Biogeography and Macroecology of Australian Marine Molluscs

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Coogee Bay, Queensland, Australia showing deposited bivalve shells during low tide. Photo: M R Kerr.

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For my parents

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Abstract

Latitudinal diversity gradients are the highest-order biodiversity patterns on Earth. Despite a large body of research into them, there is no consensus on their drivers. Furthermore, studies of latitudinal gradients tend to either ignore or simplify biogeographic structure in their analyses, despite the usefulness of biogeographic schemes in regional conservation planning. As such, there is a disconnect in our understanding of patterns of diversity and faunal composition. In this thesis I reach for a new synthesis, simultaneously establishing both biogeographic and macroecological patterns for a highly diverse group, marine molluscs, with a focus on the coastline of Australia. In the first chapter of this thesis, I give a brief account of how previous research has analysed the latitudinal diversity gradient. I also discuss various global and regional bioregionalisations and their varied methodological approaches. In the second chapter, I use factor analysis to produce a global biogeographic scheme for molluscs that improves on previous research by quantifying gradients between provinces. I then use these province definitions to examine the drivers of their boundaries, showing that as coral reefs become more common in an area its composition changes systematically. The third chapter then applies the same methods to a study of the coastline of Australia, producing a regional scheme that complements previous work. I use it to investigate spatial patterns of diversity around the continent, relating the observed changes in biogeographic structure to diversity patterns. I show that commonly flagged environmental correlates are only indirectly tied to diversity via their control of biogeographic transitions. In the following chapters I utilise a large field collection drawn from across the eastern coastline to quantify diversity. In the fourth chapter I compare the biogeographic and diversity patterns present in the field collection to those generated from routine macroecological datasets stemming from online databases. I find that latitudinal gradients are stronger in the field data, but there is much variance depending on the choice of diversity estimator and the inclusion or exclusion of observational data. In chapter five I show that despite large sample sizes and a rigorous study

design, there is no latitudinal signal in body size distributions or abundance data in the field data, contrary to previous work. The approaches taken in this thesis highlight how several generalisations about latitudinal diversity gradients do not apply to Australia. Instead, new methods applied to generating biogeographic schemes may help to explain the drivers of observed patterns. Additionally, these methods demonstrate how to retain more information in bioregionalisation schemes, potentially aiding future assessments of optimal marine reserve placement.

Statement of Originality

The work in this thesis, entitled *"Biogeography and Macroecology of Australian Marine Molluscs"*, has not previously been submitted for a degree or diploma in any university or institution.

To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself. Any help or assistance has been appropriately acknowledged.

No Ethics Committee approval was required. Fieldwork was carried out in New South Wales under a Section 37 Collection Permit (number P18/0013-1.0) and in Queensland under a Marine Park Permit (number MPP19-002001).

Matthew Roy Kerr

Candidate's statement about the impact of COVID-19 changes on the thesis.

Dear Examiner,

Many of our HDR candidates have had to make changes to their research due to the impact of COVID-19. Below you will find a statement from the candidate, approved by their Supervisory Panel, that indicates how their original research plan has been affected by COVID-19 restrictions. Relevant ongoing restrictions in place caused by COVID-19 will also be detailed by the candidate.

Thesis Title: Biogeography and Macroecology of Australian Marine Molluscs

Candidate Name: Matthew R Kerr

Department: Biological Sciences

Statement:

"An additional field season in 2020 was planned to add to the number of field sites discussed in chapters four and five of this thesis. Due to ongoing restrictions these 8 to 10 sites could not be visited, so fewer than intended are included in the analyses".

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Author Contributions

Primary Supervisor: John Alroy (Macquarie University)

Associate Supervisor: Matthew Kosnik (Macquarie University)

Contributor abbreviations:

MRK	Matthew Kerr	NC	Nicole Currie
JA	John Alroy	FW	Field volunteers (see below)
MAK	Matthew Kosnik		

Task	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Synthesis
Conception	MRK	MRK, JA	MRK, JA	MRK, MAK, JA	MRK, JA	MRK
Data collection	-	From databases	From databases	MRK, FW	MRK, FW	-
Data Processing	-	MRK	MRK	MRK, NC	MRK	-
Methods and Analysis	-	MRK	MRK	MRK	MRK, JA	-
Interpretation	-	MRK, JA	MRK, JA	MRK, MAK, JA	MRK, JA	-
Writing	MRK	MRK	MRK	MRK	MRK	MRK
Editing	MRK, JA	MRK, JA	MRK, JA	MRK, NC, MAK, JA	MRK, JA	MRK, JA

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Chapter One

Introduction

The Latitudinal Diversity Gradient

The cline in species diversity from the tropics to the poles, termed the "Latitudinal Diversity Gradient", has been a central focus of ecological research for decades (Pianka, 1966, Rohde, 1992, Blackburn and Gaston, 1996, Hillebrand, 2004). Despite the relatively large body of research on the formation and maintenance of the gradient (Hillebrand, 2004, Kinlock *et al.*, 2018), there is still a lack of consensus on a general cause. Several mechanisms arrayed in dichotomous pairs that are potential causes of the gradient have been presented, and they are fundamentally intertwined. These include proximal and distal causes; abiotic and biotic causes; and historical and equilibrial causes.

Proximal causes, meaning immediate causes, must involve speciation, extinction, and net diversification rates because diversity can only change if these rates also change. Specifically, researchers have invoked higher speciation rates and lower extinction rates in the tropics (Cardillo, 1999, Cerezer *et al.*, 2020). In these models, the tropics act as a "cradle", where new species are generated at a higher rate before dispersal out of the tropics, a "museum", where species persist for longer (Jablonski *et al.*, 2006, Arita and Vázquez-Domínguez, 2008, Moreau and Bell, 2013), or both (Moreau and Bell, 2013). Marine fishes, however, show an inverse gradient of speciation rates from what is predicted (Rabosky *et al.*, 2018) and some bird groups do not show a latitudinal gradient in speciation rates (Rabosky *et al.*, 2015).

Distal causes are intertwined with these. Specifically, changes in the environment should result in changes in diversification rates. The species-energy effect is widely discussed. In one form of this model, energy availability in the form of solar radiation may foster higher diversification rates in the tropics through control of mutation rates (Cardillo, 1999, Allen *et al.*, 2006, Wright *et al.*, 2006). Alternatively, higher energy in the tropics may influence richness by increasing the abundance of species on average and thereby decreasing extinction rates (Currie and Fritz, 1993, Currie *et al.*, 2004, Yee and Juliano, 2007, Weiser *et* *al.*, 2018), but this is not a consistent pattern (Weiser *et al.*, 2018). Changes in climate through time (an abiotic mechanism) may act as a driving force, creating gradients in both terrestrial and marine spheres (Jablonski *et al.*, 2013, Barreto *et al.*, 2019, Saupe *et al.*, 2019), and temperature specifically has been found to be a correlate of diversity in many groups (Wang *et al.*, 2009, Tittensor *et al.*, 2010, Barneche *et al.*, 2019, McFadden *et al.*, 2019, Righetti *et al.*, 2019).

Biotic mechanisms also shape these rates, however. Immigrations of new taxa can cause both origination and extinction (Foote, 2000, Webb, 2006, Jackson and Sax, 2010, Rumpf *et al.*, 2019), and may act differently at different latitudes (Berke *et al.*, 2014). Long-term competition between groups causes displacement (Sepkoski, 1984, Sepkoski *et al.*, 2000, Alroy, 2004), and competitive interactions even within one group can shape its diversity history (Sepkoski, 1978, Sepkoski *et al.*, 2000). Additionally, it is worth mentioning "Rapoport's Rule" (Stevens, 1989) – the suggestion that species have smaller range sizes in the tropics, allowing them to coexist in greater numbers. This rule is now not considered to be generally applicable and is instead treated as a regional effect that does not operate at global or continental scales (Roy *et al.*, 1994, Rohde, 1996, Gaston *et al.*, 1998, Gaston and Chown, 1999).

Outside of these mechanisms, historical effects have been shown to preside in some systems (Fraser and Currie, 1996). Boundaries removed by ocean closures (Floeter *et al.*, 2008) and created through fault systems (Gottscho, 2016) both influence biotic movement, which is discussed above. The great age of the tropics has been suggested to have resulted in high diversity, allowing more time to reach equilibrium (Clarke and Crame, 2003) and more time for diversification to proceed even if it does not reach equilibrium. However, marine organisms have inhabited the tropics since the Cambrian and terrestrial organisms have done so since the mid-Palaeozoic. Equilibrium is reached too quickly for the exact age of a system that dates back before the Mesozoic to be of great importance (Alroy, 2008, 2010 Finally, larger geographic areas have also been shown to have higher diversity, both because they include more habitats (Rosenzweig, 2003) and because they lower extinction rates by allowing for larger geographic ranges (Keil *et al.*, 2018).

Quantifying the Latitudinal Diversity Gradient

A growing problem with synthesising knowledge about latitudinal gradients is the measurement of diversity itself. Menegotto and Rangel (2018) presented a latitudinal gradient of missing species richness, discussing the issues of incomplete sampling at low latitudes as an explanation for diversity patterns seen in some groups (such as bimodality in diversity, discussed in Chaudhary *et al.*, 2016, Saeedi *et al.*, 2019). Generally, studies of latitudinal diversity patterns tend to use counts of species occurrences ("raw richness" – e.g. Macpherson, 2002, Fuhrman *et al.*, 2008, Chaudhary *et al.*, 2016), which causes issues with incomplete and spatially biased sampling (Boakes *et al.*, 2010). This is of particular importance when combining several types of data – which can be the case when estimating diversity from online databases because they may combine ecological field data, observational data, and museum records (Lepczyk, 2005, Boakes *et al.*, 2010, Tittensor *et al.*, 2010, Beck *et al.*, 2014, Robinson *et al.*, 2018). In this thesis I use a series of methods to estimate diversity, accounting for undersampling in the datasets I explore. Methodologies used to generate richness estimates are varied (Bunge *et al.*, 2014, Alroy, 2020). I detail the methods used in each chapter and document how the results depend on them.

“Range-through” is an additional method used to estimate species richness, and it involves filling gaps in species distributions with presences (Boltovskoy, 1988). This is often used in treating linear distributions, such as those along coastlines (Roy *et al.*, 1994, Roy *et al.*, 1998, Jablonski *et al.*, 2013). These methods tend to produce large edge effects (Foote, 2000, Alroy, 2008). Thus, latitudinal gradients generated using this method tend to show large changes in richness caused by range boundary clustering (e.g. Roy *et al.*, 1998, Roy *et al.*, 2009), often attributed to biogeographic boundaries (Valentine, 1966, Roy *et al.*, 1994). As a result, this protocol will not be used in this thesis.

Some modern studies measure diversity using species distribution modelling (e.g. Gagné *et al.*, 2020) or occupancy modelling (e.g. Jarzyna and Jetz, 2017). These studies tend to be restricted to regional areas where data quality is high and fieldwork is routine. However, distribution modelling has produced high-quality diversity mapping at global scales (Gagné *et al.*, 2020). These approaches focus on taxa with deep historical sampling and existing high-quality data collection at large spatial scales, or work on multiple taxa concurrently to reach a consensus. As a result, methods like these are outside the scope of this thesis, which will focus on using new fieldwork to generate richness estimates for a group not targeted by systematic collection schemes in Australia, currently or historically.

Importance of Bioregionalisation

With the need to understand how species diversity will respond to changing global conditions, it is also important to understand potential effects on regional and global biogeography. Generally, biogeography refers to spatial groupings of communities having similar biotic composition – when this is mapped it is referred to as a “bioregionalisation”. Before discussing the importance of such schemes, it is important to understand the terminology used and the spatial scales involved. Taxonomies of biogeographic units have been established by many authors. For the purposes of this thesis I am basing the overall terminology on that of Spalding *et al.* (2007).

Realms are the largest biogeographic units, generally representing continental-scale areas. Realms have historically been of interest due to the fact that they capture obvious taxonomic differences (Wallace, 1876) and phylogenetic disparity (Holt *et al.*, 2013). In terms of taxonomic composition, realms show coherence at higher levels (Cox, 2001, Spalding *et al.*, 2007). *Provinces* are subdivisions of realms, representing splits within continents. Provinces are generally areas that share sets of endemic species (Briggs and Bowen, 2012, Costello *et al.*, 2017) and are defined in order to investigate species distributions, diversity, and evolution in regional studies (Roy *et al.*, 1994, Roy and Martien, 2001, Floeter *et al.*, 2008, Briggs and Bowen, 2012, Keith *et al.*, 2013). *Ecoregions* are generally the smallest biogeographic subunits, nested within provinces. Ecoregions tend to be of local and regional importance, normally delimited by ranges of individual species and affected by local processes (Spalding *et al.*, 2007). Ecoregions are generally the most useful for making conservation decisions (CSIRO, 1996, Whittaker *et al.*, 2005, Edgar *et al.*, 2014, Brito *et al.*, 2016).

The current primary use for bioregionalisation schemes is for conservation (Lourie and Vincent, 2004). Defining individual areas of endemism, with particular attention being paid to ecoregions containing protected species, has permitted the creation of protected area zonation schemes with biological relevance (CSIRO, 1996, Brown *et al.*, 2000, Roberts *et al.*, 2003, Commonwealth of Australia, 2005, Cook and Auster, 2007, Itsukushima and Shimatani, 2015). Regional schemes such as these tend to emphasise the importance of transitional zones, a feature that global studies tend to ignore. Transitional zones are areas of biogeographical mixing, where biota from different areas overlap (Morrone, 2020) and have been treated as distinct biogeographical areas (Ferro and Morrone, 2014), caused by including geographically overlapping areas with distinct evolutionary histories (King and Ebach, 2018, Hermogenes De Mendonça and Ebach, 2020). Transition zones therefore create an issue in traditional clustering analysis of regions, which may yield misleading interpretations because they instead assume sharp boundaries. Quantifying the extent of overlap in transition zones and retaining them for use in analyses will be an aim of this thesis.

In addition to regional studies, global studies defining realms and provinces are commonplace. Rather than focusing on conservation implications, these schemes focus on describing spatial changes in communities because of their innate interest and use in larger macroecological studies. The overall terrestrial scheme grew out of the one set out by Wallace

(1876), and it has been revisited several times (Holt *et al.*, 2013) with new analyses broadly confirming the same patterns (Procheş and Ramdhani, 2012, Rueda *et al.*, 2013, Alroy, 2019). Two major marine schemes are currently in use, that of Spalding *et al.* (2007), which combines several sources to reach a synthesis, and that of Costello *et al.* (2017), which uses a large global dataset of all animals.

Differences in bioregionalisation schemes tend to reflect the methodologies used. Numerical clustering methods are commonly used, but they can be problematic when sampling is incomplete and may be biased by variation in richness depending on the similarity metric (Castro-Insua *et al.*, 2018). Phylogenetic methods have proven effective in regional studies (Floeter *et al.*, 2008, Kulbicki *et al.*, 2014, Hazzi *et al.*, 2018), but tend to only be applied when groups are well-studied and have nearly complete species-level phylogenies. Additionally, a small number of schemes based on abiotic data exist (e.g. Oliver and Irwin, 2008). They are generally used to investigate and predict long-term changes in ocean conditions (Devred *et al.*, 2009).

Coastal Australia as a Study System

This thesis will primarily focus on coastal Australia, a system with a long history of bioregionalisation but a lack of continental-scale diversity studies. Hedley (1904) offered a regionalisation scheme and area nomenclature that is now used in almost every reference to Australian biogeography (Ebach, 2012). This scheme was refined by Bennett and Pope (1952, 1960), with particular attention being paid to the intertidal zone. Southern provinces have further been confirmed in quantitative studies (Waters *et al.*, 2010) and with phylogeographic studies (York *et al.*, 2008, Teske *et al.*, 2017). Recently, Ebach *et al.* (2013) provided a synthesis of marine and terrestrial bioregions which presented a similar number of marine provinces to those previously mentioned.

Many other studies have proposed a much smaller number of provinces for Australia. A scheme for marine gastropods suggested by Wilson and Allen (1971) divided Australia into northern and southern provinces with wide transition zones, a classification often repeated in molluscan handbooks (Wilson and Gillett, 1974) but rarely mentioned in biogeographical research. Interestingly, this regionalisation matches marine realms for Australia that are uncovered in global analyses of all taxa (Costello *et al.*, 2017). An additional regionalisation scheme was carried out with the aim of developing a marine park system for coastal Australia (Commonwealth of Australia, 2005). By contrast, it divides Australian waters into fifteen provinces and nine transitional zones.

Despite these biogeographic efforts and the high species diversity of coastal Australia, few regional studies have focused on the drivers of species diversity across the entirety of the coastline, making it an important and effectively novel study system. Instead, surveys tend to focus on reef systems, and particularly on the Great Barrier Reef and Indo-Pacific coral triangle (Hughes *et al.*, 2013, Keith *et al.*, 2013, Kulbicki *et al.*, 2014). The Reef Life Survey (Edgar and Stuart-Smith, 2014) has a large concentration of data for Australia, and it has been used in some macroecological studies (Edgar *et al.*, 2017, Barneche *et al.*, 2019) that generally have a global focus.

Aims and Applications

Synthesising knowledge of climate, biogeography, and patterns of species diversity is of growing importance as environmental conditions shift. This thesis presents a series of analyses, with an emphasis on combining biogeographic schemes and diversity patterns generated from both composite datasets and field studies. I focus on marine molluscs, a group that has often been used in biogeographical and macroecological research (Crame, 1993, Roy *et al.*, 2000, Roy and Martien, 2001, Jablonski *et al.*, 2006, Roy *et al.*, 2009, Belanger *et al.*, 2012, Jablonski *et al.*, 2013) but is underrepresented in global databases (Troudet *et al.*, 2017). Bivalves in particular have been used as environmental indicators (Carroll *et al.*, 2009), making them of particular relevance to ecosystem health, and they are easy to collect in large numbers in the field.

My thesis uses two major sources of data. The second and third chapters focus on a dataset downloaded from the Ocean Biogeographic Information System (OBIS – http://obis.org), an online dataset compiled from fieldwork, museum collections, citizen science programs, and observational data. The database contains over 2.7 million molluscan records globally, making it a useful tool for understanding molluscan macroecology. My fourth and fifth chapters additionally focus on a field dataset collected specifically for this project. This dataset is made up of 5,670 bivalve specimens from 16 sites along the eastern coastline of Australia.

To begin with, the second chapter establishes a global regionalisation scheme. Unlike the previous global schemes of realms and provinces mentioned above, I assign geographic cells to provinces using factor analysis. This methodology allows measuring gradients of species composition, and it differs from traditional clustering methods because it does not assume the existence of hard boundaries. This property makes it possible to explore provincial "transition zones" in detail. I compare this new scheme with existing global ones in addition to several regional arrangements, highlighting the differences between them and showing how my new approach could further the understanding of broad-scale compositional changes. Finally, I look at the relationship between abiotic conditions and geographic trends in factor scores to investigate the drivers of biogeography at the global scale.

Having established the use of factor analysis in biogeographical analysis, I then use it in the third chapter to investigate continental-scale biogeography in coastal Australia. After establishing a bioregionalisation, I quantify the latitudinal diversity gradient for marine molluscs across the continent using a similar dataset to that used in the global analysis. This chapter focus on multiple methods of quantifying diversity, improving on previous work that tends not to control for varying sampling intensity. The link between biogeographic factors, abiotic conditions, and species richness is then explored in detail to advance knowledge of the latitudinal diversity gradient.

In my fourth chapter, I focus on the eastern coastline of Australia and utilise data from fieldwork carried out over 20º of latitude. I quantify trends in diversity across the coastline, additionally looking into family-level compositional changes not only because they are intrinsically interesting but because they are a proxy for functional differences among the assemblages. I then compare this information to a dataset compiled from online databases similar to those used in previous chapters. I pay particular attention to showing how the strength of latitudinal gradients differs between datasets and how filtering online datasets may change interpretations.

Finally, my fifth chapter investigates the relationship between biomass, abundance, and diversity. I use a series of measurements from my field dataset to quantify body size and how it trends latitudinally. Additionally, I test the "more individuals hypothesis", looking at how trends in abundance vary in my field data. I finish by synthesising these two data types to offer a new perspective on species diversity along the eastern coastline of Australia.

This thesis aims to advance understanding of the relationship between biogeography and species diversity in a highly diverse system, the marine molluscan biota of Australia. The formation and maintenance of latitudinal gradients is slowly being understood for different organisms both globally and regionally. The integration of biotic information presented in this thesis helps to open a new avenue of research into this important macroecological phenomenon.

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Chapter Two

Coral reefs are the engine of global molluscan biogeography

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Abstract

Despite the contribution of coral reef habitats to maintaining diversity at all spatial scales, few have sought to include them in analyses of global biogeographic structure. Here we analyse a large global dataset of marine mollusc occurrences to investigate the drivers of such structures and how they relate to coral reef extent. Rather than using previous marine regionalisation schemes, we define a new objective arrangement using factor analysis. Areas sharing high scores on individual factors correspond to traditional biogeographic realms, allowing transitions between them to be analysed. The factor scores are regressed against temperature, depth, latitude, and the coral reef presence counts. The new biogeographic scheme emphasises large-scale gradients between areas and is substantially different to established ones. Coral reef presence counts can significantly predict the majority of global biogeographic structure for marine molluscs: temperature and depth account for variation within, and transitions among, very few regions. The large contribution of coral reefs to biogeographic structure, and not only biodiversity, implies that declining reef condition will alter global patterns of species distribution.

Introduction

Coral reef systems are among the most important habitats on Earth, housing up to a third of all marine species and contributing heavily to spatial patterns of species richness (Barneche *et al.*, 2019, Plaisance *et al.*, 2011). Reef areas are a central focus of global and regional biogeographic studies (Kulbicki *et al.*, 2014, Edgar and Stuart-Smith, 2014), and changes in reef health are a focal point of tropical marine conservation efforts (Bellwood *et al.*, 2019). Despite this, the role of coral reefs in maintaining global biogeographic structure has not been quantified, and inclusion of reef area in global analyses is restricted to studies of assemblage diversity (e.g., Barneche *et al.*, 2019).

Biogeographic regionalisation, meaning the division of geographic areas into subunits based on faunal composition, has long been used to investigate and explain current patterns of species distributions (Beaugrand *et al.*, 2002, Whittaker *et al.*, 2005, Ramette and Tiedje, 2007, Cracraft, 2015). In recent decades, such schemes have also been used to identify areas of conservation interest (Brito *et al.*, 2016, Lourie and Vincent, 2004). These schemes have been created many times over for individual countries or areas, and global schemes have been put forth for many groups since Alfred Russel Wallace first proposed one for the terrestrial sphere (Holt *et al.*, 2013, Wallace, 1876). These schemes are generally produced by combinations of species occurrences (Kreft and Jetz, 2010) or phylogenetic trees (Holt *et al.*, 2013, Sundue *et al.*, 2014), or by consolidating previous ones (Olson *et al.*, 2001).

In the marine realm, recent similar efforts have been undertaken. Spalding *et al.* (2007) provided a well-cited scheme that delimited 12 realms, 62 provinces, and 232 ecoregions and drew together regional knowledge. Costello *et al.* (2017) produced a recent global synthesis that utilised all marine taxa, defining thirty provinces that matched with endemic species counts and stood in contrast to terrestrial schemes. These schemes largely agreed on the overall patterns with respect to differences between oceans and across oceanic boundaries, but disagreed on the breaks present within oceans. Marine biogeographic schemes have also been produced with abiotic data alone (Oliver and Irwin, 2008, Devred *et al.*, 2007), and even suggested to track long term ecological changes (Devred *et al.*, 2009). However, these are not designed to reflect biotic conditions.

The relationship between biotic provincial boundaries and environmental conditions has been previously quantified. Belanger *et al.* (2012) were able to predict up to 99% of coastal structure using temperature alone across three different biogeographic schemes. At geological time scales, thermogeography has been shown to maintain biogeographic regions (Adey and Steneck, 2001). Hale (2010) found that salinity and latitude had strong effects on species biogeographic patterns in the northwestern Atlantic, and other studies have shown geophysical constraints on species distributions to be a major driver (Keith *et al.*, 2013).

These studies quantify biogeography using frameworks that assume biogeographic structure consists of strong boundaries, usually driven by large shifts in temperature or coastline shape. In this paper we investigate the drivers of global marine mollusc biogeography using an objective methodology. We generate a global regionalisation using factor analysis, which allows us to investigate biogeographic gradients without defining strict boundaries. We then analyse gradients, both among and within provinces, using a set of abiotic variables and counts of coral reef presence counts to determine the drivers of these biogeographic structures.

Material and Methods

Data

We downloaded all molluscan records from the Ocean Biogeographic Information System (OBIS) using the R package *robis* (Provoost and Bosch, 2020). We removed all records lacking a species name and checked each name against the World Register of Marine Species (WoRMS) using the R package *worms* (Holstein, 2018, WoRMS Editorial Board, 2018). This check removed synonyms, ensured that terrestrial species were not included, and removed placeholder species names (such as "sp.", country names, or single-letter names). Records were additionally removed if the latitude or longitude precision was not to at least one decimal place. Location data were checked by placing points onto a 10-metre resolution land map downloaded from Natural Earth (https://www.naturalearthdata.com/), and only points falling outside the land polygons were retained.

Occurrences were pooled into 703 equal-area hexagonal cells, with an area equal to a 2.5° radius hexagon at the equator, using the R package *dggridr* (Barnes, 2020), and then transformed into presence-absence data for biogeographic assessment. Species present in only one cell, as well as cells containing fewer than ten species, were removed prior to analysis, leaving 655 cells and 22,460 species.

We downloaded a global ocean bathymetric grid from the General Bathymetric Chart of the Oceans (GEBCO - gebco.net). The original data were at a 10 arc second resolution. For each hexagonal cell, we extracted the median, maximum, and minimum ocean depth. Ocean temperature anomaly data were constructed by taking the residuals of the observed temperature from a model of temperature on a latitudinal gradient. Temperature data were generated from the World Ocean Atlas (Locarnini *et al.*, 2018) using the R package *ocedata* (Kelley and Richards, 2020). Cell latitude and longitude values were based on the midpoint of each hexagon.

Coral reef data were generated by combining point occurrences from the Reef Life Survey (Edgar and Stuart-Smith, 2014) and the UN Environment Programme (UNEP-WCMC and WRI, 2018). To avoid counting reefs twice, cells included in the UNEP dataset were excluded from the Reef Life Survey dataset; the UNEP dataset has a better coverage of warm-water reefs. The number of reefs in each cell was counted and included as an additional variable in our analysis.

Province assignment

We used parallel analysis (Horn, 1965) as implemented in the R package *psych* (Revelle, 2017) to objectively determine the number of provinces. Parallel analysis compares the scree of factors with a randomly generated dataset of the same size and returns the suggested number of factors (Horn, 1965). Additionally, we created biogeographic schemes using the number of provinces (30) suggested in a recent global analysis of all marine taxa (Costello *et al.*, 2017). Finally, we assigned cells to biogeographic provinces using cluster analysis. For this step we used partitioning around medoids (PAM) clustering because it is robust to outliers in similarity data (Reynolds *et al.*, 2006, Schubert and Rousseeuw, 2019).

Regression models

In order to investigate possible drivers of provincial boundaries, we compared neighbouring pairs of cells. Each cell was matched to its nearest geographical neighbour. As a first step, the ranked differences in factor scores were regressed against the ranked differences in median water depth, median temperature anomaly, and latitude. In analysing the data for each factor, a given cell pair was excluded if the focal cell had a score lower than 0.001 on that factor. The choice of threshold here is arbitrary, setting it to a number approaching zero ensures province boundaries and province interiors are included in analysis. This analysis was repeated with each factor and with factor score cut offs of 0.05 and 0.01 to guarantee that the exact value was not important. An otherwise identical analysis was then run using coral reef counts instead of latitudinal differences. For this analysis, we only included the 352 cells that each contained at least one reef (Fig. S2.1).

Results

Province assignment

Parallel analysis indicated that 19 province were appropriate for this dataset, 11 fewer than suggested by a recent global analysis also relying heavily on molluscan data (Costello *et al.*, 2017) and half the number suggested by Spalding *et al.* (2007). Cluster analysis (Fig. 2.1) and factor analysis (Fig. 2.2) each placed provinces in broadly similar geographic locations.

Nonetheless, key differences between factor analysis and cluster analysis patterns are visible. In general, factor analysis describes boundaries between closely packed provinces with better resolution. For example, in the cluster analysis the closely connected Indo-Pacific province is represented by six overlapping provinces (Fig. 2.1a-c).

Regression models

When comparing neighbouring cells in a series of models, structures within 10 provinces could be significantly explained by changes in coral reef presence counts (Table 2.1). The majority of patterns could be explained only by the coral data, but structure within the province falling in the Arctic could additionally be explained by changes in depth. Patterns within the remaining provinces could not be explained by any variable in this analysis. When the factor threshold was raised, coral remained able to explain the largest number of provinces (Tables S2.1-2), but the total number of provinces explained by any variable was reduced. Under the scenario where thirty provinces were used, coral could explain 11 provinces (Table S2.3).

When latitude was used instead of coral reef presences the provinces falling in the Western Pacific, Equatorial, South Africa and Southern South America had scores that correlated with latitudinal changes. The Northern Australian province could not be explained significantly in either analysis. The province falling in the Gulf of Mexico could additionally be explained by changes in depth when latitude was used in the analysis.

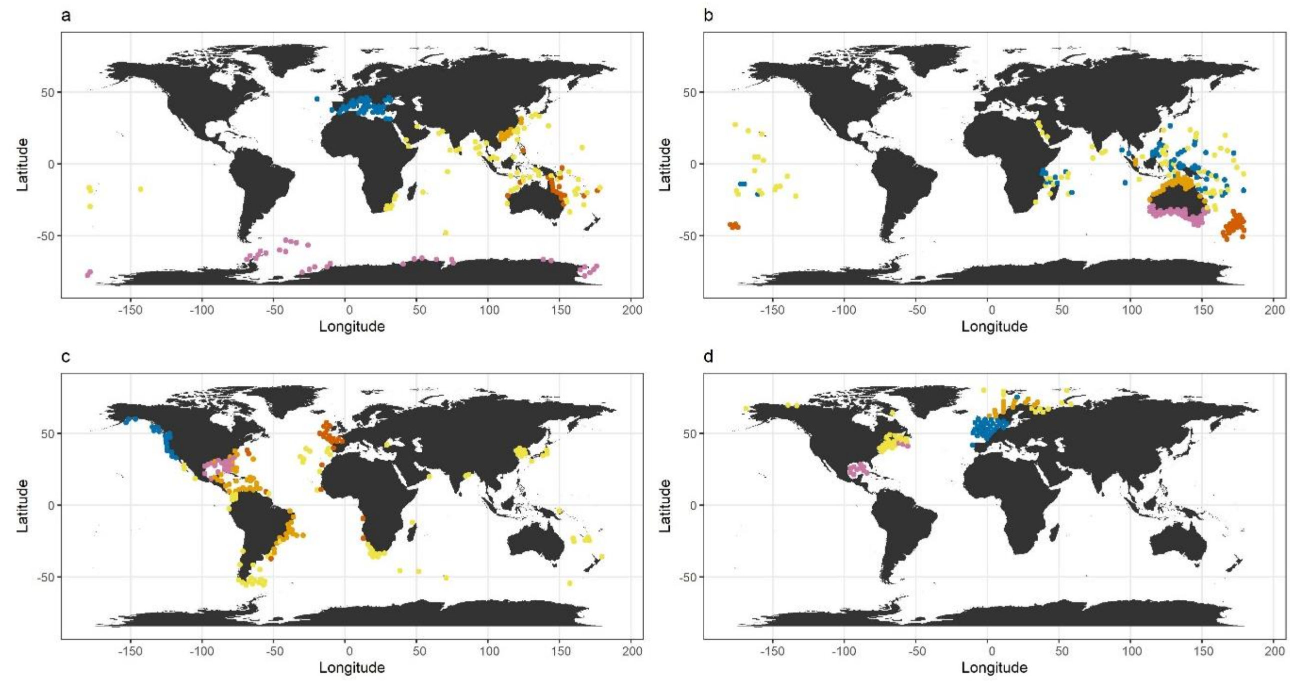

Figure 2.1. A global biogeographic scheme for marine molluscs, as determined by partitioning around medoids clustering. Nineteen provinces are shown to allow for comparison with the results of the factor analysis (Fig. 2.2), provinces are split across four panels for clarity. Data shown are for 2,192,702 molluscan specimens divided into hexagons with a radius equal to 2.5º at the equator. Colours represent individual provinces. Colour schemes in different panels are unrelated.

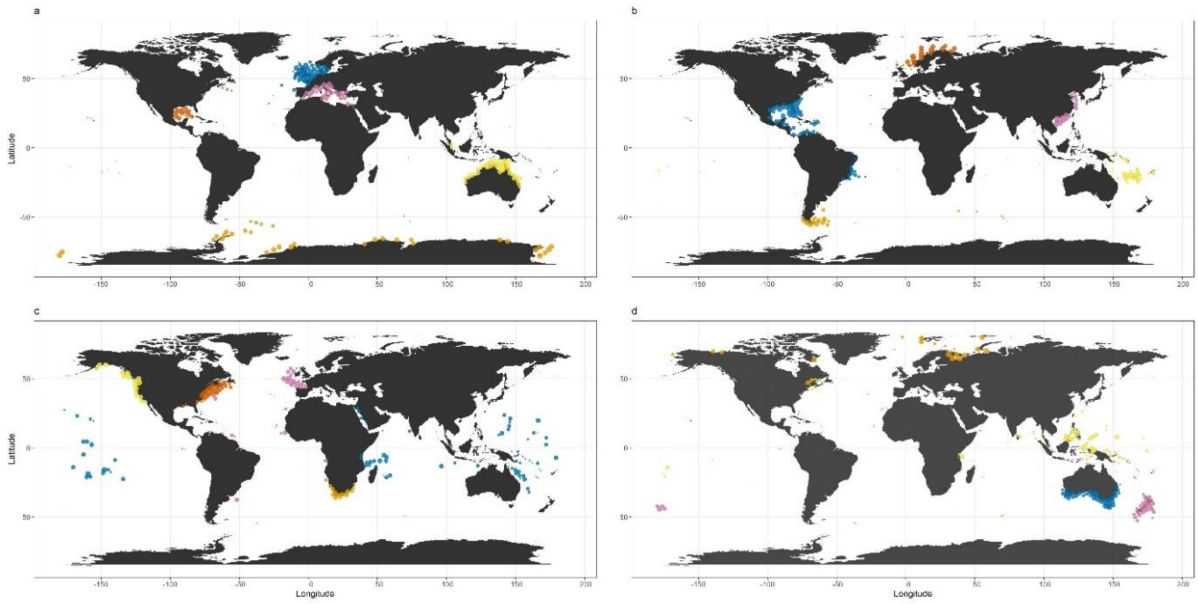

Figure 2.2. A global biogeographic scheme for marine molluscs, as determined by factor analysis. Nineteen provinces are shown, provinces are split across four panels for clarity. The number of factors was determined by a parallel analysis. Data shown are for 2,192,702 molluscan specimens divided into hexagons with a radius equal to 2.5º at the equator. Colours represent individual provinces. Colour schemes in different panels are unrelated. Each point is sized relative to the factor score for that cell. Colours overlap when a cell aligns with more than one factor. For clarity, only factor scores > 0.2 are indicated.

