014		69	0.3221	0.99	323.60	13.53	1.98	0.02
sect1FossilBOS002_013		70	0.5291	1.07	327.58	14.77	2.21	0.08
		71	0.184					
sect1FossilBOS002_012		72	0.2994	0.96	317.01	14.40	2.15	0.08
sect1FossilBOS002_011		73	0.6058	0.91	332.56	17.06	2.64	0.08
sect1FossilBOS002_010		74	0.652	0.92	349.90	17.23	2.60	0.11
sect1FossilBOS002_009		75	0.652	0.87	350.72	17.42	2.74	0.08
sect1FossilBOS002_008		76	0.56	0.95	366.81	18.88	2.70	0.09
sect1FossilBOS002_007		77	0.5293	0.82	365.00	20.80	3.05	0.13
sect1FossilBOS002_006		78	0.4371	0.82	358.32	23.96	3.15	0.13
sect1FossilBOS002_005		79	0.3067	0.76	321.88	21.57	2.68	0.12
sect1FossilBOS002_004		80	0.2914	0.71	354.75	24.60	3.16	0.10
sect1FossilBOS002_003		81	0.3527	0.71	329.63	23.62	3.11	0.17
sect1FossilBOS002_002		NA	NA	0.62	334.58	23.56	2.87	0.24
sect1FossilBOS002_001		NA	NA	0.67	351.97	22.26	2.66	

Part 3: R Code

```
# Call required packages and calculations
## meanOfOneBootstrap function from
"http://strata.uga.edu/8370/lecturenotes/resampling.html"
## add.alpha function from "https://gist.github.com/mages/5339689"

library(ggplot2)
library(CNLTtsa)
library(CNLTreg)

meanOfOneBootstrap <- function(x) {
                              bootstrappedSample <- sample(x,
size=length(x), replace=TRUE)
                              theMean <- mean(bootstrappedSample, na.rm
= TRUE)
                              theMean
                              }
alpha = 0.05

add.alpha <- function(col, alpha=1){
  if(missing(col))
    stop("Please provide a vector of colours.")
  apply(sapply(col, col2rgb)/255, 2,
                     function(x)
                       rgb(x[1], x[2], x[3], alpha=alpha))
}

# read in data and assign elements, interstrial distances, and striae
numbering to objects

bayOfSails3B  <- read.table("fullBOS3B.csv", sep = ",", header = TRUE)
bayOfSails4B <- read.table("fullBOS4B.csv", sep = ",", header = TRUE)
bayOfSailsFossil <- read.table("fullFossilBOS.csv", sep = ",", header =
TRUE)
explorersCove3B <- read.table("fullRIW3B.csv", sep = ",", header =
TRUE)
explorersCove4B <- read.table("fullRIW4B.csv", sep = ",", header =
TRUE)
explorersCoveFossil <- read.table("fullFossilEC.csv", sep = ",", header
= TRUE)

bayOfSails3Coherence  <- read.table("coherenceBayOfSails3.csv", sep =
",", header = TRUE)
bayOfSails4Coherence <- read.table("coherenceBayOfSails4.csv", sep =
",", header = TRUE)
bayOfSailsFossilCoherence <-
read.table("coherenceBayOfSailsFossil.csv", sep = ",", header = TRUE)
explorersCove3Coherence <- read.table("coherenceExplorersCove3.csv",
sep = ",", header = TRUE)
explorersCove4Coherence <- read.table("coherenceExplorersCove4.csv",
sep = ",", header = TRUE)
explorersCoveFossilCoherence <-
read.table("coherenceExplorersCoveFossil.csv", sep = ",", header =
TRUE)
```

```
bayOfSails3BStriae <- bayOfSails3B$interstrialDistance
bayOfSails3BOntogeny <- bayOfSails3B$striaeNumberCor
bayOfSails3BLi7 <- bayOfSails3B$Li7
bayOfSails3BMg26 <- bayOfSails3B$Mg26
bayOfSails3BMn55 <- bayOfSails3B$Mn55
bayOfSails3BBa137 <- bayOfSails3B$Ba137
bayOfSails3BPb208 <- bayOfSails3B$Pb208

bayOfSails4BStriae <- bayOfSails4B$interstrialDistance
bayOfSails4BOntogeny <- bayOfSails4B$striaeNumberCor
bayOfSails4BLi7 <- bayOfSails4B$Li7
bayOfSails4BMg26 <- bayOfSails4B$Mg26
bayOfSails4BMn55 <- bayOfSails4B$Mn55
bayOfSails4BBa137 <- bayOfSails4B$Ba137
bayOfSails4BPb208 <- bayOfSails4B$Pb208

bayOfSailsFossilStriae <- bayOfSailsFossil$interstrialDistance
bayOfSailsFossilOntogeny <- bayOfSailsFossil$striaeNumberCor
bayOfSailsFossilLi7 <- bayOfSailsFossil$Li7
bayOfSailsFossilMg26 <- bayOfSailsFossil$Mg26
bayOfSailsFossilMn55 <- bayOfSailsFossil$Mn55
bayOfSailsFossilBa137 <- bayOfSailsFossil$Ba137
bayOfSailsFossilPb208 <- bayOfSailsFossil$Pb208

explorersCove3BStriae <- explorersCove3B$interstrialDistance
explorersCove3BOntogeny <- explorersCove3B$striaeNumberCor
explorersCove3BLi7 <- explorersCove3B$Li7
explorersCove3BMg26 <- explorersCove3B$Mg26
explorersCove3BMn55 <- explorersCove3B$Mn55
explorersCove3BBa137 <- explorersCove3B$Ba137
explorersCove3BPb208 <- explorersCove3B$Pb208

explorersCove4BStriae <- explorersCove4B$interstrialDistance
explorersCove4BOntogeny <- explorersCove4B$striaeNumberCor
explorersCove4BLi7 <- explorersCove4B$Li7
explorersCove4BMg26 <- explorersCove4B$Mg26
explorersCove4BMn55 <- explorersCove4B$Mn55
explorersCove4BBa137 <- explorersCove4B$Ba137
explorersCove4BPb208 <- explorersCove4B$Pb208

explorersCoveFossilStriae <- explorersCoveFossil$interstrialDistance
explorersCoveFossilOntogeny <- explorersCoveFossil$striaeNumberCor
explorersCoveFossilLi7 <- explorersCoveFossil$Li7
explorersCoveFossilMg26 <- explorersCoveFossil$Mg26
explorersCoveFossilMn55 <- explorersCoveFossil$Mn55
explorersCoveFossilBa137 <- explorersCoveFossil$Ba137
explorersCoveFossilPb208 <- explorersCoveFossil$Pb208

# Pearson correlations between striae and trace elements, and between
trace element pairs
## Undifferenced data
### Bay of Sails 3B
cor.test(bayOfSails3BStriae, bayOfSails3BLi7, method = "pearson")
cor.test(bayOfSails3BStriae, bayOfSails3BMg26, method = "pearson")
cor.test(bayOfSails3BStriae, bayOfSails3BMn55, method = "pearson")
cor.test(bayOfSails3BStriae, bayOfSails3BBa137, method = "pearson")
cor.test(bayOfSails3BStriae, bayOfSails3BPb208, method = "pearson")
```

```
cor.test(bayOfSails3BOntogeny, bayOfSails3BLi7, method = "pearson")
cor.test(bayOfSails3BOntogeny, bayOfSails3BMg26, method = "pearson")
cor.test(bayOfSails3BOntogeny, bayOfSails3BMn55, method = "pearson")
cor.test(bayOfSails3BOntogeny, bayOfSails3BBa137, method = "pearson")
cor.test(bayOfSails3BOntogeny, bayOfSails3BPb208, method = "pearson")
cor.test(bayOfSails3BLi7, bayOfSails3BMg26, method = "pearson")
cor.test(bayOfSails3BLi7, bayOfSails3BMn55, method = "pearson")
cor.test(bayOfSails3BLi7, bayOfSails3BBa137, method = "pearson")
cor.test(bayOfSails3BLi7, bayOfSails3BPb208, method = "pearson")
cor.test(bayOfSails3BMg26, bayOfSails3BMn55, method = "pearson")
cor.test(bayOfSails3BMg26, bayOfSails3BBa137, method = "pearson")
cor.test(bayOfSails3BMg26, bayOfSails3BPb208, method = "pearson")
cor.test(bayOfSails3BMn55, bayOfSails3BBa137, method = "pearson")
cor.test(bayOfSails3BMn55, bayOfSails3BPb208, method = "pearson")
cor.test(bayOfSails3BBa137, bayOfSails3BPb208, method = "pearson")

### Bay of Sails 4B
cor.test(bayOfSails4BStriae, bayOfSails4BLi7, method = "pearson")
cor.test(bayOfSails4BStriae, bayOfSails4BMg26, method = "pearson")
cor.test(bayOfSails4BStriae, bayOfSails4BMn55, method = "pearson")
cor.test(bayOfSails4BStriae, bayOfSails4BBa137, method = "pearson")
cor.test(bayOfSails4BStriae, bayOfSails4BPb208, method = "pearson")
cor.test(bayOfSails4BOntogeny, bayOfSails4BLi7, method = "pearson")
cor.test(bayOfSails4BOntogeny, bayOfSails4BMg26, method = "pearson")
cor.test(bayOfSails4BOntogeny, bayOfSails4BMn55, method = "pearson")
cor.test(bayOfSails4BOntogeny, bayOfSails4BBa137, method = "pearson")
cor.test(bayOfSails4BOntogeny, bayOfSails4BPb208, method = "pearson")
cor.test(bayOfSails4BLi7, bayOfSails4BMg26, method = "pearson")
cor.test(bayOfSails4BLi7, bayOfSails4BMn55, method = "pearson")
cor.test(bayOfSails4BLi7, bayOfSails4BBa137, method = "pearson")
cor.test(bayOfSails4BLi7, bayOfSails4BPb208, method = "pearson")
cor.test(bayOfSails4BMg26, bayOfSails4BMn55, method = "pearson")
cor.test(bayOfSails4BMg26, bayOfSails4BBa137, method = "pearson")
cor.test(bayOfSails4BMg26, bayOfSails4BPb208, method = "pearson")
cor.test(bayOfSails4BMn55, bayOfSails4BBa137, method = "pearson")
cor.test(bayOfSails4BMn55, bayOfSails4BPb208, method = "pearson")
cor.test(bayOfSails4BBa137, bayOfSails4BPb208, method = "pearson")

### Bay of Sails Fossil
cor.test(bayOfSailsFossilStriae, bayOfSailsFossilLi7, method =
"pearson")
cor.test(bayOfSailsFossilStriae, bayOfSailsFossilMg26, method =
"pearson")
cor.test(bayOfSailsFossilStriae, bayOfSailsFossilMn55, method =
"pearson")
cor.test(bayOfSailsFossilStriae, bayOfSailsFossilBa137, method =
"pearson")
cor.test(bayOfSailsFossilStriae, bayOfSailsFossilPb208, method =
"pearson")
cor.test(bayOfSailsFossilOntogeny, bayOfSailsFossilLi7, method =
"pearson")
cor.test(bayOfSailsFossilOntogeny, bayOfSailsFossilMg26, method =
"pearson")
cor.test(bayOfSailsFossilOntogeny, bayOfSailsFossilMn55, method =
"pearson")
cor.test(bayOfSailsFossilOntogeny, bayOfSailsFossilBa137, method =
"pearson")
```

```
cor.test(bayOfSailsFossilOntogeny, bayOfSailsFossilPb208, method =
"pearson")
cor.test(bayOfSailsFossilLi7, bayOfSailsFossilMg26, method = "pearson")
cor.test(bayOfSailsFossilLi7, bayOfSailsFossilMn55, method = "pearson")
cor.test(bayOfSailsFossilLi7, bayOfSailsFossilBa137, method =
"pearson")
cor.test(bayOfSailsFossilLi7, bayOfSailsFossilPb208, method =
"pearson")
cor.test(bayOfSailsFossilMg26, bayOfSailsFossilMn55, method =
"pearson")
cor.test(bayOfSailsFossilMg26, bayOfSailsFossilBa137, method =
"pearson")
cor.test(bayOfSailsFossilMg26, bayOfSailsFossilPb208, method =
"pearson")
cor.test(bayOfSailsFossilMn55, bayOfSailsFossilBa137, method =
"pearson")
cor.test(bayOfSailsFossilMn55, bayOfSailsFossilPb208, method =
"pearson")
cor.test(bayOfSailsFossilBa137, bayOfSailsFossilPb208, method =
"pearson")

### Explorers Cove 3B
cor.test(explorersCove3BStriae, explorersCove3BLi7, method = "pearson")
cor.test(explorersCove3BStriae, explorersCove3BMg26, method =
"pearson")
cor.test(explorersCove3BStriae, explorersCove3BMn55, method =
"pearson")
cor.test(explorersCove3BStriae, explorersCove3BBa137, method =
"pearson")
cor.test(explorersCove3BStriae, explorersCove3BPb208, method =
"pearson")
cor.test(explorersCove3BOntogeny, explorersCove3BLi7, method =
"pearson")
cor.test(explorersCove3BOntogeny, explorersCove3BMg26, method =
"pearson")
cor.test(explorersCove3BOntogeny, explorersCove3BMn55, method =
"pearson")
cor.test(explorersCove3BOntogeny, explorersCove3BBa137, method =
"pearson")
cor.test(explorersCove3BOntogeny, explorersCove3BPb208, method =
"pearson")
cor.test(explorersCove3BLi7, explorersCove3BMg26, method = "pearson")
cor.test(explorersCove3BLi7, explorersCove3BMn55, method = "pearson")
cor.test(explorersCove3BLi7, explorersCove3BBa137, method = "pearson")
cor.test(explorersCove3BLi7, explorersCove3BPb208, method = "pearson")
cor.test(explorersCove3BMg26, explorersCove3BMn55, method = "pearson")
cor.test(explorersCove3BMg26, explorersCove3BBa137, method = "pearson")
cor.test(explorersCove3BMg26, explorersCove3BPb208, method = "pearson")
cor.test(explorersCove3BMn55, explorersCove3BBa137, method = "pearson")
cor.test(explorersCove3BMn55, explorersCove3BPb208, method = "pearson")
cor.test(explorersCove3BBa137, explorersCove3BPb208, method =
"pearson")

### Explorers Cove 4B
cor.test(explorersCove4BStriae, explorersCove4BLi7, method = "pearson")
cor.test(explorersCove4BStriae, explorersCove4BMg26, method =
"pearson")
```

```
cor.test(explorersCove4BStriae, explorersCove4BMn55, method =
"pearson")
cor.test(explorersCove4BStriae, explorersCove4BBa137, method =
"pearson")
cor.test(explorersCove4BStriae, explorersCove4BPb208, method =
"pearson")
cor.test(explorersCove4BOntogeny, explorersCove4BLi7, method =
"pearson")
cor.test(explorersCove4BOntogeny, explorersCove4BMg26, method =
"pearson")
cor.test(explorersCove4BOntogeny, explorersCove4BMn55, method =
"pearson")
cor.test(explorersCove4BOntogeny, explorersCove4BBa137, method =
"pearson")
cor.test(explorersCove4BOntogeny, explorersCove4BPb208, method =
"pearson")
cor.test(explorersCove4BLi7, explorersCove4BMg26, method = "pearson")
cor.test(explorersCove4BLi7, explorersCove4BMn55, method = "pearson")
cor.test(explorersCove4BLi7, explorersCove4BBa137, method = "pearson")
cor.test(explorersCove4BLi7, explorersCove4BPb208, method = "pearson")
cor.test(explorersCove4BMg26, explorersCove4BMn55, method = "pearson")
cor.test(explorersCove4BMg26, explorersCove4BBa137, method = "pearson")
cor.test(explorersCove4BMg26, explorersCove4BPb208, method = "pearson")
cor.test(explorersCove4BMn55, explorersCove4BBa137, method = "pearson")
cor.test(explorersCove4BMn55, explorersCove4BPb208, method = "pearson")
cor.test(explorersCove4BBa137, explorersCove4BPb208, method =
"pearson")

### Explorers Cove Fossil
cor.test(explorersCoveFossilStriae, explorersCoveFossilLi7, method =
"pearson")
cor.test(explorersCoveFossilStriae, explorersCoveFossilMg26, method =
"pearson")
cor.test(explorersCoveFossilStriae, explorersCoveFossilMn55, method =
"pearson")
cor.test(explorersCoveFossilStriae, explorersCoveFossilBa137, method =
"pearson")
cor.test(explorersCoveFossilStriae, explorersCoveFossilPb208, method =
"pearson")
cor.test(explorersCoveFossilOntogeny, explorersCoveFossilLi7, method =
"pearson")
cor.test(explorersCoveFossilOntogeny, explorersCoveFossilMg26, method =
"pearson")
cor.test(explorersCoveFossilOntogeny, explorersCoveFossilMn55, method =
"pearson")
cor.test(explorersCoveFossilOntogeny, explorersCoveFossilBa137, method
= "pearson")
cor.test(explorersCoveFossilOntogeny, explorersCoveFossilPb208, method
= "pearson")
cor.test(explorersCoveFossilLi7, explorersCoveFossilMg26, method =
"pearson")
cor.test(explorersCoveFossilLi7, explorersCoveFossilMn55, method =
"pearson")
cor.test(explorersCoveFossilLi7, explorersCoveFossilBa137, method =
"pearson")
cor.test(explorersCoveFossilLi7, explorersCoveFossilPb208, method =
"pearson")
```

```
cor.test(explorersCoveFossilMg26, explorersCoveFossilMn55, method =
"pearson")
cor.test(explorersCoveFossilMg26, explorersCoveFossilBa137, method =
"pearson")
cor.test(explorersCoveFossilMg26, explorersCoveFossilPb208, method =
"pearson")
cor.test(explorersCoveFossilMn55, explorersCoveFossilBa137, method =
"pearson")
cor.test(explorersCoveFossilMn55, explorersCoveFossilPb208, method =
"pearson")
cor.test(explorersCoveFossilBa137, explorersCoveFossilPb208, method =
"pearson")

#calculate means and 95% CIs on trace element concentrations for each
valve
# Li7
Li7MeanExplorersCove3B <- replicate(10000,
meanOfOneBootstrap(explorersCove3BLi7))
boostrappedMeanEstimateLi7ExplorersCove3B <-
mean(Li7MeanExplorersCove3B)
lowerBoostrappedMeanEstimateLi7ExplorersCove3B <-
quantile(Li7MeanExplorersCove3B, alpha/2)
upperBoostrappedMeanEstimateLi7ExplorersCove3B <-
quantile(Li7MeanExplorersCove3B, 1-alpha/2)

Li7MeanExplorersCove4B <- replicate(10000,
meanOfOneBootstrap(explorersCove4BLi7))
boostrappedMeanEstimateLi7ExplorersCove4B <-
mean(Li7MeanExplorersCove4B)
lowerBoostrappedMeanEstimateLi7ExplorersCove4B <-
quantile(Li7MeanExplorersCove4B, alpha/2)
upperBoostrappedMeanEstimateLi7ExplorersCove4B <-
quantile(Li7MeanExplorersCove4B, 1-alpha/2)

Li7MeanExplorersCoveFossil <- replicate(10000,
meanOfOneBootstrap(explorersCoveFossilLi7))
boostrappedMeanEstimateLi7ExplorersCoveFossil <-
mean(Li7MeanExplorersCoveFossil)
lowerBoostrappedMeanEstimateLi7ExplorersCoveFossil <-
quantile(Li7MeanExplorersCoveFossil, alpha/2)
upperBoostrappedMeanEstimateLi7ExplorersCoveFossil <-
quantile(Li7MeanExplorersCoveFossil, 1-alpha/2)

Li7MeanBayOfSails3B <- replicate(10000,
meanOfOneBootstrap(bayOfSails3BLi7))
boostrappedMeanEstimateLi7BayOfSails3B <- mean(Li7MeanBayOfSails3B)
lowerBoostrappedMeanEstimateLi7BayOfSails3B <-
quantile(Li7MeanBayOfSails3B, alpha/2)
upperBoostrappedMeanEstimateLi7BayOfSails3B <-
quantile(Li7MeanBayOfSails3B, 1-alpha/2)

Li7MeanBayOfSails4B <- replicate(10000,
meanOfOneBootstrap(bayOfSails4BLi7))
boostrappedMeanEstimateLi7BayOfSails4B <- mean(Li7MeanBayOfSails4B)
lowerBoostrappedMeanEstimateLi7BayOfSails4B <-
quantile(Li7MeanBayOfSails4B, alpha/2)
```

```
upperBoostrappedMeanEstimateLi7BayOfSails4B <-
quantile(Li7MeanBayOfSails4B, 1-alpha/2)

Li7MeanBayOfSailsFossil <- replicate(10000,
meanOfOneBootstrap(bayOfSailsFossilLi7))
boostrappedMeanEstimateLi7BayOfSailsFossil <-
mean(Li7MeanBayOfSailsFossil)
lowerBoostrappedMeanEstimateLi7BayOfSailsFossil <-
quantile(Li7MeanBayOfSailsFossil, alpha/2)
upperBoostrappedMeanEstimateLi7BayOfSailsFossil <-
quantile(Li7MeanBayOfSailsFossil, 1-alpha/2)

boostrappedMeanEstimateLi7ExplorersCove3B
lowerBoostrappedMeanEstimateLi7ExplorersCove3B
upperBoostrappedMeanEstimateLi7ExplorersCove3B
boostrappedMeanEstimateLi7ExplorersCove4B
lowerBoostrappedMeanEstimateLi7ExplorersCove4B
upperBoostrappedMeanEstimateLi7ExplorersCove4B
boostrappedMeanEstimateLi7ExplorersCoveFossil
lowerBoostrappedMeanEstimateLi7ExplorersCoveFossil
upperBoostrappedMeanEstimateLi7ExplorersCoveFossil
boostrappedMeanEstimateLi7BayOfSails3B
lowerBoostrappedMeanEstimateLi7BayOfSails3B
upperBoostrappedMeanEstimateLi7BayOfSails3B
boostrappedMeanEstimateLi7BayOfSails4B
lowerBoostrappedMeanEstimateLi7BayOfSails4B
upperBoostrappedMeanEstimateLi7BayOfSails4B
boostrappedMeanEstimateLi7BayOfSailsFossil
lowerBoostrappedMeanEstimateLi7BayOfSailsFossil
upperBoostrappedMeanEstimateLi7BayOfSailsFossil

range(explorersCove3BLi7, na.rm = TRUE)
range(explorersCove4BLi7, na.rm = TRUE)
range(explorersCoveFossilLi7, na.rm = TRUE)
range(bayOfSails3BLi7, na.rm = TRUE)
range(bayOfSails4BLi7, na.rm = TRUE)
range(bayOfSailsFossilLi7, na.rm = TRUE)

# Mg26
Mg26MeanExplorersCove3B <- replicate(10000,
meanOfOneBootstrap(explorersCove3BMg26))
boostrappedMeanEstimateMg26ExplorersCove3B <-
mean(Mg26MeanExplorersCove3B)
lowerBoostrappedMeanEstimateMg26ExplorersCove3B <-
quantile(Mg26MeanExplorersCove3B, alpha/2)
upperBoostrappedMeanEstimateMg26ExplorersCove3B <-
quantile(Mg26MeanExplorersCove3B, 1-alpha/2)

Mg26MeanExplorersCove4B <- replicate(10000,
meanOfOneBootstrap(explorersCove4BMg26))
boostrappedMeanEstimateMg26ExplorersCove4B <-
mean(Mg26MeanExplorersCove4B)
lowerBoostrappedMeanEstimateMg26ExplorersCove4B <-
quantile(Mg26MeanExplorersCove4B, alpha/2)
upperBoostrappedMeanEstimateMg26ExplorersCove4B <-
quantile(Mg26MeanExplorersCove4B, 1-alpha/2)
```

```
Mg26MeanExplorersCoveFossil <- replicate(10000,
meanOfOneBootstrap(explorersCoveFossilMg26))
boostrappedMeanEstimateMg26ExplorersCoveFossil <-
mean(Mg26MeanExplorersCoveFossil)
lowerBoostrappedMeanEstimateMg26ExplorersCoveFossil <-
quantile(Mg26MeanExplorersCoveFossil, alpha/2)
upperBoostrappedMeanEstimateMg26ExplorersCoveFossil <-
quantile(Mg26MeanExplorersCoveFossil, 1-alpha/2)

Mg26MeanBayOfSails3B <- replicate(10000,
meanOfOneBootstrap(bayOfSails3BMg26))
boostrappedMeanEstimateMg26BayOfSails3B <- mean(Mg26MeanBayOfSails3B)
lowerBoostrappedMeanEstimateMg26BayOfSails3B <-
quantile(Mg26MeanBayOfSails3B, alpha/2)
upperBoostrappedMeanEstimateMg26BayOfSails3B <-
quantile(Mg26MeanBayOfSails3B, 1-alpha/2)

Mg26MeanBayOfSails4B <- replicate(10000,
meanOfOneBootstrap(bayOfSails4BMg26))
boostrappedMeanEstimateMg26BayOfSails4B <- mean(Mg26MeanBayOfSails4B)
lowerBoostrappedMeanEstimateMg26BayOfSails4B <-
quantile(Mg26MeanBayOfSails4B, alpha/2)
upperBoostrappedMeanEstimateMg26BayOfSails4B <-
quantile(Mg26MeanBayOfSails4B, 1-alpha/2)

Mg26MeanBayOfSailsFossil <- replicate(10000,
meanOfOneBootstrap(bayOfSailsFossilMg26))
boostrappedMeanEstimateMg26BayOfSailsFossil <-
mean(Mg26MeanBayOfSailsFossil)
lowerBoostrappedMeanEstimateMg26BayOfSailsFossil <-
quantile(Mg26MeanBayOfSailsFossil, alpha/2)
upperBoostrappedMeanEstimateMg26BayOfSailsFossil <-
quantile(Mg26MeanBayOfSailsFossil, 1-alpha/2)

boostrappedMeanEstimateMg26ExplorersCove3B
lowerBoostrappedMeanEstimateMg26ExplorersCove3B
upperBoostrappedMeanEstimateMg26ExplorersCove3B
boostrappedMeanEstimateMg26ExplorersCove4B
lowerBoostrappedMeanEstimateMg26ExplorersCove4B
upperBoostrappedMeanEstimateMg26ExplorersCove4B
boostrappedMeanEstimateMg26ExplorersCoveFossil
lowerBoostrappedMeanEstimateMg26ExplorersCoveFossil
upperBoostrappedMeanEstimateMg26ExplorersCoveFossil
boostrappedMeanEstimateMg26BayOfSails3B
lowerBoostrappedMeanEstimateMg26BayOfSails3B
upperBoostrappedMeanEstimateMg26BayOfSails3B
boostrappedMeanEstimateMg26BayOfSails4B
lowerBoostrappedMeanEstimateMg26BayOfSails4B
upperBoostrappedMeanEstimateMg26BayOfSails4B
boostrappedMeanEstimateMg26BayOfSailsFossil
lowerBoostrappedMeanEstimateMg26BayOfSailsFossil
upperBoostrappedMeanEstimateMg26BayOfSailsFossil

range(explorersCove3BMg26, na.rm = TRUE)
range(explorersCove4BMg26, na.rm = TRUE)
range(explorersCoveFossilMg26, na.rm = TRUE)
range(bayOfSails3BMg26, na.rm = TRUE)
```

```
range(bayOfSails4BMg26, na.rm = TRUE)
range(bayOfSailsFossilMg26, na.rm = TRUE)

# Mn55
Mn55MeanExplorersCove3B <- replicate(10000,
meanOfOneBootstrap(explorersCove3BMn55))
boostrappedMeanEstimateMn55ExplorersCove3B <-
mean(Mn55MeanExplorersCove3B)
lowerBoostrappedMeanEstimateMn55ExplorersCove3B <-
quantile(Mn55MeanExplorersCove3B, alpha/2)
upperBoostrappedMeanEstimateMn55ExplorersCove3B <-
quantile(Mn55MeanExplorersCove3B, 1-alpha/2)

Mn55MeanExplorersCove4B <- replicate(10000,
meanOfOneBootstrap(explorersCove4BMn55))
boostrappedMeanEstimateMn55ExplorersCove4B <-
mean(Mn55MeanExplorersCove4B)
lowerBoostrappedMeanEstimateMn55ExplorersCove4B <-
quantile(Mn55MeanExplorersCove4B, alpha/2)
upperBoostrappedMeanEstimateMn55ExplorersCove4B <-
quantile(Mn55MeanExplorersCove4B, 1-alpha/2)

Mn55MeanExplorersCoveFossil <- replicate(10000,
meanOfOneBootstrap(explorersCoveFossilMn55))
boostrappedMeanEstimateMn55ExplorersCoveFossil <-
mean(Mn55MeanExplorersCoveFossil)
lowerBoostrappedMeanEstimateMn55ExplorersCoveFossil <-
quantile(Mn55MeanExplorersCoveFossil, alpha/2)
upperBoostrappedMeanEstimateMn55ExplorersCoveFossil <-
quantile(Mn55MeanExplorersCoveFossil, 1-alpha/2)

Mn55MeanBayOfSails3B <- replicate(10000,
meanOfOneBootstrap(bayOfSails3BMn55))
boostrappedMeanEstimateMn55BayOfSails3B <- mean(Mn55MeanBayOfSails3B)
lowerBoostrappedMeanEstimateMn55BayOfSails3B <-
quantile(Mn55MeanBayOfSails3B, alpha/2)
upperBoostrappedMeanEstimateMn55BayOfSails3B <-
quantile(Mn55MeanBayOfSails3B, 1-alpha/2)

Mn55MeanBayOfSails4B <- replicate(10000,
meanOfOneBootstrap(bayOfSails4BMn55))
boostrappedMeanEstimateMn55BayOfSails4B <- mean(Mn55MeanBayOfSails4B)
lowerBoostrappedMeanEstimateMn55BayOfSails4B <-
quantile(Mn55MeanBayOfSails4B, alpha/2)
upperBoostrappedMeanEstimateMn55BayOfSails4B <-
quantile(Mn55MeanBayOfSails4B, 1-alpha/2)

Mn55MeanBayOfSailsFossil <- replicate(10000,