Table 2.1. Results of an analysis comparing changes in factor scores within a biogeographic province with changes in three abiotic variables. Each cell was compared to its nearest geographical neighbour and considered to fall within a province if it had a factor score > 0.001. Changes in factor scores were regressed against ranked changes in coral reef presence, temperature anomaly, and median depth statistics. Values shown are beta coefficients based on a linear regression; bolded values are significant (p < 0.01).

Province Name	Temperature	Depth	Coral
Arctic	-0.046	**-0.155**	0.122
Scandinavian	-0.019	0.033	**0.253**
North Sea	-0.004	-0.047	**0.374**
Mediterranean	-0.016	0.074	0.100
Eastern Atlantic	-0.142	0.056	0.095
Western Atlantic	-0.066	0.040	**0.199**
Eastern Pacific	0.003	-0.056	**0.286**
Western Pacific	-0.036	-0.043	**0.304**
Gulf of Mexico (Perimeter)	0.014	-0.086	**0.245**
Gulf of Mexico (Internal)	-0.034	0.043	**0.253**
Equatorial	0.008	0.023	**0.185**
Indo-Pacific	0.000	0.031	0.108
Pacific Islands	0.121	-0.026	0.124
North Australia	0.013	0.017	0.061
South Australia	-0.013	0.088	0.105
New Zealand	-0.135	-0.030	**0.255**
South Africa	0.074	0.031	0.069
Southern South America	-0.019	-0.112	**0.209**
Southern Ocean	0.001	-0.036	0.098

Table 2.2. Results of an analysis comparing changes in factor scores within a biogeographic province with changes in three abiotic variables. Each cell was compared to its nearest geographical neighbour and considered to fall within a province if it had a factor score > 0.001. Changes in factor scores were regressed against ranked changes in latitude, temperature anomaly, and median depth statistics. Values shown are beta coefficients based on a linear regression; bolded values are significant (p < 0.01).

Province Name	Latitude	Temperature Anomaly	Depth
Arctic	**0.261**	-0.056	-0.167
Scandinavian	0.194	0.009	-0.018
North Sea	**0.291**	0.204	-0.041
Mediterranean	**0.411**	-0.039	0.129
Eastern Atlantic	0.161	**-0.210**	0.162
Western Atlantic	**0.303**	-0.009	0.137
Eastern Pacific	**0.312**	0.023	0.052
Western Pacific	**0.214**	-0.131	0.118
Gulf of Mexico (Perimeter)	**0.382**	-0.018	-0.083
Gulf of Mexico (Internal)	**0.360**	-0.039	**0.178**
Equatorial	**0.172**	0.022	0.010
Indo-Pacific	**0.180**	-0.037	0.018
Pacific Islands	**0.179**	0.092	-0.053
North Australia	0.121	-0.012	0.078
South Australia	**0.322**	-0.025	0.059
New Zealand	**0.366**	-0.110	-0.002
South Africa	**0.271**	0.096	0.067
Southern South America	**0.368**	-0.028	-0.140
Southern Ocean	0.104	0.162	0.054

Discussion

Global molluscan biogeography

In this study we have described a new global biogeographic scheme for marine molluscs. Despite including fewer provinces than suggested in previous global studies of marine taxa, it should be noted that the current scheme does not reduce to lumping previously seen realms and provinces. Particularly, factor analysis more greatly emphasises the relationships between provinces and shows potential for aiding analyses of global biogeography. Many region-specific patterns are apparent.

Of particular interest is the uncovering of an equatorial province, containing sites in the Indian and Pacific oceans (Fig. 2.2). Something like this has been noted before (Valentine, 1973, Belanger *et al.*, 2012, Briggs and Bowen, 2012). However, we define a thin Indo-Pacific province that cuts through the middle of the region, similar to the Tropical Indo-Pacific province found by Costello *et al.* (2017) and the Central Indo-Pacific province in Spalding *et al.* (2007). Unlike these schemes, we find that this province is divided in two (Fig.2.1a, Fig.2a-b), forming tropical southwestern and western Indo-Pacific provinces. Factor analysis shows that there is mixing of these provinces, with mid-weighted factor scores for all three provinces converging in the "eastern coral triangle" province of Spalding *et al.* (2007); a centre of dispersal and diversity (Briggs, 1999) and a major cluster for regional corals (Keith *et al.*, 2013). Our province scheme exactly matches existing global (Costello *et al.*, 2017, Spalding *et al.*, 2007) and broad-scale regional (Keith *et al.*, 2013, Wilson and Allen, 1971, Commonwealth of Australia, 2005) schemes for Australia and the far south-western Pacific, with boundaries at this scale even matching some shown in continental-scale regionalisations (Ebach *et al.*, 2013).

In the Atlantic, our results suggest provinces that have large latitudinal spans. This differs to schemes shown for reef fish (Floeter *et al.*, 2008), which suggest multiple splits along either continental shelf. Unlike other global studies (Costello *et al.*, 2017, Spalding *et* *al.*, 2007), we do not find provinces than span the width of the Atlantic. Although we find no evidence for a separate tropical eastern Atlantic province, our data are not sufficient to reject such a province. In the mid-western Atlantic, we do find some separation between Caribbean island fauna and Gulf of Mexico fauna (Fig. 2.2a-b), but the two provinces are heavily mixed. The Gulf of Mexico separates into a coastal and open ocean province in the cluster analysis (Fig. 2.1c), which is similar to smaller-scale faunal studies (Shantharam and Baco, 2020) and not seen in global studies. Additionally, there is no support for a transition between the Gulf of Mexico and Carolinian provinces on the eastern coastline of North America (Engle and Summers, 2000). Northwestern Atlantic data are scarce, but do point towards a transition into a northern province (Fig. 2.2c, "Virginian" of Engle and Summers (2000)). For the northeastern Atlantic, our results match the global scheme of Costello *et al.* (2017), with a lack of data available to distinguish an inner Baltic Sea or Black Sea province (Fig. 2d). These provinces are also supported by palaeontological data (Haq and Lohmann, 1976).

In the Southern Ocean, we find support for a single circumpolar province but cannot distinguish between southern South American provinces (Fig. 2.2b). We similarly cannot distinguish a North American Boreal province (Costello *et al.*, 2017), and instead find only one province in the Arctic.

Engines of molluscan biogeography

When comparing neighbouring cells, coral reef counts explained structures within 10 provinces. This pattern remained if we changed our biogeographic scheme to match that of a recent global analysis (Costello *et al.*, 2017 – Table S2.3). Many of the provinces have boundaries close to the tropics of Capricorn and Cancer (approx. latitudes of -23.4 and 23.4, Figs. 2.1-2), but as they do not correspond with temperature trends, provincial boundaries here are likely driven by insolation because corals require consistent insolation at all times of the year (Penland *et al.*, 2004). Thus, corals have such a key role as habitat engineers that they influence biogeographic patterns in data sets not directly involving corals. Associations between coral reef presence and species richness have been previously noted (e.g. Barneche *et al.*, 2019), but this is the first time that a relationship with biogeographic structure has been shown.

We did find that latitudinal differences could significantly explain four factor score trends not explained by changes in coral. Regional studies that did incorporate other abiotic variables yielded similar results (Hale, 2010). Latitude is a major driver of habitat composition both regionally (within provinces) and globally (Barneche *et al.*, 2019, Williams *et al.*, 2010), and has strong links to species richness. As we quantified biogeography using factor analysis, we minimised the species richness signal in our schemes. As a result, the finding of a latitudinal signal is independently derived (Castro-Insua *et al.*, 2018). In contrast to Belanger *et al.* (2012), we find that only the Eastern Atlantic province has patterns in factor scores that can be explained by differences in temperature, despite having used schemes that superficially resemble those used in their analyses. Depth, previously cited as a key biogeographical driver at regional scales (Teso *et al.*, 2019, Shantharam and Baco, 2020), is also only a significant predictor in the Gulf of Mexico. Only one province's structure could not be explained by any abiotic variables in either analysis. As these provinces are very different in size and location, a larger set of variables might elucidate their determinants.

With reef conditions likely to change under future climate scenarios (Keith *et al.*, 2016), the effects on the distribution and survival of coral and reef-associated benthos have been considered (Pratchett *et al.*, 2018). Here we have shown that the global biogeographic structure of benthic organisms may additionally be subject to considerable alteration, in tandem with changes in diversity. For statistical reasons, these trends can only be seen using alternative methodologies for delimiting biogeographic provinces. Thus, factor analysis shows promise as a tool in biogeography. Research on different taxa using this tool is needed to test the hypothesis that coral reefs maintain not only biodiversity in general but biogeographic structure in particular.

Acknowledgments

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Supplementary Material

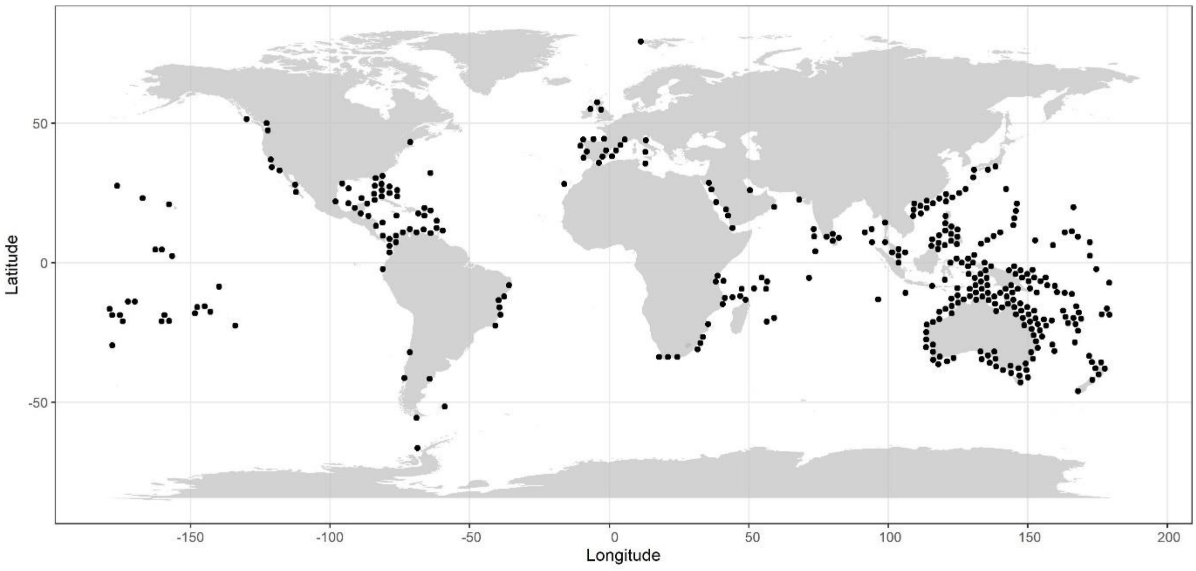

Figure S2.1 Location of cells that each contain at least one coral reef presence, as based on both the Reef Life Survey data set and the UN Environment Programme (see Material and Methods).

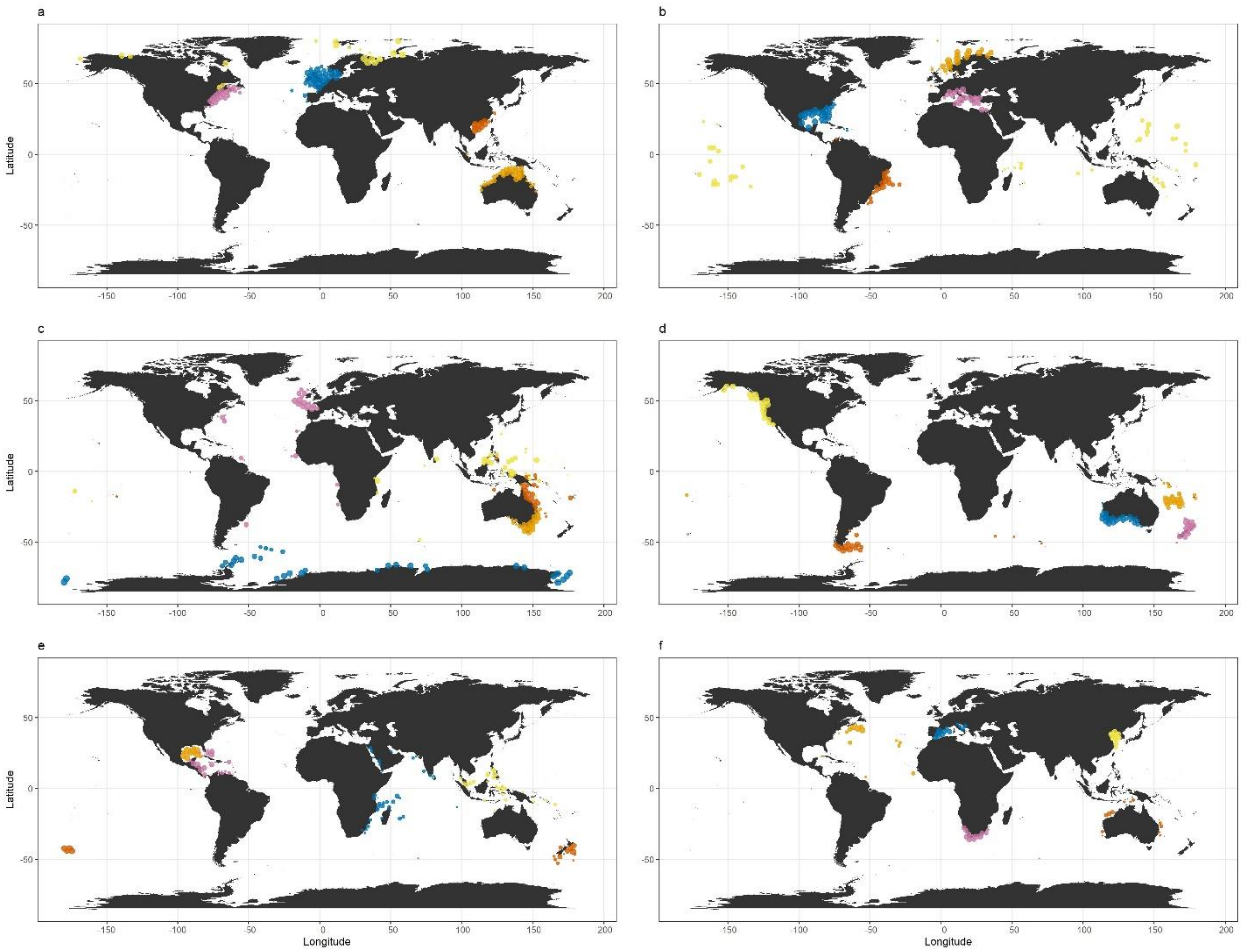

Figure S2.2 A global biogeographic scheme for marine molluscs, as determined by factor analysis. Thirty provinces are shown, i.e., the number proposed in a recent global analysis (Costello *et al.* 2017). Data shown are for 2,192,702 molluscan specimens divided into hexagons with a radius equal to 2.5º at the equator. Colours represent individual provinces. Colour schemes in different panels are unrelated. Each point is sized relative to the factor score for that cell. Colours overlap when a cell aligns with more than one factor. For clarity, only factor scores > 0.2 are indicated.

Table S2.1 Results of an analysis comparing changes in factor scores within a biogeographic province with changes in three abiotic variables. Each cell was compared to its nearest geographical neighbour and considered to fall within a province if it had a factor score > 0.01. Changes in factor scores were regressed against ranked changes in latitude, temperature anomaly, and median depth statistics. Values shown are beta coefficients based on a linear regression; bolded values are significant (p < 0.01).

Province Name	Temperature Anomaly	Depth	Coral
Arctic	-0.079	-0.178	0.131
Scandinavian	-0.003	-0.006	0.276
North Sea	0.161	-0.050	0.271
Mediterranean	-0.021	0.086	**0.236**
Eastern Atlantic	**-0.212**	0.176	0.108
Western Atlantic	-0.016	0.178	0.244
Eastern Pacific	0.031	0.031	0.289
Western Pacific	-0.058	-0.008	**0.363**
Gulf of Mexico (Perimeter)	-0.039	-0.155	**0.307**
Gulf of Mexico (Internal)	-0.046	0.109	**0.327**
Equatorial	0.033	0.066	0.175
Indo-Pacific	-0.038	0.010	0.112
Pacific Islands	0.106	-0.064	0.156
North Australia	0.001	0.078	0.043
South Australia	-0.013	0.111	-0.039
New Zealand	-0.109	0.046	**0.356**
South Africa	0.113	0.082	0.105
Southern South America	-0.040	-0.116	0.227
Southern Ocean	0.144	0.073	**0.476**

Table S2.2 Results of an analysis comparing changes in factor scores within a biogeographic province with changes in three abiotic variables. Each cell was compared to its nearest geographical neighbour and considered to fall within a province if it had a factor score > 0.05. Changes in factor scores were regressed against ranked changes in latitude, temperature anomaly, and median depth statistics. Values shown are beta coefficients based on a linear regression; bolded values are significant ($p < 0.01$).

Province Name	Temperature Anomaly	Depth	Coral
Arctic	-0.194	-0.265	0.132
Scandinavian	-0.102	-0.136	0.321
North Sea	0.241	-0.076	0.398
Mediterranean	-0.101	0.282	0.195
Eastern Atlantic	-0.244	0.212	0.083
Western Atlantic	-0.093	0.122	**0.571**
Eastern Pacific	-0.114	-0.001	0.235
Western Pacific	0.019	-0.015	**0.694**
Gulf of Mexico (Perimeter)	-0.036	-0.090	**0.314**
Gulf of Mexico (Internal)	0.092	-0.075	**0.622**
Equatorial	0.019	0.115	0.135
Indo-Pacific	-0.053	0.037	0.030
Pacific Islands	0.110	-0.143	0.151
North Australia	-0.038	-0.039	0.150
South Australia	0.079	0.005	-0.142
New Zealand	-0.397	0.216	0.069
South Africa	0.221	0.194	0.188
Southern South America	-0.163	-0.048	0.215
Southern Ocean	0.220	0.089	**0.712**

Table S2.3 Results of an analysis comparing changes in factor scores within a biogeographic province with changes in three abiotic variables. Thirty provinces are shown, i.e., the number proposed in a recent global analysis (Costello et al. 2017). Each cell was compared to its nearest geographical neighbour and considered to fall within a province if it had a factor score > 0.05. Changes in factor scores were regressed against ranked changes in latitude, temperature anomaly, and median depth statistics. Values shown are beta coefficients based on a linear regression; bolded values are significant ($p < 0.01$). Provinces in similar locations have references to panels in Fig. S2.2 in parentheses.

Province Name	Temperature Anomaly	Depth	Coral
Arctic	-0.034	-0.218	0.156
Scandinavian	0.197	-0.252	**0.356**
North Sea	0.017	-0.185	0.213
Mediterranean (S2.2b)	-0.034	0.051	0.228
Mediterranean (S2.2f)	0.080	0.031	**0.344**
Eastern Atlantic	0.249	-0.004	0.239
Atlantic (S2.2f)	-0.002	-0.067	**0.253**
North western Atlantic	-0.061	-0.111	0.217
South western Atlantic	0.143	0.012	0.206
Gulf of Mexico (Perimeter)	0.146	-0.032	**0.248**
Gulf of Mexico (Internal)	0.026	-0.035	0.057
Caribbean	0.177	-0.070	**0.343**
Equatorial	-0.056	0.008	0.177
Eastern Pacific	0.123	-0.117	**0.287**
East China Sea	0.087	-0.057	**0.269**
South China Sea	0.023	0.059	0.151
Indian Ocean	-0.102	0.045	0.118
Indo Pacific (S2.2c)	-0.033	-0.047	0.140
Indo Pacific (S2.2e)	-0.056	0.104	0.111
Pacific Islands	-0.038	0.017	0.104
Australia reef (S2.2f)	0.080	0.004	0.191
North Australia	0.031	0.013	**0.223**
North east Australia	0.103	-0.007	0.158
South east Australia	0.102	0.003	-0.044
South west Australia	0.036	0.082	0.132
New Zealand (S2.2d)	-0.017	**0.236**	0.168
New Zealand (S2.2e)	0.192	-0.119	0.194
South Africa	0.085	-0.141	**0.249**
Southern South America	0.201	0.154	**0.408**
Southern Ocean	0.165	-0.046	**0.396**

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Chapter Three

Marine diversity patterns in Australia are driven by biogeography, not the environment

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Abstract

Latitudinal diversity gradients are among the most striking patterns seen in nature, and has been observed in almost every group of living things. Despite a large body of work looking into both geographic and environmental drivers of gradients, biogeographical provinces have not been included in mathematical models of diversity patterns. Instead, geographic and spatial factors tend to focus on area and local-regional patterns. Here we investigate environmental and biogeographical controls on a latitudinal diversity pattern in Australian coastal molluscs. We use an online database of 300,210 specimens and quantify diversity using four methods to account for sampling variation. Additionally, we present a biogeographic scheme using factor analysis that allows for both gradients and sharp boundaries between clusters. Regardless of the measure used, diversity is not directly explained by combinations of abiotic variables. Instead, gradients in biogeographic factors better explain the diversity pattern seen. Biogeographic factors can in turn be explained by environmental variables, suggesting that environmental controls on diversity may be indirect. This is contrast to the species-energy hypothesis and suggests that future work should look more carefully at biogeographic gradients when investigating continental scale diversity patterns.

Introduction

Global patterns of species diversity are a central focus of ecological research. In particular, there has been substantial discussion of the decline in diversity going from tropical to temperate latitudes, a pattern seen in most major groups (Blackburn and Gaston, 1996, Hillebrand, 2004) and in the fossil record (Crame, 2020, Jablonski, Roy and Valentine, 2006, Jablonski *et al.*, 2013, Powell, 2007). Many explanations for this pattern focus on evolutionary drivers, with higher rates of speciation in the tropics (Cardillo, 1999, Jablonski *et al.*, 2006, Mittelbach *et al.*, 2007). However, higher rates of speciation at the poles (Rabosky *et al.*, 2018) and marginal effects of latitude (Rabosky, Title and Huang, 2015) have also been reported.

Geographic effects have also been found to control species richness in a number of taxa. At continental scales, however biogeographic boundaries affect species richness patterns. In North America, richness patterns of bivalves are stepwise and match provincial boundaries, (Roy *et al.*, 1994). Biogeographic boundaries have also acted as a control on temporal changes in diversity and species traits (Roy, 2001). In turn, geographic structures of marine benthic faunas have been strongly linked to environmental variables (Belanger et al., 2012).

Despite these references to biogeographic controls, recent studies do not include provinces in models of global biodiversity (Edgar *et al.*, 2017, Barneche *et al.*, 2019, McFadden *et al.*, 2019, Righetti, Vogt, Gruber, Psomas and Zimmermann, 2019, Saeedi, Costello, Warren and Brandt, 2019), despite the usefulness of province definitions for tracking species distributions and delineating protected areas (Smith, Hendershot, Nova and Daily, 2020). Instead, most references to geographic structure in species communities look into local-regional diversity patterns (for example; Caley and Schluter, 1997, Srivastava, 1999, Lessard, Belmaker, Myers, Chase and Rahbek, 2012) and are not directly concerned with controls on latitudinal gradients. Additionally, historical biogeographic effects on richness have been reported, but as a function of productivity and environment (Jetz and Fine, 2012) and not accounting for gradients in modern biogeographic structure.

The majority of the literature instead focuses only on environmental correlates, linking diversity to global variation in climate and productivity (Field *et al.*, 2008, Gagné *et al.*, 2020, Wang, Brown, Tang and Fang, 2009). Of particular interest is the consistent link between diversity and temperature (Rohde, 1992), often used as a proxy for solar energy and suggested to support higher diversification rates through fostering higher metabolism and mutation rates (Cardillo, 1999, Chaudhary, Saeedi and Costello, 2016, Costello and Chaudhary, 2017, Wright, Keeling and Gillman, 2006). Climate controls fluctuations in species richness through time, both in simulation (Saupe *et al.*, 2019) and with empirical data (Mayhew, Jenkins and Benton, 2008). Specifically, in the marine realm, temperature has been found to be the primary control on richness for a variety of marine groups (Barneche *et al.*, 2019, Edgar *et al.*, 2017, Fraser and Currie, 1996, Macpherson, 2002, Righetti *et al.*, 2019, Roy, Jablonski, Valentine and Rosenberg, 1998, Tittensor *et al.*, 2010), with nutrient levels also acting as a major control on macroinvertebrates (Edgar *et al.*, 2017) and benthic species in general (Macpherson, 2002). Depth also influences global marine biodiversity in the open ocean (Costello and Chaudhary, 2017, Gagné *et al.*, 2020, Saeedi *et al.*, 2019).

Here we test the hypothesis that biogeographic gradients, more directly govern molluscan richness in coastal Australia than does spatial variation in abiotic conditions. Australia is included in many global analyses, but rarely features in continental-scale biodiversity studies. We define provinciality using multivariate methods, not only to illustrate relationships but to showcase how diversity tracks province boundaries. We show using this approach that we are working with indistinct provincial boundaries. We then include the new province scheme for Australia in analytical models and test to see whether biogeography more directly controls diversity patterns than abiotic variables.

Material and Methods

Data

All molluscan records were downloaded from the Ocean Biodiversity Information System (OBIS) on 15th January 2020 using the *robis* package in R (Provoost and Bosch, 2020). Nomenclatural validity was checked by comparing taxa names to the World Register of Marine Species using the R package *worms*, ensuring that any non-marine species were excluded. Any record without a full species name was omitted, along with any record that did not have a latitude or longitude value resolved to at least two decimal places. Data were pooled into 0.5° cells, and any cell containing fewer than 10 species or fewer than 150 records (see Diversity Estimation) was excluded from the analysis. The final dataset from OBIS numbered 300,210 specimens of 6,323 species located in 233 cells.

As OBIS data only record presence and absence, which is only a proxy for absolute abundance, we used two datasets from the Reef Life Survey (RLS) to test our results. RLS is a global citizen science project, and it uses data collected by divers in training who survey transects in reef systems (Edgar and Stuart-Smith, 2014). RLS has a particular concentration of data from Australia. We downloaded the full dataset for fish and mobile macroinvertebrates and calculated richness and diversity in cells using the same methods as with the OBIS dataset. Results from these datasets mirror the results from the OBIS dataset: all the resulting maps and regression coefficients are in the Supplementary Material for this manuscript, with some comments on the results included in the main body of text. Because the RLS dataset focuses on reef environments and our goal is to examine the entire coastline of Australia, we focus here on the OBIS dataset.

Eight abiotic variables for the coastline of Australia were downloaded from the CSIRO Atlas of Regional Seas (Ridgway, Dunn and Wilkin, 2002: www.cmar.csiro.au/cars). These are mean annual sea surface temperature, yearly temperature standard deviation, mean annual salinity, yearly salinity standard deviation, mean annual dissolved oxygen content and mean annual nitrate, silicate, and phosphate content. The data consist of gridded mean ocean properties generated from a variety of data sources. For annual means we took the overall mean of the latest daily environmental layers. . To eliminate collinearity, abiotic variables were translated into loadings by varimax factor analysis (Kaiser, 1958, Spearman, 1904) using the function fa in the R package *psych* (Revelle, 2017). We prefer a multivariate method over a model selection approach as it preserves information in the form of factor loadings, instead of potentially excluding variables that are of biological interest. A three-factor solution was favoured based on parallel analysis and inspection of a scree plot (Fig. S1). Loading values for each abiotic factor are shown in Table S1.

Diversity estimation

Despite good overall geographical coverage of coastal Australia in this dataset, there is substantial variation in sample size between degree cells (Fig. S2). To account for the spatial bias inherent in using raw species counts as an estimate for species richness, we used a series of diversity and richness estimators. We assessed sample size by considering the number of presences for each species in each cell.

To guarantee the results were robust we used four different measures of diversity. First, we used species richness extrapolation. The Chao1 estimator (Chao, 1984) is widely used for this purpose. It yields similar results to the corrected jackknife (cJ1) equation of Alroy (2020). However, cJ1 is more stable (Supplementary Information), so we emphasise it in the main body of text. Second we applyFisher's α (Hubbell, 2015) which is typically used in studies of highly diverse systems (Hubbell, 2015, Slik *et al.*, 2015) and stable at increasing sample sizes. Third we used Simpson's D a common diversity estimator with no sample size influence (Hurlbert, 1971, Lande, 1996, Simpson, 1949). Finally, we use the analytical version (Chao and Jost, 2012) of shareholder quorum subsampling (SQS -Alroy, 2010a, Alroy, 2010b, Alroy, 2010c) to further account for sampling issues. We note that SQS is routinely referred to as coverage-based rarefaction (CBR) in the ecological literature, but not the palaeontological literature; and that the distinction between SQS and CBR is not conceptual but operational, as with the distinction between the original formulation of rarefaction (Sanders, 1968) and the analytical formulation (Hurlbert, 1971) that is now widely used.

Each of these methods reduces the effect of sample size on diversity estimates (Fig. S3) relative to using simple counts of species, which are common in large scale studies of diversity. Estimates do increase with sample size until around 150 individuals even for Fisher's alpha (Fig. S3), so any cells with fewer than 150 individuals were dropped from the analyses. To ensure consistency with previous studies using similar data, we also use face-value counts of species that are uncorrected for sampling variation. Analyses based on these counts yield the same model results as with the corrected data, but they show no latitudinal pattern. They are detailed in the supplement for this paper (Fig. S4, Table S2).

Biogeographic assignment

All analyses were carried out in R (R Core Team, 2018). Instead of using the constantly changing qualitative schemes of Australian marine biogeography (Commonwealth of Australia, 2005, Ebach *et al.*, 2013, Spalding *et al.*, 2007, WATERS *et al.*, 2010), objective bioregions were defined using the ecological data. We took two approaches to this problem. First, clusters were identified using partitioning around medoids (PAM) clustering (Park and Jun, 2009). PAM clustering generates more consistent clusters than k-means due to minimising the influence of outliers (Mächler, Rousseeuw, Struyf, Hubert and Hornik, 2012, Rousseeuw and Kaufman, 1990).

Second, loadings generated from a varimax factor analysis were used – cells which score highly on a similar factor can be considered to represent the same ecological space, with middling scores representing transition zones. The main text emphasises these results as they are more intuitive and , unlike PAM, test for both sharp ecological boundaries and smooth gradients. To guarantee cluster integrity, a correspondence analysis (Hill, 1973) was applied to the dataset and used to demonstrate the visibility of clusters.

Optimal factor counts were generated for each dataset using parallel analysis, which compares the scree patterns of factor eigenvalues with scree generated by a random data matrix of the same size (Horn, 1965). These values are highlighted over manual inspection of a scree plot as they are not subjective, although we include scree plots in the supplement for comparison. We implement both factor analysis and parallel analysis using the R package *psych* (Revelle, 2017).

Analysis

Spatial autoregressions were carried out to compare the generated richness values to both the abiotic variables and the abiotic factor scores, allowing for spatial autocorrelation in the abiotic scores. We used the implementation of models in the R package *spatialreg* (Bivand and Piras, 2015). An additional model was run that included the biogeographic loadings. Using factor scores as variables allowed provinciality to be included intuitively in the model because the resulting slopes reflect the strength of provincial signals . This analysis was then repeated with each richness metric, and for all cluster counts supported by the scree plot and parallel analysis. In addition to spatial autoregressions, we carried out linear multiple regressions. The results are included in the supplementary material, along with an analysis performed on unadjusted richness.

To further test the relationships between abiotic variables, biogeographic loadings, and diversity, we ran several additional multiple regressions. The key abiotic variables were chosen by identifying the variable with the highest loading on each of the three abiotic factors. Abiotic factors with the highest uniqueness values were also chosen because this means the variance of these variables was not explained by the factors. This resulted in a set of six key abiotic variables. Each dependent variable was then run in a multiple regression framework against each other variable in turn. Any significant relationship between two variables was recorded. Factor scores representing biological provinces were not run against each other as they are mathematically related – a high score in one province will generate a low score in other provinces.

To avoid circularity in the assignment of biogeographic provinces based purely on species distribution, a simulation was run that removed geographical distribution and focused on temperature. A temperature range for each species was generated from the data using the minimum and maximum annual temperature for each cell it occupied. A presence-absence matrix was then generated, filling each cell with species that overlapped in their temperature ranges and then sampled so that it contained the same number of species per cell as the original matrix. This created a simulated presence-absence matrix, where species presences are only controlled by temperature and not directly by geography. A factor analysis generated nominal biogeographical provinces for the sampled matrix, using the same number of provinces found in the real data. A regression model identical to the one used in the original analysis was then used to assess the relationship between simulated biogeography, temperature, and richness. As this process is stochastic, we repeated the subsampling process 10,000 times and recorded the variation in model results across replications.

Results

Species richness and biogeography

Australia exhibits a flattened diversity gradient, with high diversity in the tropics and a shallow decline southward (Fig. 3.1). Simpson's D and SQS indicate a slightly steeper drop for diversity on the southern coastline (Fig. 3.1). Overall, methods agree on the overall spatial diversity pattern. Face-value richness counts also give a latitudinal diversity gradient; however, it does not show as clear a latitudinal pattern (Fig. S3.4).