meanOfOneBootstrap(bayOfSailsFossilMn55))
boostrappedMeanEstimateMn55BayOfSailsFossil <-
mean(Mn55MeanBayOfSailsFossil)
lowerBoostrappedMeanEstimateMn55BayOfSailsFossil <-
quantile(Mn55MeanBayOfSailsFossil, alpha/2)
upperBoostrappedMeanEstimateMn55BayOfSailsFossil <-
quantile(Mn55MeanBayOfSailsFossil, 1-alpha/2)

boostrappedMeanEstimateMn55ExplorersCove3B
```

```
lowerBoostrappedMeanEstimateMn55ExplorersCove3B
upperBoostrappedMeanEstimateMn55ExplorersCove3B
boostrappedMeanEstimateMn55ExplorersCove4B
lowerBoostrappedMeanEstimateMn55ExplorersCove4B
upperBoostrappedMeanEstimateMn55ExplorersCove4B
boostrappedMeanEstimateMn55ExplorersCoveFossil
lowerBoostrappedMeanEstimateMn55ExplorersCoveFossil
upperBoostrappedMeanEstimateMn55ExplorersCoveFossil
boostrappedMeanEstimateMn55BayOfSails3B
lowerBoostrappedMeanEstimateMn55BayOfSails3B
upperBoostrappedMeanEstimateMn55BayOfSails3B
boostrappedMeanEstimateMn55BayOfSails4B
lowerBoostrappedMeanEstimateMn55BayOfSails4B
upperBoostrappedMeanEstimateMn55BayOfSails4B
boostrappedMeanEstimateMn55BayOfSailsFossil
lowerBoostrappedMeanEstimateMn55BayOfSailsFossil
upperBoostrappedMeanEstimateMn55BayOfSailsFossil

range(explorersCove3BMn55, na.rm = TRUE)
range(explorersCove4BMn55, na.rm = TRUE)
range(explorersCoveFossilMn55, na.rm = TRUE)
range(bayOfSails3BMn55, na.rm = TRUE)
range(bayOfSails4BMn55, na.rm = TRUE)
range(bayOfSailsFossilMn55, na.rm = TRUE)

# Ba137
Ba137MeanExplorersCove3B <- replicate(10000,
meanOfOneBootstrap(explorersCove3BBa137))
boostrappedMeanEstimateBa137ExplorersCove3B <-
mean(Ba137MeanExplorersCove3B)
lowerBoostrappedMeanEstimateBa137ExplorersCove3B <-
quantile(Ba137MeanExplorersCove3B, alpha/2)
upperBoostrappedMeanEstimateBa137ExplorersCove3B <-
quantile(Ba137MeanExplorersCove3B, 1-alpha/2)

Ba137MeanExplorersCove4B <- replicate(10000,
meanOfOneBootstrap(explorersCove4BBa137))
boostrappedMeanEstimateBa137ExplorersCove4B <-
mean(Ba137MeanExplorersCove4B)
lowerBoostrappedMeanEstimateBa137ExplorersCove4B <-
quantile(Ba137MeanExplorersCove4B, alpha/2)
upperBoostrappedMeanEstimateBa137ExplorersCove4B <-
quantile(Ba137MeanExplorersCove4B, 1-alpha/2)

Ba137MeanExplorersCoveFossil <- replicate(10000,
meanOfOneBootstrap(explorersCoveFossilBa137))
boostrappedMeanEstimateBa137ExplorersCoveFossil <-
mean(Ba137MeanExplorersCoveFossil)
lowerBoostrappedMeanEstimateBa137ExplorersCoveFossil <-
quantile(Ba137MeanExplorersCoveFossil, alpha/2)
upperBoostrappedMeanEstimateBa137ExplorersCoveFossil <-
quantile(Ba137MeanExplorersCoveFossil, 1-alpha/2)

Ba137MeanBayOfSails3B <- replicate(10000,
meanOfOneBootstrap(bayOfSails3BBa137))
boostrappedMeanEstimateBa137BayOfSails3B <- mean(Ba137MeanBayOfSails3B)
```

```
lowerBoostrappedMeanEstimateBa137BayOfSails3B <-
quantile(Ba137MeanBayOfSails3B, alpha/2)
upperBoostrappedMeanEstimateBa137BayOfSails3B <-
quantile(Ba137MeanBayOfSails3B, 1-alpha/2)

Ba137MeanBayOfSails4B <- replicate(10000,
meanOfOneBootstrap(bayOfSails4BBa137))
boostrappedMeanEstimateBa137BayOfSails4B <- mean(Ba137MeanBayOfSails4B)
lowerBoostrappedMeanEstimateBa137BayOfSails4B <-
quantile(Ba137MeanBayOfSails4B, alpha/2)
upperBoostrappedMeanEstimateBa137BayOfSails4B <-
quantile(Ba137MeanBayOfSails4B, 1-alpha/2)

Ba137MeanBayOfSailsFossil <- replicate(10000,
meanOfOneBootstrap(bayOfSailsFossilBa137))
boostrappedMeanEstimateBa137BayOfSailsFossil <-
mean(Ba137MeanBayOfSailsFossil)
lowerBoostrappedMeanEstimateBa137BayOfSailsFossil <-
quantile(Ba137MeanBayOfSailsFossil, alpha/2)
upperBoostrappedMeanEstimateBa137BayOfSailsFossil <-
quantile(Ba137MeanBayOfSailsFossil, 1-alpha/2)

boostrappedMeanEstimateBa137ExplorersCove3B
lowerBoostrappedMeanEstimateBa137ExplorersCove3B
upperBoostrappedMeanEstimateBa137ExplorersCove3B
boostrappedMeanEstimateBa137ExplorersCove4B
lowerBoostrappedMeanEstimateBa137ExplorersCove4B
upperBoostrappedMeanEstimateBa137ExplorersCove4B
boostrappedMeanEstimateBa137ExplorersCoveFossil
lowerBoostrappedMeanEstimateBa137ExplorersCoveFossil
upperBoostrappedMeanEstimateBa137ExplorersCoveFossil
boostrappedMeanEstimateBa137BayOfSails3B
lowerBoostrappedMeanEstimateBa137BayOfSails3B
upperBoostrappedMeanEstimateBa137BayOfSails3B
boostrappedMeanEstimateBa137BayOfSails4B
lowerBoostrappedMeanEstimateBa137BayOfSails4B
upperBoostrappedMeanEstimateBa137BayOfSails4B
boostrappedMeanEstimateBa137BayOfSailsFossil
lowerBoostrappedMeanEstimateBa137BayOfSailsFossil
upperBoostrappedMeanEstimateBa137BayOfSailsFossil

range(explorersCove3BBa137, na.rm = TRUE)
range(explorersCove4BBa137, na.rm = TRUE)
range(explorersCoveFossilBa137, na.rm = TRUE)
range(bayOfSails3BBa137, na.rm = TRUE)
range(bayOfSails4BBa137, na.rm = TRUE)
range(bayOfSailsFossilBa137, na.rm = TRUE)

# Pb208
Pb208MeanExplorersCove3B <- replicate(10000,
meanOfOneBootstrap(explorersCove3BPb208))
boostrappedMeanEstimatePb208ExplorersCove3B <-
mean(Pb208MeanExplorersCove3B)
lowerBoostrappedMeanEstimatePb208ExplorersCove3B <-
quantile(Pb208MeanExplorersCove3B, alpha/2)
upperBoostrappedMeanEstimatePb208ExplorersCove3B <-
quantile(Pb208MeanExplorersCove3B, 1-alpha/2)
```

```
Pb208MeanExplorersCove4B <- replicate(10000,
meanOfOneBootstrap(explorersCove4BPb208))
boostrappedMeanEstimatePb208ExplorersCove4B <-
mean(Pb208MeanExplorersCove4B)
lowerBoostrappedMeanEstimatePb208ExplorersCove4B <-
quantile(Pb208MeanExplorersCove4B, alpha/2)
upperBoostrappedMeanEstimatePb208ExplorersCove4B <-
quantile(Pb208MeanExplorersCove4B, 1-alpha/2)

Pb208MeanExplorersCoveFossil <- replicate(10000,
meanOfOneBootstrap(explorersCoveFossilPb208))
boostrappedMeanEstimatePb208ExplorersCoveFossil <-
mean(Pb208MeanExplorersCoveFossil)
lowerBoostrappedMeanEstimatePb208ExplorersCoveFossil <-
quantile(Pb208MeanExplorersCoveFossil, alpha/2)
upperBoostrappedMeanEstimatePb208ExplorersCoveFossil <-
quantile(Pb208MeanExplorersCoveFossil, 1-alpha/2)

Pb208MeanBayOfSails3B <- replicate(10000,
meanOfOneBootstrap(bayOfSails3BPb208))
boostrappedMeanEstimatePb208BayOfSails3B <- mean(Pb208MeanBayOfSails3B)
lowerBoostrappedMeanEstimatePb208BayOfSails3B <-
quantile(Pb208MeanBayOfSails3B, alpha/2)
upperBoostrappedMeanEstimatePb208BayOfSails3B <-
quantile(Pb208MeanBayOfSails3B, 1-alpha/2)

Pb208MeanBayOfSails4B <- replicate(10000,
meanOfOneBootstrap(bayOfSails4BPb208))
boostrappedMeanEstimatePb208BayOfSails4B <- mean(Pb208MeanBayOfSails4B)
lowerBoostrappedMeanEstimatePb208BayOfSails4B <-
quantile(Pb208MeanBayOfSails4B, alpha/2)
upperBoostrappedMeanEstimatePb208BayOfSails4B <-
quantile(Pb208MeanBayOfSails4B, 1-alpha/2)

Pb208MeanBayOfSailsFossil <- replicate(10000,
meanOfOneBootstrap(bayOfSailsFossilPb208))
boostrappedMeanEstimatePb208BayOfSailsFossil <-
mean(Pb208MeanBayOfSailsFossil)
lowerBoostrappedMeanEstimatePb208BayOfSailsFossil <-
quantile(Pb208MeanBayOfSailsFossil, alpha/2)
upperBoostrappedMeanEstimatePb208BayOfSailsFossil <-
quantile(Pb208MeanBayOfSailsFossil, 1-alpha/2)

boostrappedMeanEstimatePb208ExplorersCove3B
lowerBoostrappedMeanEstimatePb208ExplorersCove3B
upperBoostrappedMeanEstimatePb208ExplorersCove3B
boostrappedMeanEstimatePb208ExplorersCove4B
lowerBoostrappedMeanEstimatePb208ExplorersCove4B
upperBoostrappedMeanEstimatePb208ExplorersCove4B
boostrappedMeanEstimatePb208ExplorersCoveFossil
lowerBoostrappedMeanEstimatePb208ExplorersCoveFossil
upperBoostrappedMeanEstimatePb208ExplorersCoveFossil
boostrappedMeanEstimatePb208BayOfSails3B
lowerBoostrappedMeanEstimatePb208BayOfSails3B
upperBoostrappedMeanEstimatePb208BayOfSails3B
boostrappedMeanEstimatePb208BayOfSails4B
```

```
lowerBoostrappedMeanEstimatePb208BayOfSails4B
upperBoostrappedMeanEstimatePb208BayOfSails4B
boostrappedMeanEstimatePb208BayOfSailsFossil
lowerBoostrappedMeanEstimatePb208BayOfSailsFossil
upperBoostrappedMeanEstimatePb208BayOfSailsFossil

range(explorersCove3BPb208, na.rm = TRUE)
range(explorersCove4BPb208, na.rm = TRUE)
range(explorersCoveFossilPb208, na.rm = TRUE)
range(bayOfSails3BPb208, na.rm = TRUE)
range(bayOfSails4BPb208, na.rm = TRUE)
range(bayOfSailsFossilPb208, na.rm = TRUE)

# Plot each trace element and interstrial increments over ontogeny
## Color and shape assignments (RColorBrewer BrBG Palette, Bay of Sails
has brown shades, Explorers Cove has green shades)
myShapesTraceElements = c(20)
myColorsInterstrialGrowthIncrements = c("gray")
myColorsExplorersCove3B = c("#01665E")
myColorsExplorersCove3BAlpha <- add.alpha(myColorsExplorersCove3B,
alpha=0.4)
myColorsExplorersCove4B = c("#35978F")
myColorsExplorersCove4BAlpha <- add.alpha(myColorsExplorersCove4B,
alpha=0.4)
myColorsExplorersCoveFossil = c("#80CDC1")
myColorsExplorersCoveFossilAlpha <-
add.alpha(myColorsExplorersCoveFossil, alpha=0.4)
myColorsBayOfSails3B = c("#8C510A"  )
myColorsBayOfSails3BAlpha <- add.alpha(myColorsBayOfSails3B, alpha=0.4)
myColorsBayOfSails4B = c("#BF812D")
myColorsBayOfSails4BAlpha <- add.alpha(myColorsBayOfSails4B, alpha=0.4)
myColorsBayOfSailsFossil = c("#DFC27D")
myColorsBayOfSailsFossilAlpha <- add.alpha(myColorsBayOfSailsFossil,
alpha=0.4)

# Explorers Cove 3B
##Li7
explorersCove3BLi7OverOntogeny <- ggplot(data = explorersCove3B, aes(x
= striaeNumberScatter, y = Li7, color = Li7, shape = Li7))
explorersCove3BLi7OverOntogenyPlot <- explorersCove3BLi7OverOntogeny +
geom_vline(xintercept =
explorersCove3B$striaeNumberScatter[explorersCove3B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^7~"Li/ "^43~"Ca
(ppm)"))
##Mg26
explorersCove3BMg26OverOntogeny <- ggplot(data = explorersCove3B, aes(x
= striaeNumberScatter, y = Mg26, color = Mg26))
explorersCove3BMg26OverOntogenyPlot <- explorersCove3BMg26OverOntogeny
+ geom_vline(xintercept =
explorersCove3B$striaeNumberScatter[explorersCove3B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^26~"Mg/ "^43~"Ca
(ppm)"))
##Mn55
```

```
explorersCove3BMn55OverOntogeny <- ggplot(data = explorersCove3B, aes(x
= striaeNumberScatter, y = Mn55, color = Mn55))
explorersCove3BMn55OverOntogenyPlot <- explorersCove3BMn55OverOntogeny
+ geom_vline(xintercept =
explorersCove3B$striaeNumberScatter[explorersCove3B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^55~"Mn/ "^43~"Ca
(ppm)"))
##Ba137
explorersCove3BBa137OverOntogeny <- ggplot(data = explorersCove3B,
aes(x = striaeNumberScatter, y = Ba137, color = Ba137))
explorersCove3BBa137OverOntogenyPlot <-
explorersCove3BBa137OverOntogeny + geom_vline(xintercept =
explorersCove3B$striaeNumberScatter[explorersCove3B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^137~"Ba/ "^43~"Ca
(ppm)"))
##Pb208
explorersCove3BPb208OverOntogeny <- ggplot(data = explorersCove3B,
aes(x = striaeNumberScatter, y = Pb208, color = Pb208))
explorersCove3BPb208OverOntogenyPlot <-
explorersCove3BPb208OverOntogeny + geom_vline(xintercept =
explorersCove3B$striaeNumberScatter[explorersCove3B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^208~"Pb/ "^43~"Ca
(ppm)"))
##Interstrial growth increments
explorersCove3BStriaeOverOntogeny <- ggplot(data = explorersCove3B,
aes(x = striaeNumberScatter, y = interstrialDistance, color =
interstrialDistance))
explorersCove3BPStriaeOverOntogenyPlot <-
explorersCove3BStriaeOverOntogeny + geom_vline(xintercept =
explorersCove3B$striaeNumberScatter[explorersCove3B$annulus == "TRUE"],
color = "gray") + geom_line(color = myColorInterstrialGrowthIncrements,
size = 1) + theme_classic(base_size = 16) + labs (x = "Number of Striae
from Umbo", y = bquote("Interstrial Growth Increment (mm)"))

# Explorers Cove 4B
##Li7
explorersCove4BLi7OverOntogeny <- ggplot(data = explorersCove4B, aes(x
= striaeNumberScatter, y = Li7, color = Li7))
explorersCove4BLi7OverOntogenyPlot <- explorersCove4BLi7OverOntogeny +
geom_vline(xintercept =
explorersCove4B$striaeNumberScatter[explorersCove4B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^7~"Li/ "^43~"Ca
(ppm)"))
##Mg26
explorersCove4BMg26OverOntogeny <- ggplot(data = explorersCove4B, aes(x
= striaeNumberScatter, y = Mg26, color = Mg26))
explorersCove4BMg26OverOntogenyPlot <- explorersCove4BMg26OverOntogeny
+ geom_vline(xintercept =
explorersCove4B$striaeNumberScatter[explorersCove4B$annulus == "TRUE"],
```

```
color = "gray") + geom_point(color = myColorsExplorersCove4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^26~"Mg/ "^43~"Ca
(ppm)"))
##Mn55
explorersCove4BMn55OverOntogeny <- ggplot(data = explorersCove4B, aes(x
= striaeNumberScatter, y = Mn55, color = Mn55))
explorersCove4BMn55OverOntogenyPlot <- explorersCove4BMn55OverOntogeny
+ geom_vline(xintercept =
explorersCove4B$striaeNumberScatter[explorersCove4B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^55~"Mn/ "^43~"Ca
(ppm)"))
##Ba137
explorersCove4BBa137OverOntogeny <- ggplot(data = explorersCove4B,
aes(x = striaeNumberScatter, y = Ba137, color = Ba137))
explorersCove4BBa137OverOntogenyPlot <-
explorersCove4BBa137OverOntogeny + geom_vline(xintercept =
explorersCove4B$striaeNumberScatter[explorersCove4B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^137~"Ba/ "^43~"Ca
(ppm)"))
##Pb208
explorersCove4BPb208OverOntogeny <- ggplot(data = explorersCove4B,
aes(x = striaeNumberScatter, y = Pb208, color = Pb208))
explorersCove4BPb208OverOntogenyPlot <-
explorersCove4BPb208OverOntogeny + geom_vline(xintercept =
explorersCove4B$striaeNumberScatter[explorersCove4B$annulus == "TRUE"],
color = "gray") + geom_point(color = myColorsExplorersCove4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^208~"Pb/ "^43~"Ca
(ppm)"))
##Interstrial growth increments
explorersCove4BStriaeOverOntogeny <- ggplot(data = explorersCove4B,
aes(x = striaeNumberScatter, y = interstrialDistance, color =
interstrialDistance))
explorersCove4BPStriaeOverOntogenyPlot <-
explorersCove4BStriaeOverOntogeny + geom_vline(xintercept =
explorersCove4B$striaeNumberScatter[explorersCove4B$annulus == "TRUE"],
color = "gray") +  geom_line(color =
myColorInterstrialGrowthIncrements, size = 1) + theme_classic(base_size
= 16) + labs (x = "Number of Striae from Umbo", y = bquote("Interstrial
Growth Increment (mm)"))

# Explorers Cove Fossil
##Li7
explorersCoveFossilLi7OverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y = Li7, color =
Li7))
explorersCoveFossilLi7OverOntogenyPlot <-
explorersCoveFossilLi7OverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color =
myColorsExplorersCoveFossil, shape = myShapesTraceElements, size= 2.5)
```

```
+ theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote(""^7~"Li/ "^43~"Ca"))
##Mg26
explorersCoveFossilMg26OverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y = Mg26, color =
Mg26))
explorersCoveFossilMg26OverOntogenyPlot <-
explorersCoveFossilMg26OverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color =
myColorsExplorersCoveFossil, shape = myShapesTraceElements, size= 2.5)
+ theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote(""^26~"Mg/ "^43~"Ca"))
##Mn55
explorersCoveFossilMn55OverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y = Mn55, color =
Mn55))
explorersCoveFossilMn55OverOntogenyPlot <-
explorersCoveFossilMn55OverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color =
myColorsExplorersCoveFossil, shape = myShapesTraceElements, size= 2.5)
+ theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote(""^55~"Mn/ "^43~"Ca"))
##Mn55
explorersCoveFossilMn55OverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y = Mn55, color =
Mn55))
explorersCoveFossilMn55OverOntogenyPlot <-
explorersCoveFossilMn55OverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color =
myColorsExplorersCoveFossil, shape = myShapesTraceElements, size= 2.5)
+ theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote(""^55~"Mn/ "^43~"Ca"))
##Ba137
explorersCoveFossilBa137OverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y = Ba137, color =
Ba137))
explorersCoveFossilBa137OverOntogenyPlot <-
explorersCoveFossilBa137OverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray")  + geom_point(color =
myColorsExplorersCoveFossil, shape = myShapesTraceElements, size= 2.5)
+ theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote(""^137~"Ba/ "^43~"Ca"))
##Pb208
explorersCoveFossilPb208OverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y = Pb208, color =
Pb208))
explorersCoveFossilPb208OverOntogenyPlot <-
explorersCoveFossilPb208OverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray")  + geom_point(color =
myColorsExplorersCoveFossil, shape = myShapesTraceElements, size= 2.5)
+ theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote(""^208~"Pb/ "^43~"Ca"))
```

```
##Interstrial growth increments
explorersCoveFossilStriaeOverOntogeny <- ggplot(data =
explorersCoveFossil, aes(x = striaeNumberScatter, y =
interstrialDistance, color = interstrialDistance))
explorersCoveFossilPStriaeOverOntogenyPlot <-
explorersCoveFossilStriaeOverOntogeny + geom_vline(xintercept =
explorersCoveFossil$striaeNumberScatter[explorersCoveFossil$annulus ==
"TRUE"], color = "gray")  +  geom_line(color =
myColorInterstrialGrowthIncrements, size = 1) + theme_classic(base_size
= 16) + labs (x = "Number of Striae from Umbo", y = bquote("Interstrial
Growth Increment (mm)"))

# Bay of Sails 3B
##Li7
bayOfSails3BLi7OverOntogeny <- ggplot(data = bayOfSails3B, aes(x =
striaeNumberScatter, y = Li7, color = Li7))
bayOfSails3BLi7OverOntogenyPlot <- bayOfSails3BLi7OverOntogeny +
geom_vline(xintercept =
bayOfSails3B$striaeNumberScatter[bayOfSails3B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^7~"Li/ "^43~"Ca
(ppm)"))
##Mg26
bayOfSails3BMg26OverOntogeny <- ggplot(data = bayOfSails3B, aes(x =
striaeNumberScatter, y = Mg26, color = Mg26))
bayOfSails3BMg26OverOntogenyPlot <- bayOfSails3BMg26OverOntogeny +
geom_vline(xintercept =
bayOfSails3B$striaeNumberScatter[bayOfSails3B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^26~"Mg/ "^43~"Ca
(ppm)"))
##Mn55
bayOfSails3BMn55OverOntogeny <- ggplot(data = bayOfSails3B, aes(x =
striaeNumberScatter, y = Mn55, color = Mn55))
bayOfSails3BMn55OverOntogenyPlot <- bayOfSails3BMn55OverOntogeny +
geom_vline(xintercept =
bayOfSails3B$striaeNumberScatter[bayOfSails3B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^55~"Mn/ "^43~"Ca
(ppm)"))
##Ba137
bayOfSails3BBa137OverOntogeny <- ggplot(data = bayOfSails3B, aes(x =
striaeNumberScatter, y = Ba137, color = Ba137))
bayOfSails3BBa137OverOntogenyPlot <- bayOfSails3BBa137OverOntogeny +
geom_vline(xintercept =
bayOfSails3B$striaeNumberScatter[bayOfSails3B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^137~"Ba/ "^43~"Ca
(ppm)"))
##Pb208
bayOfSails3BPb208OverOntogeny <- ggplot(data = bayOfSails3B, aes(x =
striaeNumberScatter, y = Pb208, color = Pb208))
```

```
bayOfSails3BPb208OverOntogenyPlot <- bayOfSails3BPb208OverOntogeny +
geom_vline(xintercept =
bayOfSails3B$striaeNumberScatter[bayOfSails3B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails3B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^208~"Pb/ "^43~"Ca
(ppm)"))
##Interstrial growth increments
bayOfSails3BStriaeOverOntogeny <- ggplot(data = bayOfSails3B, aes(x =
striaeNumberScatter, y = interstrialDistance, color =
interstrialDistance))
bayOfSails3BPStriaeOverOntogenyPlot <- bayOfSails3BStriaeOverOntogeny +
geom_vline(xintercept =
bayOfSails3B$striaeNumberScatter[bayOfSails3B$annulus == "TRUE"], color
= "gray") + geom_line(color = myColorsInterstrialGrowthIncrements, size
= 1) + theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote("Interstrial Growth Increment (mm)"))

# Bay of Sails 4B
##Li7
bayOfSails4BLi7OverOntogeny <- ggplot(data = bayOfSails4B, aes(x =
striaeNumberScatter, y = Li7, color = Li7))
bayOfSails4BLi7OverOntogenyPlot <- bayOfSails4BLi7OverOntogeny +
geom_vline(xintercept =
bayOfSails4B$striaeNumberScatter[bayOfSails4B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^7~"Li/ "^43~"Ca
(ppm)"))
##Mg26
bayOfSails4BMg26OverOntogeny <- ggplot(data = bayOfSails4B, aes(x =
striaeNumberScatter, y = Mg26, color = Mg26))
bayOfSails4BMg26OverOntogenyPlot <- bayOfSails4BMg26OverOntogeny +
geom_vline(xintercept =
bayOfSails4B$striaeNumberScatter[bayOfSails4B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^26~"Mg/ "^43~"Ca
(ppm)"))
##Mn55
bayOfSails4BMn55OverOntogeny <- ggplot(data = bayOfSails4B, aes(x =
striaeNumberScatter, y = Mn55, color = Mn55))
bayOfSails4BMn55OverOntogenyPlot <- bayOfSails4BMn55OverOntogeny +
geom_vline(xintercept =
bayOfSails4B$striaeNumberScatter[bayOfSails4B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^55~"Mn/ "^43~"Ca
(ppm)"))
##Ba137
bayOfSails4BBa137OverOntogeny <- ggplot(data = bayOfSails4B, aes(x =
striaeNumberScatter, y = Ba137, color = Ba137))
bayOfSails4BBa137OverOntogenyPlot <- bayOfSails4BBa137OverOntogeny +
geom_vline(xintercept =
bayOfSails4B$striaeNumberScatter[bayOfSails4B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
```

```
labs (x = "Number of Striae from Umbo", y = bquote(""^137~"Ba/ "^43~"Ca
(ppm)"))
##Pb208
bayOfSails4BPb208OverOntogeny <- ggplot(data = bayOfSails4B, aes(x =
striaeNumberScatter, y = Pb208, color = Pb208))
bayOfSails4BPb208OverOntogenyPlot <- bayOfSails4BPb208OverOntogeny +
geom_vline(xintercept =
bayOfSails4B$striaeNumberScatter[bayOfSails4B$annulus == "TRUE"], color
= "gray") + geom_point(color = myColorsBayOfSails4B, shape =
myShapesTraceElements, size= 2.5) + theme_classic(base_size = 16) +
labs (x = "Number of Striae from Umbo", y = bquote(""^208~"Pb/ "^43~"Ca
(ppm)"))
##Interstrial growth increments
bayOfSails4BStriaeOverOntogeny <- ggplot(data = bayOfSails4B, aes(x =
striaeNumberScatter, y = interstrialDistance, color =
interstrialDistance))
bayOfSails4BPStriaeOverOntogenyPlot <- bayOfSails4BStriaeOverOntogeny +
geom_vline(xintercept =
bayOfSails4B$striaeNumberScatter[bayOfSails4B$annulus == "TRUE"], color
= "gray") + geom_line(color = myColorInterstrialGrowthIncrements, size
= 1) + theme_classic(base_size = 16) + labs (x = "Number of Striae from
Umbo", y = bquote("Interstrial Growth Increment (mm)"))

# Bay of Sails Fossil
##Li7
bayOfSailsFossilLi7OverOntogeny <- ggplot(data = bayOfSailsFossil,
aes(x = striaeNumberScatter, y = Li7, color = Li7))
bayOfSailsFossilLi7OverOntogenyPlot <- bayOfSailsFossilLi7OverOntogeny
+ geom_vline(xintercept =
bayOfSailsFossil$striaeNumberScatter[bayOfSailsFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color = myColorsBayOfSailsFossil,