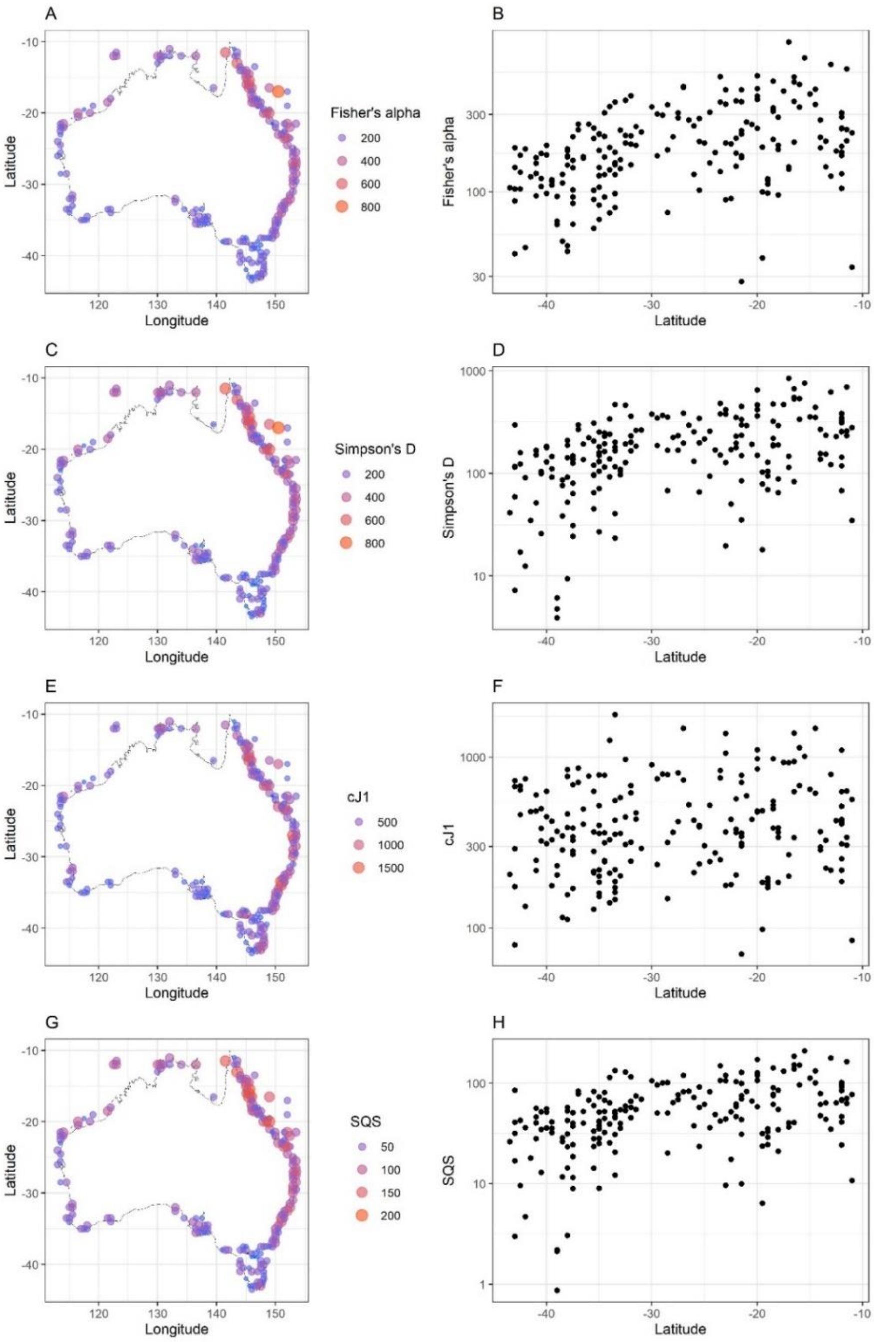

Figure 3.1: Spatial diversity patterns for Australian marine molluscs from the OBIS dataset, pooled into 0.5° cells. Four different methods are shown: Fisher's α(A and B), Simpson's D (C and D), the corrected first-order jackknife (cJ1 - E and F) and shareholder quorum subsampling (SQS – G and H). Point size and colour are scaled with diversity in A, C, E and G. The y-axis in each scatter plot is on a log scale for clarity.

Parallel analysis suggests there are five factors for the OBIS dataset, six for the RLS fish dataset and three for the RLS invertebrate dataset. Scree plots of the OBIS data suggest three factors are appropriate, so we have included this number in the main text. As parallel analysis is an objective method, we highlight these results in the main text. However, we have included the scree plots for all datasets in the supplementary material (Figs. S3.5-7).

These clusters are distinct from each other geographically (Fig. 3.2) and in ordination space (Fig. S3.8). All datasets show a broad northern and southern province spanning the western to eastern coastlines, with smaller subdivisions present along the eastern and south-eastern coastlines seen when higher cluster counts are considered. Factor analysis shows that although cluster cores are distinct, there are broad transition zones on the southern and western coastlines as provinces blend (Fig. 3.2, Fig. S3.9). Coastal northern and eastern provinces have much sharper boundaries, with a lower degree of blending (Fig. 3.2, Fig. S3.9). In the northeast, coastal and offshore reefal cells run in parallel over a large latitudinal extent when five provinces are visualised (Fig. 3.2b).

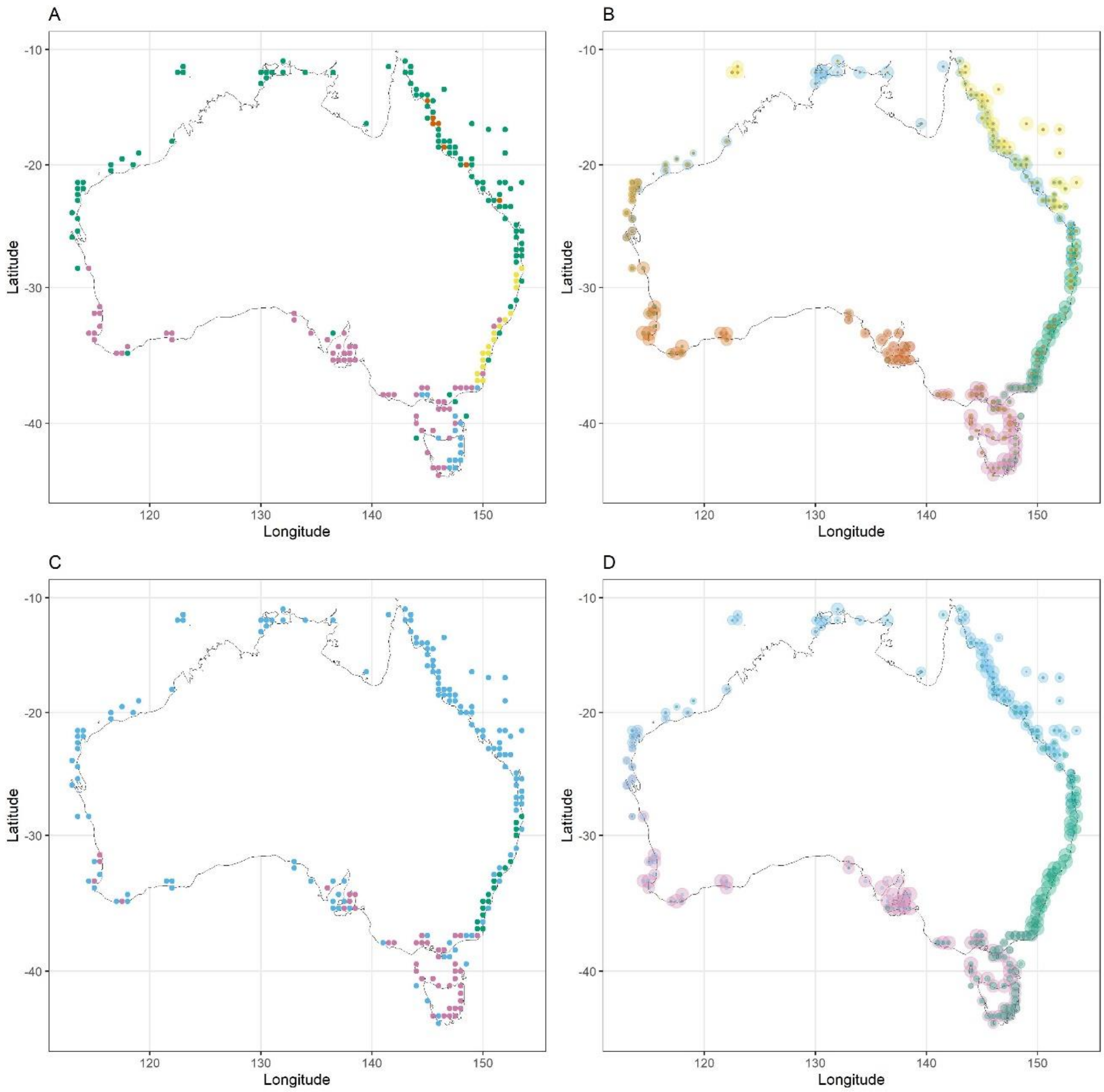

Figure 3.2: Marine provinces in Australia, determined by both a cluster analysis (A/C) and factor analysis (B/D) of ecological data extracted from OBIS. In B and D, each point on the map is scaled to the loading on each factor – a larger point shows a stronger loading. Areas where colours blend can be interpreted as transitionary zones between provinces. Five (A and B) and three (C and D) provinces are shown here – five provinces are the optimal number of factors chosen from parallel analysis, three provinces are suggested by a scree plot.

Analysis

When all abiotic variables were tested in one model, only annual temperature variation significantly explained the changes seen in species diversity for any dataset ($p < 0.01$). When combined into abiotic factors, factor one, with strong loadings of temperature variables and dissolved oxygen content, was the only one that could explain the richness pattern (Table 3.1), and only for estimates generated using the corrected jackknife equation. Variance explained by each model was low, between 9% (cJ1) and 15.7% (Simpson's D).

Diversity Estimate	**Abiotic Factor One**	**Abiotic Factor Two**	**Abiotic Factor Three**	**Adjusted R^2**
Fisher's α	0.0824	0.0462	0.0415	0.008
Simpson's D	0.1204	-0.0291	0.0013	0.000
Corrected jackknife	**0.1703**	0.0640	0.0597	0.068
SQS	0.1310	-0.0272	0.0120	0.0069

Table 3.1: Results from a series of general linear models of marine mollusc diversity against abiotic variables. Abiotic variables were collapsed into factors to avoid collinearity (for details of each factor see Table S3.1) and scaled so they are beta coefficients and therefore comparable. Values shown are slope estimates generated from the model; bolded values are significant ($p < 0.001$).

When the factor loadings for the biogeographic provinces were added as explanatory variables, the abiotic variables were no longer significant predictors of diversity patterns. Instead, factor loadings relating to the eastern, northern, and Great Barrier Reef provinces were significantly and positively related to diversity ($p < 0.01$: Table 3.2, Table S3.3). The combined analysis explained up to 46% of variation across the dataset. These results are comparable to those generated from the Reef Life Survey for fish (Table S3.4). The analysis of the RLS marine invertebrates (Table S3.5) suggested that the same variables are significant predictors, but they explained a much lower amount of variance.

When biogeographic factors were compared to abiotic factors in several multiple regressions, strong relationships were found for each one – but the important abiotic variables differed (Fig. 3.3). Temperature and dissolved oxygen content were significant for the western province and the south-eastern province, temperature and silica content were significant for the north-eastern coastal province, salinity variation was significant for the western province, and mean annual salinity was significant for the east-Tasmanian province. No environmental variable could significantly explain the Great Barrier Reef province.

When species ranges were simulated based on temperature rather than geographic position, biogeographic provinces formed east-west bands (Fig. S3.11). Temperature became a significant predictor across trials, but biogeography remained significant.

Diversity Estimate	Province One	Province Two	Province Three	Province Four	Province Five	Abiotic Factor One	Abiotic Factor Two	Abiotic Factor Three	Adjusted R^2
Fisher's α	0.106	**1.538**	**1.661**	**1.979**	0.498	0.068	-0.023	0.049	0.440
Simpson's D	-0.370	**1.859**	**1.823**	**2.281**	0.901	0.125	-0.100	0.021	0.317
Corrected jackknife	**1.183**	**2.412**	**2.101**	**2.266**	0.782	0.116	-0.028	0.045	0.460
SQS	0.174	**1.914**	**1.862**	**2.218**	0.819	0.112	-0.048	0.013	0.366

Table 3.2: Results of a series of general linear model regressions of marine mollusc diversity against biogeographic factors ("Provinces" - see main text) and abiotic variables. Abiotic variables were collapsed into factors to avoid collinearity (for details of each factor see Table S3.1) and scaled so they are comparable. A five-factor biogeographic solution is shown; for a three-factor solution see Table S3.3. Values shown are slope estimates generated from the model; bolded values are significant ($p < 0.001$).

Discussion

The latitudinal diversity pattern in Australia is strikingly different to those seen on other continents and at the global scale (Chaudhary *et al.*, 2016, Roy, Jablonski and Valentine, 1994, Tittensor *et al.*, 2010). Rather than the stepwise pattern observed in similar taxa on both coastlines in North America (Roy *et al.*, 1994) there is a gradual decline. Diversity is different on the eastern and western coastlines. In contrast to global studies, the gradient is very shallow, with a smaller difference between tropical and temperate areas. The abiotic variables we used could significantly explain diversity patterns, but they explained a much lower amount of variation than found in some studies: for example, Tittensor *et al.* (2010) obtained a pseudo-R^2 of 70 to 90 for multiple groups using global data.

The provinces we present here are generally similar to existing schemes for marine Australia (Ebach *et al.*, 2013), with the Great Barrier Reef as a separate province to coastal

Australia, a broad northern province, and several smaller provinces in the south-east. At a broader scale, the data support the north-south divide shown by both global regionalisation studies (Costello *et al.*, 2017) and local molluscan provincial definitions (Wilson and Allen, 1971). Despite this similarity, our factor analysis approach reveals the relationship between the provinces in greater detail. Province boundaries in coastal Australia are not sharp, instead presenting transition zones that cover a few degrees of latitude.Nonetheless they are smaller than the zones previously illustrated in continental maps (Commonwealth of Australia, 2005). When only two factors are used, transition zones are both smaller and farther north than suggested by local studies on molluscs (Wilson and Allen, 1971). Studies on eastern Australian corals also point to a broad transition zone around the same latitude (Sommer *et al.* 2014). Cluster analysis reveals similar province distributions to the factor analysis. However, the clusters are rarely geographically consistent and fail to define sharp boundaries at this scale accurately, as they are meant to do. This effect is easily seen when three clusters are used: cluster analysis cannot resolve the southern coastline as belonging to either province, whereas factor analysis reduces the uncertainty in the dataset (Fig. 3.2).

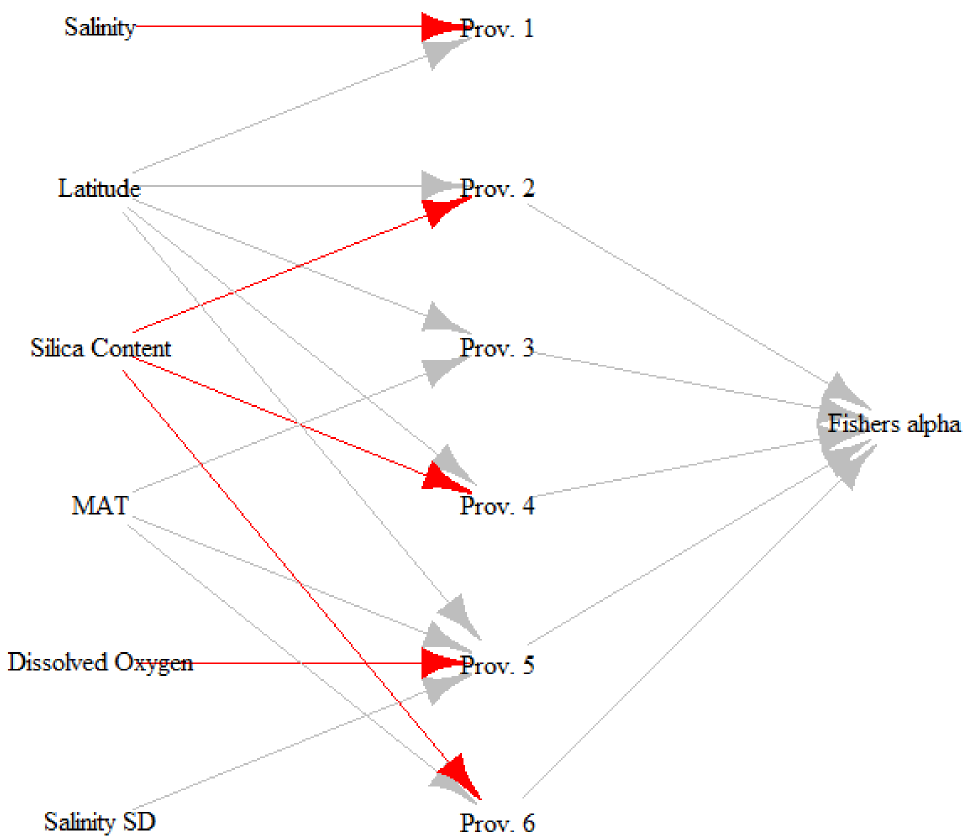

Figure 3.3: Relationships between biogeographic provinces, diversity (based on Fisher's α) and environmental variables. Relationships were derived from a series of multiple regressions; a red arrow shows a significant negative relationship ($p < 0.01$) and a grey arrow shows a significant positive relationship. MAT = Mean Annual Sea Surface Temperature, SD = Annual Standard Deviation and provinces are as follows: 1 (Eastern Tasmania), 2 (North and northeastern Australia), 3 (Southeastern Australia), 4 (Great Barrier Reef), 5 (South and southwestern Australia), 6 (Northeastern Australia).

Defining provinces with a factor analysis also allows them to be included in a model in an intuitive way. When added into models, province loadings become the only significant explanatory variable, with no environmental variable significantly explaining richness. Although diversity has been related to biogeographic boundaries before (Roy *et al.*, 1994) and biogeographic boundaries have been related to environmental variables (Belanger *et al.*, 2012), there have been no studies resolving the relationships amongst the three. Here we show that the biogeographic factors can be explained primarily by the environmental variables – although the relationships are inconsistent and different environmental variables correlate with different biogeographic factors (Fig. 3.3). This is expected, as molluscan distribution is controlled by environment and current regimes (Johnson, Allcock, Pye, Chambers and Fitton, 2001, Martel and Chia, 1991, O'Connor *et al.*, 2007). The biogeographic regions remain significant predictors of diversity even under a simulation that removes east-west biogeography. Therefore province boundaries reflect abiotic conditions and richness in turn is controlled by major province boundaries. The mechanism may be that the same species pool is sampled throughout each province, resulting in uniform richness values.

We managed to recreate this result with two completely different datasets and groups of organisms – reef fish and macroinvertebrates. Both were previously tested with environmental variables alone (Barneche *et al.*, 2019). As biogeographic factors explain twice as much variation in diversity as environmental factors, both environmental ranges of individual species and historical effects likely maintain the diversity pattern we see here.

In sum, we show here that temperature, often cited as a major control on species diversity gradients, does not directly control species diversity at a continental scale and instead has an indirect influence through control of provinces. This result highlights the need for diversity studies to more often include biogeographical provinces in their models, as the relationship between the environment and diversity may be indirect, and as diversity patterns may or may not be influenced primarily by historical effects.

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Supplementary Material

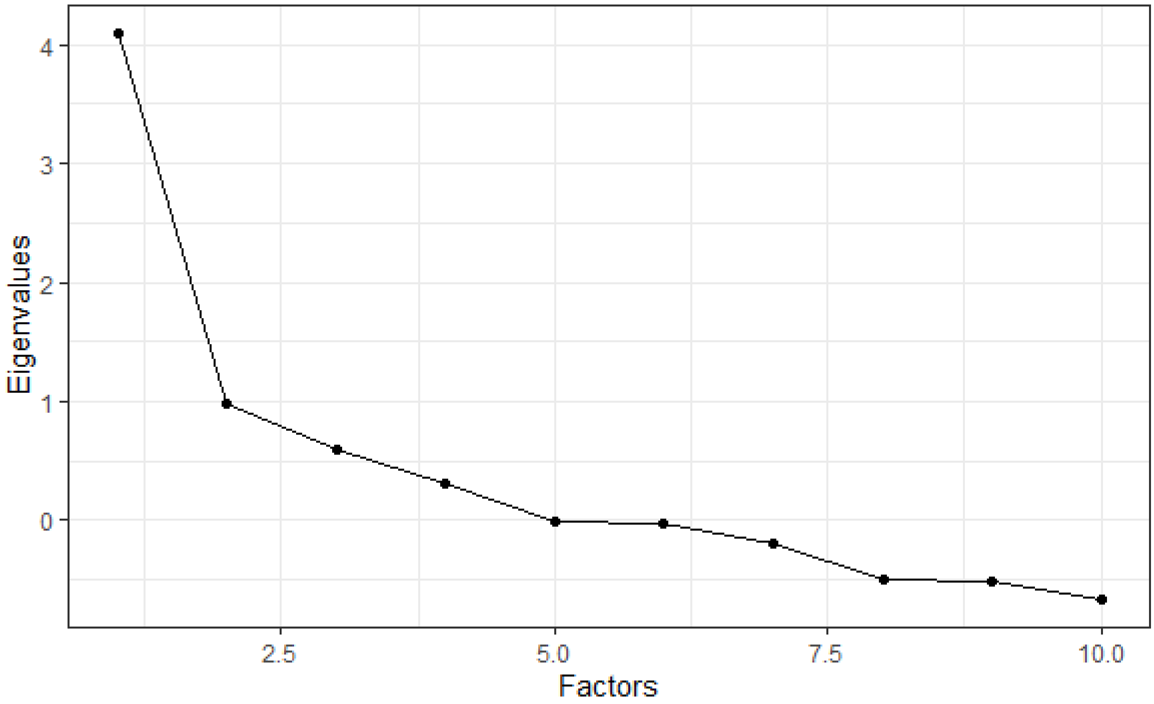

Figure S3.1: Scree plot of factor eigenvalues generated from a matrix of abiotic variables.

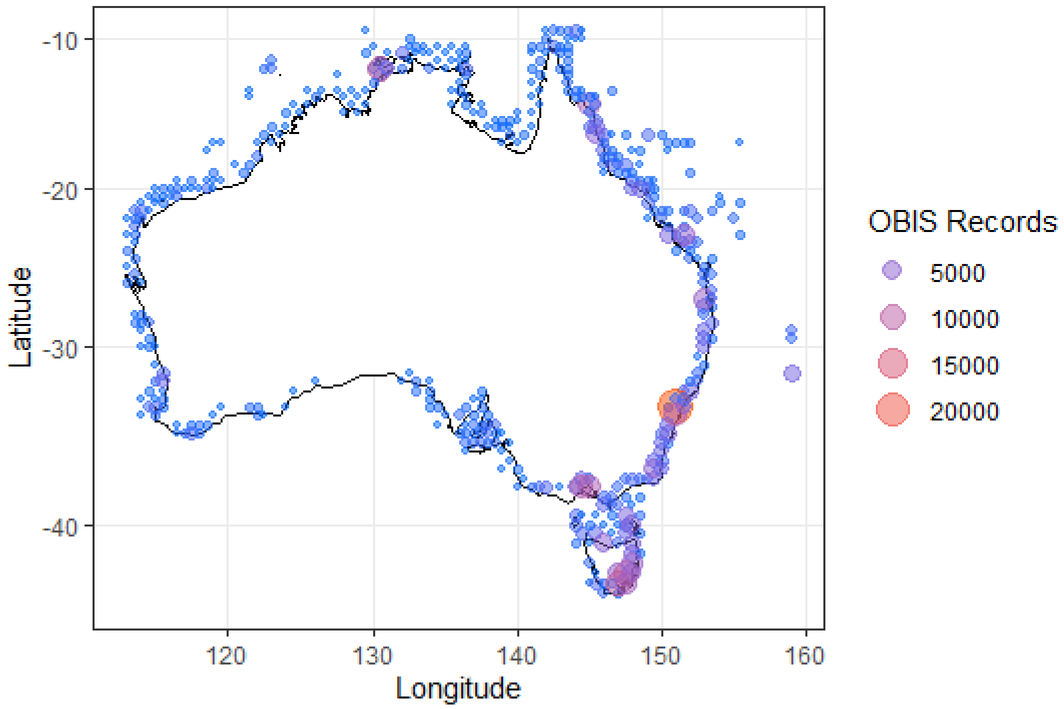

Figure S3.2: Variance in sampling of Australian marine molluscs based on the Ocean Biodiversity Information System (OBIS). All marine mollusc records were downloaded and pooled in 0.5° cells. The colour and size of each point is scaled to the number of records in that cell.

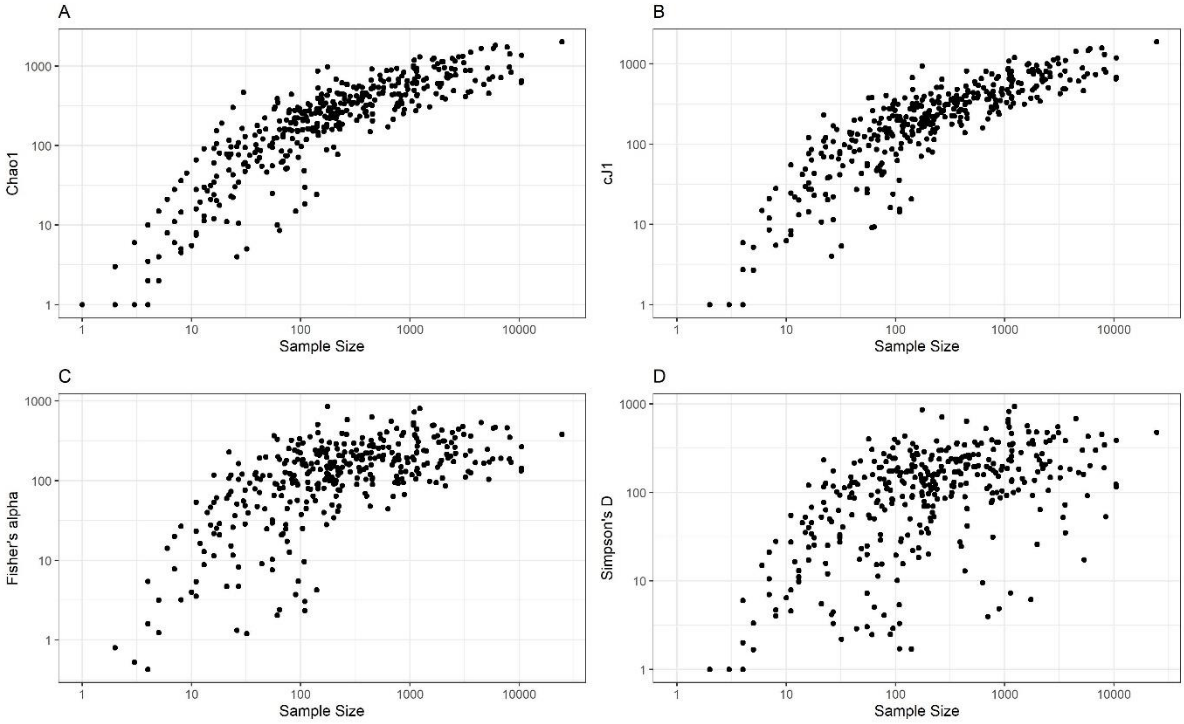

Figure S3.3: Sample size effects on species diversity estimates: Chao 1 (A), corrected jackknife (B), Fisher's α(C) and Simpson's D (D). The diversity estimate increases with sample size regardless of themethod, but the bias isreduced above 100 records and is generally weaker with Fisher's alpha and Simpson's D.

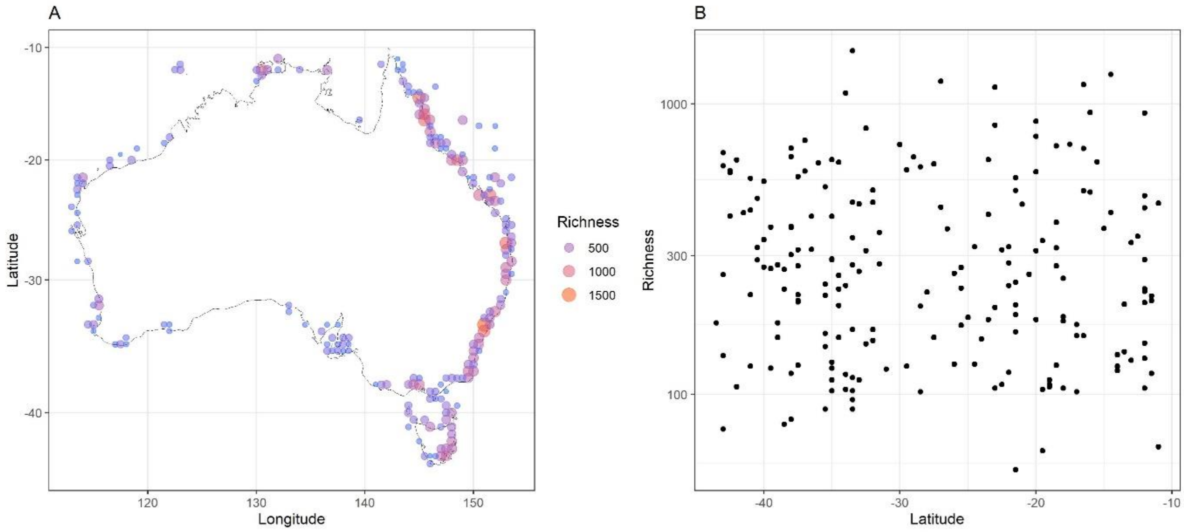

Figure S3.4: Spatial richness patterns for Australian marine molluscs from the OBIS dataset, pooled into 0.5° cells. Richness shown here is a face-value count of unique species in each cell. Point size and colour are scaled to richness in A.

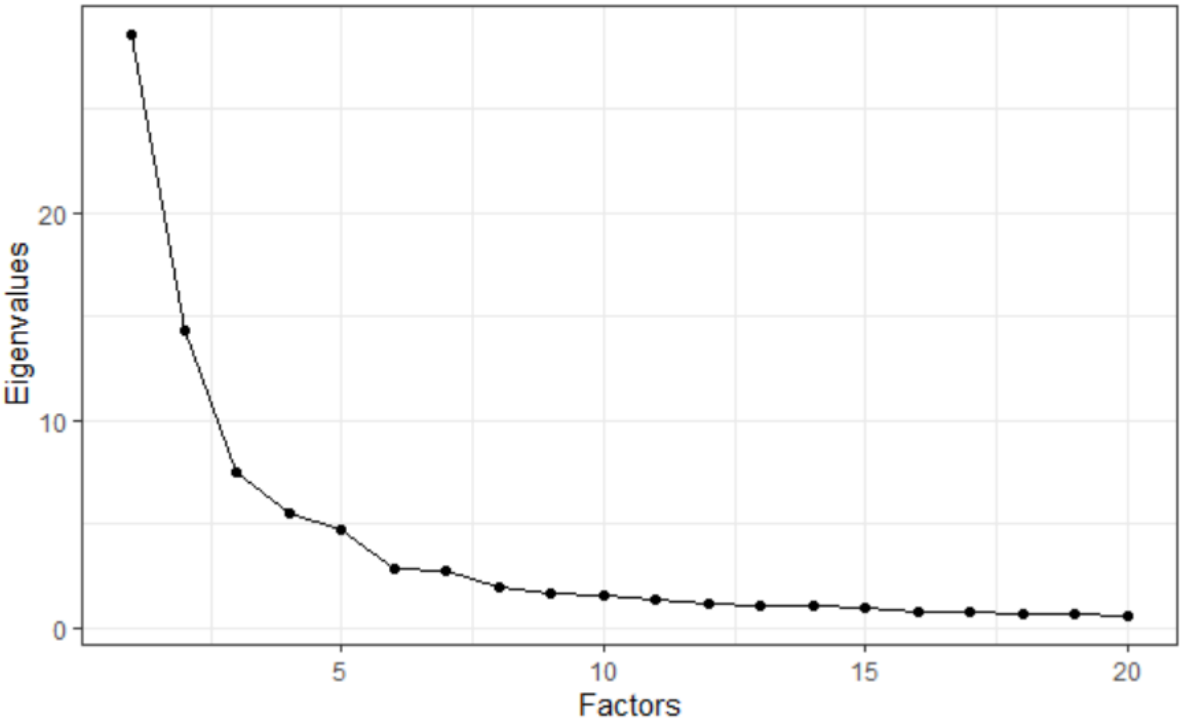

Figure S3.5: Scree plot of factor eigenvalues generated from a presence-absence matrix of Australian molluscan occurrences from OBIS. The plot levels off initially at three factors, then after five factors.

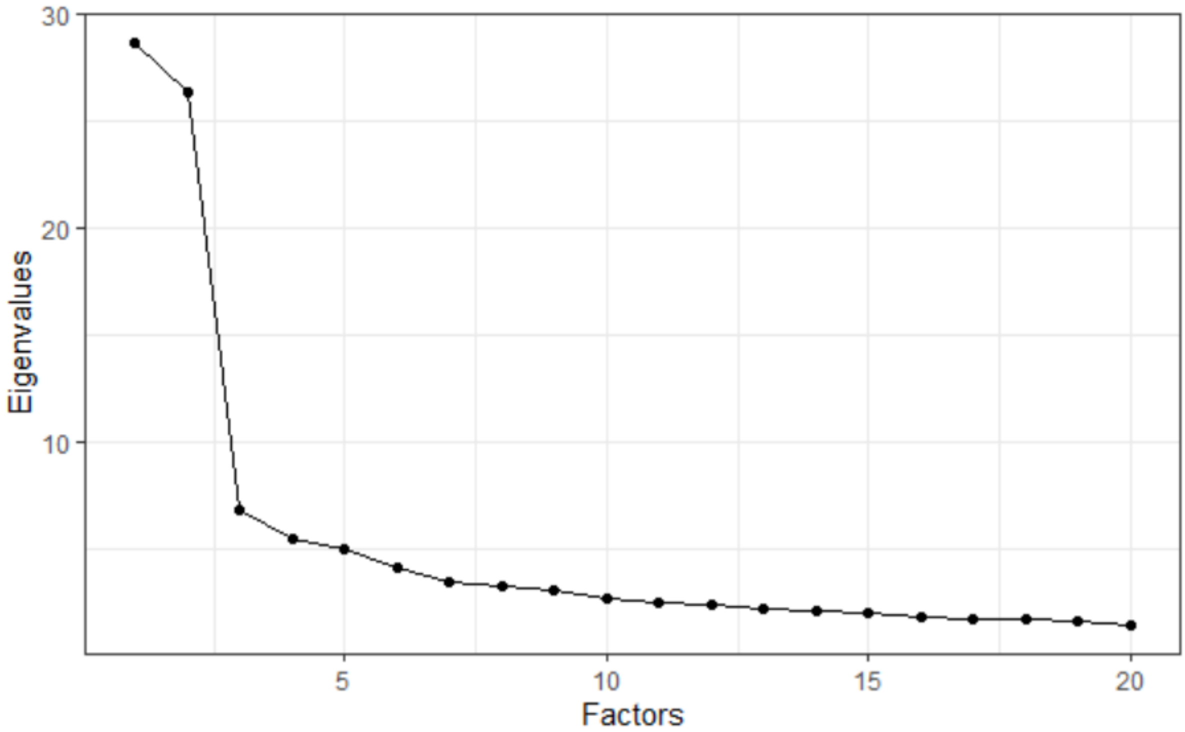

Figure S3.6: Scree plot of factor eigenvalues generated from a presence-absence matrix of Australian reef fish occurrences from the Reef Life Survey dataset. The plot levels off initially at three factors, then again at seven factors.

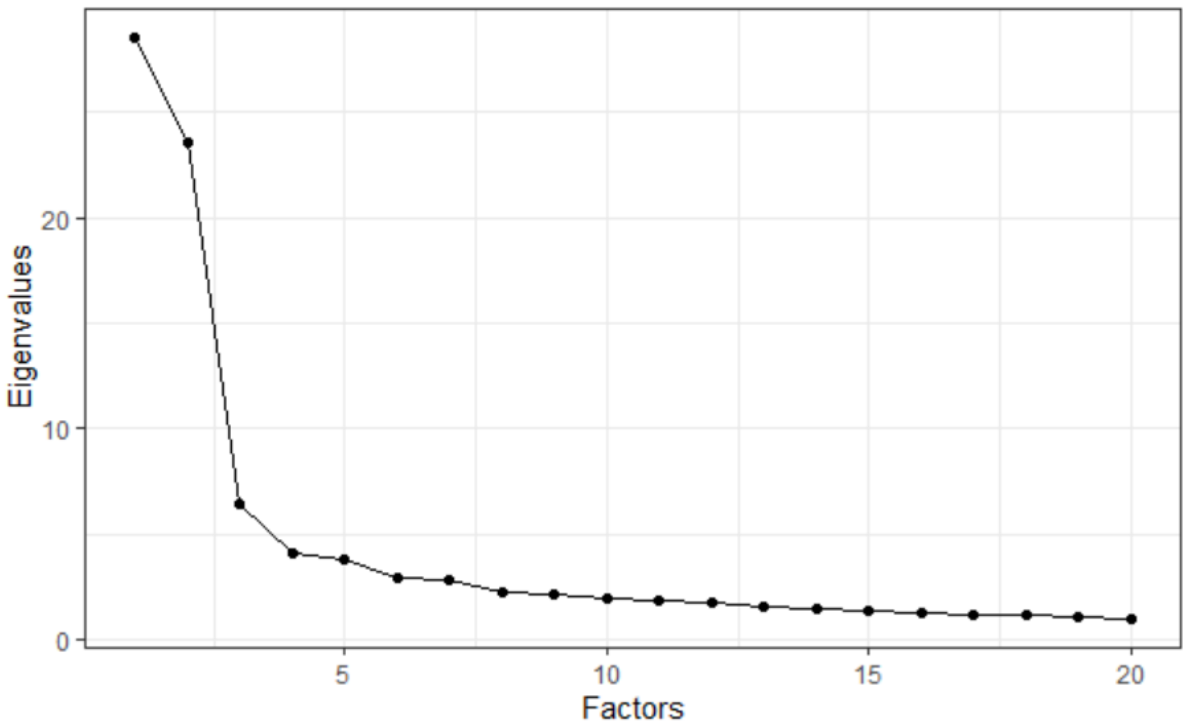

Figure S3.7: Scree plot of factor eigenvalues generated from a presence-absence matrix of Australian marine invertebrate occurrences from the Reef Life Survey dataset. The plot levels off initially at four factors, then again at six factors.

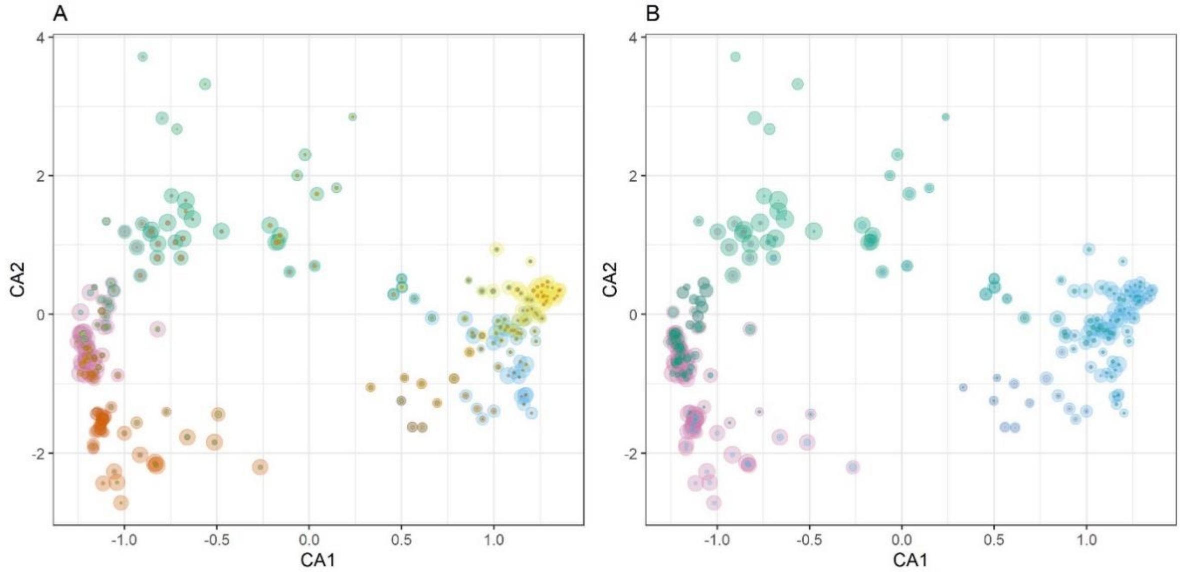

Figure S3.8: Results of a correspondence analysis of presence-absence molluscan data drawn from OBIS. Points are coloured and size-scaled to correspond with provinces generated by a factor analysis (see main text and Figure 2), assuming five factors (A) and three factors (B). Provinces are distinct in ordination space.

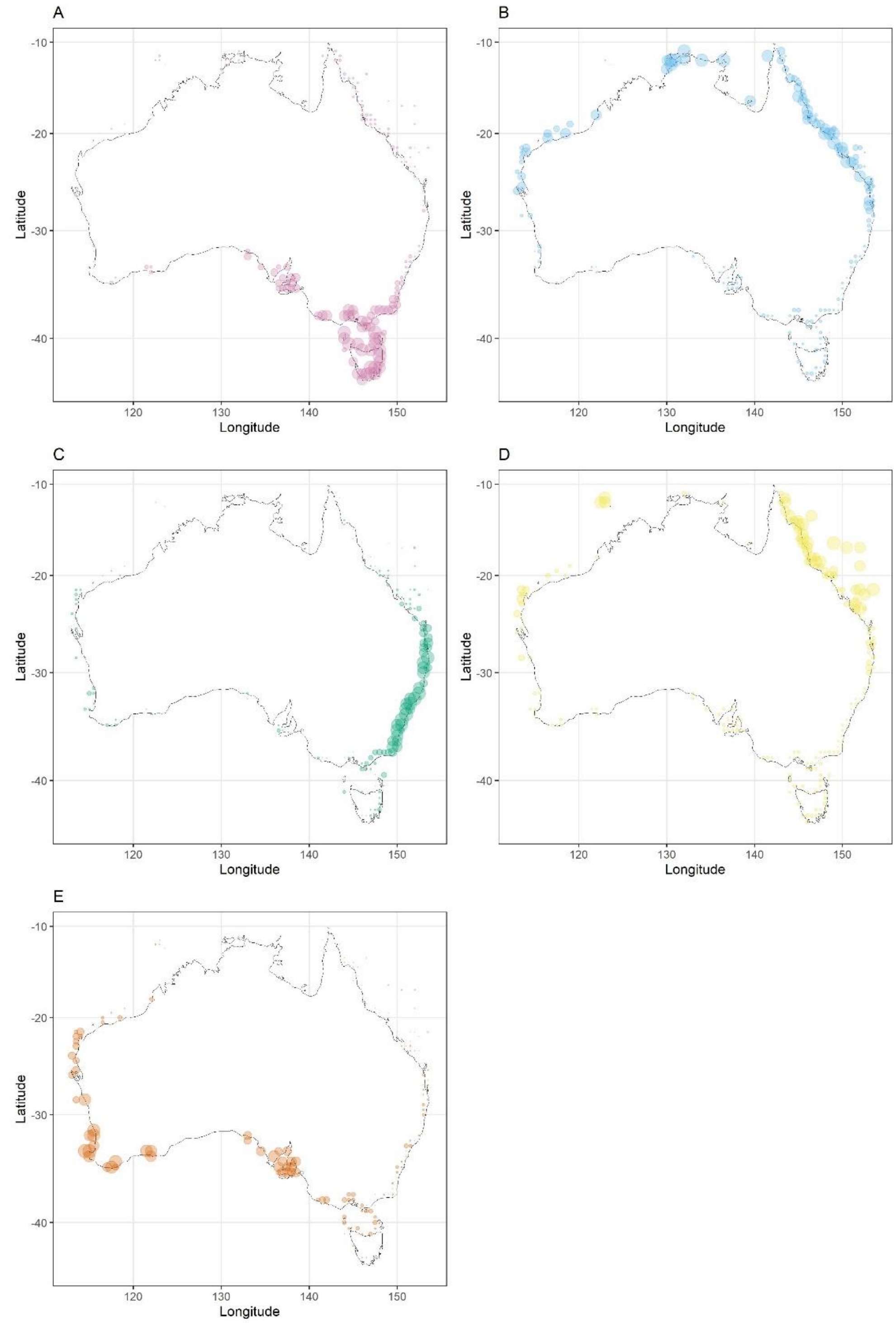

Figure S3.9: Biogeographic factors for coastal Australia, based on molluscan data downloaded from OBIS. Each panel displays a different factor deriving from a five-factor solution. Points are scaled so that factor loadings are reflected by their size. For details of the provinces see main text.

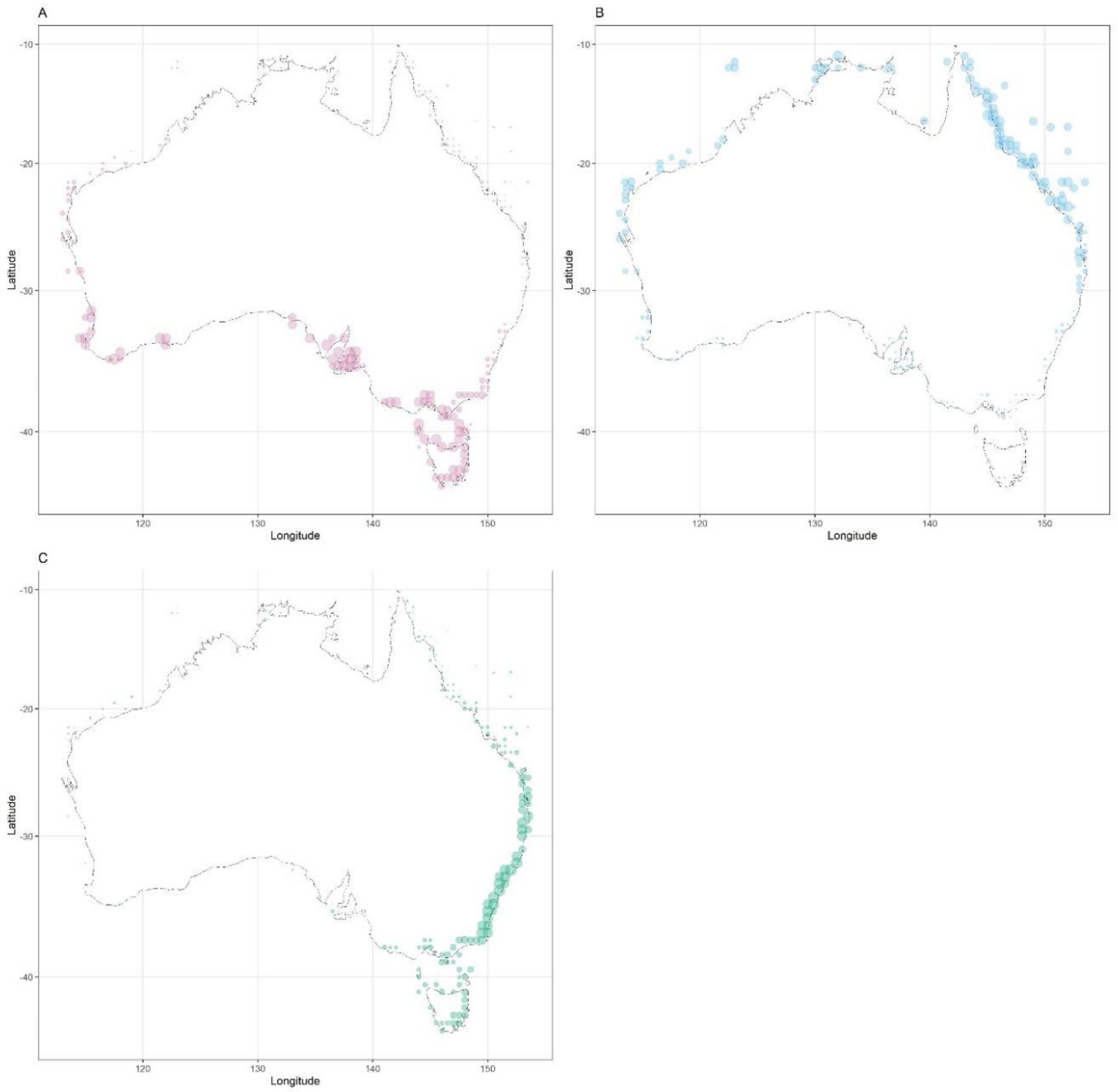

Figure S3.10: Biogeographic factors for coastal Australia, based on molluscan data downloaded from OBIS. Each panel displays a different factor deriving from a three-factor solution. Points are scaled so that factor loadings are reflected by their size. For details of the provinces see main text.

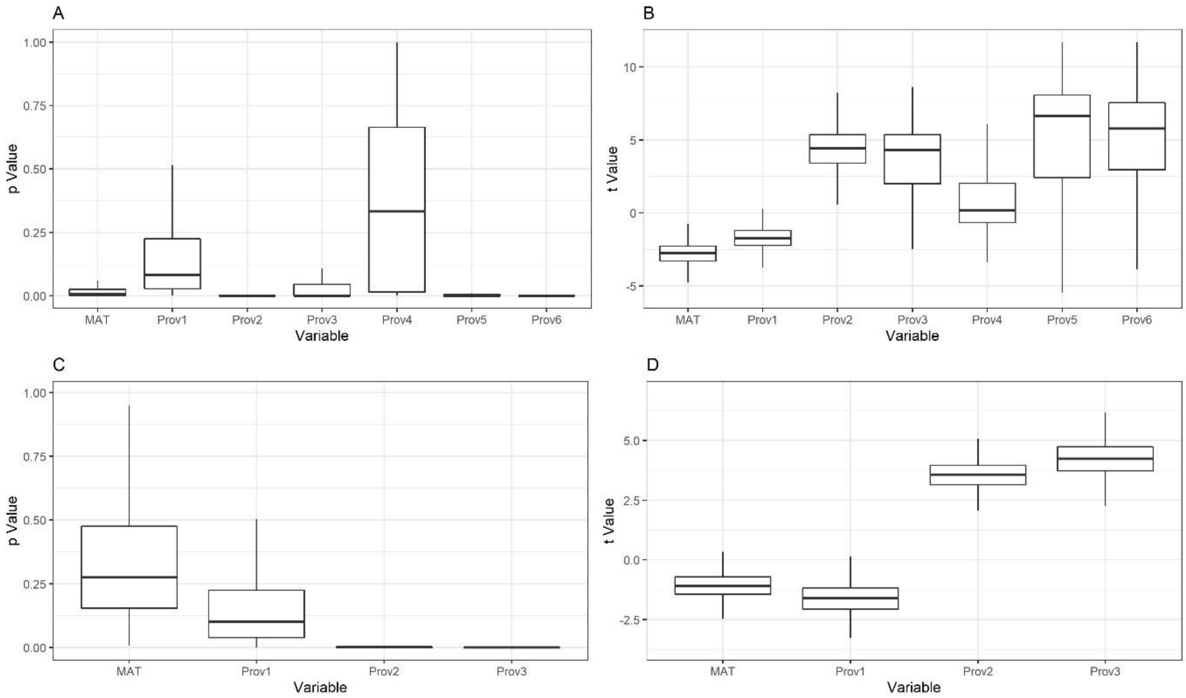

Figure S3.11: Results of a simulation in which species ranges were predicted based on temperature ranges rather than distributional ranges. The simulation was run 10,000 times and a linear model was generated for each run. The boxplots here show the spread of p-values (A, C) and t-values (B, D) across trials. The analysis was repeated with five factors (A, B) and three factors (C, D) as in the original analyses.

Table S3.1: Factor loadings for abiotic factors.

Variable	Abiotic Factor One	Abiotic Factor Two	Abiotic Factor Three
Temperature (Mean Annual)	-0.886	-0.237	0.128
Temperature (Annual Standard Deviation)	0.418	0.366	0.456
Salinity (Mean Annual)	0.006	0.881	0.007
Salinity (Annual Standard Deviation)	-0.104	0.059	0.810
Dissolved Oxygen Content (Mean Annual)	0.923	0.107	-0.088
Nitrate Content (Mean Annual)	0.812	-0.195	-0.081
Silica Content (Mean Annual)	-0.305	-0.275	0.538
Phosphate Content (Mean Annual)	0.772	-0.389	0.246

Table S3.2: Results of a linear regression analysis run on face-value species counts against biogeographic factors (see main text) and abiotic factors. Abiotic variables were collapsed into factors to avoid collinearity; for details of each factor see Table S1. Values shown are slope estimates generated from the model; bolded values are significant ($p < 0.001$).

	Province One	Province Two	Province Three	Abiotic Factor One	Abiotic Factor Two	Abiotic Factor Three	Adjusted R^2
Face-value species counts	**1.7603**	**3.0425**	**2.9394**	**0.1306**	0.0284	0.0344	0.507

Table S3.3: Results of a series of linear regression analysis of marine mollusc diversity against biogeographic factors ("Provinces" - see main text) and abiotic variables. Mollusc diversity is estimated from OBIS records. Abiotic variables were collapsed into factors to avoid collinearity; for details of each factor see Table S1. A five-factor biogeographic solution is shown. Values shown are slope estimates generated by the model; bolded values are significant ($p < 0.001$).

Diversity Estimate	Fisher's α	Simpson's D	Corrected jackknife	SQS
Province One	0.1088	-0.1149	**1.0818**	0.0262
Province Two	**2.0124**	**2.358**	**2.58**	**2.335**
Province Three	**1.2217**	**1.0357**	**2.2787**	**1.1755**
Abiotic Factor One	0.0603	0.1078	0.1112	0.1123
Abiotic Factor Two	-0.0354	-0.1237	-0.0308	-0.1196
Abiotic Factor Three	0.0305	-0.0067	0.0356	0.0017
Adjusted R^2	0.402	0.259	0.469	0.285

Table S3.4: Results of a linear regression analysis run on diversity values generated from Reef Life Survey fish data, against biogeographic factors (see main text) and abiotic factors. Abiotic variables were collapsed into factors to avoid collinearity; for details of each factor see Table S3.1. Values shown are slope estimates generated from the model; bolded values are significant (p < 0.001).

Diversity Estimate	Fisher's α	Simpson's D	Corrected jackknife	SQS
Province One	**3.2607**	**2.4156**	**3.6137**	**2.3343**
Province Two	**0.9379**	0.9622	**1.2936**	**0.9864**
Province Three	**2.0594**	**1.5627**	**2.4896**	**1.5357**
Abiotic Factor One	-0.013	-0.0083	-0.0266	-0.0241
Abiotic Factor Two	-0.0079	-0.0908	0.0006	-0.0838
Abiotic Factor Three	0.0839	-0.0038	0.0945	0.002
Adjusted R^2	0.693	0.428	0.574	0.409

Table S3.5: Results of a linear regression analysis run on diversity values generated from Reef Life Survey marine invertebrate data, against biogeographic factors (see main text) and abiotic factors. Abiotic variables were collapsed into factors to avoid collinearity; for details of each factor see Table S1. Values shown are estimates generated from the model; bolded values are significant ($p < 0.001$).

Diversity Estimate	Fisher's Alpha	Simpson's D	Corrected Jackknife	SQS
Province One	1.156	**1.114**	**1.451**	**0.965**
Province Two	**2.045**	0.871	**1.862**	0.870
Province Three	**1.284**	0.381	**1.764**	0.408
Province Four	-0.204	-0.391	-0.061	-0.376
Abiotic Factor One	0.009	-0.070	0.039	-0.047
Abiotic Factor Two	0.015	-0.022	0.005	-0.016
Abiotic Factor Three	-0.044	-0.048	-0.078	-0.032
Adjusted R^2	0.140	0.173	0.100	0.141

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Chapter Four

Field Data Reveal Strong Latitudinal Gradients in Australian Marine Bivalves

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Abstract

Latitudinal diversity gradients are among the most studied macroecological phenomena. However, they tend to be described using large composite datasets that often show taxonomic and geographic sampling bias. Here we describe a latitudinal gradient in marine bivalve diversity along the eastern coastline of Australia, spanning 2,667 km of coastline and 20° of latitude. We utilise a large, structured field dataset (5,670 individuals) in conjunction with a routine macroecological dataset downloaded from the Ocean Biodiversity Information System (OBIS: 36,226 specimens). Diversity is estimated using a series of analytical methods to account for undersampling, and biogeographic gradients in taxonomic composition are quantified and compared to existing biogeographical schemes. A strong latitudinal gradient is present in both datasets. However, the strength of the gradient depends on the dataset and analytical method used. The inclusion of observational data in the macroecological dataset obscures any latitudinal pattern. The documented biogeographic gradients are consistent with global and regional reconstructions. However, we find evidence for a strong transition zone between two clusters. Although latitudinal gradients inferred from large macroecological datasets such as OBIS can match those inferred from field data, care should be taken when curating downloaded data as small changes in protocols can generate very different results. By contrast, even modest regional field datasets can readily reconstruct latitudinal patterns.

Introduction

The latitudinal biodiversity gradient peaking in the tropics has been of key interest in macroecology for decades (Hillebrand, 2004, Kinlock *et al.*, 2018) both at regional (Edgar *et al.*, 2017, Saeedi *et al.*, 2019) and global scales (Chaudhary *et al.*, 2016, Gagné *et al.*, 2020, Righetti *et al.*, 2019, Tittensor *et al.*, 2010). In particular, the various possible environmental drivers of latitudinal gradients have been discussed at length, with focus on the effects of temperature in the context of changing climates (Field *et al.*, 2008, Gagné *et al.*, 2020, Wang *et al.*, 2009). Understanding the impacts of changing environments on such large-scale diversity patterns is of growing importance to guiding international conservation effects (Gagné *et al.*, 2020, Pimm *et al.*, 2014).

Because data on large geographic scales are required for these studies, recent research has focused on using composite datasets rather than detailed field collections (for example; Gagné *et al.*, 2020, Menegotto and Rangel, 2018, Miller *et al.*, 2018). However, there are some large-scale fieldwork schemes such as the Reef Life Survey (Barneche *et al.*, 2019, Edgar *et al.*, 2017, Edgar and Stuart-Smith, 2014) and some terrestrial compilation efforts (Cerezer *et al.*, 2020). Historically, species distributions have been based on range data, layering distributions to generate richness estimates (McKinney and Kark, 2017, Roy *et al.*, 1998, Tsianou *et al.*, 2016). Range-through, more often used in temporal studies, tends to artificially increase richness estimates and similarities towards the centre of distributions both spatially and temporally (Boltovskoy, 1988), but has been used to test many latitudinal gradient hypotheses (Hughes *et al.*, 2013, Roy *et al.*, 1994, Roy *et al.*, 1998). Atlases have similar problems and are generally only available for well-studied taxa (Donald and Fuller, 1998, Robertson *et al.*, 2010). Uneven sampling and techniques that vary between countries also have an impact, even in better-surveyed groups like mammals and birds (Robertson *et al.*, 2010, Whittaker *et al.*, 2005). Both range-through and atlas approaches result in a loss of abundance information and assume even sampling across species ranges, which makes diversity estimates misleading compared to those produced by routine field surveys (Robertson *et al.*, 1995) despite successful modelling studies using atlas data (Sadoti *et al.*, 2013).

In modern studies, large composite databases are often used to generate diversity estimates and taxonomic ranges. Although many such databases exist, the largest and most heavily cited are the Global Biodiversity Information Facility (GBIF) for terrestrial and marine studies and the Ocean Biogeographic Information System (OBIS) for marine studies. Despite the obvious benefits of these datasets, their properties can create significant issues in global-scale studies. Data included are haphazard, idiosyncratic and, like atlases, unevenly distributed across countries (Beck *et al.*, 2014, Boakes *et al.*, 2010) and globally (Menegotto and Rangel, 2018). Despite large numbers of records, they also do not give as much range information as many manual compilation methods (Beck *et al.*, 2013), and without true abundance information, they are of limited usefulness in estimating true diversity. In addition, sampling effort varies temporally (Boakes *et al.*, 2010), in intensity (Ballesteros-Mejia *et al.*, 2013), and between countries (Mora *et al.*, 2008), resulting in a lack of understanding of local-scale processes.

In this study we investigate a latitudinal diversity gradient in marine bivalves using a field dataset spanning 2,667 km of Australia's eastern coastline. Although marine bivalves are underrepresented in large datasets (Troudet *et al.*, 2017), they are well-studied in other continents (Jablonski *et al.*, 2013, Roy, 2001, Roy *et al.*, 1994) and easy to collect in large abundance in the field. Bivalves are not included in major field surveys of Australian waters, such as the Reef Life Survey. Thus, diversity estimates have been limited to small numbers of specimens and observations in OBIS. We will describe variation in bivalve diversity with respect to varying environmental conditions along the coastline, as well as across a previously identified major biogeographic transition. Finally, the strength, variation, and environmental response of this gradient will be compared to the latitudinal gradient found in analyses of a macroecological dataset generated using bivalve occurrence data from OBIS.

Data and Methods

Field Collection

Bivalve shell assemblages were collected from 16 beaches across the eastern coastline of Australia (Fig. 4.1) in August of 2018 and 2019. Beaches were selected to be evenly distributed along the eastern coastline, eastwards facing and completely open to the ocean. Ten samples were taken from each beach using 0.25 m2 quadrats: five samples were taken north of the beach midpoint and five were taken to the south. Sampling was only carried out during clear days not following a storm to avoid artefacts of depositional changes. Quadrats were randomly placed along the beach between the high and low tide marks, ensuring they were ≥ 10 m apart.

Sediment taken down to a 5 cm depth within each sample was processed through 16-, 8-, and 4-mm sieves, with all dead shell material retained. Valves that were 70% complete and identifiable to species level were identified and counted. A full list of species and taxonomic authorities used for identification is available as an Appendix (Appendix 3).

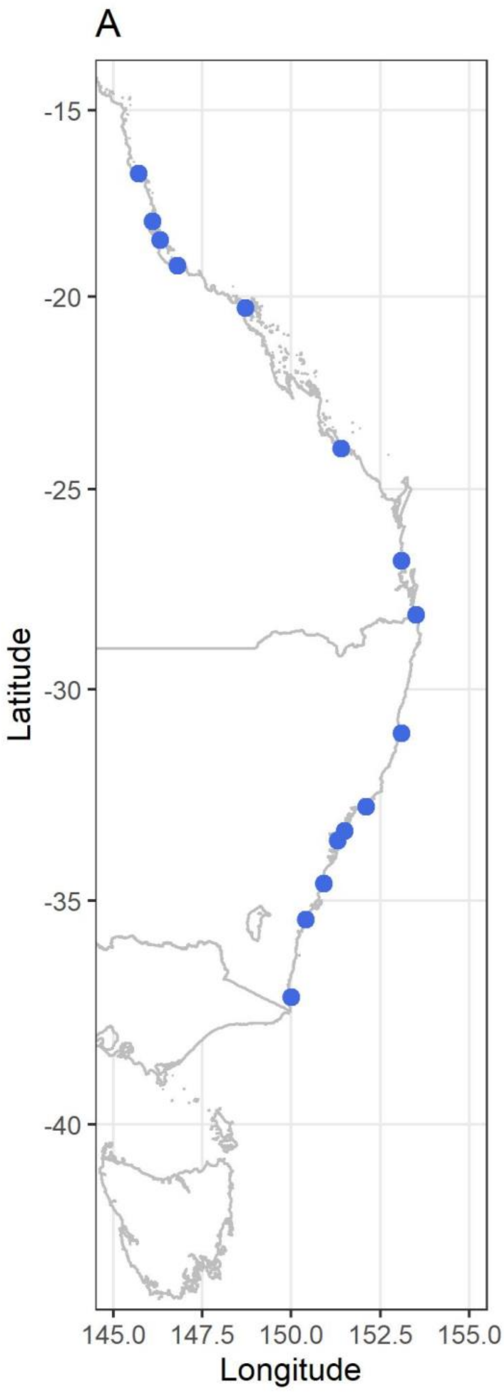

Figure 4.1 Location of sites sampled during field collection (**a**) and the 100 0.1° cells in the OBIS dataset (**b**).

Regional and Environmental Data

For comparison to the field dataset, a regional dataset was created using identifications from OBIS. All bivalve records for Australia were downloaded on 4th May 2020 using the R package *robis* (Provoost and Bosch, 2020). Data were spatially restricted to only include coastal cells within the latitudinal range of the field sites (16.7 – 37.2 °S). Species names were checked against the World Register of Marine Species using the package *worms* in R (Holstein, 2018, WoRMS Editorial Board, 2018) in order to remove erroneous species names and synonyms and to check family assignments. Only records with georeferenced collection locality data recorded to 2 decimal places, valid species names, and collection dates after 1980 were included. This resulted in a regional dataset including 7,480 records of 600 species.

For bivalves in our study area, 612 records are recorded on OBIS as "Human Observation". To avoid potentially erroneous identifications that cannot be verified, only records tagged as "Preserved Specimen" were retained for our main analysis. We ran an additional analysis with the observational data included to make comparisons, henceforth referred to as "observational" data.

Records were pooled into 0.1° cells to approximate the spatial scale of the field data. Cells with fewer than 10 records were omitted to allow for reduced uncertainty in the diversity estimation. To account for the difference in the number of cells between datasets, a subset of the OBIS data was created that only included cells centred on field sites.

Environmental data for the eastern coastline were downloaded from the CSIRO Atlas of Living Seas (Ridgway *et al.*, 2002), which provides ocean water properties on a 0.5° grid, on 10th May 2020. Variables downloaded were the most recently available ones for mean annual sea surface temperature, mean annual salinity, mean annual dissolved oxygen content, and mean annual nitrate, silicate, and phosphate content.

Diversity Estimation

To account for potential sampling issues in both datasets, diversity was estimated using three methods. Richness was estimated using the S^2/m equation of Alroy (2020). This gives similar results (Fig. S4.1) to that of Chao 1 (Chao, 1984) in our analyses but is more aggressive and a consistent lower bound (Alroy, 2020), so we emphasise it in the main text.

To supplement this, we used the analytical version (Chao and Jost, 2012) of shareholder quorum subsampling (SQS - Alroy [2010a, 2010b, 2010c]). We note that SQS is routinely referred to as coverage-based rarefaction (CBR) in the ecological literature and that the distinction between SQS and CBR is not conceptual but operational, as with the distinction between the original formulation of rarefaction (Sanders, 1968) and the analytical formulation (Hurlbert, 1971) that is now widely used.

As these methods are influenced by sample size in our data (Fig. S4.2), we use Simpson's D (Simpson, 1949) as a diversity metric. When computed using the modern formula (Hurlbert, 1971), Simpson's D is almost independent of sample size, and it has long been used in the analysis of ecological field data (Magurran, 2013, Morris *et al.*, 2014). The inclusion of this metric gives additional information about the nature of the community as it does not represent richness.

All analyses were done in R (version 4.0.2; R Core Team [2020]), and the functions for generating diversity and richness estimates have been included in the Supplementary Information.

Taxonomic Composition

We investigated taxonomic composition at the species and family level. In order to show how taxonomic composition changes with latitude, presence-absence data were transformed into a dissimilarity matrix using a revised version of the Forbes index (Alroy, 2015, Forbes, 1907). We then used Principal Coordinates Analysis (PCoA: Gower [1966]) to visualise the differences. We implemented PCoA using the cmdscale function in the *base* R package. Based on accepted biogeographical schemes for molluscs in the study area (Ebach *et al.*, 2013, Wilson and Allen, 1971), two major provinces and a long transition zone were expected to be seen.

Analysis

Spatial autoregression was used to investigate the relationship between bivalve diversity and environmental variables (R package *spatialreg*: Bivand *et al.*, 2013). For each model, logged diversity was compared with the eight environmental variables as predictors. This was repeated for each dataset and diversity metric. Finally, to identify the best predictor variables for each diversity metric and dataset, an optimal submodel was chosen using the function RegBest in the R package *FactoMineR* (Lê *et al.*, 2008). This analysis was repeated using the taxonomic composition data to test for the underlying causes of any biogeographic gradient.

Results

Data

Field collections included 5,670 individuals of 179 species. Two sites (“Shelly Central” and “Bermagui”) did not contain enough shell material (<30 individuals) to accurately predict richness, so they were excluded from the analyses. Northern quadrats made up 3,218 individuals and southern quadrats made up 2,334 individuals.

The full OBIS dataset numbered 600 species and 7,480 records. After low sample size cells were removed, the dataset numbered 579 species and 6,226 records. One hundred forty-six cells were used in the final analysis. Observational data contributed an additional 775 records.

Latitudinal Gradients

Strong latitudinal gradients were observed in both the field and the OBIS data (Fig. 4.2). For the field S^2/m data, the relationship with latitude was stronger ($\rho = 0.765$, $p < 0.001$) than it was in the OBIS S^2/m data ($\rho = 0.682$, $p < 0.001$). When using SQS, no significant pattern was found in the field data; Simpson's D returned a stronger gradient in the OBIS data (Table 4.1). When only cells centred on field sites were included, a much weaker pattern was observed using S^2/m ($\rho = 0.556$, $p < 0.05$), a stronger pattern was observed using SQS, and no pattern was returned using Simpson's D. Including observational data in the OBIS dataset consistently reduced the latitudinal signal, as measured by ρ, across all combinations of analytical methods and diversity metrics (Fig. 4.2, Table 4.1).

The spatial autoregressions show that field diversity is strongly predicted by a set of abiotic variables (R^2 = 86.5% for S^2/m: Table 4.2). Diversity is not as well predicted by abiotic variables when using OBIS datasets. Submodels for each dataset and metric show that temperature is the best consistent overall predictor of richness in each case (Table 4.2, Table S4.1-2), with nitrate and phosphate content also important for subsets of OBIS data.

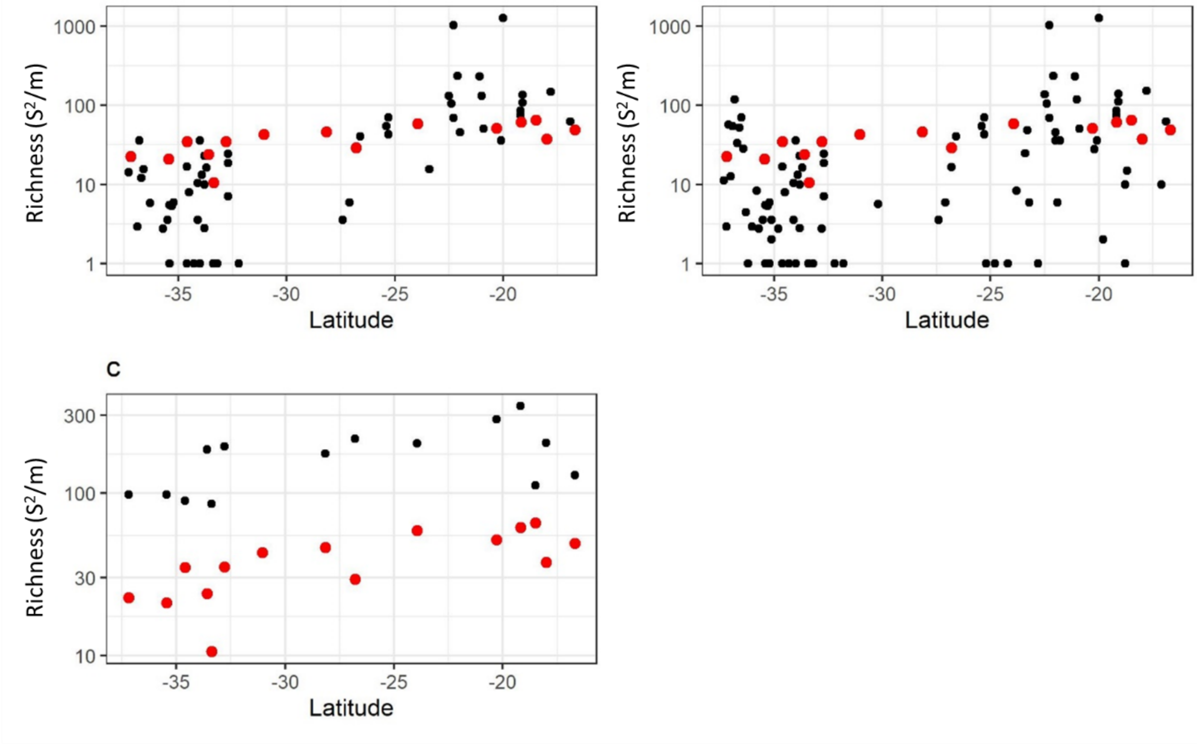

Figure 4.2 Variation in the species richness of marine bivalves across a latitudinal gradient on the eastern coastline of Australia, estimated using the S^2/m equation of Alroy (2020). Panels show different subsets of an OBIS dataset – the full dataset (**a**), inclusive of observational data (**b**), and with cells matched to field data (**c**). Red points in each panel show estimates based on field data for comparison. All y-axes are logged for clarity.