shape = myShapesTraceElements, size= 2.5) + theme_classic(base_size =
16) + labs (x = "Number of Striae from Umbo", y = bquote(""^7~"Li/
"^43~"Ca (ppm)"))
##Mg26
bayOfSailsFossilMg26OverOntogeny <- ggplot(data = bayOfSailsFossil,
aes(x = striaeNumberScatter, y = Mg26, color = Mg26))
bayOfSailsFossilMg26OverOntogenyPlot <-
bayOfSailsFossilMg26OverOntogeny + geom_vline(xintercept =
bayOfSailsFossil$striaeNumberScatter[bayOfSailsFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color = myColorsBayOfSailsFossil,
shape = myShapesTraceElements, size= 2.5) + theme_classic(base_size =
16) + labs (x = "Number of Striae from Umbo", y = bquote(""^26~"Mg/
"^43~"Ca (ppm)"))
##Mn55
bayOfSailsFossilMn55OverOntogeny <- ggplot(data = bayOfSailsFossil,
aes(x = striaeNumberScatter, y = Mn55, color = Mn55))
bayOfSailsFossilMn55OverOntogenyPlot <-
bayOfSailsFossilMn55OverOntogeny + geom_vline(xintercept =
bayOfSailsFossil$striaeNumberScatter[bayOfSailsFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color = myColorsBayOfSailsFossil,
shape = myShapesTraceElements, size= 2.5) + theme_classic(base_size =
16) + labs (x = "Number of Striae from Umbo", y = bquote(""^55~"Mn/
"^43~"Ca (ppm)"))
##Ba137
bayOfSailsFossilBa137OverOntogeny <- ggplot(data = bayOfSailsFossil,
aes(x = striaeNumberScatter, y = Ba137, color = Ba137))
```

```
bayOfSailsFossilBa137OverOntogenyPlot <-
bayOfSailsFossilBa137OverOntogeny + geom_vline(xintercept =
bayOfSailsFossil$striaeNumberScatter[bayOfSailsFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color = myColorsBayOfSailsFossil,
shape = myShapesTraceElements, size= 2.5) + theme_classic(base_size =
16) + labs (x = "Number of Striae from Umbo", y = bquote(""^137~"Ba/
"^43~"Ca (ppm)"))
##Pb208
bayOfSailsFossilPb208OverOntogeny <- ggplot(data = bayOfSailsFossil,
aes(x = striaeNumberScatter, y = Pb208, color = Pb208))
bayOfSailsFossilPb208OverOntogenyPlot <-
bayOfSailsFossilPb208OverOntogeny + geom_vline(xintercept =
bayOfSailsFossil$striaeNumberScatter[bayOfSailsFossil$annulus ==
"TRUE"], color = "gray") + geom_point(color = myColorsBayOfSailsFossil,
shape = myShapesTraceElements, size= 2.5) + theme_classic(base_size =
16) + labs (x = "Number of Striae from Umbo", y = bquote(""^208~"Pb/
"^43~"Ca (ppm)"))
##Interstrial growth increments
bayOfSailsFossilStriaeOverOntogeny <- ggplot(data = bayOfSailsFossil,
aes(x = striaeNumberScatter, y = interstrialDistance, color =
interstrialDistance))
bayOfSailsFossilPStriaeOverOntogenyPlot <-
bayOfSailsFossilStriaeOverOntogeny + geom_vline(xintercept =
bayOfSailsFossil$striaeNumberScatter[bayOfSailsFossil$annulus ==
"TRUE"], color = "gray") +  geom_line(color =
myColorInterstrialGrowthIncrements, size = 1) + theme_classic(base_size
= 16) + labs (x = "Number of Striae from Umbo", y = bquote("Interstrial
Growth Increment (mm)"))

# Save the plots

ggsave(filename = "explorersCove3BLi7OverOntogenyPlot.svg", plot =
explorersCove3BLi7OverOntogenyPlot, device = "svg", units = "in", width
= 11, height = 5)
ggsave(filename = "explorersCove3BMg26OverOntogenyPlot.svg", plot =
explorersCove3BMg26OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove3BMn55OverOntogenyPlot.svg", plot =
explorersCove3BMn55OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove3BBa137OverOntogenyPlot.svg", plot =
explorersCove3BBa137OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove3BPb208OverOntogenyPlot.svg", plot =
explorersCove3BPb208OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove3BPStriaeOverOntogenyPlot.svg", plot =
explorersCove3BPStriaeOverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove4BLi7OverOntogenyPlot.svg", plot =
explorersCove4BLi7OverOntogenyPlot, device = "svg", units = "in", width
= 11, height = 5)
ggsave(filename = "explorersCove4BMg26OverOntogenyPlot.svg", plot =
explorersCove4BMg26OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
```

```
ggsave(filename = "explorersCove4BMn55OverOntogenyPlot.svg", plot =
explorersCove4BMn55OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove4BBa137OverOntogenyPlot.svg", plot =
explorersCove4BBa137OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove4BPb208OverOntogenyPlot.svg", plot =
explorersCove4BPb208OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCove4BPStriaeOverOntogenyPlot.svg", plot =
explorersCove4BPStriaeOverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCoveFossilLi7OverOntogenyPlot.svg", plot =
explorersCoveFossilLi7OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCoveFossilMg26OverOntogenyPlot.svg", plot =
explorersCoveFossilMg26OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCoveFossilMn55OverOntogenyPlot.svg", plot =
explorersCoveFossilMn55OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "explorersCoveFossilBa137OverOntogenyPlot.svg", plot
= explorersCoveFossilBa137OverOntogenyPlot, device = "svg", units =
"in", width = 11, height = 5)
ggsave(filename = "explorersCoveFossilPb208OverOntogenyPlot.svg", plot
= explorersCoveFossilPb208OverOntogenyPlot, device = "svg", units =
"in", width = 11, height = 5)
ggsave(filename = "explorersCoveFossilPStriaeOverOntogenyPlot.svg",
plot = explorersCoveFossilPStriaeOverOntogenyPlot, device = "svg",
units = "in", width = 11, height = 5)
ggsave(filename = "bayOfSails3BLi7OverOntogenyPlot.svg", plot =
bayOfSails3BLi7OverOntogenyPlot, device = "svg", units = "in", width =
11, height = 5)
ggsave(filename = "bayOfSails3BMg26OverOntogenyPlot.svg", plot =
bayOfSails3BMg26OverOntogenyPlot, device = "svg", units = "in", width =
11, height = 5)
ggsave(filename = "bayOfSails3BMn55OverOntogenyPlot.svg", plot =
bayOfSails3BMn55OverOntogenyPlot, device = "svg", units = "in", width =
11, height = 5)
ggsave(filename = "bayOfSails3BBa137OverOntogenyPlot.svg", plot =
bayOfSails3BBa137OverOntogenyPlot, device = "svg", units = "in", width
= 11, height = 5)
ggsave(filename = "bayOfSails3BPb208OverOntogenyPlot.svg", plot =
bayOfSails3BPb208OverOntogenyPlot, device = "svg", units = "in", width
= 11, height = 5)
ggsave(filename = "bayOfSails3BPStriaeOverOntogenyPlot.svg", plot =
bayOfSails3BPStriaeOverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSails4BLi7OverOntogenyPlot.svg", plot =
bayOfSails4BLi7OverOntogenyPlot, device = "svg", units = "in", width =
11, height = 5)
ggsave(filename = "bayOfSails4BMg26OverOntogenyPlot.svg", plot =
bayOfSails4BMg26OverOntogenyPlot, device = "svg", units = "in", width =
11, height = 5)
ggsave(filename = "bayOfSails4BMn55OverOntogenyPlot.svg", plot =
bayOfSails4BMn55OverOntogenyPlot, device = "svg", units = "in", width =
11, height = 5)
```

```
ggsave(filename = "bayOfSails4BBa137OverOntogenyPlot.svg", plot =
bayOfSails4BBa137OverOntogenyPlot, device = "svg", units = "in", width
= 11, height = 5)
ggsave(filename = "bayOfSails4BPb208OverOntogenyPlot.svg", plot =
bayOfSails4BPb208OverOntogenyPlot, device = "svg", units = "in", width
= 11, height = 5)
ggsave(filename = "bayOfSails4BPStriaeOverOntogenyPlot.svg", plot =
bayOfSails4BPStriaeOverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSailsFossilLi7OverOntogenyPlot.svg", plot =
bayOfSailsFossilLi7OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSailsFossilMg26OverOntogenyPlot.svg", plot =
bayOfSailsFossilMg26OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSailsFossilMn55OverOntogenyPlot.svg", plot =
bayOfSailsFossilMn55OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSailsFossilBa137OverOntogenyPlot.svg", plot =
bayOfSailsFossilBa137OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSailsFossilPb208OverOntogenyPlot.svg", plot =
bayOfSailsFossilPb208OverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)
ggsave(filename = "bayOfSailsFossilPStriaeOverOntogenyPlot.svg", plot =
bayOfSailsFossilPStriaeOverOntogenyPlot, device = "svg", units = "in",
width = 11, height = 5)


# Wavelet coherence and phase among trace elements and between each
trace element and interstrial growth increment for all valves
##Explorers Cove Valve 3
explorersCove3InterstrialIncrementsLi7 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$interstrialDistance, f2 =
explorersCove3Coherence$Li7, P = 500)
explorersCove3InterstrialIncrementsLi7Spec <- cnlt.spec(x =
explorersCove3InterstrialIncrementsLi7)

explorersCove3InterstrialIncrementsMg26 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$interstrialDistance, f2 =
explorersCove3Coherence$Mg26, P = 500)
explorersCove3InterstrialIncrementsMg26Spec <- cnlt.spec(x =
explorersCove3InterstrialIncrementsMg26)

explorersCove3InterstrialIncrementsMn55 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$interstrialDistance, f2 =
explorersCove3Coherence$Mn55, P = 500)
explorersCove3InterstrialIncrementsMn55Spec <- cnlt.spec(x =
explorersCove3InterstrialIncrementsMn55)

explorersCove3InterstrialIncrementsBa137 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$interstrialDistance, f2 =
explorersCove3Coherence$Ba137, P = 500)
```

```
explorersCove3InterstrialIncrementsBa137Spec <- cnlt.spec(x =
explorersCove3InterstrialIncrementsBa137)

explorersCove3InterstrialIncrementsPb208 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$interstrialDistance, f2 =
explorersCove3Coherence$Pb208, P = 500)
explorersCove3InterstrialIncrementsPb208Spec <- cnlt.spec(x =
explorersCove3InterstrialIncrementsPb208)

explorersCove3Li7Mg26 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Li7, f2 = explorersCove3Coherence$Mg26, P =
500)
explorersCove3Li7Mg26Spec <- cnlt.spec(x = explorersCove3Li7Mg26)

explorersCove3Li7Mn55 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Li7, f2 = explorersCove3Coherence$Mn55, P =
500)
explorersCove3Li7Mn55Spec <- cnlt.spec(x = explorersCove3Li7Mn55)

explorersCove3Li7Ba137 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Li7, f2 = explorersCove3Coherence$Ba137, P =
500)
explorersCove3Li7Ba137Spec <- cnlt.spec(x = explorersCove3Li7Ba137)

explorersCove3Li7Pb208 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Li7, f2 = explorersCove3Coherence$Pb208, P =
500)
explorersCove3Li7Pb208Spec <- cnlt.spec(x = explorersCove3Li7Pb208)

explorersCove3Mg26Mn55 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Mg26, f2 = explorersCove3Coherence$Mn55, P =
500)
explorersCove3Mg26Mn55Spec <- cnlt.spec(x = explorersCove3Mg26Mn55)

explorersCove3Mg26Ba137 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Mg26, f2 = explorersCove3Coherence$Ba137, P =
500)
explorersCove3Mg26Ba137Spec <- cnlt.spec(x = explorersCove3Mg26Ba137)

explorersCove3Mg26Pb208 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Mg26, f2 = explorersCove3Coherence$Pb208, P =
500)
explorersCove3Mg26Pb208Spec <- cnlt.spec(x = explorersCove3Mg26Pb208)

explorersCove3Mn55Ba137 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Mn55, f2 = explorersCove3Coherence$Ba137, P =
500)
explorersCove3Mn55Ba137Spec <- cnlt.spec(x = explorersCove3Mn55Ba137)
```

```
explorersCove3Mn55Pb208 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Mn55, f2 = explorersCove3Coherence$Pb208, P =
500)
explorersCove3Mn55Pb208Spec <- cnlt.spec(x = explorersCove3Mn55Pb208)

explorersCove3Ba137Pb208 <- cnlt.biv(x1 =
explorersCove3Coherence$striaeNumberCor, f1 =
explorersCove3Coherence$Ba137, f2 = explorersCove3Coherence$Pb208, P =
500)
explorersCove3Ba137Pb208Spec <- cnlt.spec(x = explorersCove3Ba137Pb208)

### SVG images Explorers Cove 3
svg("explorersCove3InterstrialIncrementsLi7SpecPlot.svg", height = 3,
width = 5)
explorersCove3InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsLi7Spec$coh, timevec =
explorersCove3InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsMg26SpecPlot.svg", height = 3,
width = 5)
explorersCove3InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMg26Spec$coh, timevec
= explorersCove3InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsMn55SpecPlot.svg", height = 3,
width = 5)
explorersCove3InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMn55Spec$coh, timevec
= explorersCove3InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsBa137SpecPlot.svg", height = 3,
width = 5)
explorersCove3InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsBa137Spec$coh, timevec
= explorersCove3InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsPb208SpecPlot.svg", height = 3,
width = 5)
explorersCove3InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsPb208Spec$coh, timevec
= explorersCove3InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3Li7Mg26SpecPlot.svg", height = 3, width = 5)
explorersCove3Li7Mg26SpecPlot <-
cnltspec.plot(explorersCove3Li7Mg26Spec$coh, timevec =
```

```
explorersCove3Li7Mg26Spec$mtime, scale =
explorersCove3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Li7Mn55SpecPlot.svg", height = 3, width = 5)
explorersCove3Li7Mn55SpecPlot <-
cnltspec.plot(explorersCove3Li7Mn55Spec$coh, timevec =
explorersCove3Li7Mn55Spec$mtime, scale =
explorersCove3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Li7Ba137SpecPlot.svg", height = 3, width = 5)
explorersCove3Li7Ba137SpecPlot <-
cnltspec.plot(explorersCove3Li7Ba137Spec$coh, timevec =
explorersCove3Li7Ba137Spec$mtime, scale =
explorersCove3Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Li7Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove3Li7Pb208SpecPlot <-
cnltspec.plot(explorersCove3Li7Pb208Spec$coh, timevec =
explorersCove3Li7Pb208Spec$mtime, scale =
explorersCove3Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mg26Mn55SpecPlot.svg", height = 3, width = 5)
explorersCove3Mg26Mn55SpecPlot <-
cnltspec.plot(explorersCove3Mg26Mn55Spec$coh, timevec =
explorersCove3Mg26Mn55Spec$mtime, scale =
explorersCove3Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mg26Ba137SpecPlot.svg", height = 3, width = 5)
explorersCove3Mg26Ba137SpecPlot <-
cnltspec.plot(explorersCove3Mg26Ba137Spec$coh, timevec =
explorersCove3Mg26Ba137Spec$mtime, scale =
explorersCove3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mg26Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove3Mg26Pb208SpecPlot <-
cnltspec.plot(explorersCove3Mg26Pb208Spec$coh, timevec =
explorersCove3Mg26Pb208Spec$mtime, scale =
explorersCove3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mn55Ba137SpecPlot.svg", height = 3, width = 5)
explorersCove3Mn55Ba137SpecPlot <-
cnltspec.plot(explorersCove3Mn55Ba137Spec$coh, timevec =
explorersCove3Mn55Ba137Spec$mtime, scale =
explorersCove3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mn55Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove3Mn55Pb208SpecPlot <-
cnltspec.plot(explorersCove3Mn55Pb208Spec$coh, timevec =
explorersCove3Mn55Pb208Spec$mtime, scale =
```

```
explorersCove3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Ba137Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove3Ba137Pb208SpecPlot <-
cnltspec.plot(explorersCove3Ba137Pb208Spec$coh, timevec =
explorersCove3Ba137Pb208Spec$mtime, scale =
explorersCove3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

svg("explorersCove3InterstrialIncrementsLi7SpecPhasePlot.svg", height =
3, width = 5)
explorersCove3InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsLi7Spec$phase, timevec
= explorersCove3InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsMg26SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove3InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMg26Spec$phase,
timevec = explorersCove3InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsMn55SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove3InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMn55Spec$phase,
timevec = explorersCove3InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsBa137SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove3InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsBa137Spec$phase,
timevec = explorersCove3InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3InterstrialIncrementsPb208SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove3InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsPb208Spec$phase,
timevec = explorersCove3InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove3Li7Mg26SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Li7Mg26SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Mg26Spec$phase, timevec =
explorersCove3Li7Mg26Spec$mtime, scale =
explorersCove3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
```

```
dev.off()
svg("explorersCove3Li7Mn55SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Li7Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Mn55Spec$phase, timevec =
explorersCove3Li7Mn55Spec$mtime, scale =
explorersCove3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Li7Ba137SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Li7Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Ba137Spec$phase, timevec =
explorersCove3Li7Ba137Spec$mtime, scale =
explorersCove3Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Li7Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Li7Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Pb208Spec$phase, timevec =
explorersCove3Li7Pb208Spec$mtime, scale =
explorersCove3Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mg26Mn55SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Mg26Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove3Mg26Mn55Spec$phase, timevec =
explorersCove3Mg26Mn55Spec$mtime, scale =
explorersCove3Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mg26Ba137SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Mg26Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove3Mg26Ba137Spec$phase, timevec =
explorersCove3Mg26Ba137Spec$mtime, scale =
explorersCove3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mg26Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Mg26Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Mg26Pb208Spec$phase, timevec =
explorersCove3Mg26Pb208Spec$mtime, scale =
explorersCove3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mn55Ba137SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Mn55Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove3Mn55Ba137Spec$phase, timevec =
explorersCove3Mn55Ba137Spec$mtime, scale =
explorersCove3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove3Mn55Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Mn55Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Mn55Pb208Spec$phase, timevec =
explorersCove3Mn55Pb208Spec$mtime, scale =
explorersCove3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
```

```
svg("explorersCove3Ba137Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove3Ba137Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Ba137Pb208Spec$phase, timevec =
explorersCove3Ba137Pb208Spec$mtime, scale =
explorersCove3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

### PNG images Explorers Cove 3
png("explorersCove3InterstrialIncrementsLi7SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsLi7Spec$coh, timevec =
explorersCove3InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsMg26SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMg26Spec$coh, timevec
= explorersCove3InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsMn55SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMn55Spec$coh, timevec
= explorersCove3InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsBa137SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsBa137Spec$coh, timevec
= explorersCove3InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsPb208SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsPb208Spec$coh, timevec
= explorersCove3InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3Li7Mg26SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove3Li7Mg26SpecPlot <-
cnltspec.plot(explorersCove3Li7Mg26Spec$coh, timevec =
explorersCove3Li7Mg26Spec$mtime, scale =
explorersCove3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
```

```
png("explorersCove3Li7Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove3Li7Mn55SpecPlot <-
cnltspec.plot(explorersCove3Li7Mn55Spec$coh, timevec =
explorersCove3Li7Mn55Spec$mtime, scale =
explorersCove3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Li7Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove3Li7Ba137SpecPlot <-
cnltspec.plot(explorersCove3Li7Ba137Spec$coh, timevec =
explorersCove3Li7Ba137Spec$mtime, scale =
explorersCove3Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Li7Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove3Li7Pb208SpecPlot <-
cnltspec.plot(explorersCove3Li7Pb208Spec$coh, timevec =
explorersCove3Li7Pb208Spec$mtime, scale =
explorersCove3Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mg26Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove3Mg26Mn55SpecPlot <-
cnltspec.plot(explorersCove3Mg26Mn55Spec$coh, timevec =
explorersCove3Mg26Mn55Spec$mtime, scale =
explorersCove3Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mg26Ba137SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove3Mg26Ba137SpecPlot <-
cnltspec.plot(explorersCove3Mg26Ba137Spec$coh, timevec =
explorersCove3Mg26Ba137Spec$mtime, scale =
explorersCove3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mg26Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove3Mg26Pb208SpecPlot <-
cnltspec.plot(explorersCove3Mg26Pb208Spec$coh, timevec =
explorersCove3Mg26Pb208Spec$mtime, scale =
explorersCove3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mn55Ba137SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove3Mn55Ba137SpecPlot <-
cnltspec.plot(explorersCove3Mn55Ba137Spec$coh, timevec =
explorersCove3Mn55Ba137Spec$mtime, scale =
explorersCove3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
```

```
png("explorersCove3Mn55Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove3Mn55Pb208SpecPlot <-
cnltspec.plot(explorersCove3Mn55Pb208Spec$coh, timevec =
explorersCove3Mn55Pb208Spec$mtime, scale =
explorersCove3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Ba137Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove3Ba137Pb208SpecPlot <-
cnltspec.plot(explorersCove3Ba137Pb208Spec$coh, timevec =
explorersCove3Ba137Pb208Spec$mtime, scale =
explorersCove3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

png("explorersCove3InterstrialIncrementsLi7SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsLi7Spec$phase, timevec
= explorersCove3InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsMg26SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMg26Spec$phase,
timevec = explorersCove3InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsMn55SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsMn55Spec$phase,
timevec = explorersCove3InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsBa137SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsBa137Spec$phase,
timevec = explorersCove3InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove3InterstrialIncrementsPb208SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove3InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(explorersCove3InterstrialIncrementsPb208Spec$phase,
timevec = explorersCove3InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
```

```
png("explorersCove3Li7Mg26SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Li7Mg26SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Mg26Spec$phase, timevec =
explorersCove3Li7Mg26Spec$mtime, scale =
explorersCove3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Li7Mn55SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Li7Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Mn55Spec$phase, timevec =
explorersCove3Li7Mn55Spec$mtime, scale =
explorersCove3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Li7Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Li7Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Ba137Spec$phase, timevec =
explorersCove3Li7Ba137Spec$mtime, scale =
explorersCove3Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Li7Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Li7Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Li7Pb208Spec$phase, timevec =
explorersCove3Li7Pb208Spec$mtime, scale =
explorersCove3Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mg26Mn55SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Mg26Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove3Mg26Mn55Spec$phase, timevec =
explorersCove3Mg26Mn55Spec$mtime, scale =
explorersCove3Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mg26Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Mg26Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove3Mg26Ba137Spec$phase, timevec =
explorersCove3Mg26Ba137Spec$mtime, scale =
explorersCove3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mg26Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Mg26Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Mg26Pb208Spec$phase, timevec =
explorersCove3Mg26Pb208Spec$mtime, scale =
explorersCove3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
```

```
png("explorersCove3Mn55Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Mn55Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove3Mn55Ba137Spec$phase, timevec =
explorersCove3Mn55Ba137Spec$mtime, scale =
explorersCove3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Mn55Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Mn55Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Mn55Pb208Spec$phase, timevec =
explorersCove3Mn55Pb208Spec$mtime, scale =
explorersCove3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove3Ba137Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove3Ba137Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove3Ba137Pb208Spec$phase, timevec =
explorersCove3Ba137Pb208Spec$mtime, scale =
explorersCove3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

## Explorers Cove Valve 4
explorersCove4InterstrialIncrementsLi7 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$interstrialDistance, f2 =
explorersCove4Coherence$Li7, P = 500)
explorersCove4InterstrialIncrementsLi7Spec <- cnlt.spec(x =
explorersCove4InterstrialIncrementsLi7)

explorersCove4InterstrialIncrementsMg26 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$interstrialDistance, f2 =
explorersCove4Coherence$Mg26, P = 500)
explorersCove4InterstrialIncrementsMg26Spec <- cnlt.spec(x =
explorersCove4InterstrialIncrementsMg26)

explorersCove4InterstrialIncrementsMn55 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$interstrialDistance, f2 =
explorersCove4Coherence$Mn55, P = 500)
explorersCove4InterstrialIncrementsMn55Spec <- cnlt.spec(x =
explorersCove4InterstrialIncrementsMn55)

explorersCove4InterstrialIncrementsBa137 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$interstrialDistance, f2 =
explorersCove4Coherence$Ba137, P = 500)
explorersCove4InterstrialIncrementsBa137Spec <- cnlt.spec(x =
explorersCove4InterstrialIncrementsBa137)

explorersCove4InterstrialIncrementsPb208 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
```

```
explorersCove4Coherence$interstrialDistance, f2 =
explorersCove4Coherence$Pb208, P = 500)
explorersCove4InterstrialIncrementsPb208Spec <- cnlt.spec(x =
explorersCove4InterstrialIncrementsPb208)

explorersCove4Li7Mg26 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Li7, f2 = explorersCove4Coherence$Mg26, P =
500)
explorersCove4Li7Mg26Spec <- cnlt.spec(x = explorersCove4Li7Mg26)

explorersCove4Li7Mn55 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Li7, f2 = explorersCove4Coherence$Mn55, P =
500)
explorersCove4Li7Mn55Spec <- cnlt.spec(x = explorersCove4Li7Mn55)

explorersCove4Li7Ba137 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Li7, f2 = explorersCove4Coherence$Ba137, P =
500)
explorersCove4Li7Ba137Spec <- cnlt.spec(x = explorersCove4Li7Ba137)

explorersCove4Li7Pb208 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Li7, f2 = explorersCove4Coherence$Pb208, P =
500)
explorersCove4Li7Pb208Spec <- cnlt.spec(x = explorersCove4Li7Pb208)

explorersCove4Mg26Mn55 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Mg26, f2 = explorersCove4Coherence$Mn55, P =
500)
explorersCove4Mg26Mn55Spec <- cnlt.spec(x = explorersCove4Mg26Mn55)

explorersCove4Mg26Ba137 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Mg26, f2 = explorersCove4Coherence$Ba137, P =
500)
explorersCove4Mg26Ba137Spec <- cnlt.spec(x = explorersCove4Mg26Ba137)

explorersCove4Mg26Pb208 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Mg26, f2 = explorersCove4Coherence$Pb208, P =
500)
explorersCove4Mg26Pb208Spec <- cnlt.spec(x = explorersCove4Mg26Pb208)

explorersCove4Mn55Ba137 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Mn55, f2 = explorersCove4Coherence$Ba137, P =
500)
explorersCove4Mn55Ba137Spec <- cnlt.spec(x = explorersCove4Mn55Ba137)

explorersCove4Mn55Pb208 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Mn55, f2 = explorersCove4Coherence$Pb208, P =
500)
```

```
explorersCove4Mn55Pb208Spec <- cnlt.spec(x = explorersCove4Mn55Pb208)

explorersCove4Ba137Pb208 <- cnlt.biv(x1 =
explorersCove4Coherence$striaeNumberCor, f1 =
explorersCove4Coherence$Ba137, f2 = explorersCove4Coherence$Pb208, P =
500)
explorersCove4Ba137Pb208Spec <- cnlt.spec(x = explorersCove4Ba137Pb208)

### SVG images Explorers Cove 4
svg("explorersCove4InterstrialIncrementsLi7SpecPlot.svg", height = 3,
width = 5)
explorersCove4InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsLi7Spec$coh, timevec =
explorersCove4InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsMg26SpecPlot.svg", height = 3,
width = 5)
explorersCove4InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMg26Spec$coh, timevec
= explorersCove4InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsMn55SpecPlot.svg", height = 3,
width = 5)
explorersCove4InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMn55Spec$coh, timevec
= explorersCove4InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsBa137SpecPlot.svg", height = 3,
width = 5)
explorersCove4InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsBa137Spec$coh, timevec
= explorersCove4InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsPb208SpecPlot.svg", height = 3,
width = 5)
explorersCove4InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsPb208Spec$coh, timevec
= explorersCove4InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4Li7Mg26SpecPlot.svg", height = 3, width = 5)
explorersCove4Li7Mg26SpecPlot <-
cnltspec.plot(explorersCove4Li7Mg26Spec$coh, timevec =
explorersCove4Li7Mg26Spec$mtime, scale =
explorersCove4Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Li7Mn55SpecPlot.svg", height = 3, width = 5)
```

```
explorersCove4Li7Mn55SpecPlot <-
cnltspec.plot(explorersCove4Li7Mn55Spec$coh, timevec =
explorersCove4Li7Mn55Spec$mtime, scale =
explorersCove4Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Li7Ba137SpecPlot.svg", height = 3, width = 5)
explorersCove4Li7Ba137SpecPlot <-
cnltspec.plot(explorersCove4Li7Ba137Spec$coh, timevec =
explorersCove4Li7Ba137Spec$mtime, scale =
explorersCove4Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Li7Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove4Li7Pb208SpecPlot <-
cnltspec.plot(explorersCove4Li7Pb208Spec$coh, timevec =
explorersCove4Li7Pb208Spec$mtime, scale =
explorersCove4Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mg26Mn55SpecPlot.svg", height = 3, width = 5)
explorersCove4Mg26Mn55SpecPlot <-
cnltspec.plot(explorersCove4Mg26Mn55Spec$coh, timevec =
explorersCove4Mg26Mn55Spec$mtime, scale =
explorersCove4Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mg26Ba137SpecPlot.svg", height = 3, width = 5)
explorersCove4Mg26Ba137SpecPlot <-
cnltspec.plot(explorersCove4Mg26Ba137Spec$coh, timevec =
explorersCove4Mg26Ba137Spec$mtime, scale =
explorersCove4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mg26Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove4Mg26Pb208SpecPlot <-
cnltspec.plot(explorersCove4Mg26Pb208Spec$coh, timevec =
explorersCove4Mg26Pb208Spec$mtime, scale =
explorersCove4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mn55Ba137SpecPlot.svg", height = 3, width = 5)
explorersCove4Mn55Ba137SpecPlot <-
cnltspec.plot(explorersCove4Mn55Ba137Spec$coh, timevec =
explorersCove4Mn55Ba137Spec$mtime, scale =
explorersCove4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mn55Pb208SpecPlot.svg", height = 3, width = 5)
explorersCove4Mn55Pb208SpecPlot <-
cnltspec.plot(explorersCove4Mn55Pb208Spec$coh, timevec =
explorersCove4Mn55Pb208Spec$mtime, scale =
explorersCove4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Ba137Pb208SpecPlot.svg", height = 3, width = 5)
```

```
explorersCove4Ba137Pb208SpecPlot <-
cnltspec.plot(explorersCove4Ba137Pb208Spec$coh, timevec =
explorersCove4Ba137Pb208Spec$mtime, scale =
explorersCove4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

svg("explorersCove4InterstrialIncrementsLi7SpecPhasePlot.svg", height =
3, width = 5)
explorersCove4InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsLi7Spec$phase, timevec
= explorersCove4InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsMg26SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove4InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMg26Spec$phase,
timevec = explorersCove4InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsMn55SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove4InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMn55Spec$phase,
timevec = explorersCove4InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsBa137SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove4InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsBa137Spec$phase,
timevec = explorersCove4InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4InterstrialIncrementsPb208SpecPhasePlot.svg", height
= 3, width = 5)
explorersCove4InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsPb208Spec$phase,
timevec = explorersCove4InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCove4Li7Mg26SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Li7Mg26SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Mg26Spec$phase, timevec =
explorersCove4Li7Mg26Spec$mtime, scale =
explorersCove4Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Li7Mn55SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Li7Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Mn55Spec$phase, timevec =
```

```
explorersCove4Li7Mn55Spec$mtime, scale =
explorersCove4Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Li7Ba137SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Li7Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Ba137Spec$phase, timevec =
explorersCove4Li7Ba137Spec$mtime, scale =
explorersCove4Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Li7Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Li7Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Pb208Spec$phase, timevec =
explorersCove4Li7Pb208Spec$mtime, scale =
explorersCove4Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mg26Mn55SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Mg26Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove4Mg26Mn55Spec$phase, timevec =
explorersCove4Mg26Mn55Spec$mtime, scale =
explorersCove4Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mg26Ba137SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Mg26Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove4Mg26Ba137Spec$phase, timevec =
explorersCove4Mg26Ba137Spec$mtime, scale =
explorersCove4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mg26Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Mg26Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Mg26Pb208Spec$phase, timevec =
explorersCove4Mg26Pb208Spec$mtime, scale =
explorersCove4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mn55Ba137SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Mn55Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove4Mn55Ba137Spec$phase, timevec =
explorersCove4Mn55Ba137Spec$mtime, scale =
explorersCove4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Mn55Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Mn55Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Mn55Pb208Spec$phase, timevec =
explorersCove4Mn55Pb208Spec$mtime, scale =
explorersCove4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("explorersCove4Ba137Pb208SpecPhasePlot.svg", height = 3, width = 5)
explorersCove4Ba137Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Ba137Pb208Spec$phase, timevec =
explorersCove4Ba137Pb208Spec$mtime, scale =
```

```
explorersCove4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

### PNG images Explorers Cove 4
png("explorersCove4InterstrialIncrementsLi7SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsLi7Spec$coh, timevec =
explorersCove4InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsMg26SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMg26Spec$coh, timevec
= explorersCove4InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsMn55SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMn55Spec$coh, timevec
= explorersCove4InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsBa137SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsBa137Spec$coh, timevec
= explorersCove4InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsPb208SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsPb208Spec$coh, timevec
= explorersCove4InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4Li7Mg26SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove4Li7Mg26SpecPlot <-
cnltspec.plot(explorersCove4Li7Mg26Spec$coh, timevec =
explorersCove4Li7Mg26Spec$mtime, scale =
explorersCove4Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Li7Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove4Li7Mn55SpecPlot <-
cnltspec.plot(explorersCove4Li7Mn55Spec$coh, timevec =
```

```
explorersCove4Li7Mn55Spec$mtime, scale =
explorersCove4Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Li7Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove4Li7Ba137SpecPlot <-
cnltspec.plot(explorersCove4Li7Ba137Spec$coh, timevec =
explorersCove4Li7Ba137Spec$mtime, scale =
explorersCove4Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Li7Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove4Li7Pb208SpecPlot <-
cnltspec.plot(explorersCove4Li7Pb208Spec$coh, timevec =
explorersCove4Li7Pb208Spec$mtime, scale =
explorersCove4Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mg26Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
explorersCove4Mg26Mn55SpecPlot <-
cnltspec.plot(explorersCove4Mg26Mn55Spec$coh, timevec =
explorersCove4Mg26Mn55Spec$mtime, scale =
explorersCove4Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mg26Ba137SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove4Mg26Ba137SpecPlot <-
cnltspec.plot(explorersCove4Mg26Ba137Spec$coh, timevec =
explorersCove4Mg26Ba137Spec$mtime, scale =
explorersCove4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mg26Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove4Mg26Pb208SpecPlot <-
cnltspec.plot(explorersCove4Mg26Pb208Spec$coh, timevec =
explorersCove4Mg26Pb208Spec$mtime, scale =
explorersCove4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mn55Ba137SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove4Mn55Ba137SpecPlot <-
cnltspec.plot(explorersCove4Mn55Ba137Spec$coh, timevec =
explorersCove4Mn55Ba137Spec$mtime, scale =
explorersCove4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mn55Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove4Mn55Pb208SpecPlot <-
cnltspec.plot(explorersCove4Mn55Pb208Spec$coh, timevec =
explorersCove4Mn55Pb208Spec$mtime, scale =
```

```
explorersCove4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Ba137Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
explorersCove4Ba137Pb208SpecPlot <-
cnltspec.plot(explorersCove4Ba137Pb208Spec$coh, timevec =
explorersCove4Ba137Pb208Spec$mtime, scale =
explorersCove4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

png("explorersCove4InterstrialIncrementsLi7SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsLi7Spec$phase, timevec
= explorersCove4InterstrialIncrementsLi7Spec$mtime, scale =
explorersCove4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsMg26SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMg26Spec$phase,
timevec = explorersCove4InterstrialIncrementsMg26Spec$mtime, scale =
explorersCove4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsMn55SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsMn55Spec$phase,
timevec = explorersCove4InterstrialIncrementsMn55Spec$mtime, scale =
explorersCove4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsBa137SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsBa137Spec$phase,
timevec = explorersCove4InterstrialIncrementsBa137Spec$mtime, scale =
explorersCove4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4InterstrialIncrementsPb208SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCove4InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(explorersCove4InterstrialIncrementsPb208Spec$phase,
timevec = explorersCove4InterstrialIncrementsPb208Spec$mtime, scale =
explorersCove4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCove4Li7Mg26SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Li7Mg26SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Mg26Spec$phase, timevec =
explorersCove4Li7Mg26Spec$mtime, scale =
```

```
explorersCove4Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Li7Mn55SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Li7Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Mn55Spec$phase, timevec =
explorersCove4Li7Mn55Spec$mtime, scale =
explorersCove4Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Li7Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Li7Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Ba137Spec$phase, timevec =
explorersCove4Li7Ba137Spec$mtime, scale =
explorersCove4Li7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Li7Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Li7Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Li7Pb208Spec$phase, timevec =
explorersCove4Li7Pb208Spec$mtime, scale =
explorersCove4Li7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mg26Mn55SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Mg26Mn55SpecPhasePlot <-
cnltspec.plot(explorersCove4Mg26Mn55Spec$phase, timevec =
explorersCove4Mg26Mn55Spec$mtime, scale =
explorersCove4Mg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mg26Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Mg26Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove4Mg26Ba137Spec$phase, timevec =
explorersCove4Mg26Ba137Spec$mtime, scale =
explorersCove4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mg26Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Mg26Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Mg26Pb208Spec$phase, timevec =
explorersCove4Mg26Pb208Spec$mtime, scale =
explorersCove4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mn55Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Mn55Ba137SpecPhasePlot <-
cnltspec.plot(explorersCove4Mn55Ba137Spec$phase, timevec =
explorersCove4Mn55Ba137Spec$mtime, scale =
```

```
explorersCove4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Mn55Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Mn55Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Mn55Pb208Spec$phase, timevec =
explorersCove4Mn55Pb208Spec$mtime, scale =
explorersCove4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("explorersCove4Ba137Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCove4Ba137Pb208SpecPhasePlot <-
cnltspec.plot(explorersCove4Ba137Pb208Spec$phase, timevec =
explorersCove4Ba137Pb208Spec$mtime, scale =
explorersCove4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()

## Explorers Cove Fossil
explorersCoveFossilInterstrialIncrementsLi7 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$interstrialDistance, f2 =
explorersCoveFossilCoherence$Li7, P = 500)
explorersCoveFossilInterstrialIncrementsLi7Spec <- cnlt.spec(x =
explorersCoveFossilInterstrialIncrementsLi7)

explorersCoveFossilInterstrialIncrementsMg26 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$interstrialDistance, f2 =
explorersCoveFossilCoherence$Mg26, P = 500)