Dataset	S^2/m	D	SQS
Field	0.765**	0.544**	0.494
OBIS	0.682**	0.694**	0.618**
OBIS (including observations)	0.313**	0.282**	0.156
OBIS (field matched)	0.556*	0.064	0.741*

Table 4.1 Spearman's rank correlation (ρ) coefficients for marine bivalve diversity contrasted with latitude. Data are for the eastern coastline of Australia, based either on field collections ("field") or on subsets of OBIS (the full dataset containing records after 1980, OBIS inclusive of observational data, and a subset of OBIS that contains cells centered on field data). Diversity metrics shown are the S^2/m equation of Alroy (2020), Simpson's *D* (D) and Shareholder Quorum Subsampling (SQS). Asterisks show significant values (*p<0.05, **p<0.01).

	Field	OBIS	OBIS (including observations)	OBIS (field matched)
MAT	0.287*	1.463**	1.079**	0.608*
Salinity	-0.021	0.091	-0.021	0.070
Nitrate	0.243*	0.339	0.233	-0.184
Silica	0.219*	-0.246	-0.209	-0.352*
Phosphate	-0.441**	0.589**	0.634	0.449*
Adjusted-R^2	0.865	0.358	0.200	0.611
Optimal submodel	MAT** (0.673)	MAT** (0.145)	MAT/Phosphate (0.146)	Nitrate* (0.339)

Table 4.2 Results of spatial autoregressions of marine bivalve diversity on environmental variables. Diversity values shown are for the S^2/m equation of Alroy (2020); other diversity metrics are detailed in the supplementary material (Table S4.1-2). Values are beta coefficients generated by each model (significance values $*p<0.05$, $**p<0.01$). R^2 values are for the whole model. "Optimal submodel" details the best subset of environmental predictors for each dataset (see main text); the values in parentheses are the R^2s for those submodels. MAT = Mean Annual Temperature.

Taxonomic Composition

The PCoA shows that the majority of taxonomic variation can be explained by one axis (68.8% for field data, 52.0% for the full OBIS dataset: Fig. 4.3). Latitudinally, this axis represents a broad northern and southern cluster with a transition in between (Fig. 4.3). This biogeographic pattern is present regardless of data subsetting, but clustering is more apparent in the field data than in any OBIS dataset. This is consistent with results based on family level data (Fig. S4.3). When comparing family-level changes in the field data, northern sites have higher proportions of Cardiidae, Psammobiidae, Tellinidae, and Veneridae (Fig. 4.4). Southern sites are represented by higher proportions of Carditidae and of smaller families (Fig. 4.4).

When biogeographic variables were compared to environmental variables in a series of spatial autoregressions, temperature was consistently a significant predictor of biogeographic structure across all datasets (Table S4.3).

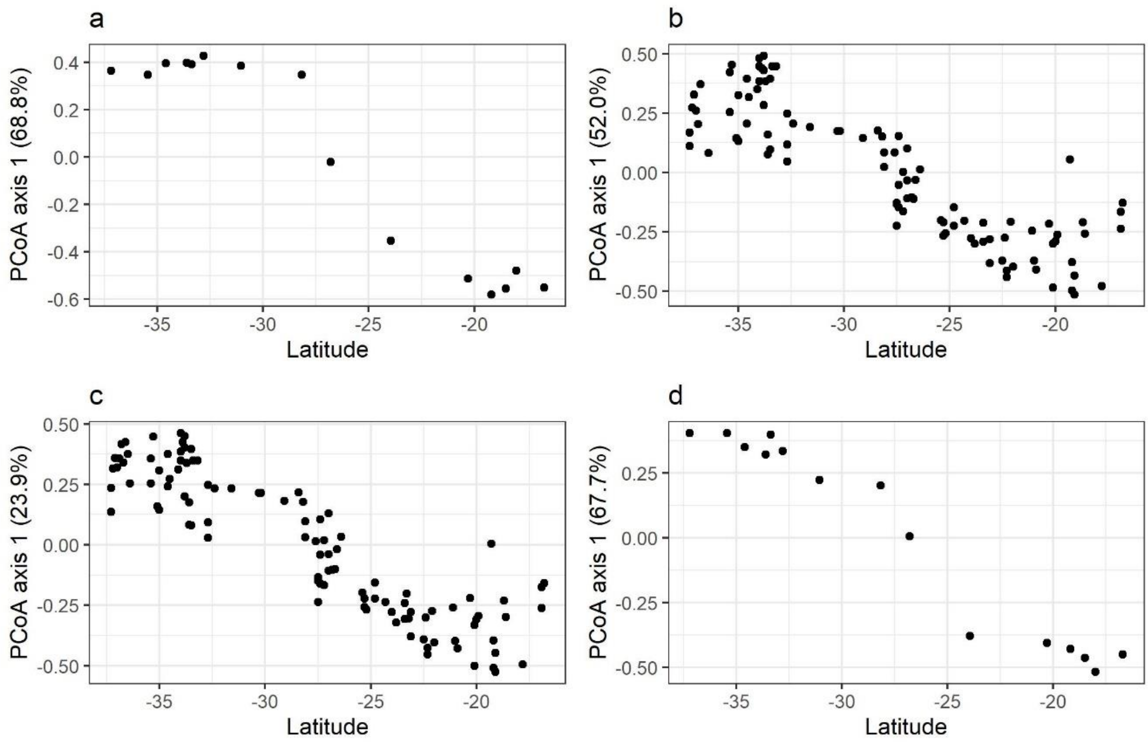

Figure 4.3 Variation in species-level taxonomic composition of marine bivalves across a latitudinal gradient along the eastern coastline of Australia. The y-axis in each panel shows the position of the point along the first axis of a Principal Coordinates Analysis (PCoA). Sites that cluster together vertically are inferred to have a similar taxonomic composition. (**a**) Results from field collection. The other panels show different subsets of an OBIS dataset – the full dataset (**b**), inclusive of observational data (**c**) and matched to field sites (**d**).

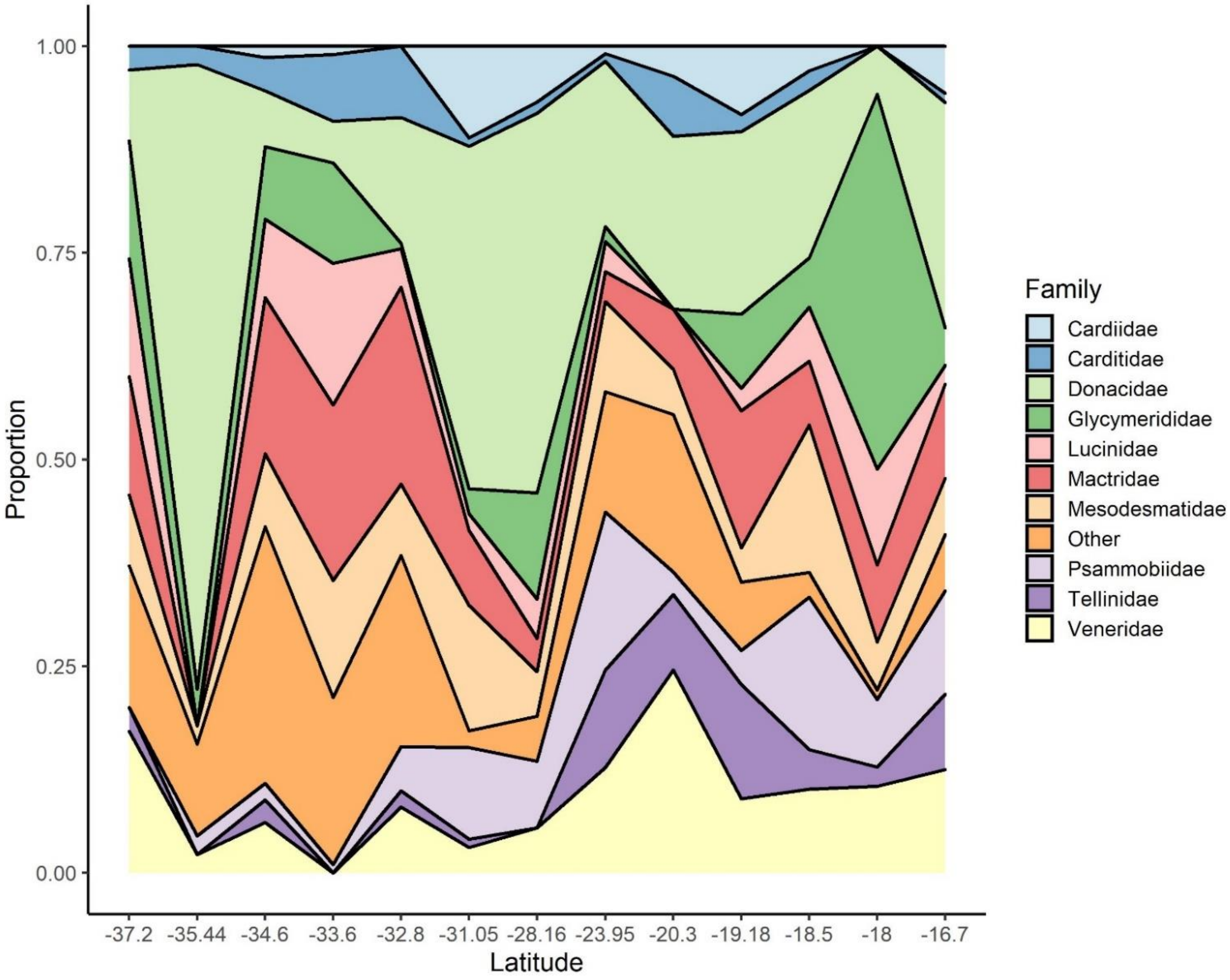

Figure 4.4 Variation in the family-level taxonomic composition of marine bivalves across a latitudinal gradient along the eastern coastline of Australia. Data shown are based on field surveys of 16 sites. Proportions are of individuals at each site. Only the most common 10 families are shown for clarity.

Discussion

A strong latitudinal diversity pattern can be seen for marine bivalves along the eastern coastline of Australia.

Strong latitudinal gradients were found regardless of the diversity metric used. Depending on the method used, however, the intensity of the latitudinal gradient changed substantially. Estimated richness values (S^2/m) were the most compelling in the field data, which showed weaker gradients using other metrics. OBIS data showed a consistent gradient using all methods but failed to show consistency when the dataset was reduced to measure richness at a local scale, presumably due to insufficient sample sizes.

Including observational data in the OBIS datasets resulted in the largest shift in gradient strength. Observational records made up less than 20% of the data, but their inclusion massively reduced the latitudinal diversity signal across all the analytical treatments (Fig. 4.2, Table 4.1). Previous studies have shown large discrepancies in sampling effort across space (Brown *et al.*, 2000, Pressey, 2004), with a higher degree of observations often resulting in apparent undersampling (Geldmann *et al.*, 2016). Observational values are typically included in global studies, where they are often subject to screening based on species ecology (Gagné *et al.*, 2020), but as shown here, they may present issues at the regional scale. Compiling citizen science information presents a similar challenge to that of using composite datasets: the sampling method often highly varies (Pocock *et al.*, 2017) and very few schemes operate at scales large enough to measure latitudinal patterns – especially for invertebrate groups.

Despite inconsistencies in sampling effort and methods present in large, composite datasets such as OBIS, they do suggest latitudinal diversity patterns in marine bivalves that are broadly consistent with those demonstrated by field collections arrayed at a regional scale. This fact indicates that OBIS data, previously used in many global studies for marine diversity and biogeographic patterns (Chaudhary *et al.*, 2016, Costello *et al.*, 2017, Miller *et al.*, 2018, Menegotto and Rangel, 2018, Gagné *et al.*, 2020), are at least minimally suitable for studying diversity dynamics at regional scales – even in underrepresented groups such as bivalved molluscs. Additionally, temperature was found to be the main predictor of taxonomic diversity in the field data, with spatial autoregression explaining 67% of the variation, consistent with previous studies (Barneche *et al.*, 2019, Saeedi *et al.*, 2019, Gagné *et al.*, 2020). Abiotic variables could not predict diversity patterns to the same extent in the OBIS data: the variation explained in models based on those data was half as great. This is likely due to the smaller individual sample sizes in cells for the OBIS dataset. Our field dataset may be a better reflection of true latitudinal diversity patterns because our sampling effort was uniform and intense.

Neither the OBIS data nor the field data are consistent with latitudinal patterns for bivalves seen in other continents (Roy *et al.*, 1994) or in global reconstructions (Chaudhary *et al.*, 2016), with a much smoother gradient and no stepwise change that matches a provincial boundary. On the other hand, the biogeographic gradient seen in the field and OBIS data is broadly consistent with published regional biogeographic schemes (Ebach *et al.*, 2013, Wilson and Allen, 1971), including two provinces, and is similar to Australian provincial patterns shown in global schemes (Costello *et al.*, 2017). The biogeographic interpretation in our data is that bivalves do not form clear clusters along the Australian coastline, but a long transition that spans a biogeographic boundary.

The biogeographic transition is robust at both species and family level (Fig. 4.3, Fig. S4.3), with northern and southern provinces having distinct proportional composition (Fig. 4.4) despite most families being present at every field site. Ebach *et al.* (2013) list the upper limit of the Peronian (a province containing NSW and Victoria) as -32.7º, which falls at the start of the transition zone represented in both datasets. Both global and local assessments tend to agree on a two-cluster scheme (Ebach *et al.* 2013, Costello *et al.* 2017). Studies on eastern Australian corals also point to a broad transition zone around the same latitude (Sommer et al. 2014, 2018), as found in the present study.

Historically, transitions have either been recognised as overlapping biotic zones or as mixing zones (Hermogenes De Mendonça and Ebach, 2020). Here, a gradient between two tight clusters can be seen across datasets, with temperature being able to explain it in most cases (Table S4.3). A change in beach geomorphology along the transition zone (Short *et al.*, 2000, Short *et al.*, 2007) may be a contributing factor, but further research is needed to fully determine the histories of the zones in order to assess the relationship.

Here we show that latitudinal gradients seen in data downloaded from OBIS match those shown in field data – confirming their comparability in diversity studies. OBIS data are less useful, however, for recreating local patterns, where the presence and strength of the gradient are largely dependent on the choice of diversity measure. Adding observational data weakens or removes any clear latitudinal signal, which is likely to be of concern when data sets are largely made up of such information. At the same time, latitudinal and biogeographic patterns were uncovered here using a relatively small number of field sites. Thus, we suggest that regional diversity patterns can be quantified easily using well-spaced, high-intensity sampling to supplement existing databases.

Acknowledgments

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Supplementary Material

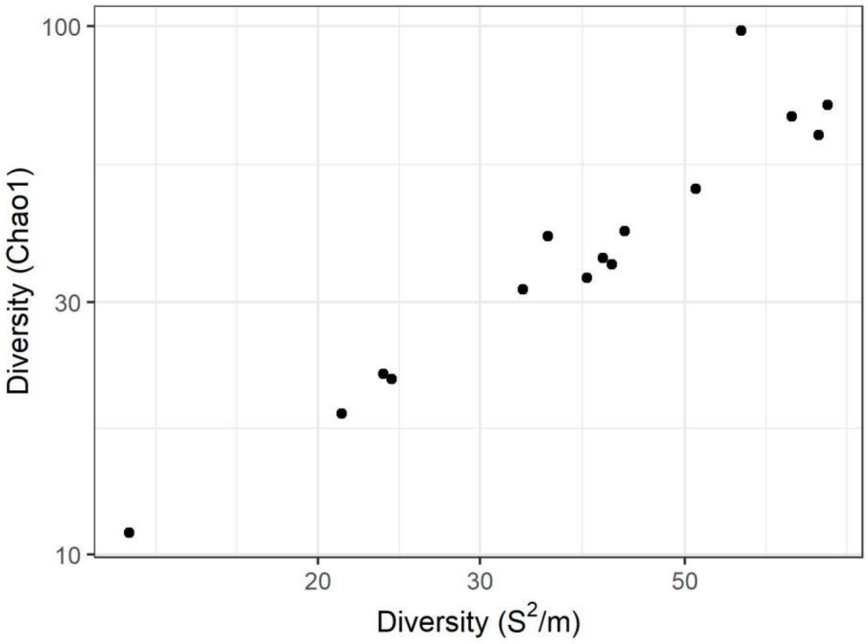

Figure S4.1 A comparison between diversity estimated from two different methods, Chao1 (Chao, 1984) and S^2/m (Alroy, 2020), for bivalves on the eastern coastline of Australia. Each point represents a site, both axes are logged for clarity. Methods generally agree on the diversity trends shown here; however, S^2/m is a more consistent lower bound (Alroy, 2020) and is emphasised in this chapter.

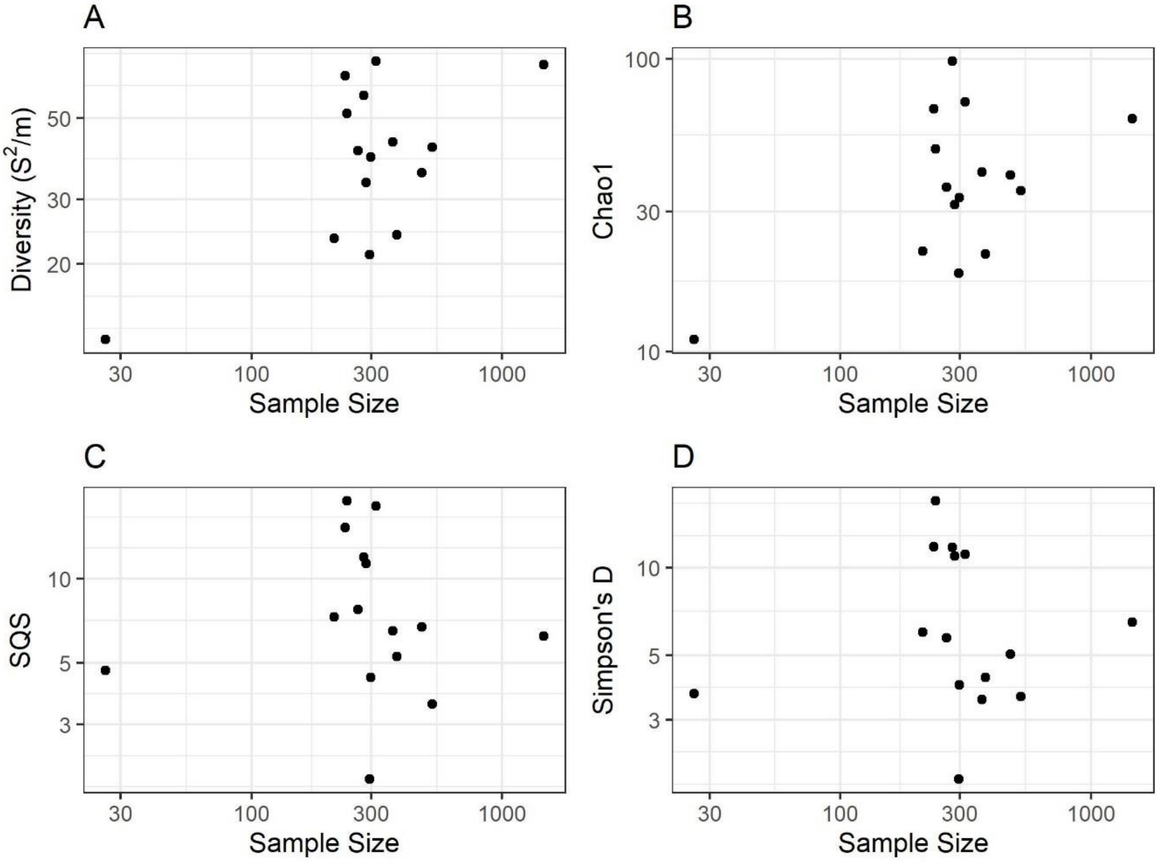

Figure S4.2 Variation in diversity estimates for bivalves on the eastern coastline of Australia, with respect to sample size. Four methods are shown, A: S^2/m (Alroy, 2020), B: Chao1 (Chao, 1984), C: Shareholder Quorum Subsampling (SQS – Alroy, 2010a, 2010b, 2010c) and D: Simpson's D (Simpson, 1949). All methods have a response to sample size, but the signal is much lower in SQS and Simpson's D.

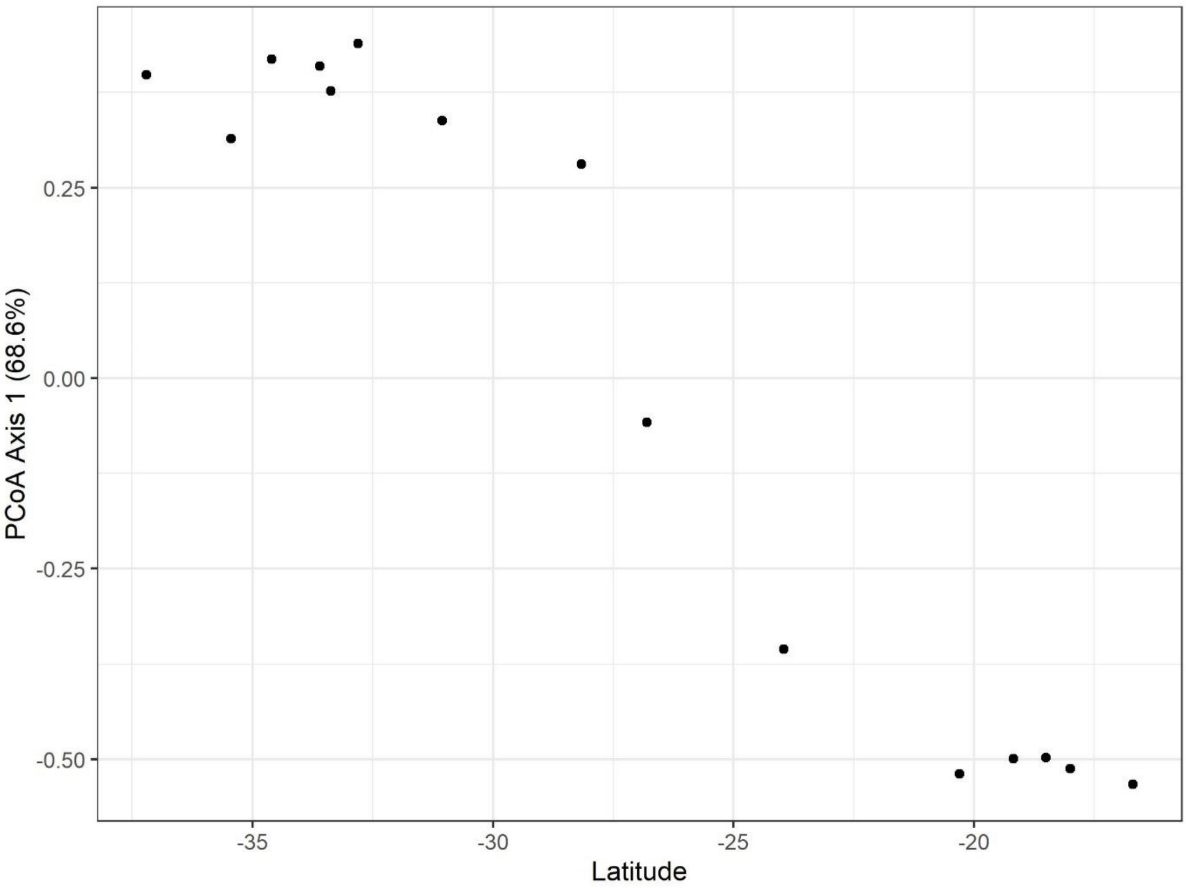

Figure S4.3 Variation in family-level taxonomic composition of marine bivalves across a latitudinal gradient along the eastern coastline of Australia, generated from field data. The y-axis in each panel shows the position of the point along the first axis of a Principal Coordinates Analysis (PCoA). Sites that cluster together vertically are inferred to have a similar taxonomic composition

Table S4.1 Results of spatial autoregressions of marine bivalve diversity on environmental variables. Diversity values shown are generated by Simpson's D (Simpson, 1949). Values are beta coefficients generated by each model (significance values **p*<0.05, ***p*<0.01). R^2 values are for the whole model. "Optimal submodel" details the best subset of environmental predictors for each dataset (see main text); the values in parentheses are the R^2s for those submodels. MAT = Mean Annual Temperature.

	Field	OBIS	OBIS (including observations)	OBIS (field matched)
MAT	-0.367**	0.679**	0.577**	0.734**
Salinity	-0.133*	0.207	0.102	0.269*
Nitrate	-0.956**	0.031	0.096	-0.313**
Silica	-0.913**	-0.013	0.009	-0.220
Phosphate	-0.317*	0.284*	0.193	0.490**
Adjusted-R^2	0.749	0.235	0.145	0.738
Optimal submodel	Silica (0.145)	MAT** (0.206)	MAT** (0.128)	Nitrate** (0.479)

Table S4.2 Results of spatial autoregressions of marine bivalve diversity on environmental variables. Diversity values shown are generated by Shareholder Quorum Subsampling (SQS – Alroy, 2010a, 2010b, 2010c. Values are beta coefficients generated by each model (significance values **p*<0.05, ***p*<0.01). R^2 values are for the whole model. "Optimal submodel" details the best subset of environmental predictors for each dataset (see main text); the values in parentheses are the R^2s for those submodels. MAT = Mean Annual Temperature.

	Field	OBIS	OBIS (including observations)	OBIS (field matched)
MAT	0.026	0.894**	0.581	0.002
Salinity	-0.182*	0.096	-0.053	-0.123
Nitrate	-0.903**	0.230	0.161	-0.334**
Silica	-1.085**	-0.189**	0.084	0.284
Phosphate	0.729**	0.286	0.033	-0.108
Adjusted-R^2	0.710	0.167	0.166	0.733
Optimal submodel	Nitrate/Silica/ Phosphate (0.268)	MAT** (0.131)	MAT** (0.113)	Nitrate** (0.463)

Table S4.3 Results of spatial autoregressions of marine bivalve biogeography on environmental variables. Biogeographic factors shown here are axis one from the results of a principal coordinates analysis (see Materials and Methods). Values are beta coefficients generated by each model (significance values **p*<0.05, ***p*<0.01). R^2 values are for the whole model.

	Field	OBIS	OBIS (including observations)	OBIS (field matched)
MAT	-2.648**	0.312**	0.312**	6.621**
Salinity	-0.137	0.036	0.034	1.380**
Nitrate	-0.885**	0.022	0.018	1.317*
Silica	0.053	-0.002	-0.002	-0.606
Phosphate	-0.171	0.045	0.042	1.260
Adjusted-R^2	0.912	0.900	0.904	0.867

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Chapter Five

Body Size and Abundance are Decoupled from Diversity in Australian Marine Bivalves

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Abstract

In addition to gradients in diversity, changes in body size and biomass distributions with latitude have been noted in several taxonomic groups. In particular, the "more individuals hypothesis" suggests that increasing species abundances lead to increases in diversity. Support for this hypothesis has been mixed and varies between taxa. In this paper we investigate latitudinal changes in body size and abundance distributions for marine bivalves along the eastern coastline of Australia. We utilise a large, structured field dataset spanning 20º of latitude and crossing a major biogeographic break. We contrast changes in diversity in addition to body size and abundance distributions. Despite uncovering a strong diversity gradient, we find no significant gradient in body size at any taxonomic level. This result contrasts with previous work, which found family-level trends in bivalve size. Additionally, because we find no gradient in abundance we reject the "more individuals hypothesis" for our system. Our results suggest that diversity trends in coastal Australia result instead from a gradient in environmental stochasticity.

Introduction

In addition to changes in species richness, trends in the body size of organisms with increasing latitude have been of key interest to biologists for over a century (Bergmann, 1847, Cushman *et al.*, 1993, Blackburn *et al.*, 1999). However, the directionality and even the existence of these gradients has been shown to be inconsistent between groups and at differenttaxonomic levels (McNab, 1971, Blackburn *et al.*, 1999, Roy and Martien, 2001, Meiri and Dayan, 2003, Ashton, 2004, Linse *et al.*, 2006, Adams and Church, 2008).

Researchers starting with Bergmann (1847) have illustrated a general trend of smaller body sizes with decreasing latitude. This trend has been extensively documented in endothermic tetrapods (Meiri and Dayan, 2003, Ashton, 2004). As a result of these latitudinal patterns, changes in body size have been linked to the latitudinal diversity gradient (Hillebrand and Azovsky, 2001, Cardillo, 2002, Barneche *et al.*, 2019). Some larger-bodied organisms have been shown to have stronger latitudinal diversity gradients (Hillebrand and Azovsky, 2001, Weiser *et al.*, 2018), and body size has been directly matched to global diversity patterns in reef fish (Barneche *et al.*, 2019). However, inverse relationships exist for many groups (Pincheira-Donoso *et al.*, 2008, Moles *et al.*, 2009, Angielczyk *et al.*, 2015). In marine animals, similar gradients have been found with depth (Smith and Brown, 2002), but these general patterns are not consistent within smaller taxonomic units (Berke *et al.*, 2013) and size can vary more with geographic location than latitude (Linse *et al.*, 2006).

The "more individuals" hypothesis is a leading explanation for diversity gradients that relates to these body size trends (Currie and Fritz, 1993, Currie *et al.*, 2004, Storch *et al.*, 2018). This hypothesis suggests that productivity increases species richness by increasing the size of viable populations and therefore lowering extinction rates. The number of individuals has been shown to increase with diversity in several groups, across taxa and environments (Siemann *et al.*, 1999, Yee and Juliano, 2007, Seoane *et al.*, 2017, Müller *et al.*, 2018). However, recent reviews regarding this hypothesis showed that support for it is mixed (Storch *et al.*, 2018), with scale-dependence a highly important factor in determining the existence of an abundance gradient. The "more individuals" pattern has been suggested to be an instantiation of the species-energy effect (Currie *et al.*, 2004), but the connection is not direct. A variety of mechanisms linking energy to diversity gradients have been proposed other than just increases in abundance (Allen *et al.*, 2002, Allen *et al.*, 2006, Storch, 2016), such as increased mutation rates, and the effects of local disturbances alter the nature of richness-abundance relationships (McGlynn *et al.*, 2010). Because results have been mixed, well-designed, field-based tests of these relationships at a large scale are needed to fully evaluate the "more individuals" hypothesis.

In this paper we investigate the relationship between body size, abundance, and diversity in marine bivalves along the eastern Australian coastline. Globally, marine bivalves have been shown to have size-vs.-latitude trends (Berke *et al.*, 2013), but the exact relationships differ between groups and cannot be generalised. We utilise a systematically collected field dataset, rather than an ad hoc observational dataset. It covers 20.5º of latitude spanning the temperate and tropical zones and crosses a major biogeographical boundary. Thus, any link between these variables should be easy to detect if it exists. The overall trends in body size and abundance will be described before relationships between them and diversity are discussed.

Material and Methods

Field collection

Bivalve shell assemblages were collected from 16 beaches across the eastern coastline of Australia (Fig. 5.1) in August of 2018 and 2019. Beaches were selected to be evenly distributed along the eastern coastline, eastwards facing and completely open to the ocean.

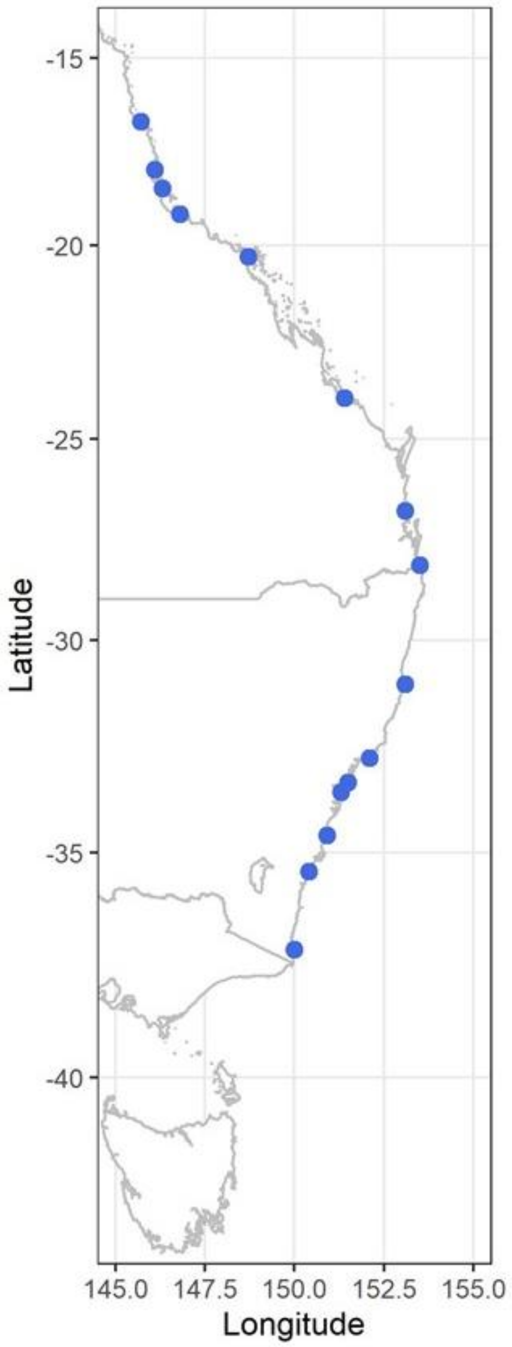

Figure 5.1 Location of sites sampled during field collection.

Ten samples were taken from each beach using 0.25 m^2 quadrats: five samples were taken north of the beach midpoint and five were taken to the south. Sampling was only carried out during clear days not following a storm to avoid artefacts of changes in depositional mode. Quadrats were randomly placed along the beach between the high and low tide marks, ensuring they were $\geq$ 10 m apart. Sediment recovered down to a 5 cm depth within each sample was processed through 16, 8, and 4 mm sieves, with all shell material retained and identified. Our total dataset was 5,670 shells representing 157 species (Appendix 3 of this thesis).