explorersCoveFossilInterstrialIncrementsMg26Spec <- cnlt.spec(x =
explorersCoveFossilInterstrialIncrementsMg26)

explorersCoveFossilInterstrialIncrementsMn55 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$interstrialDistance, f2 =
explorersCoveFossilCoherence$Mn55, P = 500)
explorersCoveFossilInterstrialIncrementsMn55Spec <- cnlt.spec(x =
explorersCoveFossilInterstrialIncrementsMn55)

explorersCoveFossilInterstrialIncrementsBa137 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$interstrialDistance, f2 =
explorersCoveFossilCoherence$Ba137, P = 500)
explorersCoveFossilInterstrialIncrementsBa137Spec <- cnlt.spec(x =
explorersCoveFossilInterstrialIncrementsBa137)

explorersCoveFossilInterstrialIncrementsPb208 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$interstrialDistance, f2 =
explorersCoveFossilCoherence$Pb208, P = 500)
explorersCoveFossilInterstrialIncrementsPb208Spec <- cnlt.spec(x =
explorersCoveFossilInterstrialIncrementsPb208)
```

```
explorersCoveFossilLi7Mg26 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Li7, f2 =
explorersCoveFossilCoherence$Mg26, P = 500)
explorersCoveFossilLi7Mg26Spec <- cnlt.spec(x =
explorersCoveFossilLi7Mg26)

explorersCoveFossilLi7Mn55 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Li7, f2 =
explorersCoveFossilCoherence$Mn55, P = 500)
explorersCoveFossilLi7Mn55Spec <- cnlt.spec(x =
explorersCoveFossilLi7Mn55)

explorersCoveFossilLi7Ba137 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Li7, f2 =
explorersCoveFossilCoherence$Ba137, P = 500)
explorersCoveFossilLi7Ba137Spec <- cnlt.spec(x =
explorersCoveFossilLi7Ba137)

explorersCoveFossilLi7Pb208 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Li7, f2 =
explorersCoveFossilCoherence$Pb208, P = 500)
explorersCoveFossilLi7Pb208Spec <- cnlt.spec(x =
explorersCoveFossilLi7Pb208)

explorersCoveFossilMg26Mn55 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Mg26, f2 =
explorersCoveFossilCoherence$Mn55, P = 500)
explorersCoveFossilMg26Mn55Spec <- cnlt.spec(x =
explorersCoveFossilMg26Mn55)

explorersCoveFossilMg26Ba137 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Mg26, f2 =
explorersCoveFossilCoherence$Ba137, P = 500)
explorersCoveFossilMg26Ba137Spec <- cnlt.spec(x =
explorersCoveFossilMg26Ba137)

explorersCoveFossilMg26Pb208 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Mg26, f2 =
explorersCoveFossilCoherence$Pb208, P = 500)
explorersCoveFossilMg26Pb208Spec <- cnlt.spec(x =
explorersCoveFossilMg26Pb208)

explorersCoveFossilMn55Ba137 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Mn55, f2 =
explorersCoveFossilCoherence$Ba137, P = 500)
explorersCoveFossilMn55Ba137Spec <- cnlt.spec(x =
explorersCoveFossilMn55Ba137)
```

```
explorersCoveFossilMn55Pb208 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Mn55, f2 =
explorersCoveFossilCoherence$Pb208, P = 500)
explorersCoveFossilMn55Pb208Spec <- cnlt.spec(x =
explorersCoveFossilMn55Pb208)

explorersCoveFossilBa137Pb208 <- cnlt.biv(x1 =
explorersCoveFossilCoherence$striaeNumberCor, f1 =
explorersCoveFossilCoherence$Ba137, f2 =
explorersCoveFossilCoherence$Pb208, P = 500)
explorersCoveFossilBa137Pb208Spec <- cnlt.spec(x =
explorersCoveFossilBa137Pb208)

### SVG images Explorers Cove Fossil
svg("explorersCoveFossilInterstrialIncrementsLi7SpecPlot.svg", height =
3, width = 5)
explorersCoveFossilInterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsLi7Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsLi7Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsMg26SpecPlot.svg", height
= 3, width = 5)
explorersCoveFossilInterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMg26Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsMg26Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMg26Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsMn55SpecPlot.svg", height
= 3, width = 5)
explorersCoveFossilInterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMn55Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsMn55Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMn55Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsBa137SpecPlot.svg", height
= 3, width = 5)
explorersCoveFossilInterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsBa137Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsBa137Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsBa137Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsPb208SpecPlot.svg", height
= 3, width = 5)
explorersCoveFossilInterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsPb208Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsPb208Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsPb208Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Mg26SpecPlot.svg", height = 3, width = 5)
```

```
explorersCoveFossilLi7Mg26SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Mg26Spec$coh, timevec =
explorersCoveFossilLi7Mg26Spec$mtime, scale =
explorersCoveFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Mn55SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilLi7Mn55SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Mn55Spec$coh, timevec =
explorersCoveFossilLi7Mn55Spec$mtime, scale =
explorersCoveFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Ba137SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilLi7Ba137SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Ba137Spec$coh, timevec =
explorersCoveFossilLi7Ba137Spec$mtime, scale =
explorersCoveFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Pb208SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilLi7Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Pb208Spec$coh, timevec =
explorersCoveFossilLi7Pb208Spec$mtime, scale =
explorersCoveFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMg26Mn55SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilMg26Mn55SpecPlot <-
cnltspec.plot(explorersCoveFossilMg26Mn55Spec$coh, timevec =
explorersCoveFossilMg26Mn55Spec$mtime, scale =
explorersCoveFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMg26Ba137SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilMg26Ba137SpecPlot <-
cnltspec.plot(explorersCoveFossilMg26Ba137Spec$coh, timevec =
explorersCoveFossilMg26Ba137Spec$mtime, scale =
explorersCoveFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMg26Pb208SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilMg26Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilMg26Pb208Spec$coh, timevec =
explorersCoveFossilMg26Pb208Spec$mtime, scale =
explorersCoveFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMn55Ba137SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilMn55Ba137SpecPlot <-
cnltspec.plot(explorersCoveFossilMn55Ba137Spec$coh, timevec =
explorersCoveFossilMn55Ba137Spec$mtime, scale =
explorersCoveFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMn55Pb208SpecPlot.svg", height = 3, width = 5)
```

```
explorersCoveFossilMn55Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilMn55Pb208Spec$coh, timevec =
explorersCoveFossilMn55Pb208Spec$mtime, scale =
explorersCoveFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilBa137Pb208SpecPlot.svg", height = 3, width = 5)
explorersCoveFossilBa137Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilBa137Pb208Spec$coh, timevec =
explorersCoveFossilBa137Pb208Spec$mtime, scale =
explorersCoveFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()

svg("explorersCoveFossilInterstrialIncrementsLi7SpecPhasePlot.svg",
height = 3, width = 5)
explorersCoveFossilInterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsLi7Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsLi7Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsMg26SpecPhasePlot.svg",
height = 3, width = 5)
explorersCoveFossilInterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMg26Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsMg26Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMg26Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsMn55SpecPhasePlot.svg",
height = 3, width = 5)
explorersCoveFossilInterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMn55Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsMn55Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMn55Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsBa137SpecPhasePlot.svg",
height = 3, width = 5)
explorersCoveFossilInterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsBa137Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsBa137Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsBa137Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilInterstrialIncrementsPb208SpecPhasePlot.svg",
height = 3, width = 5)
explorersCoveFossilInterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsPb208Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsPb208Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsPb208Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Mg26SpecPhasePlot.svg", height = 3, width =
5)
```

```
explorersCoveFossilLi7Mg26SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Mg26Spec$phase, timevec =
explorersCoveFossilLi7Mg26Spec$mtime, scale =
explorersCoveFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Mn55SpecPhasePlot.svg", height = 3, width =
5)
explorersCoveFossilLi7Mn55SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Mn55Spec$phase, timevec =
explorersCoveFossilLi7Mn55Spec$mtime, scale =
explorersCoveFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Ba137SpecPhasePlot.svg", height = 3, width =
5)
explorersCoveFossilLi7Ba137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Ba137Spec$phase, timevec =
explorersCoveFossilLi7Ba137Spec$mtime, scale =
explorersCoveFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilLi7Pb208SpecPhasePlot.svg", height = 3, width =
5)
explorersCoveFossilLi7Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Pb208Spec$phase, timevec =
explorersCoveFossilLi7Pb208Spec$mtime, scale =
explorersCoveFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMg26Mn55SpecPhasePlot.svg", height = 3, width =
5)
explorersCoveFossilMg26Mn55SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMg26Mn55Spec$phase, timevec =
explorersCoveFossilMg26Mn55Spec$mtime, scale =
explorersCoveFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMg26Ba137SpecPhasePlot.svg", height = 3, width
= 5)
explorersCoveFossilMg26Ba137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMg26Ba137Spec$phase, timevec =
explorersCoveFossilMg26Ba137Spec$mtime, scale =
explorersCoveFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMg26Pb208SpecPhasePlot.svg", height = 3, width
= 5)
explorersCoveFossilMg26Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMg26Pb208Spec$phase, timevec =
explorersCoveFossilMg26Pb208Spec$mtime, scale =
explorersCoveFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMn55Ba137SpecPhasePlot.svg", height = 3, width
= 5)
```

```
explorersCoveFossilMn55Ba137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMn55Ba137Spec$phase, timevec =
explorersCoveFossilMn55Ba137Spec$mtime, scale =
explorersCoveFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilMn55Pb208SpecPhasePlot.svg", height = 3, width
= 5)
explorersCoveFossilMn55Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMn55Pb208Spec$phase, timevec =
explorersCoveFossilMn55Pb208Spec$mtime, scale =
explorersCoveFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
svg("explorersCoveFossilBa137Pb208SpecPhasePlot.svg", height = 3, width
= 5)
explorersCoveFossilBa137Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilBa137Pb208Spec$phase, timevec =
explorersCoveFossilBa137Pb208Spec$mtime, scale =
explorersCoveFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()

### PNG images Explorers Cove Fossil
png("explorersCoveFossilInterstrialIncrementsLi7SpecPlot.png", height =
3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsLi7Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsLi7Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilInterstrialIncrementsMg26SpecPlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMg26Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsMg26Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMg26Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilInterstrialIncrementsMn55SpecPlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMn55Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsMn55Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMn55Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilInterstrialIncrementsBa137SpecPlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsBa137Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsBa137Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsBa137Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
```

```
png("explorersCoveFossilInterstrialIncrementsPb208SpecPlot.png", height
= 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsPb208Spec$coh,
timevec = explorersCoveFossilInterstrialIncrementsPb208Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsPb208Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilLi7Mg26SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilLi7Mg26SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Mg26Spec$coh, timevec =
explorersCoveFossilLi7Mg26Spec$mtime, scale =
explorersCoveFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilLi7Mn55SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilLi7Mn55SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Mn55Spec$coh, timevec =
explorersCoveFossilLi7Mn55Spec$mtime, scale =
explorersCoveFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilLi7Ba137SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilLi7Ba137SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Ba137Spec$coh, timevec =
explorersCoveFossilLi7Ba137Spec$mtime, scale =
explorersCoveFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilLi7Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilLi7Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilLi7Pb208Spec$coh, timevec =
explorersCoveFossilLi7Pb208Spec$mtime, scale =
explorersCoveFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMg26Mn55SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilMg26Mn55SpecPlot <-
cnltspec.plot(explorersCoveFossilMg26Mn55Spec$coh, timevec =
explorersCoveFossilMg26Mn55Spec$mtime, scale =
explorersCoveFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMg26Ba137SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilMg26Ba137SpecPlot <-
cnltspec.plot(explorersCoveFossilMg26Ba137Spec$coh, timevec =
explorersCoveFossilMg26Ba137Spec$mtime, scale =
explorersCoveFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
```

```
png("explorersCoveFossilMg26Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilMg26Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilMg26Pb208Spec$coh, timevec =
explorersCoveFossilMg26Pb208Spec$mtime, scale =
explorersCoveFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMn55Ba137SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilMn55Ba137SpecPlot <-
cnltspec.plot(explorersCoveFossilMn55Ba137Spec$coh, timevec =
explorersCoveFossilMn55Ba137Spec$mtime, scale =
explorersCoveFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMn55Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilMn55Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilMn55Pb208Spec$coh, timevec =
explorersCoveFossilMn55Pb208Spec$mtime, scale =
explorersCoveFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilBa137Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
explorersCoveFossilBa137Pb208SpecPlot <-
cnltspec.plot(explorersCoveFossilBa137Pb208Spec$coh, timevec =
explorersCoveFossilBa137Pb208Spec$mtime, scale =
explorersCoveFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()

png("explorersCoveFossilInterstrialIncrementsLi7SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsLi7Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsLi7Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilInterstrialIncrementsMg26SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMg26Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsMg26Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMg26Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilInterstrialIncrementsMn55SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsMn55Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsMn55Spec$mtime, scale
= explorersCoveFossilInterstrialIncrementsMn55Spec$mscale, axis4 =
TRUE, SFratio = 2, xtitle = "")
dev.off()
```

```
png("explorersCoveFossilInterstrialIncrementsBa137SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsBa137Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsBa137Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsBa137Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilInterstrialIncrementsPb208SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
explorersCoveFossilInterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilInterstrialIncrementsPb208Spec$phase,
timevec = explorersCoveFossilInterstrialIncrementsPb208Spec$mtime,
scale = explorersCoveFossilInterstrialIncrementsPb208Spec$mscale, axis4
= TRUE, SFratio = 2, xtitle = "")
dev.off()
png("explorersCoveFossilLi7Mg26SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
explorersCoveFossilLi7Mg26SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Mg26Spec$phase, timevec =
explorersCoveFossilLi7Mg26Spec$mtime, scale =
explorersCoveFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilLi7Mn55SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
explorersCoveFossilLi7Mn55SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Mn55Spec$phase, timevec =
explorersCoveFossilLi7Mn55Spec$mtime, scale =
explorersCoveFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilLi7Ba137SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
explorersCoveFossilLi7Ba137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Ba137Spec$phase, timevec =
explorersCoveFossilLi7Ba137Spec$mtime, scale =
explorersCoveFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilLi7Pb208SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
explorersCoveFossilLi7Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilLi7Pb208Spec$phase, timevec =
explorersCoveFossilLi7Pb208Spec$mtime, scale =
explorersCoveFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMg26Mn55SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
explorersCoveFossilMg26Mn55SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMg26Mn55Spec$phase, timevec =
explorersCoveFossilMg26Mn55Spec$mtime, scale =
explorersCoveFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
```

```
png("explorersCoveFossilMg26Ba137SpecPhasePlot.png", height = 3, width
= 5, unit = "in", res = 600)
explorersCoveFossilMg26Ba137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMg26Ba137Spec$phase, timevec =
explorersCoveFossilMg26Ba137Spec$mtime, scale =
explorersCoveFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMg26Pb208SpecPhasePlot.png", height = 3, width
= 5, unit = "in", res = 600)
explorersCoveFossilMg26Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMg26Pb208Spec$phase, timevec =
explorersCoveFossilMg26Pb208Spec$mtime, scale =
explorersCoveFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMn55Ba137SpecPhasePlot.png", height = 3, width
= 5, unit = "in", res = 600)
explorersCoveFossilMn55Ba137SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMn55Ba137Spec$phase, timevec =
explorersCoveFossilMn55Ba137Spec$mtime, scale =
explorersCoveFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilMn55Pb208SpecPhasePlot.png", height = 3, width
= 5, unit = "in", res = 600)
explorersCoveFossilMn55Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilMn55Pb208Spec$phase, timevec =
explorersCoveFossilMn55Pb208Spec$mtime, scale =
explorersCoveFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()
png("explorersCoveFossilBa137Pb208SpecPhasePlot.png", height = 3, width
= 5, unit = "in", res = 600)
explorersCoveFossilBa137Pb208SpecPhasePlot <-
cnltspec.plot(explorersCoveFossilBa137Pb208Spec$phase, timevec =
explorersCoveFossilBa137Pb208Spec$mtime, scale =
explorersCoveFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "")
dev.off()

## Bay of Sails 3
bayOfSails3InterstrialIncrementsLi7 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 =
bayOfSails3Coherence$interstrialDistance, f2 =
bayOfSails3Coherence$Li7, P = 500)
bayOfSails3InterstrialIncrementsLi7Spec <- cnlt.spec(x =
bayOfSails3InterstrialIncrementsLi7)

bayOfSails3InterstrialIncrementsMg26 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 =
bayOfSails3Coherence$interstrialDistance, f2 =
bayOfSails3Coherence$Mg26, P = 500)
bayOfSails3InterstrialIncrementsMg26Spec <- cnlt.spec(x =
bayOfSails3InterstrialIncrementsMg26)
```

```
bayOfSails3InterstrialIncrementsMn55 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 =
bayOfSails3Coherence$interstrialDistance, f2 =
bayOfSails3Coherence$Mn55, P = 500)
bayOfSails3InterstrialIncrementsMn55Spec <- cnlt.spec(x =
bayOfSails3InterstrialIncrementsMn55)

bayOfSails3InterstrialIncrementsBa137 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 =
bayOfSails3Coherence$interstrialDistance, f2 =
bayOfSails3Coherence$Ba137, P = 500)
bayOfSails3InterstrialIncrementsBa137Spec <- cnlt.spec(x =
bayOfSails3InterstrialIncrementsBa137)

bayOfSails3InterstrialIncrementsPb208 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 =
bayOfSails3Coherence$interstrialDistance, f2 =
bayOfSails3Coherence$Pb208, P = 500)
bayOfSails3InterstrialIncrementsPb208Spec <- cnlt.spec(x =
bayOfSails3InterstrialIncrementsPb208)

bayOfSails3Li7Mg26 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Li7, f2
= bayOfSails3Coherence$Mg26, P = 500)
bayOfSails3Li7Mg26Spec <- cnlt.spec(x = bayOfSails3Li7Mg26)

bayOfSails3Li7Mn55 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Li7, f2
= bayOfSails3Coherence$Mn55, P = 500)
bayOfSails3Li7Mn55Spec <- cnlt.spec(x = bayOfSails3Li7Mn55)

bayOfSails3Li7Ba137 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Li7, f2
= bayOfSails3Coherence$Ba137, P = 500)
bayOfSails3Li7Ba137Spec <- cnlt.spec(x = bayOfSails3Li7Ba137)

bayOfSails3Li7Pb208 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Li7, f2
= bayOfSails3Coherence$Pb208, P = 500)
bayOfSails3Li7Pb208Spec <- cnlt.spec(x = bayOfSails3Li7Pb208)

bayOfSails3Mg26Mn55 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Mg26,
f2 = bayOfSails3Coherence$Mn55, P = 500)
bayOfSails3Mg26Mn55Spec <- cnlt.spec(x = bayOfSails3Mg26Mn55)

bayOfSails3Mg26Ba137 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Mg26,
f2 = bayOfSails3Coherence$Ba137, P = 500)
bayOfSails3Mg26Ba137Spec <- cnlt.spec(x = bayOfSails3Mg26Ba137)

bayOfSails3Mg26Pb208 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Mg26,
f2 = bayOfSails3Coherence$Pb208, P = 500)
bayOfSails3Mg26Pb208Spec <- cnlt.spec(x = bayOfSails3Mg26Pb208)
```

```
bayOfSails3Mn55Ba137 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Mn55,
f2 = bayOfSails3Coherence$Ba137, P = 500)
bayOfSails3Mn55Ba137Spec <- cnlt.spec(x = bayOfSails3Mn55Ba137)

bayOfSails3Mn55Pb208 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Mn55,
f2 = bayOfSails3Coherence$Pb208, P = 500)
bayOfSails3Mn55Pb208Spec <- cnlt.spec(x = bayOfSails3Mn55Pb208)

bayOfSails3Ba137Pb208 <- cnlt.biv(x1 =
bayOfSails3Coherence$striaeNumberCor, f1 = bayOfSails3Coherence$Ba137,
f2 = bayOfSails3Coherence$Pb208, P = 500)
bayOfSails3Ba137Pb208Spec <- cnlt.spec(x = bayOfSails3Ba137Pb208)

### SVG images Bay of Sails 3
svg("bayOfSails3InterstrialIncrementsLi7SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsLi7Spec$coh, timevec =
bayOfSails3InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsMg26SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMg26Spec$coh, timevec =
bayOfSails3InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsMn55SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMn55Spec$coh, timevec =
bayOfSails3InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsBa137SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsBa137Spec$coh, timevec =
bayOfSails3InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsPb208SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsPb208Spec$coh, timevec =
bayOfSails3InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Mg26SpecPlot.svg", height = 3, width = 5)
```

```
bayOfSails3Li7Mg26SpecPlot <- cnltspec.plot(bayOfSails3Li7Mg26Spec$coh,
timevec = bayOfSails3Li7Mg26Spec$mtime, scale =
bayOfSails3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Mn55SpecPlot <- cnltspec.plot(bayOfSails3Li7Mn55Spec$coh,
timevec = bayOfSails3Li7Mn55Spec$mtime, scale =
bayOfSails3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Li7Ba137Spec$coh, timevec =
bayOfSails3Li7Ba137Spec$mtime, scale = bayOfSails3Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Li7Pb208Spec$coh, timevec =
bayOfSails3Li7Pb208Spec$mtime, scale = bayOfSails3Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Mg26Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mg26Mn55SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Mn55Spec$coh, timevec =
bayOfSails3Mg26Mn55Spec$mtime, scale = bayOfSails3Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Mg26Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mg26Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Ba137Spec$coh, timevec =
bayOfSails3Mg26Ba137Spec$mtime, scale =
bayOfSails3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mg26Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mg26Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Pb208Spec$coh, timevec =
bayOfSails3Mg26Pb208Spec$mtime, scale =
bayOfSails3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mn55Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mn55Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Mn55Ba137Spec$coh, timevec =
bayOfSails3Mn55Ba137Spec$mtime, scale =
bayOfSails3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mn55Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mn55Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Mn55Pb208Spec$coh, timevec =
bayOfSails3Mn55Pb208Spec$mtime, scale =
bayOfSails3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Ba137Pb208SpecPlot.svg", height = 3, width = 5)
```

```
bayOfSails3Ba137Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Ba137Pb208Spec$coh, timevec =
bayOfSails3Ba137Pb208Spec$mtime, scale =
bayOfSails3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

### SVG images Bay of Sails 3
svg("bayOfSails3InterstrialIncrementsLi7SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsLi7Spec$coh, timevec =
bayOfSails3InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsMg26SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMg26Spec$coh, timevec =
bayOfSails3InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsMn55SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMn55Spec$coh, timevec =
bayOfSails3InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsBa137SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsBa137Spec$coh, timevec =
bayOfSails3InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsPb208SpecPlot.svg", height = 3,
width = 5)
bayOfSails3InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsPb208Spec$coh, timevec =
bayOfSails3InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Mg26SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Mg26SpecPlot <- cnltspec.plot(bayOfSails3Li7Mg26Spec$coh,
timevec = bayOfSails3Li7Mg26Spec$mtime, scale =
bayOfSails3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Mn55SpecPlot <- cnltspec.plot(bayOfSails3Li7Mn55Spec$coh,
timevec = bayOfSails3Li7Mn55Spec$mtime, scale =
bayOfSails3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
```

```
dev.off()
svg("bayOfSails3Li7Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Li7Ba137Spec$coh, timevec =
bayOfSails3Li7Ba137Spec$mtime, scale = bayOfSails3Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Li7Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Li7Pb208Spec$coh, timevec =
bayOfSails3Li7Pb208Spec$mtime, scale = bayOfSails3Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Mg26Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mg26Mn55SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Mn55Spec$coh, timevec =
bayOfSails3Mg26Mn55Spec$mtime, scale = bayOfSails3Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Mg26Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mg26Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Ba137Spec$coh, timevec =
bayOfSails3Mg26Ba137Spec$mtime, scale =
bayOfSails3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mg26Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mg26Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Pb208Spec$coh, timevec =
bayOfSails3Mg26Pb208Spec$mtime, scale =
bayOfSails3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mn55Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mn55Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Mn55Ba137Spec$coh, timevec =
bayOfSails3Mn55Ba137Spec$mtime, scale =
bayOfSails3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mn55Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Mn55Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Mn55Pb208Spec$coh, timevec =
bayOfSails3Mn55Pb208Spec$mtime, scale =
bayOfSails3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Ba137Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails3Ba137Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Ba137Pb208Spec$coh, timevec =
bayOfSails3Ba137Pb208Spec$mtime, scale =
bayOfSails3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

svg("bayOfSails3InterstrialIncrementsLi7SpecPhasePlot.svg", height = 3,
width = 5)
```

```
bayOfSails3InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsLi7Spec$phase, timevec =
bayOfSails3InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsMg26SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails3InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMg26Spec$phase, timevec =
bayOfSails3InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsMn55SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails3InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMn55Spec$phase, timevec =
bayOfSails3InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsBa137SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails3InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsBa137Spec$phase, timevec
= bayOfSails3InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3InterstrialIncrementsPb208SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails3InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsPb208Spec$phase, timevec
= bayOfSails3InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Mg26SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Li7Mg26SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Mg26Spec$phase, timevec =
bayOfSails3Li7Mg26Spec$mtime, scale = bayOfSails3Li7Mg26Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Mn55SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Li7Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Mn55Spec$phase, timevec =
bayOfSails3Li7Mn55Spec$mtime, scale = bayOfSails3Li7Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Li7Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Ba137Spec$phase, timevec =
bayOfSails3Li7Ba137Spec$mtime, scale = bayOfSails3Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Li7Pb208SpecPhasePlot.svg", height = 3, width = 5)
```

```
bayOfSails3Li7Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Pb208Spec$phase, timevec =
bayOfSails3Li7Pb208Spec$mtime, scale = bayOfSails3Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Mg26Mn55SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Mg26Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mg26Mn55Spec$phase, timevec =
bayOfSails3Mg26Mn55Spec$mtime, scale = bayOfSails3Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails3Mg26Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Mg26Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mg26Ba137Spec$phase, timevec =
bayOfSails3Mg26Ba137Spec$mtime, scale =
bayOfSails3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mg26Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Mg26Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mg26Pb208Spec$phase, timevec =
bayOfSails3Mg26Pb208Spec$mtime, scale =
bayOfSails3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mn55Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Mn55Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mn55Ba137Spec$phase, timevec =
bayOfSails3Mn55Ba137Spec$mtime, scale =
bayOfSails3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Mn55Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Mn55Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mn55Pb208Spec$phase, timevec =
bayOfSails3Mn55Pb208Spec$mtime, scale =
bayOfSails3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails3Ba137Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails3Ba137Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Ba137Pb208Spec$phase, timevec =
bayOfSails3Ba137Pb208Spec$mtime, scale =
bayOfSails3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

### PNG images Bay of Sails 3
png("bayOfSails3InterstrialIncrementsLi7SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsLi7Spec$coh, timevec =
bayOfSails3InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
```

```
png("bayOfSails3InterstrialIncrementsMg26SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMg26Spec$coh, timevec =
bayOfSails3InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3InterstrialIncrementsMn55SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMn55Spec$coh, timevec =
bayOfSails3InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3InterstrialIncrementsBa137SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsBa137Spec$coh, timevec =
bayOfSails3InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3InterstrialIncrementsPb208SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsPb208Spec$coh, timevec =
bayOfSails3InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Mg26SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Li7Mg26SpecPlot <- cnltspec.plot(bayOfSails3Li7Mg26Spec$coh,
timevec = bayOfSails3Li7Mg26Spec$mtime, scale =
bayOfSails3Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Li7Mn55SpecPlot <- cnltspec.plot(bayOfSails3Li7Mn55Spec$coh,
timevec = bayOfSails3Li7Mn55Spec$mtime, scale =
bayOfSails3Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Li7Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Li7Ba137Spec$coh, timevec =
bayOfSails3Li7Ba137Spec$mtime, scale = bayOfSails3Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Li7Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Li7Pb208Spec$coh, timevec =
bayOfSails3Li7Pb208Spec$mtime, scale = bayOfSails3Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
```

```
dev.off()
png("bayOfSails3Mg26Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Mg26Mn55SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Mn55Spec$coh, timevec =
bayOfSails3Mg26Mn55Spec$mtime, scale = bayOfSails3Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Mg26Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Mg26Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Ba137Spec$coh, timevec =
bayOfSails3Mg26Ba137Spec$mtime, scale =
bayOfSails3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Mg26Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Mg26Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Mg26Pb208Spec$coh, timevec =
bayOfSails3Mg26Pb208Spec$mtime, scale =
bayOfSails3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Mn55Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Mn55Ba137SpecPlot <-
cnltspec.plot(bayOfSails3Mn55Ba137Spec$coh, timevec =
bayOfSails3Mn55Ba137Spec$mtime, scale =
bayOfSails3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Mn55Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Mn55Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Mn55Pb208Spec$coh, timevec =
bayOfSails3Mn55Pb208Spec$mtime, scale =
bayOfSails3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Ba137Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails3Ba137Pb208SpecPlot <-
cnltspec.plot(bayOfSails3Ba137Pb208Spec$coh, timevec =
bayOfSails3Ba137Pb208Spec$mtime, scale =
bayOfSails3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

png("bayOfSails3InterstrialIncrementsLi7SpecPhasePlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsLi7Spec$phase, timevec =
bayOfSails3InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails3InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
```

```
png("bayOfSails3InterstrialIncrementsMg26SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMg26Spec$phase, timevec =
bayOfSails3InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3InterstrialIncrementsMn55SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsMn55Spec$phase, timevec =
bayOfSails3InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails3InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3InterstrialIncrementsBa137SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsBa137Spec$phase, timevec
= bayOfSails3InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails3InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3InterstrialIncrementsPb208SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails3InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3InterstrialIncrementsPb208Spec$phase, timevec
= bayOfSails3InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails3InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Mg26SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails3Li7Mg26SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Mg26Spec$phase, timevec =
bayOfSails3Li7Mg26Spec$mtime, scale = bayOfSails3Li7Mg26Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Mn55SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails3Li7Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Mn55Spec$phase, timevec =
bayOfSails3Li7Mn55Spec$mtime, scale = bayOfSails3Li7Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Ba137SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails3Li7Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Ba137Spec$phase, timevec =
bayOfSails3Li7Ba137Spec$mtime, scale = bayOfSails3Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Li7Pb208SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails3Li7Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Li7Pb208Spec$phase, timevec =
```

```
bayOfSails3Li7Pb208Spec$mtime, scale = bayOfSails3Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Mg26Mn55SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails3Mg26Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mg26Mn55Spec$phase, timevec =
bayOfSails3Mg26Mn55Spec$mtime, scale = bayOfSails3Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails3Mg26Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails3Mg26Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mg26Ba137Spec$phase, timevec =
bayOfSails3Mg26Ba137Spec$mtime, scale =
bayOfSails3Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Mg26Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails3Mg26Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mg26Pb208Spec$phase, timevec =
bayOfSails3Mg26Pb208Spec$mtime, scale =
bayOfSails3Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Mn55Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails3Mn55Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mn55Ba137Spec$phase, timevec =
bayOfSails3Mn55Ba137Spec$mtime, scale =
bayOfSails3Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Mn55Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails3Mn55Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Mn55Pb208Spec$phase, timevec =
bayOfSails3Mn55Pb208Spec$mtime, scale =
bayOfSails3Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails3Ba137Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails3Ba137Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails3Ba137Pb208Spec$phase, timevec =
bayOfSails3Ba137Pb208Spec$mtime, scale =
bayOfSails3Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

## Bay of Sails 4
bayOfSails4InterstrialIncrementsLi7 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 =
bayOfSails4Coherence$interstrialDistance, f2 =
bayOfSails4Coherence$Li7, P = 500)
```

```
bayOfSails4InterstrialIncrementsLi7Spec <- cnlt.spec(x =
bayOfSails4InterstrialIncrementsLi7)

bayOfSails4InterstrialIncrementsMg26 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 =
bayOfSails4Coherence$interstrialDistance, f2 =
bayOfSails4Coherence$Mg26, P = 500)
bayOfSails4InterstrialIncrementsMg26Spec <- cnlt.spec(x =
bayOfSails4InterstrialIncrementsMg26)

bayOfSails4InterstrialIncrementsMn55 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 =
bayOfSails4Coherence$interstrialDistance, f2 =
bayOfSails4Coherence$Mn55, P = 500)
bayOfSails4InterstrialIncrementsMn55Spec <- cnlt.spec(x =
bayOfSails4InterstrialIncrementsMn55)

bayOfSails4InterstrialIncrementsBa137 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 =
bayOfSails4Coherence$interstrialDistance, f2 =
bayOfSails4Coherence$Ba137, P = 500)
bayOfSails4InterstrialIncrementsBa137Spec <- cnlt.spec(x =
bayOfSails4InterstrialIncrementsBa137)

bayOfSails4InterstrialIncrementsPb208 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 =
bayOfSails4Coherence$interstrialDistance, f2 =
bayOfSails4Coherence$Pb208, P = 500)
bayOfSails4InterstrialIncrementsPb208Spec <- cnlt.spec(x =
bayOfSails4InterstrialIncrementsPb208)

bayOfSails4Li7Mg26 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Li7, f2
= bayOfSails4Coherence$Mg26, P = 500)
bayOfSails4Li7Mg26Spec <- cnlt.spec(x = bayOfSails4Li7Mg26)

bayOfSails4Li7Mn55 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Li7, f2
= bayOfSails4Coherence$Mn55, P = 500)
bayOfSails4Li7Mn55Spec <- cnlt.spec(x = bayOfSails4Li7Mn55)

bayOfSails4Li7Ba137 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Li7, f2
= bayOfSails4Coherence$Ba137, P = 500)
bayOfSails4Li7Ba137Spec <- cnlt.spec(x = bayOfSails4Li7Ba137)

bayOfSails4Li7Pb208 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Li7, f2
= bayOfSails4Coherence$Pb208, P = 500)
bayOfSails4Li7Pb208Spec <- cnlt.spec(x = bayOfSails4Li7Pb208)

bayOfSails4Mg26Mn55 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Mg26,
f2 = bayOfSails4Coherence$Mn55, P = 500)
bayOfSails4Mg26Mn55Spec <- cnlt.spec(x = bayOfSails4Mg26Mn55)
```

```
bayOfSails4Mg26Ba137 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Mg26,
f2 = bayOfSails4Coherence$Ba137, P = 500)
bayOfSails4Mg26Ba137Spec <- cnlt.spec(x = bayOfSails4Mg26Ba137)

bayOfSails4Mg26Pb208 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Mg26,
f2 = bayOfSails4Coherence$Pb208, P = 500)
bayOfSails4Mg26Pb208Spec <- cnlt.spec(x = bayOfSails4Mg26Pb208)

bayOfSails4Mn55Ba137 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Mn55,
f2 = bayOfSails4Coherence$Ba137, P = 500)
bayOfSails4Mn55Ba137Spec <- cnlt.spec(x = bayOfSails4Mn55Ba137)

bayOfSails4Mn55Pb208 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Mn55,
f2 = bayOfSails4Coherence$Pb208, P = 500)
bayOfSails4Mn55Pb208Spec <- cnlt.spec(x = bayOfSails4Mn55Pb208)

bayOfSails4Ba137Pb208 <- cnlt.biv(x1 =
bayOfSails4Coherence$striaeNumberCor, f1 = bayOfSails4Coherence$Ba137,
f2 = bayOfSails4Coherence$Pb208, P = 500)
bayOfSails4Ba137Pb208Spec <- cnlt.spec(x = bayOfSails4Ba137Pb208)

### SVG images Bay of Sails 4
svg("bayOfSails4InterstrialIncrementsLi7SpecPlot.svg", height = 3,
width = 5)
bayOfSails4InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsLi7Spec$coh, timevec =
bayOfSails4InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsMg26SpecPlot.svg", height = 3,
width = 5)
bayOfSails4InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMg26Spec$coh, timevec =
bayOfSails4InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsBa137SpecPlot.svg", height = 3,
width = 5)
bayOfSails4InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsBa137Spec$coh, timevec =