Analysis

We assessed the latitudinal relationships between body size, richness, and abundance. For logistical reasons, the largest complete valve for each species at each site was measured using traditional linear measurements (length and height of the valve: Fig. S5.1). Size was calculated as in Berke *et al.* (2013) by taking the geometric mean of shell length and height on a $\log_2$ scale. This statistic correlates well with other size metrics (Kosnik *et al.*, 2006). Although only the largest valve was measured, species identity explained 57.5% of the variation in maximum size ($p < 0.001$) and therefore is a suitable proxy.

Our full measurement dataset contained 361 shells from 12 sites, composed of 155 species from 26 families (Appendix 4 of this thesis). Species present at a site that could not be measured directly were assigned the geometric mean of all other occurrences of that species as a proxy value. Size was analysed on both a species basis, where only one measurement per species was included, and an individual basis, where size was weighted by species abundance at each site. Richness was estimated from the full data collection using the S^2/m equation of Alroy (2020), which is more aggressive than related estimators such as Chao 1 (Chao, 1984) but still a consistent lower bound. We obtain similar results using Chao 1 and a variety of other measures (Table S5.1).

We further assessed the spatial patterns of body size and abundance between environmental conditions. We downloaded values for eight variables at each of our sites; mean annual sea surface temperature, annual temperature standard deviation, mean annual salinity, annual salinity standard deviation, mean annual dissolved oxygen content and mean annual concentrations for nitrate, phosphate and silica. Values were downloaded from the CSIRO Atlas of Regional Seas (Ridgway et al., 2002, Condie and Dunn, 2006) on 4th November 2020.

We tested the relationship between the environmental variables, body size, abundance and richness using structural equation modelling (SEM). Latent variables were constructed based on results from an exploratory factor analysis rather than using predetermined sets of variables. The number of latent variables was determined by a parallel analysis run on the abiotic variables, comparing the scree of the data with that of a randomized table of the same size (Horn, 1965). Each abiotic variable was then assigned to a latent variable based on which factor it was loaded the most strongly. The final model was run using the environmental variables and data for species richness, body mass and abundance from the field specimens. All functions for the exploratory factor analysis were from the R package *psych* (Revelle, 2019). We implemented the final model using the R package *lavaan* (Rosseel, 2012).

A subsampling routine was performed to investigate whether any trends in the within-site spacing of size distributions might reflect random assembly from the regional species pool. For each site, the pool of all measured species was randomly sampled down to the number of species present in that site. A random measurement was taken from the measured shells for each species and the median nearest neighbour distance for each measured species was computed from the subsampled measurements. This routine was carried out 10,000 times to generate a null distribution, which was then compared to the true median distances between species within the samples. The position of the true median along the null distributions can be used to draw conclusions about the assembly of the community from the regional pool.

Results

Our data show a strong species richness gradient along the eastern coastline of Australia (Spearman's rank-order correlation $\rho = 0.836$, $p < 0.001$: Fig. 5.2a). However, the number of individuals present at a site does not significantly change with latitude ($\rho = 0.264$, $p = 0.340$: Fig. 5.2b) or with diversity ($\rho = 0.232$, $p = 0.404$: Fig 5.2c).

Median body size at a site does not significantly change with latitude when unweighted ($\rho = 0.350$, $p = 0.201$: Fig. 5.3a) or weighted by relative abundance ($\rho = 0.468$, $p = 0.081$: Fig. 5.3b). This pattern also holds true at the family level (Fig. S5.2, Table S5.2). However, species with larger geographic ranges in the field dataset do have larger maximum body sizes (slope = 1.55, $p < 0.01$, $R^2 = 0.067$: Fig. S5.3).

Results from the structural equation model show a strong relationship between latent variable one (temperature, dissolved oxygen concentration, nitrate concentration and phosphate concentration) and species richness (Fig. 5.4). No strong relationships are present for other latent variables and richness or with any latent variable and body size or abundance. No relationship can be found between body size, abundance and species richness.

Results from the nearest neighbour analysis show no pattern in the locations of the true medians, with the true median falling almost exactly on or near the median of the null distribution every time (Fig. S5.4-5.7). There is also no latitudinal pattern in the position of the true medians (Fig. S5.8).

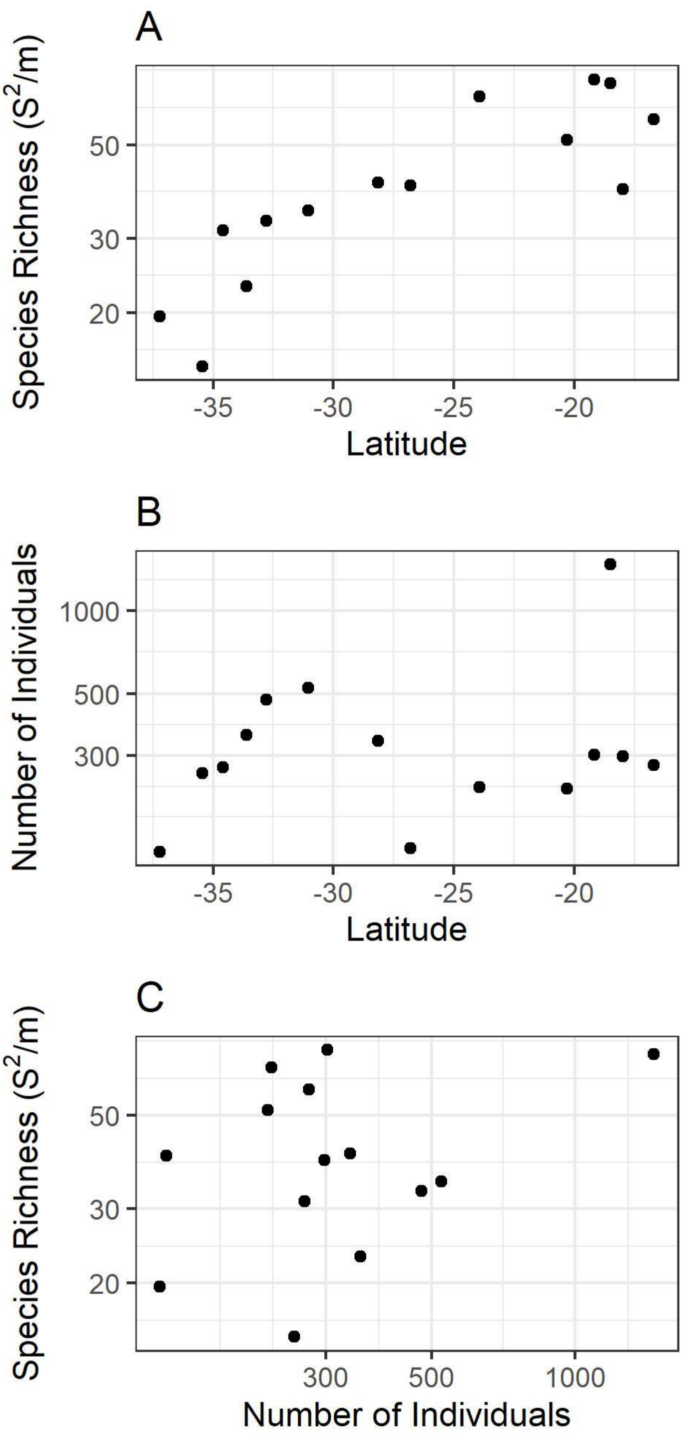

Figure 5.1. Latitudinal gradients in species richness (A) and the number of individuals (B) observed in bivalve samples spanning the eastern coastline of Australia. Species richness is estimated using the S^2/m method of Alroy (2020), but similar patterns are seen when other measures are used. The lack of a relationship between species richness and the number of individuals is shown in panel C. Axes other than latitude are logged for clarity.

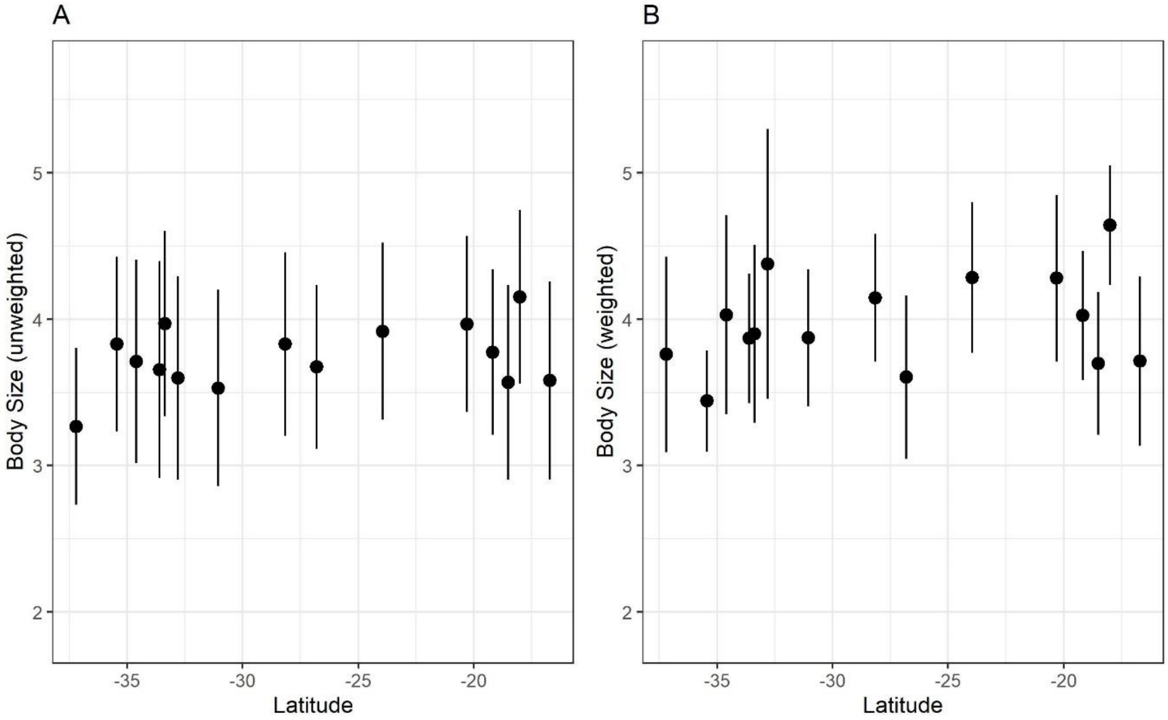

Figure 5.2. The latitudinal gradient of body size in east coast Australian marine bivalves. Points represent mean body sizes for species at each site, unweighted in panel A and weighted by abundance in panel B. Error bars are one standard deviation around the mean.

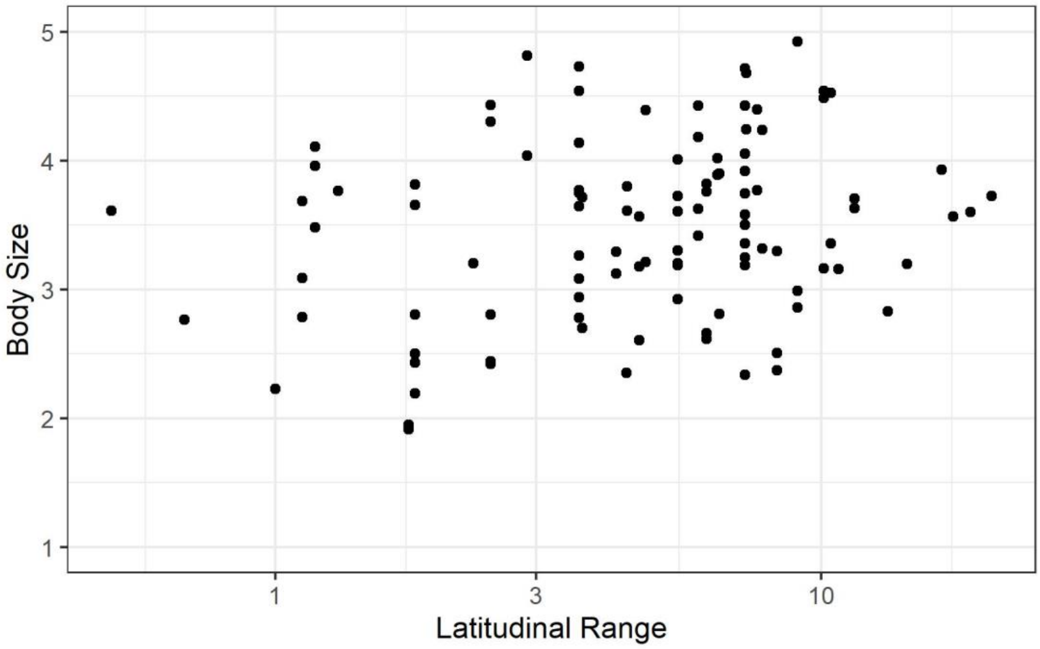

Figure 5.3. The relationship between mean body size and latitudinal range for marine bivalve species sampled from along the eastern coastline of Australia. Larger-bodied organisms have slightly larger latitudinal ranges (slope = 1.551, $p < 0.01$, $R^2 = 0.066$). Body size is calculated as the geometric mean of length and height (see Materials and Methods). Only species that appear in more than one site are included.

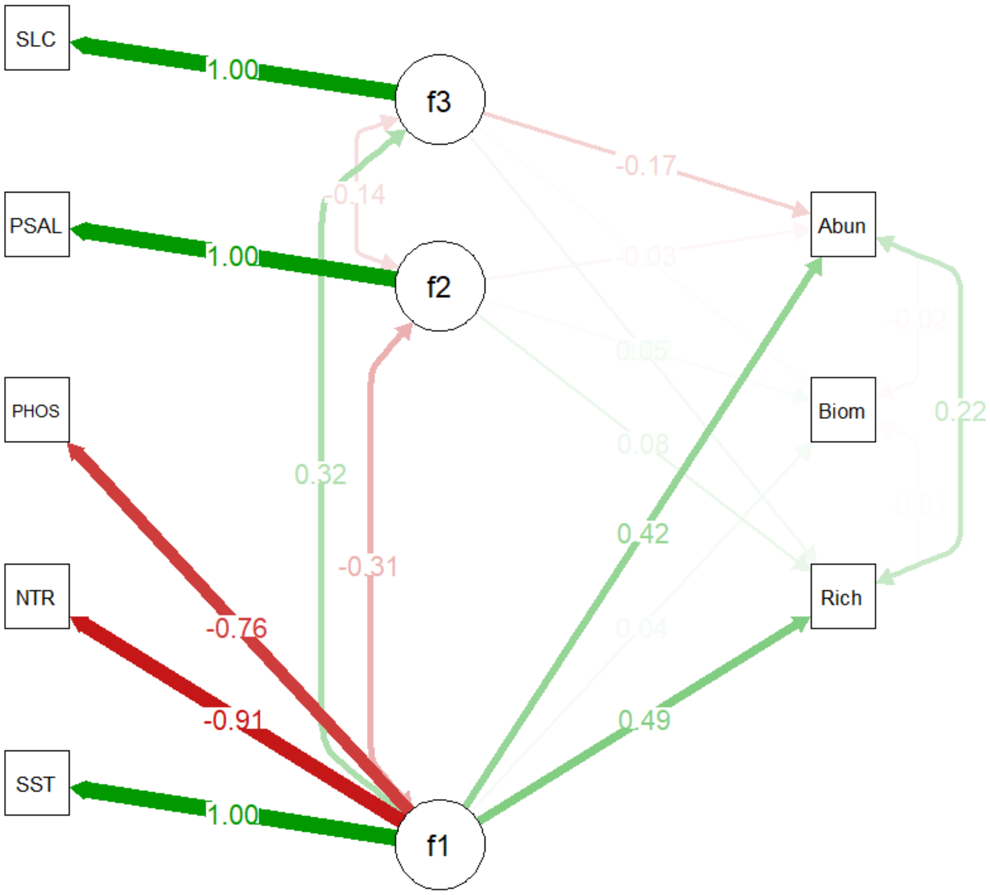

Figure 5.4 Results from a structural equation model run on marine bivalve abundance (Abun), body size (Biom) and species richness (Rich) with environmental correlates. Numbers of arrows show the relationship between the variables, scaled to be between -1 and 1. Red arrows show negative relationships, green arrows show positive relationships and the width and transparency of the arrows are scaled to the strength of the uncovered relationship. Environmental correlates are expressed as three latent variables (f1-3), the make-up of which was determined by a factor analysis prior to the model run. Environmental variables are as follows; Sea-surface temperature (SST), Salinity (PSAL) and nutrient concentration (NTR: Nitrate, PHOS: Phosphate, SLC: Silica).

Discussion

Despite a strong latitudinal gradient in bivalve richness for the eastern coastline of Australia (Fig. 5.1), there is no significant gradient in the body size of species (Fig. 5.2). The lack of a body size gradient here is not surprising, as prior research into bivalves has shown no general trends (Linse *et al.*, 2006, Berke *et al.*, 2013). However, this result persists (Table S5.2) even if the dataset is broken into family groupings: no gradient is found in any family – contrary to the results of Berke *et al.* (2013), an analysis containing the geographic area we covered. Although our analysis used only the largest specimen of each species at a site, we differ from Berke *et al*. (2013) by allowing for geographic changes in body size and this may explain the family-level differences between the studies.

Our analysis did cover a major biogeographical break in coastal Australia (Spalding *et al.*, 2007), but we still did not observe any trends between the two quite distinct provinces sampled here. Although another analysis of biogeographical effects on body size trends covers a broader latitudinal range (Roy and Martien, 2001), ours nonetheless documents the lack of a pattern at a continental scale. Body size trends in our dataset are also not observed even when the data are weighted for species abundance, showing that changes in biomass are also small. Similar analyses could not have featured in previous studies because they did not employ rigorously collected field data.

Our nearest-neighbour analysis shows that communities do not diverge from randomly assembled ones having the same species richness. This shows that site-level communities are not overly clumped or highly disparate with respect to the regional species pool, and that the size relationships within sites are stable. This result applies to both temperate and tropical sites. Most of the families represented here fall within a similar functional grouping, as our sampling regime targeted intertidal organisms. It is also important to note that strong latitudinal trends in beach geomorphology across our sites (Short *et al.*, 2000, Short *et al.*,

2007) do not influence our results. Specifically, the dataset contrasts predominantly wave-dominated beaches in the south with tide-dominated beaches in the north (Short, 2006). In sum, given our sampling regime, there is every reason to think that trends would have been found if any factor relevant to molluscan biology had an impact on body size distributions.

Importantly, we find no support for the "more individuals" hypothesis. The abundance of species in a standardised sampling area does not significantly change across our entire study area (Fig. 5.1b) despite the strong diversity gradient (Fig. 5.1a). The presence of an abundance gradient in terrestrial invertebrates is largely supported by the literature, as with gradients in other taxa (Storch *et al.*, 2018). Marine invertebrates are not often examined in these studies, despite the species-energy relationship having a long-known presence in marine systems and across taxa (Tittensor *et al.*, 2010). As our study was based on standardised sampling at a large spatial scale, we can be confident that these effects are not due to issues arising with other studies testing the hypothesis (Storch *et al.*, 2018, Vagle and McCain, 2020). Although our sampling was based on dead shell assemblages, taphonomic effects are unlikely to change abundances (), and our field sampling can therefore be inferred to reflect living conditions.

Based on these results, we suggest that diversity trends in coastal Australia result from a gradient in environmental stochasticity that favours the tropics, therefore allowing rare species to persist, and not from changes in biomass or population size. Although we do find a strong relationship between body size and geographic range in our dataset, geographic range also has no relationship with species richness. The major biogeographic break in our dataset is consistent with offshore changes in reef area, and subsequently a change in the potential for dispersal of populations resulting from changes in current regimes (Church *et al.*, 1985, Martel and Chia, 1991). Changes in environmental stochasity have been shown to impact population dyanmics for low abundance sites in other taxa (Feldman *et al*. 2015). As more species can therefore be viable, we predict that higher net diversification rates are present in the tropics and that bivalves in temperate zones therefore have longer phylogenetic branch lengths. As general evolutionary data on bivalves are lacking, a fruitful area of future research would be to further test these relationships using an extensive, highly-resolved phylogenetic dataset.

Here we have shown that both body size and abundance of marine bivalves do not vary with latitude or across a biogeographic boundary, despite a large shift in richness. Species diversity is therefore decoupled from these variables, contrary to older studies documenting relationships between them and supporting newer reviews (Storch *et al.*, 2018, Weiser *et al.*, 2018) on the general validity of these trends.

Acknowledgments

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Supplementary Material

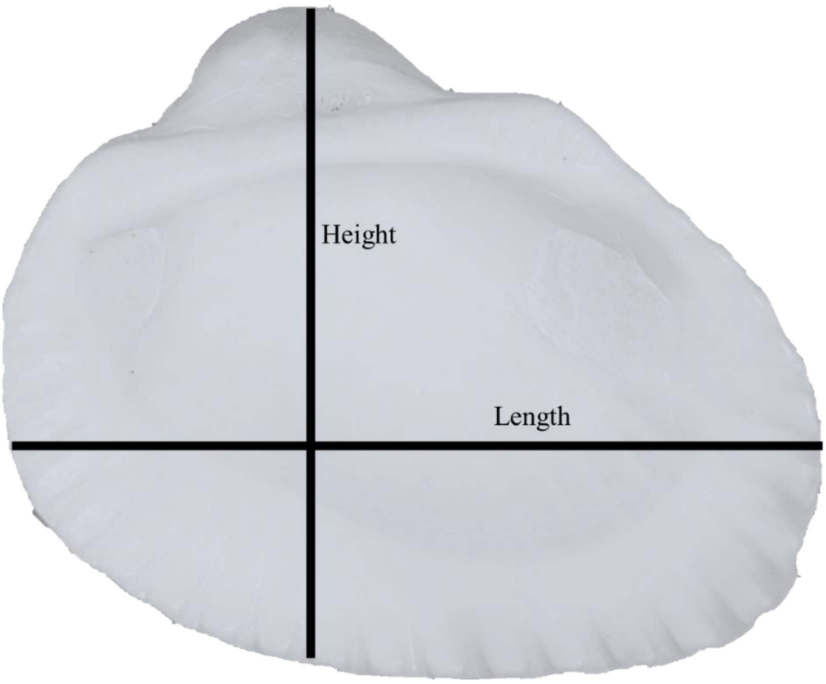

Figure S5.1 Shell diagram indicating measurements of length and height taken for this study. Shell is shown in lateral orientation.

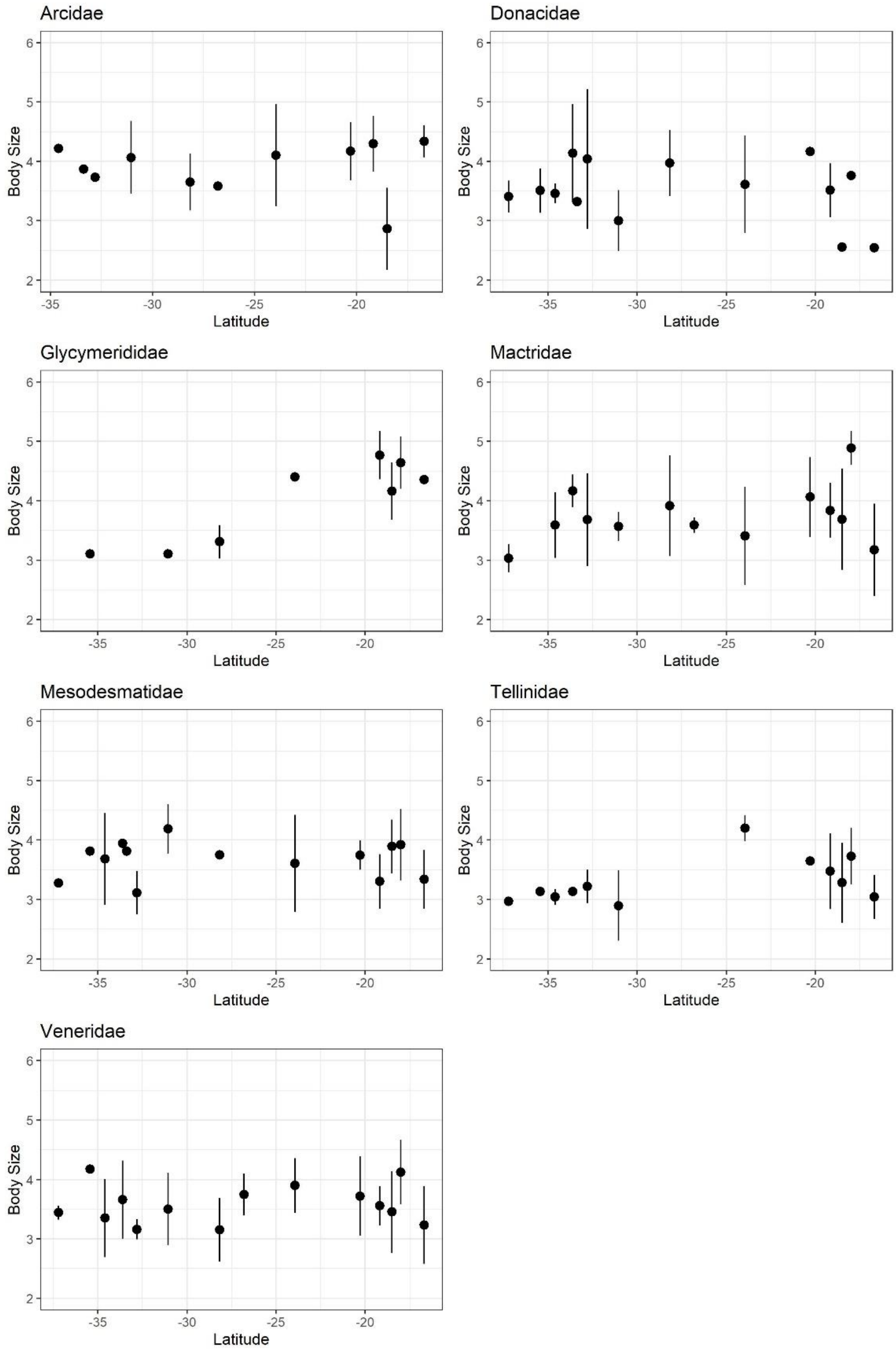

Figure S5.2. Latitudinal trends in mean body size along the eastern coastline of Australia for the seven largest families of marine bivalves. Body size is calculated as the geometric mean of length and height (see main text). No trend is statistically significant (Table S5.2).

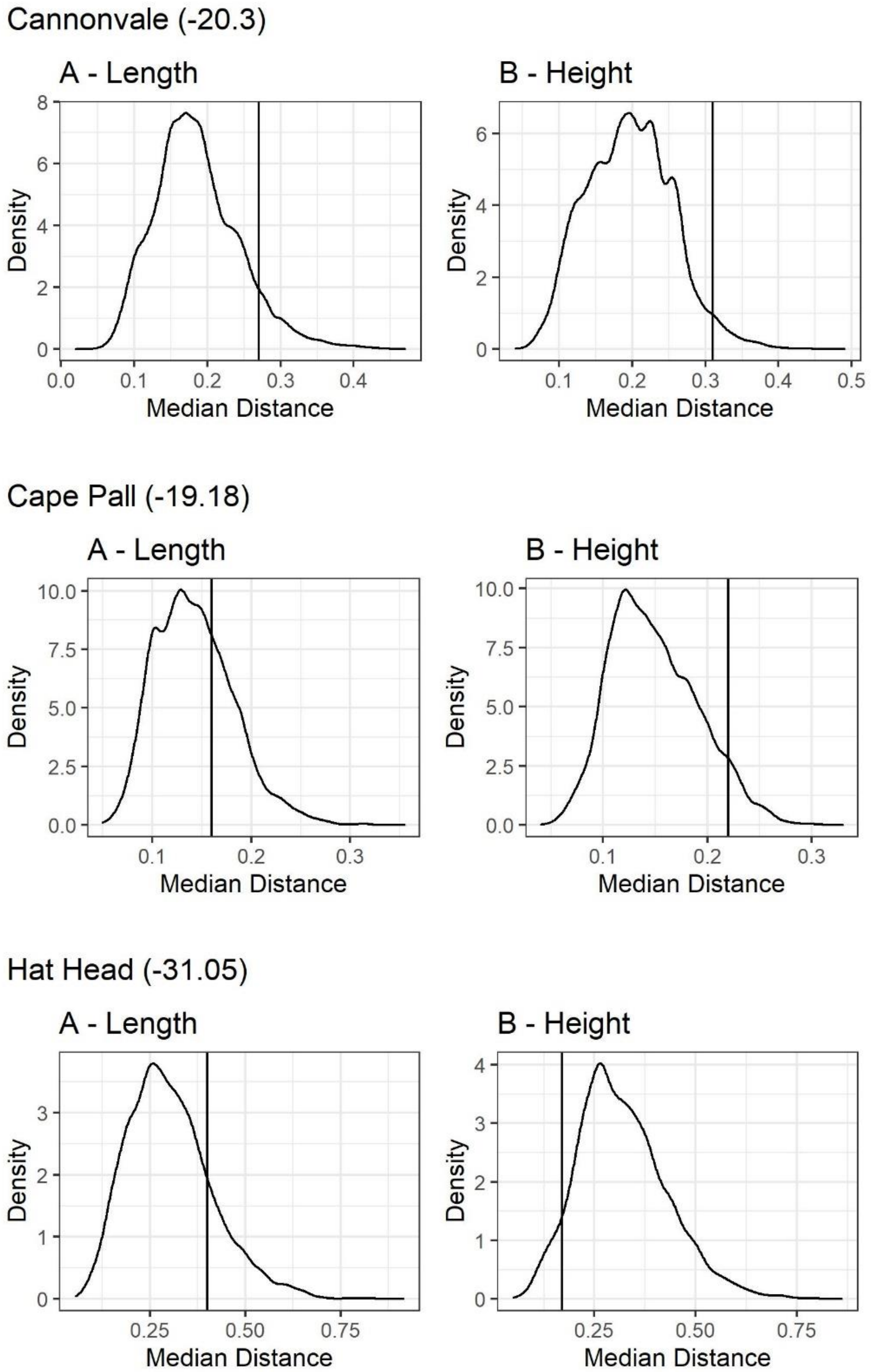

Figure S5.4. Results of a nearest-neighbour analysis of valve dimensions (A = length and B = height) of marine bivalves sampled from along the eastern coastline of Australia. The vertical line represents the true median of nearest-neighbour distances for the site. The probability density curve represents values resulting from a subsampling procedure and is generated from all bivalve measurements drawn from across the coastline. See text for full details. Site latitude is shown in parentheses.

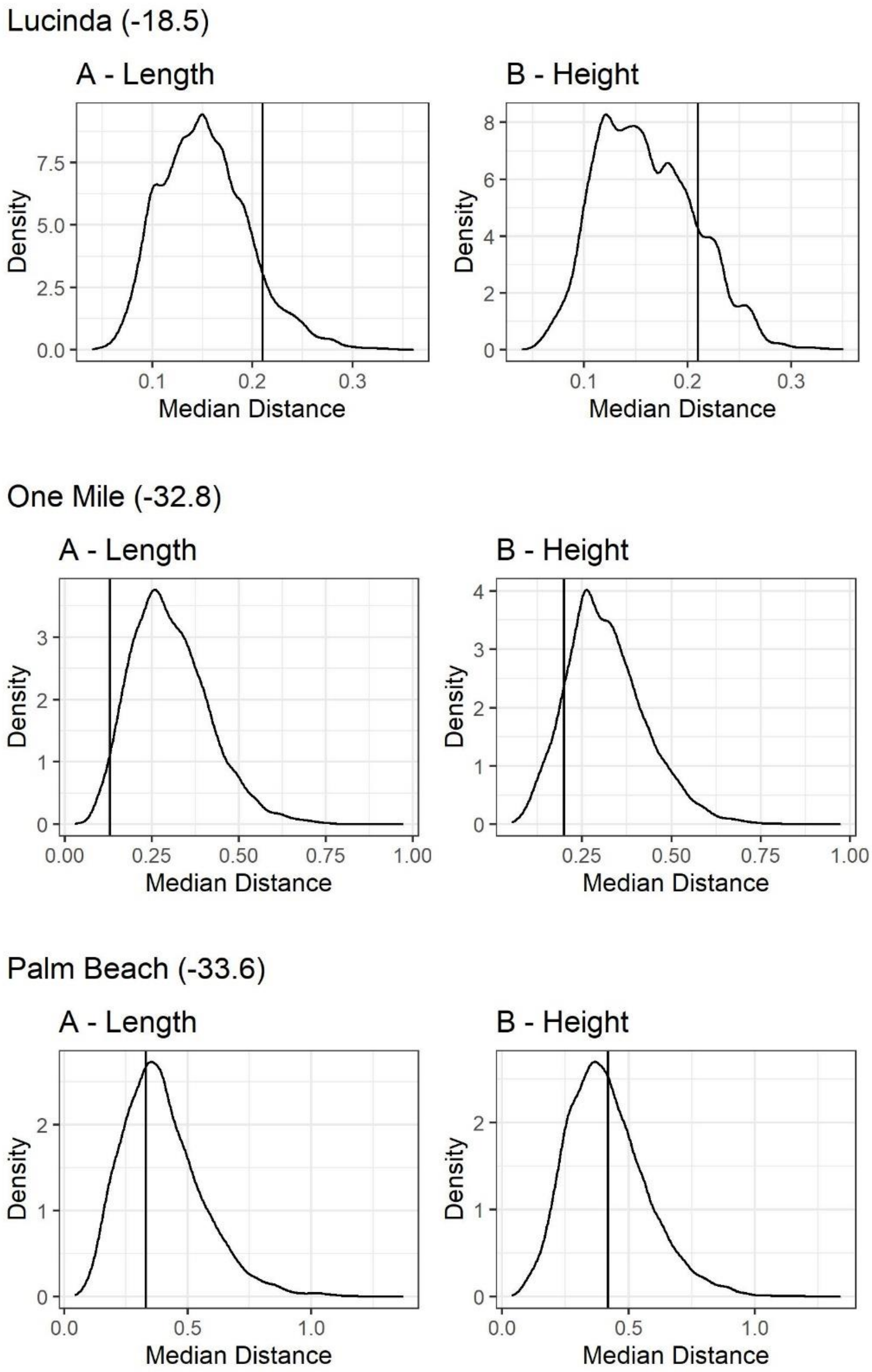

Figure S5.5. Results of a nearest-neighbour analysis of valve dimensions (A = length and B = height) of marine bivalves sampled from along the eastern coastline of Australia. The vertical line represents the true median of nearest-neighbour distances for the site. The probability density curve represents values resulting from a subsampling procedure and is generated from all bivalve measurements drawn from across the coastline. See text for full details. Site latitude is shown in parentheses.