bayOfSails4InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsMn55SpecPlot.svg", height = 3,
width = 5)
bayOfSails4InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMn55Spec$coh, timevec =
bayOfSails4InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
```

```
dev.off()
svg("bayOfSails4InterstrialIncrementsPb208SpecPlot.svg", height = 3,
width = 5)
bayOfSails4InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsPb208Spec$coh, timevec =
bayOfSails4InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Mg26SpecPlot.svg", height = 3, width = 5)
bayOfSails4Li7Mg26SpecPlot <- cnltspec.plot(bayOfSails4Li7Mg26Spec$coh,
timevec = bayOfSails4Li7Mg26Spec$mtime, scale =
bayOfSails4Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSails4Li7Mn55SpecPlot <- cnltspec.plot(bayOfSails4Li7Mn55Spec$coh,
timevec = bayOfSails4Li7Mn55Spec$mtime, scale =
bayOfSails4Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails4Li7Ba137SpecPlot <-
cnltspec.plot(bayOfSails4Li7Ba137Spec$coh, timevec =
bayOfSails4Li7Ba137Spec$mtime, scale = bayOfSails4Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails4Li7Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Li7Pb208Spec$coh, timevec =
bayOfSails4Li7Pb208Spec$mtime, scale = bayOfSails4Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Mg26Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSails4Mg26Mn55SpecPlot <-
cnltspec.plot(bayOfSails4Mg26Mn55Spec$coh, timevec =
bayOfSails4Mg26Mn55Spec$mtime, scale = bayOfSails4Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Mg26Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails4Mg26Ba137SpecPlot <-
cnltspec.plot(bayOfSails4Mg26Ba137Spec$coh, timevec =
bayOfSails4Mg26Ba137Spec$mtime, scale =
bayOfSails4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails4Mg26Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails4Mg26Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Mg26Pb208Spec$coh, timevec =
bayOfSails4Mg26Pb208Spec$mtime, scale =
bayOfSails4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails4Mn55Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSails4Mn55Ba137SpecPlot <-
cnltspec.plot(bayOfSails4Mn55Ba137Spec$coh, timevec =
bayOfSails4Mn55Ba137Spec$mtime, scale =
bayOfSails4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
```

```
dev.off()
svg("bayOfSails4Mn55Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails4Mn55Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Mn55Pb208Spec$coh, timevec =
bayOfSails4Mn55Pb208Spec$mtime, scale =
bayOfSails4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails4Ba137Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSails4Ba137Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Ba137Pb208Spec$coh, timevec =
bayOfSails4Ba137Pb208Spec$mtime, scale =
bayOfSails4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

svg("bayOfSails4InterstrialIncrementsLi7SpecPhasePlot.svg", height = 3,
width = 5)
bayOfSails4InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsLi7Spec$phase, timevec =
bayOfSails4InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsMg26SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails4InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMg26Spec$phase, timevec =
bayOfSails4InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsBa137SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails4InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsBa137Spec$phase, timevec
= bayOfSails4InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsMn55SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails4InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMn55Spec$phase, timevec =
bayOfSails4InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4InterstrialIncrementsPb208SpecPhasePlot.svg", height =
3, width = 5)
bayOfSails4InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsPb208Spec$phase, timevec
= bayOfSails4InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Mg26SpecPhasePlot.svg", height = 3, width = 5)
```

```
bayOfSails4Li7Mg26SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Mg26Spec$phase, timevec =
bayOfSails4Li7Mg26Spec$mtime, scale = bayOfSails4Li7Mg26Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Mn55SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Li7Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Mn55Spec$phase, timevec =
bayOfSails4Li7Mn55Spec$mtime, scale = bayOfSails4Li7Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Li7Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Ba137Spec$phase, timevec =
bayOfSails4Li7Ba137Spec$mtime, scale = bayOfSails4Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Li7Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Li7Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Pb208Spec$phase, timevec =
bayOfSails4Li7Pb208Spec$mtime, scale = bayOfSails4Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Mg26Mn55SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Mg26Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mg26Mn55Spec$phase, timevec =
bayOfSails4Mg26Mn55Spec$mtime, scale = bayOfSails4Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSails4Mg26Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Mg26Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mg26Ba137Spec$phase, timevec =
bayOfSails4Mg26Ba137Spec$mtime, scale =
bayOfSails4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails4Mg26Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Mg26Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mg26Pb208Spec$phase, timevec =
bayOfSails4Mg26Pb208Spec$mtime, scale =
bayOfSails4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails4Mn55Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Mn55Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mn55Ba137Spec$phase, timevec =
bayOfSails4Mn55Ba137Spec$mtime, scale =
bayOfSails4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSails4Mn55Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Mn55Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mn55Pb208Spec$phase, timevec =
bayOfSails4Mn55Pb208Spec$mtime, scale =
bayOfSails4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
```

```
svg("bayOfSails4Ba137Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSails4Ba137Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Ba137Pb208Spec$phase, timevec =
bayOfSails4Ba137Pb208Spec$mtime, scale =
bayOfSails4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

### PNG images Bay of Sails 4
png("bayOfSails4InterstrialIncrementsLi7SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsLi7Spec$coh, timevec =
bayOfSails4InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsMg26SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMg26Spec$coh, timevec =
bayOfSails4InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsMn55SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMn55Spec$coh, timevec =
bayOfSails4InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsBa137SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsBa137Spec$coh, timevec =
bayOfSails4InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsPb208SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsPb208Spec$coh, timevec =
bayOfSails4InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Mg26SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Li7Mg26SpecPlot <- cnltspec.plot(bayOfSails4Li7Mg26Spec$coh,
timevec = bayOfSails4Li7Mg26Spec$mtime, scale =
bayOfSails4Li7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
```

```
bayOfSails4Li7Mn55SpecPlot <- cnltspec.plot(bayOfSails4Li7Mn55Spec$coh,
timevec = bayOfSails4Li7Mn55Spec$mtime, scale =
bayOfSails4Li7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Li7Ba137SpecPlot <-
cnltspec.plot(bayOfSails4Li7Ba137Spec$coh, timevec =
bayOfSails4Li7Ba137Spec$mtime, scale = bayOfSails4Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Li7Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Li7Pb208Spec$coh, timevec =
bayOfSails4Li7Pb208Spec$mtime, scale = bayOfSails4Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Mg26Mn55SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Mg26Mn55SpecPlot <-
cnltspec.plot(bayOfSails4Mg26Mn55Spec$coh, timevec =
bayOfSails4Mg26Mn55Spec$mtime, scale = bayOfSails4Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Mg26Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Mg26Ba137SpecPlot <-
cnltspec.plot(bayOfSails4Mg26Ba137Spec$coh, timevec =
bayOfSails4Mg26Ba137Spec$mtime, scale =
bayOfSails4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Mg26Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Mg26Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Mg26Pb208Spec$coh, timevec =
bayOfSails4Mg26Pb208Spec$mtime, scale =
bayOfSails4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Mn55Ba137SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Mn55Ba137SpecPlot <-
cnltspec.plot(bayOfSails4Mn55Ba137Spec$coh, timevec =
bayOfSails4Mn55Ba137Spec$mtime, scale =
bayOfSails4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Mn55Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Mn55Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Mn55Pb208Spec$coh, timevec =
bayOfSails4Mn55Pb208Spec$mtime, scale =
bayOfSails4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
```

```
png("bayOfSails4Ba137Pb208SpecPlot.png", height = 3, width = 5, unit =
"in", res = 600)
bayOfSails4Ba137Pb208SpecPlot <-
cnltspec.plot(bayOfSails4Ba137Pb208Spec$coh, timevec =
bayOfSails4Ba137Pb208Spec$mtime, scale =
bayOfSails4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

png("bayOfSails4InterstrialIncrementsLi7SpecPhasePlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsLi7Spec$phase, timevec =
bayOfSails4InterstrialIncrementsLi7Spec$mtime, scale =
bayOfSails4InterstrialIncrementsLi7Spec$mscale, axis4 = TRUE, SFratio =
2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsMg26SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMg26Spec$phase, timevec =
bayOfSails4InterstrialIncrementsMg26Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMg26Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsMn55SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsMn55Spec$phase, timevec =
bayOfSails4InterstrialIncrementsMn55Spec$mtime, scale =
bayOfSails4InterstrialIncrementsMn55Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsBa137SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsBa137Spec$phase, timevec
= bayOfSails4InterstrialIncrementsBa137Spec$mtime, scale =
bayOfSails4InterstrialIncrementsBa137Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4InterstrialIncrementsPb208SpecPhasePlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSails4InterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4InterstrialIncrementsPb208Spec$phase, timevec
= bayOfSails4InterstrialIncrementsPb208Spec$mtime, scale =
bayOfSails4InterstrialIncrementsPb208Spec$mscale, axis4 = TRUE, SFratio
= 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Mg26SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails4Li7Mg26SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Mg26Spec$phase, timevec =
bayOfSails4Li7Mg26Spec$mtime, scale = bayOfSails4Li7Mg26Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
```

```
png("bayOfSails4Li7Mn55SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails4Li7Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Mn55Spec$phase, timevec =
bayOfSails4Li7Mn55Spec$mtime, scale = bayOfSails4Li7Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Ba137SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails4Li7Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Ba137Spec$phase, timevec =
bayOfSails4Li7Ba137Spec$mtime, scale = bayOfSails4Li7Ba137Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Li7Pb208SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails4Li7Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Li7Pb208Spec$phase, timevec =
bayOfSails4Li7Pb208Spec$mtime, scale = bayOfSails4Li7Pb208Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Mg26Mn55SpecPhasePlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSails4Mg26Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mg26Mn55Spec$phase, timevec =
bayOfSails4Mg26Mn55Spec$mtime, scale = bayOfSails4Mg26Mn55Spec$mscale,
axis4 = TRUE, SFratio = 2, xtitle = "")
dev.off()
png("bayOfSails4Mg26Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails4Mg26Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mg26Ba137Spec$phase, timevec =
bayOfSails4Mg26Ba137Spec$mtime, scale =
bayOfSails4Mg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Mg26Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails4Mg26Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mg26Pb208Spec$phase, timevec =
bayOfSails4Mg26Pb208Spec$mtime, scale =
bayOfSails4Mg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Mn55Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails4Mn55Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mn55Ba137Spec$phase, timevec =
bayOfSails4Mn55Ba137Spec$mtime, scale =
bayOfSails4Mn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Mn55Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails4Mn55Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Mn55Pb208Spec$phase, timevec =
bayOfSails4Mn55Pb208Spec$mtime, scale =
```

```
bayOfSails4Mn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSails4Ba137Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSails4Ba137Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSails4Ba137Pb208Spec$phase, timevec =
bayOfSails4Ba137Pb208Spec$mtime, scale =
bayOfSails4Ba137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()

## Bay of Sails Fossil
bayOfSailsFossilInterstrialIncrementsLi7 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$interstrialDistance, f2 =
bayOfSailsFossilCoherence$Li7, P = 500)
bayOfSailsFossilInterstrialIncrementsLi7Spec <- cnlt.spec(x =
bayOfSailsFossilInterstrialIncrementsLi7)

bayOfSailsFossilInterstrialIncrementsMg26 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$interstrialDistance, f2 =
bayOfSailsFossilCoherence$Mg26, P = 500)
bayOfSailsFossilInterstrialIncrementsMg26Spec <- cnlt.spec(x =
bayOfSailsFossilInterstrialIncrementsMg26)

bayOfSailsFossilInterstrialIncrementsMn55 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$interstrialDistance, f2 =
bayOfSailsFossilCoherence$Mn55, P = 500)
bayOfSailsFossilInterstrialIncrementsMn55Spec <- cnlt.spec(x =
bayOfSailsFossilInterstrialIncrementsMn55)

bayOfSailsFossilInterstrialIncrementsBa137 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$interstrialDistance, f2 =
bayOfSailsFossilCoherence$Ba137, P = 500)
bayOfSailsFossilInterstrialIncrementsBa137Spec <- cnlt.spec(x =
bayOfSailsFossilInterstrialIncrementsBa137)

bayOfSailsFossilInterstrialIncrementsPb208 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$interstrialDistance, f2 =
bayOfSailsFossilCoherence$Pb208, P = 500)
bayOfSailsFossilInterstrialIncrementsPb208Spec <- cnlt.spec(x =
bayOfSailsFossilInterstrialIncrementsPb208)

bayOfSailsFossilLi7Mg26 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Li7, f2 = bayOfSailsFossilCoherence$Mg26, P =
500)
bayOfSailsFossilLi7Mg26Spec <- cnlt.spec(x = bayOfSailsFossilLi7Mg26)

bayOfSailsFossilLi7Mn55 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
```

```
bayOfSailsFossilCoherence$Li7, f2 = bayOfSailsFossilCoherence$Mn55, P =
500)
bayOfSailsFossilLi7Mn55Spec <- cnlt.spec(x = bayOfSailsFossilLi7Mn55)

bayOfSailsFossilLi7Ba137 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Li7, f2 = bayOfSailsFossilCoherence$Ba137, P
= 500)
bayOfSailsFossilLi7Ba137Spec <- cnlt.spec(x = bayOfSailsFossilLi7Ba137)

bayOfSailsFossilLi7Pb208 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Li7, f2 = bayOfSailsFossilCoherence$Pb208, P
= 500)
bayOfSailsFossilLi7Pb208Spec <- cnlt.spec(x = bayOfSailsFossilLi7Pb208)

bayOfSailsFossilMg26Mn55 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Mg26, f2 = bayOfSailsFossilCoherence$Mn55, P
= 500)
bayOfSailsFossilMg26Mn55Spec <- cnlt.spec(x = bayOfSailsFossilMg26Mn55)

bayOfSailsFossilMg26Ba137 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Mg26, f2 = bayOfSailsFossilCoherence$Ba137, P
= 500)
bayOfSailsFossilMg26Ba137Spec <- cnlt.spec(x =
bayOfSailsFossilMg26Ba137)

bayOfSailsFossilMg26Pb208 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Mg26, f2 = bayOfSailsFossilCoherence$Pb208, P
= 500)
bayOfSailsFossilMg26Pb208Spec <- cnlt.spec(x =
bayOfSailsFossilMg26Pb208)

bayOfSailsFossilMn55Ba137 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Mn55, f2 = bayOfSailsFossilCoherence$Ba137, P
= 500)
bayOfSailsFossilMn55Ba137Spec <- cnlt.spec(x =
bayOfSailsFossilMn55Ba137)

bayOfSailsFossilMn55Pb208 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Mn55, f2 = bayOfSailsFossilCoherence$Pb208, P
= 500)
bayOfSailsFossilMn55Pb208Spec <- cnlt.spec(x =
bayOfSailsFossilMn55Pb208)

bayOfSailsFossilBa137Pb208 <- cnlt.biv(x1 =
bayOfSailsFossilCoherence$striaeNumberCor, f1 =
bayOfSailsFossilCoherence$Ba137, f2 = bayOfSailsFossilCoherence$Pb208,
P = 500)
bayOfSailsFossilBa137Pb208Spec <- cnlt.spec(x =
bayOfSailsFossilBa137Pb208)
```

```
### SVG images Bay of Sails Fossil
svg("bayOfSailsFossilInterstrialIncrementsLi7SpecPlot.svg", height = 3,
width = 5)
bayOfSailsFossilInterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsLi7Spec$coh, timevec
= bayOfSailsFossilInterstrialIncrementsLi7Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsMg26SpecPlot.svg", height =
3, width = 5)
bayOfSailsFossilInterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMg26Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsMg26Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsMn55SpecPlot.svg", height =
3, width = 5)
bayOfSailsFossilInterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMn55Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsMn55Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsBa137SpecPlot.svg", height =
3, width = 5)
bayOfSailsFossilInterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsBa137Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsBa137Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsPb208SpecPlot.svg", height =
3, width = 5)
bayOfSailsFossilInterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsPb208Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsPb208Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilLi7Mg26SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Mg26SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Mg26Spec$coh, timevec =
bayOfSailsFossilLi7Mg26Spec$mtime, scale =
bayOfSailsFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSailsFossilLi7Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Mn55SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Mn55Spec$coh, timevec =
bayOfSailsFossilLi7Mn55Spec$mtime, scale =
bayOfSailsFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSailsFossilLi7Ba137SpecPlot.svg", height = 3, width = 5)
```

```
bayOfSailsFossilLi7Ba137SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Ba137Spec$coh, timevec =
bayOfSailsFossilLi7Ba137Spec$mtime, scale =
bayOfSailsFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
svg("bayOfSailsFossilLi7Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Pb208Spec$coh, timevec =
bayOfSailsFossilLi7Pb208Spec$mtime, scale =
bayOfSailsFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
svg("bayOfSailsFossilMg26Mn55SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilMg26Mn55SpecPlot <-
cnltspec.plot(bayOfSailsFossilMg26Mn55Spec$coh, timevec =
bayOfSailsFossilMg26Mn55Spec$mtime, scale =
bayOfSailsFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
svg("bayOfSailsFossilMg26Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilMg26Ba137SpecPlot <-
cnltspec.plot(bayOfSailsFossilMg26Ba137Spec$coh, timevec =
bayOfSailsFossilMg26Ba137Spec$mtime, scale =
bayOfSailsFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilMg26Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilMg26Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilMg26Pb208Spec$coh, timevec =
bayOfSailsFossilMg26Pb208Spec$mtime, scale =
bayOfSailsFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilMn55Ba137SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilMn55Ba137SpecPlot <-
cnltspec.plot(bayOfSailsFossilMn55Ba137Spec$coh, timevec =
bayOfSailsFossilMn55Ba137Spec$mtime, scale =
bayOfSailsFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilMn55Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilMn55Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilMn55Pb208Spec$coh, timevec =
bayOfSailsFossilMn55Pb208Spec$mtime, scale =
bayOfSailsFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilBa137Pb208SpecPlot.svg", height = 3, width = 5)
bayOfSailsFossilBa137Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilBa137Pb208Spec$coh, timevec =
bayOfSailsFossilBa137Pb208Spec$mtime, scale =
bayOfSailsFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "" )
dev.off()
```

```
svg("bayOfSailsFossilInterstrialIncrementsLi7SpecPhasePlot.svg", height
= 3, width = 5)
bayOfSailsFossilInterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsLi7Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsLi7Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsMg26SpecPhasePlot.svg",
height = 3, width = 5)
bayOfSailsFossilInterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMg26Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsMg26Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsMn55SpecPhasePlot.svg",
height = 3, width = 5)
bayOfSailsFossilInterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMn55Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsMn55Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsBa137SpecPhasePlot.svg",
height = 3, width = 5)
bayOfSailsFossilInterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsBa137Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsBa137Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilInterstrialIncrementsPb208SpecPhasePlot.svg",
height = 3, width = 5)
bayOfSailsFossilInterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsPb208Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsPb208Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
svg("bayOfSailsFossilLi7Mg26SpecPhasePlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Mg26SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Mg26Spec$phase, timevec =
bayOfSailsFossilLi7Mg26Spec$mtime, scale =
bayOfSailsFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSailsFossilLi7Mn55SpecPhasePlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Mn55Spec$phase, timevec =
bayOfSailsFossilLi7Mn55Spec$mtime, scale =
bayOfSailsFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
svg("bayOfSailsFossilLi7Ba137SpecPhasePlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Ba137Spec$phase, timevec =
```

```
bayOfSailsFossilLi7Ba137Spec$mtime, scale =
bayOfSailsFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
svg("bayOfSailsFossilLi7Pb208SpecPhasePlot.svg", height = 3, width = 5)
bayOfSailsFossilLi7Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Pb208Spec$phase, timevec =
bayOfSailsFossilLi7Pb208Spec$mtime, scale =
bayOfSailsFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
svg("bayOfSailsFossilMg26Mn55SpecPhasePlot.svg", height = 3, width = 5)
bayOfSailsFossilMg26Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMg26Mn55Spec$phase, timevec =
bayOfSailsFossilMg26Mn55Spec$mtime, scale =
bayOfSailsFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
svg("bayOfSailsFossilMg26Ba137SpecPhasePlot.svg", height = 3, width =
5)
bayOfSailsFossilMg26Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMg26Ba137Spec$phase, timevec =
bayOfSailsFossilMg26Ba137Spec$mtime, scale =
bayOfSailsFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilMg26Pb208SpecPhasePlot.svg", height = 3, width =
5)
bayOfSailsFossilMg26Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMg26Pb208Spec$phase, timevec =
bayOfSailsFossilMg26Pb208Spec$mtime, scale =
bayOfSailsFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilMn55Ba137SpecPhasePlot.svg", height = 3, width =
5)
bayOfSailsFossilMn55Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMn55Ba137Spec$phase, timevec =
bayOfSailsFossilMn55Ba137Spec$mtime, scale =
bayOfSailsFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilMn55Pb208SpecPhasePlot.svg", height = 3, width =
5)
bayOfSailsFossilMn55Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMn55Pb208Spec$phase, timevec =
bayOfSailsFossilMn55Pb208Spec$mtime, scale =
bayOfSailsFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
svg("bayOfSailsFossilBa137Pb208SpecPhasePlot.svg", height = 3, width =
5)
bayOfSailsFossilBa137Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilBa137Pb208Spec$phase, timevec =
bayOfSailsFossilBa137Pb208Spec$mtime, scale =
bayOfSailsFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "" )
```

```
dev.off()

### PNG images Bay of Sails Fossil
png("bayOfSailsFossilInterstrialIncrementsLi7SpecPlot.png", height = 3,
width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsLi7SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsLi7Spec$coh, timevec
= bayOfSailsFossilInterstrialIncrementsLi7Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsMg26SpecPlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsMg26SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMg26Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsMg26Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsMn55SpecPlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsMn55SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMn55Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsMn55Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsBa137SpecPlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsBa137SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsBa137Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsBa137Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsPb208SpecPlot.png", height =
3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsPb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsPb208Spec$coh,
timevec = bayOfSailsFossilInterstrialIncrementsPb208Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilLi7Mg26SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSailsFossilLi7Mg26SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Mg26Spec$coh, timevec =
bayOfSailsFossilLi7Mg26Spec$mtime, scale =
bayOfSailsFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSailsFossilLi7Mn55SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSailsFossilLi7Mn55SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Mn55Spec$coh, timevec =
bayOfSailsFossilLi7Mn55Spec$mtime, scale =
```

```
bayOfSailsFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSailsFossilLi7Ba137SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSailsFossilLi7Ba137SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Ba137Spec$coh, timevec =
bayOfSailsFossilLi7Ba137Spec$mtime, scale =
bayOfSailsFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
png("bayOfSailsFossilLi7Pb208SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSailsFossilLi7Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilLi7Pb208Spec$coh, timevec =
bayOfSailsFossilLi7Pb208Spec$mtime, scale =
bayOfSailsFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
png("bayOfSailsFossilMg26Mn55SpecPlot.png", height = 3, width = 5, unit
= "in", res = 600)
bayOfSailsFossilMg26Mn55SpecPlot <-
cnltspec.plot(bayOfSailsFossilMg26Mn55Spec$coh, timevec =
bayOfSailsFossilMg26Mn55Spec$mtime, scale =
bayOfSailsFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
png("bayOfSailsFossilMg26Ba137SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilMg26Ba137SpecPlot <-
cnltspec.plot(bayOfSailsFossilMg26Ba137Spec$coh, timevec =
bayOfSailsFossilMg26Ba137Spec$mtime, scale =
bayOfSailsFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilMg26Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilMg26Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilMg26Pb208Spec$coh, timevec =
bayOfSailsFossilMg26Pb208Spec$mtime, scale =
bayOfSailsFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilMn55Ba137SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilMn55Ba137SpecPlot <-
cnltspec.plot(bayOfSailsFossilMn55Ba137Spec$coh, timevec =
bayOfSailsFossilMn55Ba137Spec$mtime, scale =
bayOfSailsFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilMn55Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilMn55Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilMn55Pb208Spec$coh, timevec =
bayOfSailsFossilMn55Pb208Spec$mtime, scale =
```

```
bayOfSailsFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilBa137Pb208SpecPlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilBa137Pb208SpecPlot <-
cnltspec.plot(bayOfSailsFossilBa137Pb208Spec$coh, timevec =
bayOfSailsFossilBa137Pb208Spec$mtime, scale =
bayOfSailsFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "" )
dev.off()

png("bayOfSailsFossilInterstrialIncrementsLi7SpecPhasePlot.png", height
= 3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsLi7SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsLi7Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsLi7Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsLi7Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsMg26SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsMg26SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMg26Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsMg26Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMg26Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsMn55SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsMn55SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsMn55Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsMn55Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsMn55Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsBa137SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsBa137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsBa137Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsBa137Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsBa137Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilInterstrialIncrementsPb208SpecPhasePlot.png",
height = 3, width = 5, unit = "in", res = 600)
bayOfSailsFossilInterstrialIncrementsPb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilInterstrialIncrementsPb208Spec$phase,
timevec = bayOfSailsFossilInterstrialIncrementsPb208Spec$mtime, scale =
bayOfSailsFossilInterstrialIncrementsPb208Spec$mscale, axis4 = TRUE,
SFratio = 2, xtitle = "")
dev.off()
png("bayOfSailsFossilLi7Mg26SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilLi7Mg26SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Mg26Spec$phase, timevec =
bayOfSailsFossilLi7Mg26Spec$mtime, scale =
```

```
bayOfSailsFossilLi7Mg26Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSailsFossilLi7Mn55SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilLi7Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Mn55Spec$phase, timevec =
bayOfSailsFossilLi7Mn55Spec$mtime, scale =
bayOfSailsFossilLi7Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle =
"")
dev.off()
png("bayOfSailsFossilLi7Ba137SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilLi7Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Ba137Spec$phase, timevec =
bayOfSailsFossilLi7Ba137Spec$mtime, scale =
bayOfSailsFossilLi7Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
png("bayOfSailsFossilLi7Pb208SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilLi7Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilLi7Pb208Spec$phase, timevec =
bayOfSailsFossilLi7Pb208Spec$mtime, scale =
bayOfSailsFossilLi7Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
png("bayOfSailsFossilMg26Mn55SpecPhasePlot.png", height = 3, width = 5,
unit = "in", res = 600)
bayOfSailsFossilMg26Mn55SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMg26Mn55Spec$phase, timevec =
bayOfSailsFossilMg26Mn55Spec$mtime, scale =
bayOfSailsFossilMg26Mn55Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "")
dev.off()
png("bayOfSailsFossilMg26Ba137SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
bayOfSailsFossilMg26Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMg26Ba137Spec$phase, timevec =
bayOfSailsFossilMg26Ba137Spec$mtime, scale =
bayOfSailsFossilMg26Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilMg26Pb208SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
bayOfSailsFossilMg26Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMg26Pb208Spec$phase, timevec =
bayOfSailsFossilMg26Pb208Spec$mtime, scale =
bayOfSailsFossilMg26Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilMn55Ba137SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
bayOfSailsFossilMn55Ba137SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMn55Ba137Spec$phase, timevec =
bayOfSailsFossilMn55Ba137Spec$mtime, scale =
```

```
bayOfSailsFossilMn55Ba137Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilMn55Pb208SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
bayOfSailsFossilMn55Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilMn55Pb208Spec$phase, timevec =
bayOfSailsFossilMn55Pb208Spec$mtime, scale =
bayOfSailsFossilMn55Pb208Spec$mscale, axis4 = TRUE, SFratio = 2, xtitle
= "" )
dev.off()
png("bayOfSailsFossilBa137Pb208SpecPhasePlot.png", height = 3, width =
5, unit = "in", res = 600)
bayOfSailsFossilBa137Pb208SpecPhasePlot <-
cnltspec.plot(bayOfSailsFossilBa137Pb208Spec$phase, timevec =
bayOfSailsFossilBa137Pb208Spec$mtime, scale =
bayOfSailsFossilBa137Pb208Spec$mscale, axis4 = TRUE, SFratio = 2,
xtitle = "" )
dev.off()

#difference data for differenced Pearson correlations (note that
ontogeny is not differenced. ontogeny is proxied by striae number, so
# the differenced ontogeny all = 1 and therefore doesn't correlate.
differencedBayOfSails3BStriae <- diff(bayOfSails3B$interstrialDistance)
differencedBayOfSails3BLi7 <- diff(bayOfSails3B$Li7)
differencedBayOfSails3BMg26 <- diff(bayOfSails3B$Mg26)
differencedBayOfSails3BBa137 <- diff(bayOfSails3B$Ba137)
differencedBayOfSails3BBa137 <- diff(bayOfSails3B$Ba137)
differencedBayOfSails3BPb208 <- diff(bayOfSails3B$Pb208)

differencedBayOfSails4BStriae <- diff(bayOfSails4B$interstrialDistance)
differencedBayOfSails4BLi7 <- diff(bayOfSails4B$Li7)
differencedBayOfSails4BMg26 <- diff(bayOfSails4B$Mg26)
differencedBayOfSails4BBa137 <- diff(bayOfSails4B$Ba137)
differencedBayOfSails4BBa137 <- diff(bayOfSails4B$Ba137)
differencedBayOfSails4BPb208 <- diff(bayOfSails4B$Pb208)

differencedBayOfSailsFossilStriae <-
diff(bayOfSailsFossil$interstrialDistance)
differencedBayOfSailsFossilOntogeny <-
diff(bayOfSailsFossil$striaeNumber)
differencedBayOfSailsFossilLi7 <- diff(bayOfSailsFossil$Li7)
differencedBayOfSailsFossilMg26 <- diff(bayOfSailsFossil$Mg26)
differencedBayOfSailsFossilBa137 <- diff(bayOfSailsFossil$Ba137)
differencedBayOfSailsFossilBa137 <- diff(bayOfSailsFossil$Ba137)
differencedBayOfSailsFossilPb208 <- diff(bayOfSailsFossil$Pb208)

differencedExplorersCove3BStriae <-
diff(explorersCove3B$interstrialDistance)
differencedExplorersCove3BLi7 <- diff(explorersCove3B$Li7)
differencedExplorersCove3BMg26 <- diff(explorersCove3B$Mg26)
differencedExplorersCove3BBa137 <- diff(explorersCove3B$Ba137)
differencedExplorersCove3BBa137 <- diff(explorersCove3B$Ba137)
differencedExplorersCove3BPb208 <- diff(explorersCove3B$Pb208)

differencedExplorersCove4BStriae <-
diff(explorersCove4B$interstrialDistance)
```

```
differencedExplorersCove4BLi7 <- diff(explorersCove4B$Li7)
differencedExplorersCove4BMg26 <- diff(explorersCove4B$Mg26)
differencedExplorersCove4BBa137 <- diff(explorersCove4B$Ba137)
differencedExplorersCove4BBa137 <- diff(explorersCove4B$Ba137)
differencedExplorersCove4BPb208 <- diff(explorersCove4B$Pb208)

differencedExplorersCoveFossilStriae <-
diff(explorersCoveFossil$interstrialDistance)
differencedExplorersCoveFossilOntogeny <-
diff(explorersCoveFossil$striaeNumber)
differencedExplorersCoveFossilLi7 <- diff(explorersCoveFossil$Li7)
differencedExplorersCoveFossilMg26 <- diff(explorersCoveFossil$Mg26)
differencedExplorersCoveFossilBa137 <- diff(explorersCoveFossil$Ba137)
differencedExplorersCoveFossilBa137 <- diff(explorersCoveFossil$Ba137)
differencedExplorersCoveFossilPb208 <- diff(explorersCoveFossil$Pb208)


## Pearson correlations of differenced data
### Bay of Sails 3B
cor.test(differencedBayOfSails3BStriae, differencedBayOfSails3BLi7,
method = "pearson")
cor.test(differencedBayOfSails3BStriae, differencedBayOfSails3BMg26,
method = "pearson")
cor.test(differencedBayOfSails3BStriae, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BStriae, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BStriae, differencedBayOfSails3BPb208,
method = "pearson")
cor.test(differencedBayOfSails3BLi7, differencedBayOfSails3BMg26,
method = "pearson")
cor.test(differencedBayOfSails3BLi7, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BLi7, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BLi7, differencedBayOfSails3BPb208,
method = "pearson")
cor.test(differencedBayOfSails3BMg26, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BMg26, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BMg26, differencedBayOfSails3BPb208,
method = "pearson")
cor.test(differencedBayOfSails3BBa137, differencedBayOfSails3BBa137,
method = "pearson")
cor.test(differencedBayOfSails3BBa137, differencedBayOfSails3BPb208,
method = "pearson")
cor.test(differencedBayOfSails3BBa137, differencedBayOfSails3BPb208,
method = "pearson")

### Bay of Sails 4B
cor.test(differencedBayOfSails4BStriae, differencedBayOfSails4BLi7,
method = "pearson")
cor.test(differencedBayOfSails4BStriae, differencedBayOfSails4BMg26,
method = "pearson")
cor.test(differencedBayOfSails4BStriae, differencedBayOfSails4BBa137,
method = "pearson")
```

```
cor.test(differencedBayOfSails4BStriae, differencedBayOfSails4BBa137,
method = "pearson")
cor.test(differencedBayOfSails4BStriae, differencedBayOfSails4BPb208,
method = "pearson")
cor.test(differencedBayOfSails4BLi7, differencedBayOfSails4BMg26,
method = "pearson")
cor.test(differencedBayOfSails4BLi7, differencedBayOfSails4BBa137,
method = "pearson")
cor.test(differencedBayOfSails4BLi7, differencedBayOfSails4BBa137,
method = "pearson")
cor.test(differencedBayOfSails4BLi7, differencedBayOfSails4BPb208,
method = "pearson")
cor.test(differencedBayOfSails4BMg26, differencedBayOfSails4BBa137,
method = "pearson")
cor.test(differencedBayOfSails4BMg26, differencedBayOfSails4BBa137,
method = "pearson")
cor.test(differencedBayOfSails4BMg26, differencedBayOfSails4BPb208,
method = "pearson")
cor.test(differencedBayOfSails4BBa137, differencedBayOfSails4BBa137,
method = "pearson")
cor.test(differencedBayOfSails4BBa137, differencedBayOfSails4BPb208,
method = "pearson")
cor.test(differencedBayOfSails4BBa137, differencedBayOfSails4BPb208,
method = "pearson")

### Bay of Sails Fossil
cor.test(differencedBayOfSailsFossilStriae,
differencedBayOfSailsFossilLi7, method = "pearson")
cor.test(differencedBayOfSailsFossilStriae,
differencedBayOfSailsFossilMg26, method = "pearson")
cor.test(differencedBayOfSailsFossilStriae,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilStriae,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilStriae,
differencedBayOfSailsFossilPb208, method = "pearson")
cor.test(differencedBayOfSailsFossilLi7,
differencedBayOfSailsFossilMg26, method = "pearson")
cor.test(differencedBayOfSailsFossilLi7,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilLi7,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilLi7,
differencedBayOfSailsFossilPb208, method = "pearson")
cor.test(differencedBayOfSailsFossilMg26,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilMg26,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilMg26,
differencedBayOfSailsFossilPb208, method = "pearson")
cor.test(differencedBayOfSailsFossilBa137,
differencedBayOfSailsFossilBa137, method = "pearson")
cor.test(differencedBayOfSailsFossilBa137,
differencedBayOfSailsFossilPb208, method = "pearson")
cor.test(differencedBayOfSailsFossilBa137,
differencedBayOfSailsFossilPb208, method = "pearson")
```

```
### Explorers Cove 3B
cor.test(differencedExplorersCove3BStriae,
differencedExplorersCove3BLi7, method = "pearson")
cor.test(differencedExplorersCove3BStriae,
differencedExplorersCove3BMg26, method = "pearson")
cor.test(differencedExplorersCove3BStriae,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BStriae,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BStriae,
differencedExplorersCove3BPb208, method = "pearson")
cor.test(differencedExplorersCove3BLi7, differencedExplorersCove3BMg26,
method = "pearson")
cor.test(differencedExplorersCove3BLi7,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BLi7,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BLi7,
differencedExplorersCove3BPb208, method = "pearson")
cor.test(differencedExplorersCove3BMg26,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BMg26,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BMg26,
differencedExplorersCove3BPb208, method = "pearson")
cor.test(differencedExplorersCove3BBa137,
differencedExplorersCove3BBa137, method = "pearson")
cor.test(differencedExplorersCove3BBa137,
differencedExplorersCove3BPb208, method = "pearson")
cor.test(differencedExplorersCove3BBa137,
differencedExplorersCove3BPb208, method = "pearson")

### Explorers Cove 4B
cor.test(differencedExplorersCove4BStriae,
differencedExplorersCove4BLi7, method = "pearson")
cor.test(differencedExplorersCove4BStriae,
differencedExplorersCove4BMg26, method = "pearson")
cor.test(differencedExplorersCove4BStriae,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BStriae,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BStriae,
differencedExplorersCove4BPb208, method = "pearson")
cor.test(differencedExplorersCove4BLi7, differencedExplorersCove4BMg26,
method = "pearson")
cor.test(differencedExplorersCove4BLi7,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BLi7,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BLi7,
differencedExplorersCove4BPb208, method = "pearson")
cor.test(differencedExplorersCove4BMg26,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BMg26,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BMg26,
differencedExplorersCove4BPb208, method = "pearson")
```

```
cor.test(differencedExplorersCove4BBa137,
differencedExplorersCove4BBa137, method = "pearson")
cor.test(differencedExplorersCove4BBa137,
differencedExplorersCove4BPb208, method = "pearson")
cor.test(differencedExplorersCove4BBa137,
differencedExplorersCove4BPb208, method = "pearson")

### Explorers Cove Fossil
cor.test(differencedExplorersCoveFossilStriae,
differencedExplorersCoveFossilLi7, method = "pearson")
cor.test(differencedExplorersCoveFossilStriae,
differencedExplorersCoveFossilMg26, method = "pearson")
cor.test(differencedExplorersCoveFossilStriae,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilStriae,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilStriae,
differencedExplorersCoveFossilPb208, method = "pearson")
cor.test(differencedExplorersCoveFossilLi7,
differencedExplorersCoveFossilMg26, method = "pearson")
cor.test(differencedExplorersCoveFossilLi7,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilLi7,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilLi7,
differencedExplorersCoveFossilPb208, method = "pearson")
cor.test(differencedExplorersCoveFossilMg26,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilMg26,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilMg26,
differencedExplorersCoveFossilPb208, method = "pearson")
cor.test(differencedExplorersCoveFossilBa137,
differencedExplorersCoveFossilBa137, method = "pearson")
cor.test(differencedExplorersCoveFossilBa137,
differencedExplorersCoveFossilPb208, method = "pearson")
cor.test(differencedExplorersCoveFossilBa137,
differencedExplorersCoveFossilPb208, method = "pearson")
```