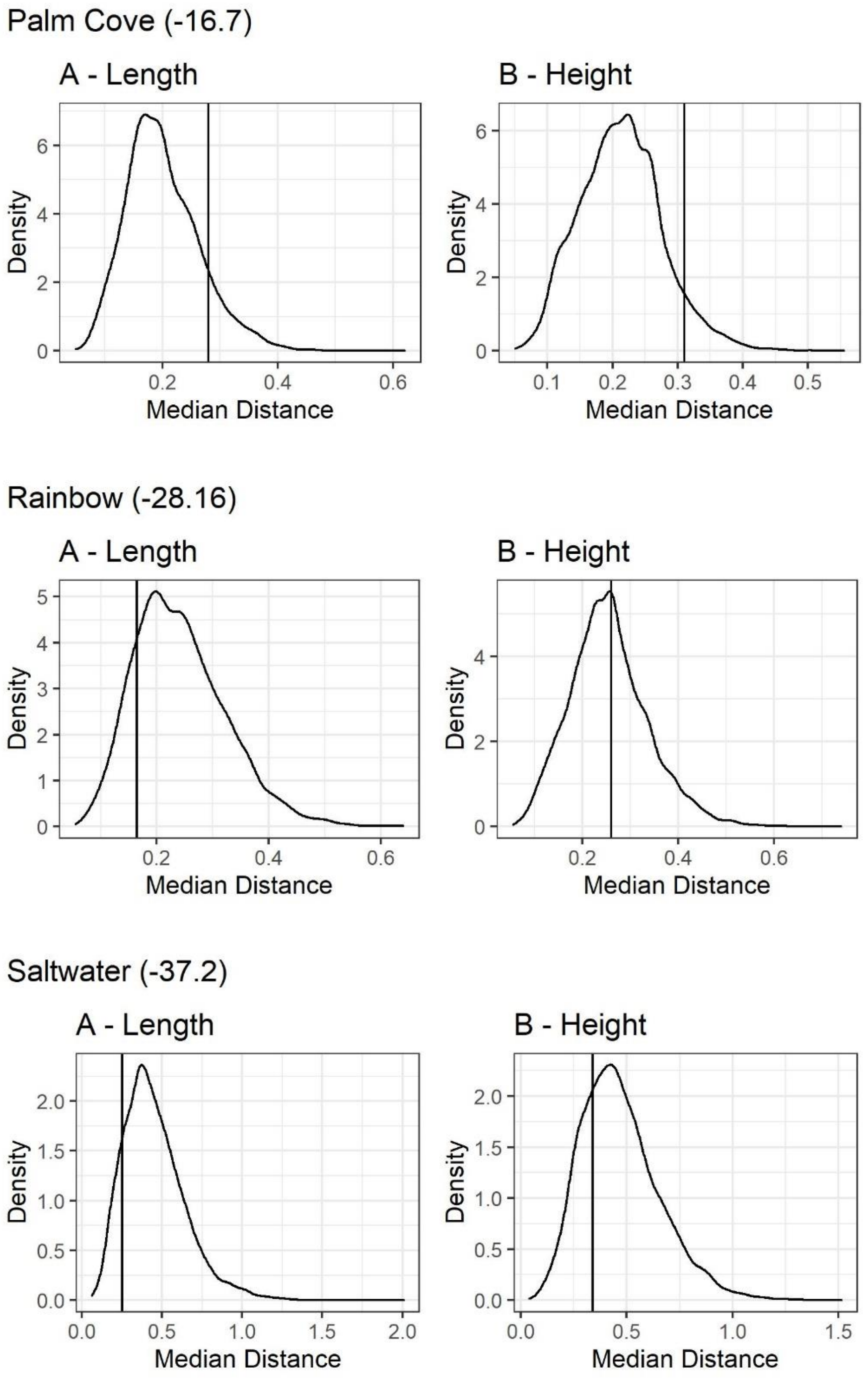

Figure S5.6. Results of a nearest-neighbour analysis of valve dimensions (A = length and B = height) of marine bivalves sampled from along the eastern coastline of Australia. The vertical line represents the true median of nearest-neighbour distances for the site. The probability density curve represents values resulting from a subsampling procedure and is generated from all bivalve measurements drawn from across the coastline. See text for full details. Site latitude is shown in parentheses.

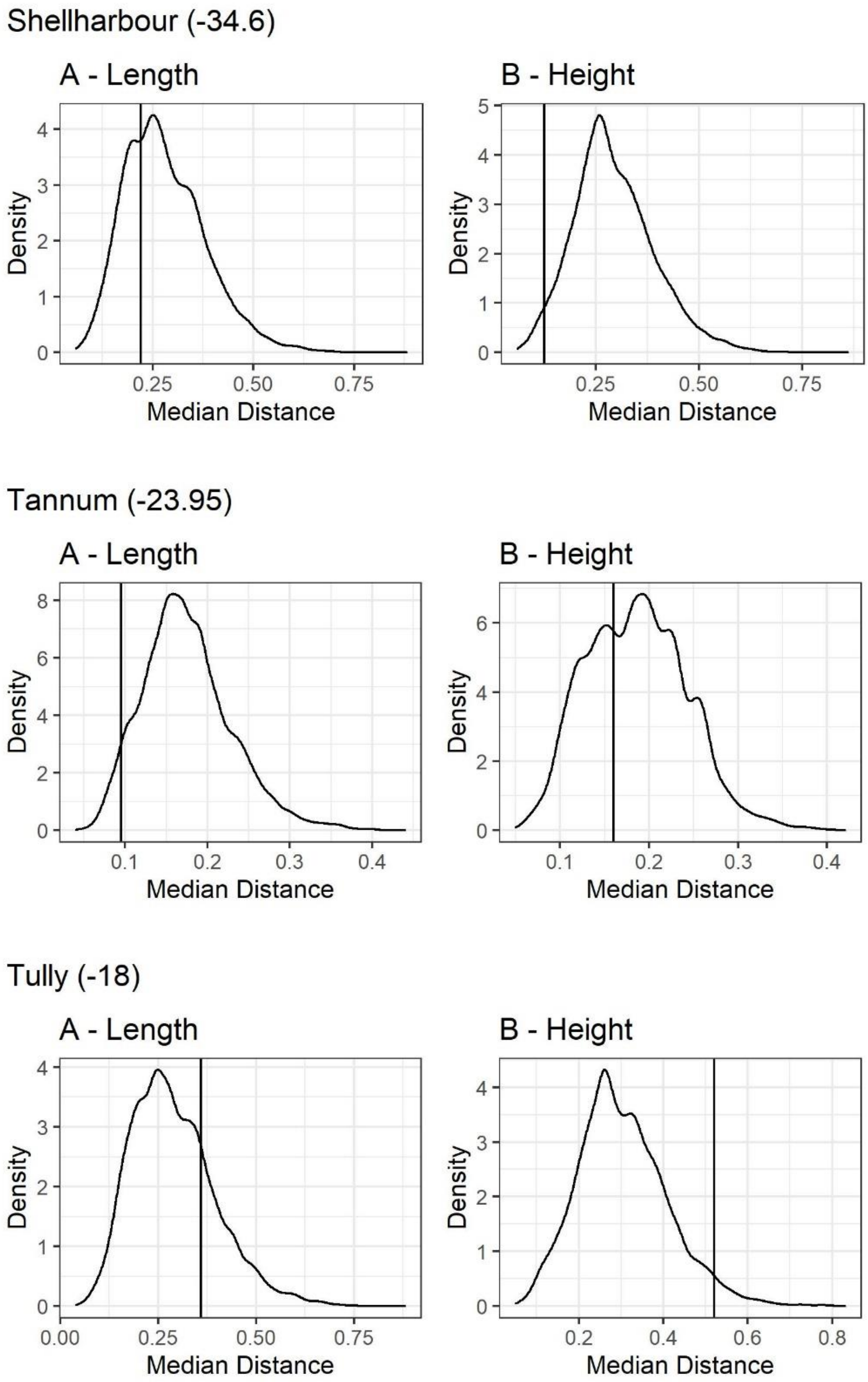

Figure S5.7. Results of a nearest-neighbour analysis of valve dimensions (A = length and B = height) of marine bivalves sampled from along the eastern coastline of Australia. The vertical line represents the true median of nearest-neighbour distances for the site. The probability density curve represents values resulting from a subsampling procedure and is generated from all bivalve measurements drawn from across the coastline. See text for full details. Site latitude is shown in parentheses.

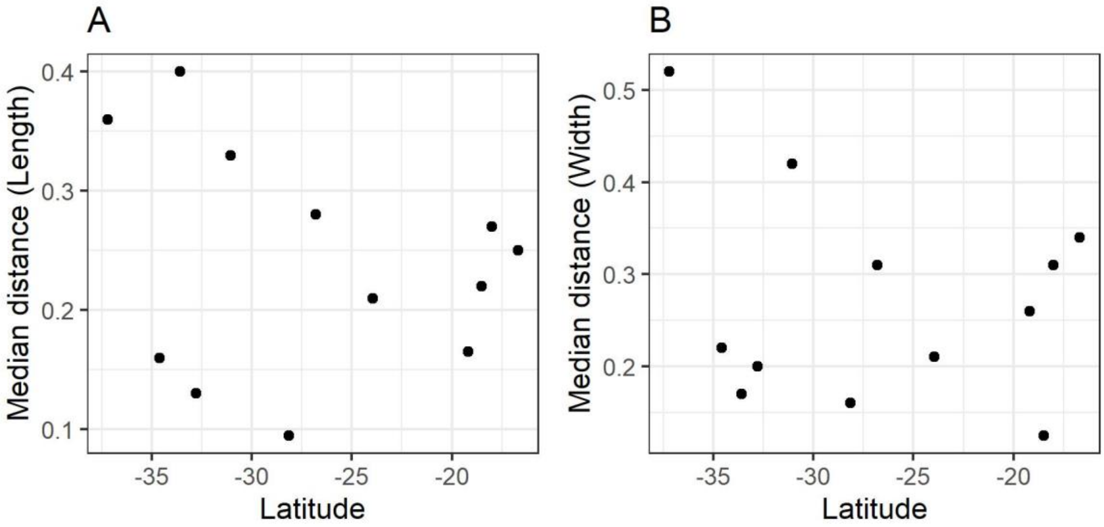

Figure S5.8 Latitudinal distribution of the true median retained in a nearest-neighbour analysis. Smaller values represent sites with a lower median distance between a shell measurement and the closest measurement from other shells at the same site. Results are shown for two valve dimensions (A = length and B = height).

Table S5.1 The strength of the latitudinal gradient in marine bivalves on the eastern coastline of Australia. Shown are Spearman's rank correlations (ρ) and slopes of diversity against latitude. Five different diversity measures are shown: Chao1 (Chao, 1984), S^2/m (Alroy, 2020), Fisher's alpha (Hubbell, 2015), Simpson's D and raw richness. **Bolded** values are significant ($p < 0.01$).

Method	ρ	Slope
Chao1	**0.764**	**2.543**
S^2/m	**0.818**	**2.180**
Fisher's alpha	**0.686**	**0.827**
Simpson's D	0.571	**0.809**
Raw richness	**0.776**	**1.441**

Table S5.2 Spearman's rank correlations (ρ) between latitude and median body size for the largest seven families of marine bivalves on the eastern coastline of Australia, with associated *p*-values. Body size is calculated as the geometric mean between length and height (see Materials and Methods). Family trends are shown visually in Fig. S5.2.

Family Name	ρ	*p* value
Arcidae	0.182	0.595
Donacidae	-0.090	0.762
Glycymerididae	0.683	0.062
Mactridae	0.236	0.437
Mesodesmatidae	0.048	0.869
Tellinidae	0.504	0.094
Veneridae	0.086	0.773

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Chapter Six

Synthesis

Summary

The primary aim of this thesis was to investigate the relationship between biogeography and species diversity in marine molluscs. By means of studying bivalves, underrepresented in collections, in Australia, a continent with a large continuous coastline, the work presented here expands knowledge in key macroecological areas. In order to complete it, I investigated patterns of molluscan distribution at three different spatial scales: global, continental and regional.

I started at a global scale, looking at the factors that may shape molluscan biogeography. By using factor analysis, I was able to preserve subtle information about biogeographical gradients. This revealed transition zones at broad scales, but also enabled analysing realms in a more sophisticated way than just predicting the location of hard boundaries. Most importantly, I was able to use the information contained in factor scores to show that changes in coral reef presences significantly affected global changes in molluscan biogeography, a result with implications for conservation and the future state of marine systems.

I then applied these methodologies at a continental scale and looked at how these biogeographical gradients interact with spatial diversity patterns on a two-dimensional coastline. I found that no abiotic factor could explain the observed changes in diversity, contrary to many other studies on marine diversity at similar scales. Instead, the biogeographic scores found through factor analysis were the primary predictors. These results suggest that simple tests of abiotic variables may oversimplify explanations of latitudinal patterns of diversity.

The basis of my fourth chapter was a significant field collection used to look specifically at the eastern coastline of Australia. My field data supported the presence of a strong latitudinal gradient in bivalves. The biogeographical interpretation of two east coast provinces presented in my third chapter was also supported, with the extent of the transition zone made clear by

my analysis. Additionally, I was able to demonstrate how changes in methodology significantly change the perceived strength of the latitudinal gradient. Specifically, different diversity metrics presented different patterns, which also varied among datasets. The inclusion of observational data in an online dataset weakened latitudinal signal in some cases. This is of particular importance when dealing with taxa which are underrepresented in aggregate datasets, such as bivalves, and highlights the importance of ongoing, high quality field collections for such groups. It is obvious from these results that care should be taken when analysing latitudinal gradients from any source, and that multiple methods should be employed in a study in order to elucidate spatial diversity patterns.

Finally, I used body size measurements from the collected bivalves to test for latitudinal gradients in biomass, body size, and abundance. I found no evidence of any gradient in these variables, contrary to other reviews at similar scales. I finished this chapter by discussing possible evolutionary controls on diversity patterns, touching on possible mechanisms for diversity patterns beyond the scope of the thesis.

The Relationship Between Biogeography and Species Diversity

As mentioned, the relationship between biogeography and species diversity was the key focus of this project. In my second and third chapters, I highlighted factor analysis as a method for examining biogeographic structure at two different spatial scales. In both cases, the method broadly matched previous regionalization schemes but provided crucial details. In both chapters the geographic continuity of clusters was maintained to a higher degree by factor analysis, with fewer misplaced cells and a greater degree of boundary certainty.

The major benefit of the method is to show subtle relationships between factors, allowing a more complete inspection of transition zones. In Australia, transition zones have generally been treated as separate units in bioregionalization reports (see CSIRO, 1996, Commonwealth of Australia, 2005). In this thesis, I have instead shown that continuous gradients exist between geographic regions. My fourth chapter followed previous ones by uncovering a biogeographic gradient along the eastern coastline of Australia.

In addition to highlighting the advantages of mapping these biogeographic gradients, this approach enables new analyses. Global provinces could be explained more intuitively by variables such as coral reef presence in the analysis presented in chapter two. The same analysis also allowed biogeography to be included in diversity models in a much easier way than would be possible if traditional boundary schemes had been used.

This thesis also presented new evidence for drivers of latitudinal diversity gradients. In chapters three, four, and five I illustrated different approaches to the measurement of diversity. The results differed to those found in many similar studies, with no correlation between temperature and diversity being found across Australia and no gradient in either body size or abundance being found along the east coast. Importantly, chapter four showed that the choice of methods used significantly altered the perceived strength of the gradient. Field-collected data also yielded stronger signals than did online datasets, and even modest amounts of fieldwork could change patterns found in many other groups. Carelessly assembling a macroecological dataset and using few diversity estimators could have impacted the outcomes of similar studies. Including rigorous data treatment and varied measures in future studies of any taxa will be important for creating a full picture of spatial variation in diversity.

Future Steps

The major aspect missing from both the biogeographical and macroecological approaches used in this thesis are phylogenetic approaches. I stressed in the introduction that long-term rates of speciation and extinction are integral to the dynamics that underpin latitudinal diversity gradients, as changing diversity requires changing rates. Latitudinal changes in these rates have been examined for a few groups having highly resolved phylogenies, for example birds (Weir and Schluter, 2007, Rabosky *et al.*, 2015), fishes (Rabosky *et al.*, 2018), and mammals (Weir and Schluter, 2007, Rolland *et al.*, 2014). Phylogenetic methods for delimiting biogeographical areas are also now commonplace, and are used to understand the long-term histories of regions (e.g. Hazzi *et al.*, 2018). However, they may suffer from the same sorts of problems that handicap traditional biogeographical schemes, namely assuming hard boundaries and not allowing for differing degrees of turnover between adjacent regions. Comparisons between different methods of producing biogeographic schemes do exist, the distinctions between them and the methods I have presented will prove to be of interest in biogeographic research. As a high-resolution phylogeny for molluscs does not currently exist, much future work would be required to directly build on the results showcased in this thesis.

Finally, what are the conservation implications that arise from this work? By presenting bioregionalization schemes that do not necessarily contain sharp boundaries, one may be drawn to the belief that these results are of no use for delimiting marine protected areas, a common goal of creating regional schemes (see Lourie and Vincent, 2004). However, this thesis has instead shown that understanding the internal structure of these provinces is important for understanding spatial diversity patterns. In my second chapter, I showed how coral reef presence not only controls provincial patterns in molluscs at a global scale, but determines the transitions within and between provinces. In my third chapter, I showed that biogeographic gradients are important for maintaining diversity patterns, with environmental variables only offering indirect controls. New bioregionalization schemes should focus on the nature of provinces and boundaries: care with applying methods will certainly aid regional conservation management in Australia and elsewhere.

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Appendices

1. Code and data availability

Chapter Two

- R code relating to chapter two can be found at https://github.com/MattRKerr
- The data from OBIS was downloaded using the R package *robis* using the following parameters; scientificname = “Mollusca”
- Point data were checked against a 10 metre resolution map downloaded from https://www.naturalearthdata.com/downloads/10m-physical-vectors/
- Ocean temperature data from taken from the Levitus dataset, contained within the R package *ocedata*.
- Coral Reef locations were taken from the UN Environment Programme, (downloaded from https://data.unep-wcmc.org/datasets/1) and the Reef Life Survey (downloaded from https://reeflifesurvey.com/survey-data/)
- Depth data were downloaded from the General Bathymetric Chart of the Oceans, downloaded from https://www.gebco.net/data_and_products/gridded_bathymetry_data

Chapter Three

- R code relating to chapter three can be found at https://github.com/MattRKerr
- The data from OBIS was downloaded using the R package *robis* using the following parameters; scientificname = “Mollusca”, areaid = 8
- The data from the Reef Life Survey were downloaded from https://reeflifesurvey.com/survey-data
- The abiotic data was accessed from https://portal.aodn.org.au/

Chapter Four

- The data from OBIS was downloaded using the R package *robis* using the following parameters; scientificname = “Bivalvia”, areaid = 8. Data were restricted to latitudes between -16.7 and -37.2 and a minimum longitude of 145.7
- The abiotic data was accessed from https://portal.aodn.org.au/
- Field collections used in this chapter are attached as Appendix 3
- Shell specimens are currently housed in the Palaeobiology Lab at Macquarie University and will be deposited in a public collection when any subsequent work arising from this thesis by the author has finished

Chapter Five

- Field collections used in this chapter are attached as Appendix 3
- Measurements made of shells used in this chapter are attached as Appendix 4
- Shell specimens are currently housed in the Palaeobiology Lab at Macquarie University and will be deposited in a public collection when any subsequent work arising from this thesis by the author has finished

2. Conference presentations during candidature

2020 **Kerr MR*,** Currie N, Kosnik MA and Alroy J. A Latitudinal Gradient in Australian Marine Bivalves Revealed by a Large Field Survey. *60th National conference of the Ecological Society of Australia*. 30 November – 4 December. (Oral presentation, online)

2020 Steller L*, Teece BL*, Hengst S and **Kerr MR.** Learn by Doing: A New Approach to Online Engagement with Astrobiology. *Astrobiology Australasia Meeting*. 9-11 September. (Oral presentation, online)

2019 **Kerr MR*** and Alroy, J. Abiotic variables cannot explain latitudinal diversity patterns for Australian marine invertebrates. *Annual meeting of the British Ecological Society, Belfast, UK*. 10-13 December. (Oral presentation)

2019 **Kerr MR*** and Alroy J. What determines coastal richness in Australia? *Annual meeting of the Australian Marine Sciences Association, Fremantle, Western Australia*. 7-11 July. (Oral presentation)

2019 **Kerr MR*** and Alroy, J. Biogeography, not temperature, predicts marine diversity in Australia. *9th Biennial conference of the International Biogeography Society, Málaga, Spain.* 8-12 January. (Oral presentation)

2018 **Kerr MR***. Where would she sell shells: What is the best predictor of Australian shell diversity? *Annual meeting of the British Ecological Society, Birmingham, UK.* 16-19 December. (Poster presentation)

*Indicates speaker(s)

3. Details of sites sampled during fieldwork

Beach numbers are taken from

- Short, A (2000). *Beaches of the Queensland Coast: Cooktown to Coolangatta : a Guide to Their Nature, Characteristics, Surf, and Safety*. Sydney University Press
- Short, A (2007). *Beaches of the New South Wales Coast: A Guide to Their Nature, Characteristics, Surf and Safety*. Sydney University Press

Beach Name	Beach Number	Latitude	Longitude
Palm Cove	QLD715	-16.70	145.7
Tully	QLD790	-18.00	146.1
Lucinda	QLD828	-18.50	146.3
Cape Pallarenda	QLD857	-19.18	146.8
Cannonvale	QLD1014	-20.30	148.7
Tannum	QLD1433	-23.95	151.4
Shelly Beach (Sunshine Coast)	QLD1553	-26.80	153.1
Rainbow Bay	QLD1600	-28.16	153.5
Hat Head	NSW144c	-31.05	153.1
One Mile	NSW232	-32.80	152.1
Shelly Beach (Central Coast)	NSW280	-33.37	151.5
Palm Beach	NSW300B	-33.60	151.3
Shellharbour	NSW383	-34.60	150.9
Tabourie North	NSW479	-35.44	150.4
Bermagui Entrance	NSW624	-36.40	150.1
Saltwater	NSW708	-37.20	150.0

4. **Bivalve occurrence data used in Chapters 4 and 5. All bivalves listed here were collected by MRK for the work carried out for this thesis. Site details are in Appendix 3**

Taxonomic authorities:

- Lamprell, K. and Whitehead, T. (1992). *Bivalves of Australia, Volume 1*, Crawford House Press.
- Lamprell, K. and Healy, J. (1998). *Bivalves of Australia, Volume 2*, Crawford House Press.

site	sample	fraction	n	family	genus	specificEpithet	species	authority
Cannonvale	1	8	2	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cannonvale	1	16	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cannonvale	2	8	2	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cannonvale	3	8	2	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cannonvale	5	8	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cannonvale	9	4	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cannonvale	5	8	4	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cannonvale	2	4	4	Arcidae	Andara	dautzenbergi	Andara dautzenbergi	Lamprell and Healy, 1998
Cannonvale	2	4	7	Arcidae	Andara	dautzenbergi	Andara dautzenbergi	Lamprell and Healy, 1998
Cannonvale	2	8	3	Arcidae	Andara	dautzenbergi	Andara dautzenbergi	Lamprell and Healy, 1998
Cannonvale	2	8	12	Arcidae	Andara	dautzenbergi	Andara	Lamprell and

							dautzenbergi	Healy, 1998
Cannonvale	3	8	3	Arcidae	Andara	dautzenbergi	Andara dautzenbergi	Lamprell and Healy, 1998
Cannonvale	8	8	1	Dimyidae	Anomia	trigonopsis	Anomia trigonopsis	Lamprell and Healy, 1998
Cannonvale	9	8	4	Dimyidae	Anomia	trigonopsis	Anomia trigonopsis	Lamprell and Healy, 1998
Cannonvale	10	16	1	Dimyidae	Anomia	trigonopsis	Anomia trigonopsis	Lamprell and Healy, 1998
Cannonvale	2	4	2	Noetiidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Cannonvale	3	8	2	Noetiidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Cannonvale	9	4	1	Noetiidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Cannonvale	2	8	1	Arcidae	Barbatia	foliata	Barbatia foliata	Lamprell and Healy, 1998
Cannonvale	2	4	1	Arcidae	Barbatia	pistachia	Barbatia pistachia	Lamprell and Healy, 1998
Cannonvale	2	8	1	Arcidae	Barbatia	pistachia	Barbatia pistachia	Lamprell and Healy, 1998
Cannonvale	2	8	3	Arcidae	Barbatia	pistachia	Barbatia pistachia	Lamprell and Healy, 1998
Cannonvale	1	16	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cannonvale	2	16	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cannonvale	4	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cannonvale	5	8	4	Carditidae	Cardita	crassicosta	Cardita	Lamprell and

							crassicosta	Whitehead, 1992
Cannonvale	1	16	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cannonvale	2	16	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cannonvale	9	4	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cannonvale	6	4	1	Veneridae	Circe	mistura	Circe mistura	Lamprell and Whitehead, 1992
Cannonvale	1	8	2	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Cannonvale	2	8	6	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Cannonvale	1	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	2	4	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	2	8	5	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	2	8	9	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	2	16	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	2	16	4	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	3	8	6	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	4	8	5	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	5	8	3	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and

								Whitehead, 1992
Cannonvale	5	16	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cannonvale	6	4	1	Veneridae	Eumarcia	fumigata	Eumarcia fumigata	Lamprell and Whitehead, 1992
Cannonvale	2	4	1	Cardiidae	Fragum	hemicardium	Fragum hemicardium	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Cardiidae	Fragum	hemicardium	Fragum hemicardium	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Cardiidae	Fragum	hemicardium	Fragum hemicardium	Lamprell and Whitehead, 1992
Cannonvale	1	8	2	Veneridae	Gafrarium	menkei	Gafrarium menkei	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Veneridae	Gafrarium	menkei	Gafrarium menkei	Lamprell and Whitehead, 1992
Cannonvale	2	16	1	Veneridae	Gafrarium	menkei	Gafrarium menkei	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Veneridae	Gafrarium	menkei	Gafrarium menkei	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Veneridae	Gafrarium	pectinatum	Gafrarium pectinatum	Lamprell and Whitehead, 1992
Cannonvale	2	8	3	Veneridae	Gafrarium	pectinatum	Gafrarium pectinatum	Lamprell and Whitehead, 1992
Cannonvale	5	16	1	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Cannonvale	1	16	1	Limidae	Lima	vulgaris	Lima vulgaris	Lamprell and Whitehead, 1992
Cannonvale	4	8	1	Limidae	Limaria	fragilis	Limaria fragilis	Lamprell and Whitehead, 1992
Cannonvale	6	4	1	Limidae	Limaria	fragilis	Limaria fragilis	Lamprell and Whitehead, 1992
Cannonvale	2	4	1	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Cannonvale	2	8	4	Veneridae	Lioconcha	annettae	Lioconcha	Lamprell and

							annettae	Whitehead, 1992
Cannonvale	4	8	4	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Cannonvale	9	4	4	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Cannonvale	1	16	4	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	2	16	2	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	5	8	1	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	5	16	2	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	9	16	1	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	10	16	9	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Cannonvale	1	8	4	Veneridae	Lioconcha	fastigiata	Lioconcha fastigiata	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Veneridae	Lioconcha	fastigiata	Lioconcha fastigiata	Lamprell and Whitehead, 1992
Cannonvale	3	8	4	Veneridae	Lioconcha	fastigiata	Lioconcha fastigiata	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Cannonvale	1	8	2	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cannonvale	6	4	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cannonvale	7	8	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Mactridae	Mactra	dissimilis	Mactra	Lamprell and

							dissimilis	Whitehead, 1992
Cannonvale	2	8	3	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cannonvale	2	16	3	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cannonvale	9	4	2	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cannonvale	1	8	3	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Cannonvale	9	16	2	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Cannonvale	5	8	1	Veneridae	Marcia	hiantina	Marcia hiantina	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Mactridae	Meropesta	nicobarica	Meropesta nicobarica	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Cannonvale	4	8	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Cannonvale	1	8	3	Anomiidae	Patro	australis	Patro australis	Lamprell and Healy, 1998
Cannonvale	2	8	1	Anomiidae	Patro	australis	Patro australis	Lamprell and Healy, 1998
Cannonvale	3	8	1	Anomiidae	Patro	australis	Patro australis	Lamprell and Healy, 1998
Cannonvale	2	4	1	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and

								Whitehead, 1992
Cannonvale	3	8	1	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and Whitehead, 1992
Cannonvale	2	4	1	Veneridae	Pitar	subpellucidus	Pitar subpellucidus	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Veneridae	Placamen	tiara	Placamen tiara	Lamprell and Whitehead, 1992
Cannonvale	3	16	1	Plicatulidae	Plicatula	chiensis	Plicatula chiensis	Lamprell and Healy, 1998
Cannonvale	9	16	1	Plicatulidae	Plicatula	chiensis	Plicatula chiensis	Lamprell and Healy, 1998
Cannonvale	2	8	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Semelidae	Semele	lamellosa	Semele lamellosa	Lamprell and Whitehead, 1992
Cannonvale	5	8	2	Semelidae	Semele	lamellosa	Semele lamellosa	Lamprell and Whitehead, 1992
Cannonvale	5	16	1	Semelidae	Semele	lamellosa	Semele lamellosa	Lamprell and Whitehead, 1992
Cannonvale	2	8	1	Mytilidae	Septifer	bilocularis	Septifer bilocularis	Lamprell and Healy, 1998
Cannonvale	1	8	1	Solenidae	Solen	roseomaculatus	Solen roseomaculatus	Lamprell and Healy, 1998
Cannonvale	2	8	1	Veneridae	Tapes	literatus	Tapes literatus	Lamprell and Whitehead, 1992
Cannonvale	3	8	1	Veneridae	Tapes	literatus	Tapes literatus	Lamprell and Whitehead, 1992
Cannonvale	2	4	2	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cannonvale	2	8	2	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cannonvale	3	8	2	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cannonvale	4	8	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and

								Whitehead, 1992
Cannonvale	5	8	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	1	8	1	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Cape Pall	2	8	5	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Cape Pall	4	8	3	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Cape Pall	8	4	2	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Cape Pall	8	8	1	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Cape Pall	10	8	2	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Cape Pall	8	8	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cape Pall	10	4	2	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cape Pall	10	8	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Cape Pall	2	8	3	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	4	4	2	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	4	8	3	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	4	16	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	5	8	3	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	8	4	2	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	8	4	3	Arcidae	Anadara	gubernaculum	Anadara	Lamprell and

							guvernaculum	Healy, 1998
Cape Pall	8	8	7	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	8	8	9	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	10	4	8	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	10	8	3	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	10	8	7	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Cape Pall	8	4	2	Arcidae	Barbatia	foliata	Barbatia foliata	Lamprell and Healy, 1998
Cape Pall	2	16	1	Arcidae	Barbatia	terebrans	Barbatia terebrans	Lamprell and Healy, 1998
Cape Pall	1	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cape Pall	4	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cape Pall	5	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cape Pall	10	8	3	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Cape Pall	1	8	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Cape Pall	2	8	2	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Cape Pall	4	8	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and

								Whitehead, 1992
Cape Pall	8	4	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Cape Pall	10	8	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Cape Pall	2	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	4	4	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	4	8	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	5	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	10	4	4	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	10	8	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Cape Pall	10	8	1	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Cape Pall	10	4	2	Tellinidae	Exotica	obliquaria	Exotica obliquaria	Lamprell and Whitehead, 1992
Cape Pall	2	8	3	Veneridae	Gafrarium	equivocum	Gafrarium equivocum	Lamprell and Whitehead, 1992
Cape Pall	2	8	1	Psammobiidae	Gari	maculosa	Gari maculosa	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Cape Pall	10	4	3	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Cape Pall	10	8	3	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and

								Whitehead, 1992
Cape Pall	2	16	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Cape Pall	4	16	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Cape Pall	2	16	1	Glycymerididae	Glycymeris	hedleyi	Glycymeris hedleyi	Lamprell and Whitehead, 1992
Cape Pall	2	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Cape Pall	2	16	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Cape Pall	4	4	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Cape Pall	4	16	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Cape Pall	10	8	3	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Cape Pall	10	16	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Cape Pall	2	16	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Cape Pall	5	8	2	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Cape Pall	10	16	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Cape Pall	5	8	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Healy, 1998
Cape Pall	8	4	1	Kellidae	Kellia	rotunda	Kellia rotunda	Lamprell and Healy, 1998
Cape Pall	8	4	2	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Limidae	Lima	vulgaris	Lima vulgaris	Lamprell and

								Whitehead, 1992
Cape Pall	10	8	1	Limidae	Lima	vulgaris	Lima vulgaris	Lamprell and Whitehead, 1992
Cape Pall	4	8	1	Veneridae	Lioconcha	fastigiata	Lioconcha fastigiata	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Cape Pall	10	4	1	Tellinidae	Macoma	dispar	Macoma dispar	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cape Pall	5	8	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cape Pall	8	8	2	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cape Pall	10	4	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Cape Pall	1	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	1	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	1	4	2	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	1	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	2	8	2	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Mactridae	Mactra	dissimilis	Mactra	Lamprell and

							dissimilis	Whitehead, 1992
Cape Pall	8	8	3	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Mactridae	Mactra	turgida	Mactra turgida	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Cape Pall	2	16	1	Pectinidae	Minnivola	pyxidata	Minnivola pyxidata	Lamprell and Whitehead, 1992
Cape Pall	2	16	6	Cardiidae	Nemocardium	lyratum	Nemocardium lyratum	Lamprell and Whitehead, 1992
Cape Pall	2	8	1	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Cape Pall	10	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Cape Pall	1	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Cape Pall	1	4	2	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Cape Pall	10	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Cape Pall	10	4	4	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Cape Pall	1	4	1	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and Whitehead, 1992
Cape Pall	4	4	2	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and

								Whitehead, 1992
Cape Pall	8	8	1	Veneridae	Pitar	subpellucidus	Pitar subpellucidus	Lamprell and Whitehead, 1992
Cape Pall	9	8	1	Mactridae	Raeta	pellicula	Raeta pellicula	Lamprell and Whitehead, 1992
Cape Pall	1	4	2	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	1	4	3	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	1	8	8	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	1	16	2	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	2	8	2	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	2	16	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	2	16	3	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	3	16	3	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	4	4	4	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	4	8	7	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	5	8	11	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	8	8	6	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	10	4	7	Semelidae	Semele	crenulata	Semele	Lamprell and

							crenulata	Whitehead, 1992
Cape Pall	10	8	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	10	8	6	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Cape Pall	2	8	1	Mytilidae	Septifer	bilocularis	Septifer bilocularis	Lamprell and Healy, 1998
Cape Pall	10	8	1	Mytilidae	Septifer	bilocularis	Septifer bilocularis	Lamprell and Healy, 1998
Cape Pall	2	8	1	Solenidae	Solen	roseomaculatus	Solen roseomaculatus	Lamprell and Healy, 1998
Cape Pall	10	4	1	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and Whitehead, 1992
Cape Pall	5	8	1	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and Whitehead, 1992
Cape Pall	10	8	2	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and Whitehead, 1992
Cape Pall	8	4	2	Tellinidae	Strigilla	tomlini	Strigilla tomlini	Lamprell and Whitehead, 1992
Cape Pall	8	8	2	Tellinidae	Strigilla	tomlini	Strigilla tomlini	Lamprell and Whitehead, 1992
Cape Pall	10	8	1	Tellinidae	Tellina	bougei	Tellina bougei	Lamprell and Whitehead, 1992
Cape Pall	1	4	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	1	4	3	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	2	8	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	4	4	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and

								Whitehead, 1992
Cape Pall	4	8	3	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	5	8	2	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	8	4	2	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	8	8	3	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	10	4	6	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	10	8	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	10	8	3	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Cape Pall	2	16	1	Tellinidae	Tellina	emarginata	Tellina emarginata	Lamprell and Whitehead, 1992
Cape Pall	1	4	4	Tellinidae	Tellina	radians	Tellina radians	Lamprell and Whitehead, 1992
Cape Pall	8	4	2	Tellinidae	Tellina	radians	Tellina radians	Lamprell and Whitehead, 1992
Cape Pall	8	8	1	Veneridae	Timoclea	recognita	Timoclea recognita	Lamprell and Whitehead, 1992
Cape Pall	4	8	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Cape Pall	8	4	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Cape Pall	10	4	1	Lucinidae	Wallucina	assimilis	Wallucina	Lamprell and

							assimilis	Whitehead, 1992
Hat Head	2	8	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Hat Head	3	16	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Hat Head	10	4	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Hat Head	4	8	1	Arcidae	Barbatia	pistachia	Barbatia pistachia	Lamprell and Healy, 1998
Hat Head	3	4	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Hat Head	5	8	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Hat Head	2	4	1	Carditidae	Cardiocardita	raouli	Cardiocardita raouli	Lamprell and Whitehead, 1992
Hat Head	1	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Hat Head	1	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	1	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	2	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	2	4	8	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	5	4	11	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	8	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	9	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	10	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Hat Head	2	4	3	Donacidae	Donax	deltoides	Donax	Lamprell and

							deltoides	Whitehead, 1992
Hat Head	2	8	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Hat Head	5	4	3	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Hat Head	9	4	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Hat Head	10	4	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Hat Head	1	4	15	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	1	4	24	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	2	4	14	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	2	4	108	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	5	4	45	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	5	8	3	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	8	4	9	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	9	4	9	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	10	4	11	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Hat Head	5	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Hat Head	10	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Hat Head	2	8	1	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Hat Head	8	8	1	Veneridae	Dosinia	nedigna	Dosinia	Lamprell and

							nedigna	Whitehead, 1992
Hat Head	2	4	3	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Hat Head	2	8	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Hat Head	8	8	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Hat Head	9	8	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Hat Head	1	8	1	Psammobiidae	Gari	truncata	Gari truncata	Lamprell and Whitehead, 1992
Hat Head	2	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Hat Head	4	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Hat Head	5	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Hat Head	5	4	1	Hemidonacidae	Hemidonax	dactylus	Hemidonax dactylus	Lamprell and Whitehead, 1992
Hat Head	1	4	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Hat Head	2	8	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Hat Head	5	4	4	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Hat Head	10	16	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Hat Head	4	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Hat Head	10	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Hat Head	1	4	1	Mactridae	Mactra	eximia	Mactra eximia	Lamprell and Whitehead, 1992
Hat Head	1	4	2	Mactridae	Mactra	eximia	Mactra eximia	Lamprell and

								Whitehead, 1992
Hat Head	2	4	1	Mactridae	Mactra	eximia	Mactra eximia	Lamprell and Whitehead, 1992
Hat Head	2	4	2	Mactridae	Mactra	eximia	Mactra eximia	Lamprell and Whitehead, 1992
Hat Head	2	4	2	Mactridae	Mactra	eximia	Mactra eximia	Lamprell and Whitehead, 1992
Hat Head	5	4	2	Mactridae	Mactra	eximia	Mactra eximia	Lamprell and Whitehead, 1992
Hat Head	1	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	1	4	10	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	2	4	5	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	2	4	17	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	5	4	9	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	8	4	2	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	9	4	4	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	10	4	4	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Hat Head	1	4	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	1	4	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	1	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	1	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies	Lamprell and

							elongata	Whitehead, 1992
Hat Head	2	4	8	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	2	4	37	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	2	8	17	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	3	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	3	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	4	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	5	4	33	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	5	8	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	8	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	8	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	9	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	9	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	10	4	5	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Hat Head	1	8	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	2	8	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	3	8	2	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	5	4	2	Cardiidae	Plagiocardium	setosum	Plagiocardium	Lamprell and

							setosum	Whitehead, 1992
Hat Head	5	8	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	5	16	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	8	8	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	10	16	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Hat Head	10	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
Hat Head	2	4	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Hat Head	2	4	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Hat Head	10	4	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Hat Head	1	8	1	Tellinidae	Tellina	lilium	Tellina lilium	Lamprell and Whitehead, 1992
Hat Head	2	8	1	Tellinidae	Tellina	lilium	Tellina lilium	Lamprell and Whitehead, 1992
Hat Head	2	4	1	Tellinidae	Tellina	modestina	Tellina modestina	Lamprell and Whitehead, 1992
Hat Head	10	4	2	Tellinidae	Tellina	modestina	Tellina modestina	Lamprell and Whitehead, 1992
Hat Head	9	4	1	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
Hat Head	1	4	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Hat Head	5	4	3	Carditidae	Venericardia	cavatica	Venericardia cavatica	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Lucinda	1	4	2	Arcidae	Anadara	gubernaculum	Anadara	Lamprell and

							guvernaculum	Healy, 1998
Lucinda	8	4	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Lucinda	8	8	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Lucinda	10	4	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Lucinda	1	4	5	Lucinidae	Anodontia	omissa	Anodontia omissa	Lamprell and Whitehead, 1992
Lucinda	5	8	1	Lucinidae	Anodontia	omissa	Anodontia omissa	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Lucinda	9	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Carditidae	Cardita	variegata	Cardita variegata	Lamprell and Whitehead, 1992
Lucinda	9	4	1	Carditidae	Cardita	variegata	Cardita variegata	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Veneridae	Circe	mistura	Circe mistura	Lamprell and Whitehead, 1992
Lucinda	8	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Lucinda	9	4	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Lucinda	10	4	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Lucinda	1	4	19	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Lucinda	3	8	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Lucinda	3	16	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Lucinda	8	4	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and

								Whitehead, 1992
Lucinda	8	8	6	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Lucinda	10	4	8	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Lucinda	10	8	3	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Lucinda	1	4	6	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Lucinda	8	4	3	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Lucinda	8	8	4	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Lucinda	9	4	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Lucinda	9	8	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Lucinda	10	4	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Veneridae	Dosinia	sculpta	Dosinia sculpta	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Cardiidae	Fragum	hemicardium	Fragum hemicardium	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Veneridae	Gafrarium	catillus	Gafrarium catillus	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Veneridae	Gafrarium	catillus	Gafrarium catillus	Lamprell and Whitehead, 1992
Lucinda	10	4	1	Veneridae	Gafrarium	catillus	Gafrarium catillus	Lamprell and Whitehead, 1992
Lucinda	1	4	3	Veneridae	Gafrarium	equivocum	Gafrarium equivocum	Lamprell and Whitehead, 1992
Lucinda	2	4	1	Veneridae	Gafrarium	equivocum	Gafrarium equivocum	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Psammobiidae	Gari	anomala	Gari anomala	Lamprell and

								Whitehead, 1992
Lucinda	1	4	35	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	3	4	3	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	3	8	1	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	4	4	2	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	4	8	1	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	8	4	10	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	8	8	7	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	9	4	2	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	10	4	11	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Lucinda	1	4	114	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	1	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	2	4	3	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	2	4	4	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	3	4	9	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	3	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	4	4	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	4	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and

								Whitehead, 1992
Lucinda	5	4	10	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	8	4	45	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	8	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	10	4	56	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	10	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Lucinda	1	4	8	Psammobiidae	Gari	weinkauffi	Gari weinkauffi	Lamprell and Whitehead, 1992
Lucinda	3	4	1	Psammobiidae	Gari	weinkauffi	Gari weinkauffi	Lamprell and Whitehead, 1992
Lucinda	8	4	3	Psammobiidae	Gari	weinkauffi	Gari weinkauffi	Lamprell and Whitehead, 1992
Lucinda	10	4	3	Psammobiidae	Gari	weinkauffi	Gari weinkauffi	Lamprell and Whitehead, 1992
Lucinda	3	16	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Lucinda	9	16	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Lucinda	5	8	1	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Lucinda	8	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Lucinda	10	8	5	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Lucinda	8	4	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Lucinda	1	4	5	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and

								Healy, 1998
Lucinda	8	4	2	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Lucinda	8	8	3	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Lucinda	10	4	1	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Lucinda	10	16	1	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Lucinda	2	8	1	Limopsidae	Limopsis	multistriatus	Limopsis multistriatus	Lamprell and Healy, 1998
Lucinda	1	4	1	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Tellinidae	Macoma	praetexta	Macoma praetexta	Lamprell and Whitehead, 1992
Lucinda	3	4	2	Tellinidae	Macoma	praetexta	Macoma praetexta	Lamprell and Whitehead, 1992
Lucinda	10	4	1	Tellinidae	Macoma	praetexta	Macoma praetexta	Lamprell and Whitehead, 1992
Lucinda	10	4	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Lucinda	10	8	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Lucinda	1	4	28	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	5	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	8	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	8	8	19	Mactridae	Mactra	dissimilis	Mactra	Lamprell and

							dissimilis	Whitehead, 1992
Lucinda	8	16	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	9	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	10	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	10	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	10	16	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Mactridae	Mactra	queenslandica	Mactra queenslandica	Lamprell and Whitehead, 1992
Lucinda	10	4	1	Veneridae	Marcia	hiantina	Marcia hiantina	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Lucinda	5	8	1	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Lucinda	1	4	4	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Lucinda	3	16	1	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Lucinda	8	4	3	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Lucinda	9	4	1	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Lucinda	10	4	3	Veneridae	Paphia	crassisulca	Paphia	Lamprell and

							crassisulca	Whitehead, 1992
Lucinda	1	4	13	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	1	4	73	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	1	8	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	2	16	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	3	4	14	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	3	8	5	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	4	4	6	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	4	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	5	4	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	5	8	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	8	4	37	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	8	8	6	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	9	4	9	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	9	8	11	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	10	4	20	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Lucinda	10	8	5	Mesodesmatidae	Paphies	elongata	Paphies	Lamprell and

							elongata	Whitehead, 1992
Lucinda	1	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	1	4	5	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	1	4	5	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	1	4	254	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	2	4	3	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	3	4	6	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	4	4	2	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	5	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	8	4	49	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	8	8	2	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	9	4	5	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	9	4	17	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	10	4	65	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Lucinda	1	4	3	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Lucinda	10	8	1	Plicatulidae	Plicatula	chiensis	Plicatula chiensis	Lamprell and Healy, 1998
Lucinda	10	8	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Lucinda	8	8	2	Semelidae	Semele	lamellosa	Semele	Lamprell and

							lamellosa	Whitehead, 1992
Lucinda	1	4	2	Solenidae	Solen	roseomaculatus	Solen roseomaculatus	Lamprell and Healy, 1998
Lucinda	1	4	2	Solenidae	Solen	roseomaculatus	Solen roseomaculatus	Lamprell and Healy, 1998
Lucinda	4	8	1	Solenidae	Solen	roseomaculatus	Solen roseomaculatus	Lamprell and Healy, 1998
Lucinda	8	8	6	Solenidae	Solen	roseomaculatus	Solen roseomaculatus	Lamprell and Healy, 1998
Lucinda	1	4	39	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Lucinda	2	4	2	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Lucinda	8	4	19	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Lucinda	9	4	1	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Lucinda	10	4	12	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Lucinda	1	4	7	Veneridae	Tapes	belcheri	Tapes belcheri	Lamprell and Whitehead, 1992
Lucinda	10	4	1	Veneridae	Tapes	belcheri	Tapes belcheri	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Veneridae	Tawera	subnodulosa	Tawera subnodulosa	Lamprell and Whitehead, 1992
Lucinda	8	8	1	Tellinidae	Tellina	bougei	Tellina bougei	Lamprell and Whitehead, 1992
Lucinda	8	8	2	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Tellinidae	Tellina	parvitas	Tellina parvitas	Lamprell and Whitehead, 1992
Lucinda	1	4	1	Tellinidae	Tellina	radians	Tellina radians	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Tellinidae	Tellina	vernalis	Tellina	Lamprell and

							vernalis	Whitehead, 1992
Lucinda	8	4	1	Tellinidae	Tellina	vernalis	Tellina vernalis	Lamprell and Whitehead, 1992
Lucinda	10	8	1	Tellinidae	Tellina	vernalis	Tellina vernalis	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Veneridae	Timoclea	recognita	Timoclea recognita	Lamprell and Whitehead, 1992
Lucinda	1	4	2	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	1	4	50	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	2	4	2	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	3	4	10	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	4	8	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	8	4	61	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	8	8	5	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	9	4	19	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	9	8	3	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Lucinda	10	4	34	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
One Mile	1	8	1	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
One Mile	3	4	2	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
One Mile	3	8	1	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
One Mile	5	8	1	Arcidae	Barbatia	trapezina	Barbatia	Lamprell and

							trapezina	Healy, 1998
One Mile	9	4	1	Veneridae	Bassina	jacksoni	Bassina jacksoni	Lamprell and Whitehead, 1992
One Mile	1	4	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
One Mile	5	4	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
One Mile	8	4	2	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
One Mile	9	4	2	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
One Mile	9	4	2	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
One Mile	1	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	1	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	2	4	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	2	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	3	4	2	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	4	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	4	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	5	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	10	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
One Mile	1	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	1	4	5	Carditidae	Cardita	excavata	Cardita	Lamprell and

							excavata	Whitehead, 1992
One Mile	2	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	3	4	3	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	3	4	3	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	3	4	7	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	4	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	4	8	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	4	8	5	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	5	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	5	8	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	8	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	8	8	8	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
One Mile	1	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
One Mile	1	4	2	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
One Mile	1	8	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
One Mile	3	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
One Mile	8	8	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
One Mile	9	4	1	Pectinidae	Chlamys	aktinos	Chlamys	Lamprell and

							aktinos	Whitehead, 1992
One Mile	10	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
One Mile	1	4	6	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	1	4	20	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	1	4	39	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	1	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	1	8	7	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	2	4	10	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	2	4	19	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	2	16	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	3	8	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	4	4	12	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	4	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	5	4	14	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	5	8	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	8	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	8	4	22	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	8	8	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and

								Whitehead, 1992
One Mile	9	4	7	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	9	4	17	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	10	4	8	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
One Mile	1	8	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
One Mile	3	4	1	Lucinidae	Epicodakia	gunnamatta	Epicodakia gunnamatta	Lamprell and Whitehead, 1992
One Mile	1	4	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
One Mile	2	4	1	Psammobiidae	Gari	truncata	Gari truncata	Lamprell and Whitehead, 1992
One Mile	10	4	1	Psammobiidae	Gari	truncata	Gari truncata	Lamprell and Whitehead, 1992
One Mile	2	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
One Mile	1	4	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
One Mile	1	8	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
One Mile	4	4	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
One Mile	4	8	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
One Mile	8	8	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
One Mile	9	4	2	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
One Mile	1	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
One Mile	1	4	2	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and

								Whitehead, 1992
One Mile	2	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
One Mile	4	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
One Mile	5	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
One Mile	1	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	1	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	1	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	1	4	3	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	1	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	2	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	2	4	7	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	2	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	3	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	3	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	4	4	3	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	8	4	4	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	9	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	9	4	2	Mactridae	Lutraria	rhynchaena	Lutraria	Lamprell and

							rhynchaena	Whitehead, 1992
One Mile	10	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
One Mile	1	4	4	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	1	4	4	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	1	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	2	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	2	8	2	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	3	4	3	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	3	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	8	4	2	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	8	8	3	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	9	16	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
One Mile	1	4	4	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	1	4	8	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	1	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	2	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	2	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	2	8	1	Mactridae	Mactra	jacksonensis	Mactra	Lamprell and

							jacksonensis	Whitehead, 1992
One Mile	4	4	8	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	4	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	5	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	8	4	6	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	8	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	9	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	10	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
One Mile	2	4	1	Mytilidae	Modiolus	peronianus	Modiolus peronianus	Lamprell and Healy, 1998
One Mile	1	4	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	1	4	13	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	1	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	2	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	2	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	4	4	8	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	5	4	6	Mesodesmatidae	Paphies	elongata	Paphies	Lamprell and

							elongata	Whitehead, 1992
One Mile	8	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	8	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	9	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	9	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	9	4	5	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
One Mile	2	4	1	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
One Mile	3	4	2	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
One Mile	4	4	1	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
One Mile	4	8	1	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
One Mile	1	4	2	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	1	4	2	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	2	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	3	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	4	8	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	8	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	9	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	9	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and

								Healy, 1998
One Mile	10	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
One Mile	10	8	1	Mactridae	Spisula	trigonella	Spisula trigonella	Lamprell and Whitehead, 1992
One Mile	2	4	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
One Mile	2	4	4	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
One Mile	5	8	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
One Mile	10	4	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
One Mile	1	4	5	Tellinidae	Tellina	modestina	Tellina modestina	Lamprell and Whitehead, 1992
One Mile	1	4	2	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
One Mile	1	4	4	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
One Mile	5	8	1	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
One Mile	8	8	1	Carditidae	Venericardia	amabilis	Venericardia amabilis	Lamprell and Whitehead, 1992
Palm Beach	2	8	1	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Palm Beach	2	4	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Palm Beach	2	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Palm Beach	8	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Palm Beach	9	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Palm Beach	1	4	1	Carditidae	Cardita	excavata	Cardita	Lamprell and

							excavata	Whitehead, 1992
Palm Beach	2	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	2	4	19	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	2	8	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	3	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	5	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	8	4	4	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	9	4	12	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Palm Beach	8	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
Palm Beach	1	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Palm Beach	2	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Palm Beach	3	16	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Palm Beach	9	4	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Palm Beach	9	4	1	Lucinidae	Epicodakia	gunnamatta	Epicodakia gunnamatta	Lamprell and Whitehead, 1992
Palm Beach	9	4	2	Cardiidae	Fulvia	tenuicosta	Fulvia tenuicosta	Lamprell and Whitehead, 1992
Palm Beach	1	8	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	2	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	2	8	2	Glycymerididae	Glycymeris	grayana	Glycymeris	Lamprell and

							grayana	Whitehead, 1992
Palm Beach	3	4	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	3	8	5	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	5	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	8	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	8	8	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	9	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	9	4	3	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	9	8	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	9	8	3	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Palm Beach	1	4	2	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	2	4	4	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	2	8	2	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	3	4	4	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	5	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	5	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	8	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	9	4	4	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and

								Whitehead, 1992
Palm Beach	9	8	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	10	4	2	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Palm Beach	2	4	2	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Palm Beach	2	8	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Palm Beach	9	4	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Palm Beach	2	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	2	4	9	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	3	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	5	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	8	4	3	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	9	4	6	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	9	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	10	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	10	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Palm Beach	1	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	1	4	2	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	1	4	16	Mactridae	Mactra	contraria	Mactra	Lamprell and

							contraria	Whitehead, 1992
Palm Beach	1	8	4	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	2	4	5	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	2	4	68	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	2	8	3	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	2	8	8	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	3	4	20	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	3	8	2	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	4	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	5	4	8	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	5	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	8	4	4	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	8	4	5	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	8	8	2	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	9	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	9	4	19	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Palm Beach	1	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Palm Beach	2	4	10	Mactridae	Mactra	jacksonensis	Mactra	Lamprell and

							jacksonensis	Whitehead, 1992
Palm Beach	5	4	2	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Palm Beach	8	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Palm Beach	9	4	9	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Palm Beach	9	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Palm Beach	1	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	1	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	1	8	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	2	4	10	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	2	8	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	3	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	3	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	4	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	5	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	8	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	9	4	8	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	9	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	10	4	2	Mesodesmatidae	Paphies	elongata	Paphies	Lamprell and

							elongata	Whitehead, 1992
Palm Beach	10	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Beach	2	4	1	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
Palm Beach	2	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
Palm Beach	9	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
Palm Beach	9	4	3	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Palm Beach	1	4	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Palm Beach	1	8	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Palm Beach	10	4	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Palm Cove	2	4	3	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Palm Cove	2	8	5	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Palm Cove	8	8	2	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Palm Cove	2	16	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Palm Cove	2	4	3	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Palm Cove	2	8	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Palm Cove	2	8	8	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Palm Cove	5	4	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Palm Cove	9	4	1	Arcidae	Anadara	gubernaculum	Anadara	Lamprell and

							guvernaculum	Healy, 1998
Palm Cove	6	4	1	Arcidae	Barbatia	bistrigata	Barbatia bistrigata	Lamprell and Healy, 1998
Palm Cove	8	8	1	Carditidae	Cardita	crassicosta	Cardita crassicosta	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Palm Cove	9	16	1	Solenidae	Ensiculus	cultellus	Ensiculus cultellus	Lamprell and Healy, 1998
Palm Cove	2	4	2	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Palm Cove	6	4	1	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Tellinidae	Exotica	obliquaria	Exotica obliquaria	Lamprell and Whitehead, 1992
Palm Cove	2	4	2	Tellinidae	Exotica	obliquaria	Exotica obliquaria	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Psammobiidae	Gari	maculosa	Gari maculosa	Lamprell and Whitehead, 1992
Palm Cove	2	4	8	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Palm Cove	2	4	11	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Palm Cove	2	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Palm Cove	2	4	2	Psammobiidae	Gari	weinkauffi	Gari weinkauffi	Lamprell and Whitehead, 1992
Palm Cove	5	4	1	Psammobiidae	Gari	weinkauffi	Gari weinkauffi	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris	Lamprell and

							queenslandica	Whitehead, 1992
Palm Cove	2	16	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Palm Cove	9	16	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Healy, 1998
Palm Cove	2	4	2	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Healy, 1998
Palm Cove	2	4	19	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Healy, 1998
Palm Cove	5	4	2	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Healy, 1998
Palm Cove	2	8	1	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Palm Cove	2	4	19	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Palm Cove	2	4	28	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Palm Cove	5	4	1	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Palm Cove	9	4	1	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Palm Cove	2	4	3	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Veneridae	Lioconcha	annettae	Lioconcha annettae	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Veneridae	Lioconcha	castrensis	Lioconcha	Lamprell and

							castrensis	Whitehead, 1992
Palm Cove	2	8	3	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Palm Cove	2	16	1	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Tellinidae	Macoma	dispar	Macoma dispar	Lamprell and Whitehead, 1992
Palm Cove	2	4	3	Tellinidae	Macoma	praetexta	Macoma praetexta	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Mactridae	Mactra	abbreviata	Mactra abbreviata	Lamprell and Whitehead, 1992
Palm Cove	8	8	2	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Mactridae	Mactra	queenslandica	Mactra queenslandica	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Veneridae	Marcia	hiantina	Marcia hiantina	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Mactridae	Meropesta	nicobarica	Meropesta nicobarica	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Cove	9	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Palm Cove	5	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Palm Cove	2	4	3	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and

								Whitehead, 1992
Palm Cove	2	4	17	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Palm Cove	2	8	9	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Palm Cove	8	8	10	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and Whitehead, 1992
Palm Cove	2	4	1	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and Whitehead, 1992
Palm Cove	2	4	4	Veneridae	Pitar	nipponica	Pitar nipponica	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Ostreidae	Saccostrea	cucullata	Saccostrea cucullata	Lamprell and Healy, 1998
Palm Cove	2	4	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	2	4	5	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	2	8	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	2	8	6	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	2	16	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	2	16	7	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	8	8	6	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	9	4	2	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Palm Cove	10	4	1	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and

								Whitehead, 1992
Palm Cove	2	4	13	Mactridae	Standella	pellucida	Standella pellucida	Lamprell and Whitehead, 1992
Palm Cove	5	4	4	Mactridae	Standella	pellucida	Standella pellucida	Lamprell and Whitehead, 1992
Palm Cove	9	16	1	Noetiidae	Striarca	olivacea	Striarca olivacea	Lamprell and Healy, 1998
Palm Cove	2	4	1	Tellinidae	Strigilla	tomlini	Strigilla tomlini	Lamprell and Whitehead, 1992
Palm Cove	2	8	3	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Palm Cove	5	4	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Palm Cove	9	4	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Palm Cove	2	4	2	Tellinidae	Tellina	radians	Tellina radians	Lamprell and Whitehead, 1992
Palm Cove	2	4	5	Tellinidae	Tellina	radians	Tellina radians	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Tellinidae	Tellina	radians	Tellina radians	Lamprell and Whitehead, 1992
Palm Cove	2	4	2	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Palm Cove	8	8	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Rainbow Bay	1	8	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Rainbow Bay	2	4	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Rainbow Bay	3	4	1	Arcidae	Anadara	trapezia	Anadara trapezia	Lamprell and Healy, 1998
Rainbow	9	8	1	Arcidae	Anadara	trapezia	Anadara	Lamprell and

Bay							trapezia	Healy, 1998
Rainbow Bay	4	4	1	Arcidae	Barbatia	parvivillosa	Barbatia parvivillosa	Lamprell and Healy, 1998
Rainbow Bay	2	16	1	Arcidae	Barbatia	pistachia	Barbatia pistachia	Lamprell and Healy, 1998
Rainbow Bay	2	8	1	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
Rainbow Bay	3	8	1	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
Rainbow Bay	3	8	1	Arcidae	Barbatia	wednti	Barbatia wendti	Lamprell and Healy, 1998
Rainbow Bay	1	4	2	Veneridae	Bassina	jacksoni	Bassina jacksoni	Lamprell and Whitehead, 1992
Rainbow Bay	1	8	1	Veneridae	Bassina	jacksoni	Bassina jacksoni	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Veneridae	Circe	sulcata	Circe sulcata	Lamprell and Whitehead, 1992
Rainbow Bay	10	8	2	Veneridae	Circe	sulcata	Circe sulcata	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	12	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	13	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	14	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	1	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow	2	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and

Bay								Whitehead, 1992
Rainbow Bay	2	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	4	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	4	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	5	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	10	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	30	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	3	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	3	8	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	13	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	27	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	5	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	5	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow	8	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and

Bay								Whitehead, 1992
Rainbow Bay	8	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	8	4	12	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	9	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	9	4	6	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	3	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	10	8	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	10	8	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	2	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	2	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Rainbow Bay	2	16	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	2	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Rainbow	5	16	1	Donacidae	Donax	faba	Donax faba	Lamprell and

Bay								Whitehead, 1992
Rainbow Bay	1	4	4	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	4	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	6	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	3	8	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	5	16	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	8	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	8	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	9	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Rainbow Bay	3	8	2	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	2	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	3	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	2	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow	3	4	2	Psammobiidae	Gari	livida	Gari livida	Lamprell and

Bay								Whitehead, 1992
Rainbow Bay	3	4	4	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	8	4	2	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	8	8	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	1	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	2	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	10	8	2	Psammobiidae	Gari	livida	Gari livida	Lamprell and Whitehead, 1992
Rainbow Bay	9	4	1	Veneridae	Globivenus	capricornea	Globivenus capricornea	Lamprell and Whitehead, 1992
Rainbow Bay	1	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	1	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	1	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	4	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	4	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow	3	4	3	Glycymerididae	Glycymeris	grayana	Glycymeris	Lamprell and

Bay							grayana	Whitehead, 1992
Rainbow Bay	3	8	4	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	4	16	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	4	16	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	5	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	8	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	8	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	9	8	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	10	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	10	16	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	1	Glycymerididae	Glycymeris	hedleyi	Glycymeris hedleyi	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	5	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	2	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Rainbow Bay	3	8	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Rainbow	4	4	4	Hemidonacidae	Hemidonax	pictus	Hemidonax	Lamprell and

Bay							pictus	Whitehead, 1992
Rainbow Bay	2	8	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Rainbow Bay	5	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	1	Mactridae	Mactra	antecedens	Mactra antecedens	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	1	Mactridae	Mactra	antecedens	Mactra antecedens	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Mactridae	Mactra	antecedens	Mactra antecedens	Lamprell and Whitehead, 1992
Rainbow Bay	10	8	2	Mactridae	Mactra	antecedens	Mactra antecedens	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	1	16	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	2	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	2	16	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	2	16	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	4	16	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow Bay	4	16	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Rainbow	2	8	1	Mactridae	Mactra	cuneata	Mactra cuneata	Lamprell and

Bay								Whitehead, 1992
Rainbow Bay	4	4	1	Mactridae	Mactra	cuneata	Mactra cuneata	Lamprell and Whitehead, 1992
Rainbow Bay	4	8	1	Mactridae	Mactra	cuneata	Mactra cuneata	Lamprell and Whitehead, 1992
Rainbow Bay	2	16	1	Mytilidae	Modiolus	micropterus	Modiolus micropterus	Lamprell and Healy, 1998
Rainbow Bay	2	16	1	Mytilidae	Modiolus	micropterus	Modiolus micropterus	Lamprell and Healy, 1998
Rainbow Bay	4	8	1	Mytilidae	Modiolus	micropterus	Modiolus micropterus	Lamprell and Healy, 1998
Rainbow Bay	1	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	3	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	3	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	8	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	1	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Rainbow	3	8	1	Cardiidae	Plagiocardium	setosum	Plagiocardium	Lamprell and

Bay							setosum	Whitehead, 1992
Rainbow Bay	4	4	2	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Rainbow Bay	8	4	1	Cardiidae	Plagiocardium	setosum	Plagiocardium setosum	Lamprell and Whitehead, 1992
Rainbow Bay	1	4	1	Mactridae	Spisula	trigonella	Spisula trigonella	Lamprell and Whitehead, 1992
Rainbow Bay	4	4	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Rainbow Bay	10	4	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Rainbow Bay	6	16	1	Cardiidae	Vepricardium	multispinosum	Vepicardium multispinosum	Lamprell and Whitehead, 1992
Rainbow Bay	5	4	1	Lucinidae	Wallucina	haddoni	Wallucina haddoni	Lamprell and Whitehead, 1992
Saltwater	1	4	8	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Saltwater	2	4	2	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Saltwater	1	4	3	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Saltwater	10	4	7	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Saltwater	1	4	17	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Saltwater	2	4	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Saltwater	10	4	28	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Saltwater	10	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Saltwater	2	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
Saltwater	1	4	4	Donacidae	Donax	deltoides	Donax	Lamprell and

							deltoides	Whitehead, 1992
Saltwater	1	4	3	Pectinidae	Equichlamys	bifrons	Equichlamys bifrons	Lamprell and Whitehead, 1992
Saltwater	1	4	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Saltwater	1	4	9	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Saltwater	2	4	7	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Saltwater	2	4	16	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Saltwater	10	4	43	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Saltwater	1	4	3	Veneridae	Katelysia	rhytiphora	Katelysia rhytiphora	Lamprell and Whitehead, 1992
Saltwater	2	4	1	Veneridae	Katelysia	rhytiphora	Katelysia rhytiphora	Lamprell and Whitehead, 1992
Saltwater	10	4	3	Veneridae	Katelysia	rhytiphora	Katelysia rhytiphora	Lamprell and Whitehead, 1992
Saltwater	10	4	4	Veneridae	Katelysia	rhytiphora	Katelysia rhytiphora	Lamprell and Whitehead, 1992
Saltwater	1	4	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Saltwater	1	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Saltwater	1	4	6	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Saltwater	2	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Saltwater	10	4	3	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Saltwater	1	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Saltwater	10	4	6	Mactridae	Mactra	contraria	Mactra	Lamprell and

							contraria	Whitehead, 1992
Saltwater	10	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Saltwater	1	4	1	Cardiidae	Neocardium	thetidis	Neocardium thetidis	Lamprell and Whitehead, 1992
Saltwater	1	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Saltwater	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Saltwater	10	4	8	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Saltwater	10	4	8	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
Saltwater	1	4	2	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
Saltwater	10	4	3	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Shellharbour	10	4	3	Veneridae	Antigona	persimilis	Antigona persimilis	Lamprell and Whitehead, 1992
Shellharbour	10	8	1	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
Shellharbour	1	8	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Shellharbour	5	8	3	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Shellharbour	10	8	1	Veneridae	Bassina	pachyphylla	Bassina	Lamprell and

							pachyphylla	Whitehead, 1992
Shellharbour	10	8	1	Veneridae	Bassina	pachyphylla	Bassina pachyphylla	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	1	4	4	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	1	16	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	2	16	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	2	16	2	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	3	16	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	4	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	4	16	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	5	8	5	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	5	16	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	8	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	9	4	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	9	8	3	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	9	16	2	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	10	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shellharbour	10	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes	Lamprell and

							rostratus	Healy, 1998
Shellharbour	1	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shellharbour	5	4	3	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shellharbour	10	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shellharbour	10	8	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
Shellharbour	5	4	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
Shellharbour	9	16	1	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
Shellharbour	10	4	2	Pectinidae	Chlamys	aktinos	Chlamys aktinos	Lamprell and Whitehead, 1992
Shellharbour	1	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Shellharbour	10	4	2	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Shellharbour	3	4	1	Donacidae	Donax	faba	Donax faba	Lamprell and

								Whitehead, 1992
Shellharbour	9	4	1	Donacidae	Donax	faba	Donax faba	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Lucinidae	Epicodakia	gunnamatta	Epicodakia gunnamatta	Lamprell and Whitehead, 1992
Shellharbour	4	4	1	Lucinidae	Epicodakia	gunnamatta	Epicodakia gunnamatta	Lamprell and Whitehead, 1992
Shellharbour	10	4	3	Lucinidae	Epicodakia	gunnamatta	Epicodakia gunnamatta	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Cardiidae	Fulvia	tenuicosta	Fulvia tenuicosta	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Cardiidae	Fulvia	tenuicosta	Fulvia tenuicosta	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	2	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	3	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	3	16	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	5	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	5	4	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	5	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	8	4	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	8	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	9	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris	Lamprell and

							grayana	Whitehead, 1992
Shellharbour	10	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	10	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shellharbour	1	4	2	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
Shellharbour	5	4	2	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
Shellharbour	10	8	1	Veneridae	Granicorium	indutum	Granicorium indutum	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	2	4	4	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	5	8	2	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	8	4	3	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	8	8	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	9	4	2	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	9	16	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and

								Whitehead, 1992
Shellharbour	10	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	1	4	2	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	3	8	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	3	16	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	4	4	3	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	8	16	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Limidae	Limatula	strangei	Limatula strangei	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	1	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	1	4	10	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	2	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	5	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	5	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	8	4	1	Mactridae	Lutraria	rhynchaena	Lutraria	Lamprell and

							rhynchaena	Whitehead, 1992
Shellharbour	9	4	2	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	9	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	10	4	4	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	10	6	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	10	8	1	Mactridae	Lutraria	rhynchaena	Lutraria rhynchaena	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	2	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	2	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	3	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	3	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	5	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	9	8	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	10	4	1	Mactridae	Mactra	contraria	Mactra contraria	Lamprell and Whitehead, 1992
Shellharbour	1	4	2	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	1	4	15	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Mactridae	Mactra	jacksonensis	Mactra	Lamprell and

							jacksonensis	Whitehead, 1992
Shellharbour	2	4	2	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	2	4	3	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	5	4	2	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	8	4	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	8	8	1	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	9	4	2	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	10	4	5	Mactridae	Mactra	jacksonensis	Mactra jacksonensis	Lamprell and Whitehead, 1992
Shellharbour	1	4	3	Mactridae	Mactra	parkesiana	Mactra parkesiana	Lamprell and Whitehead, 1992
Shellharbour	10	4	3	Mactridae	Mactra	parkesiana	Mactra parkesiana	Lamprell and Whitehead, 1992
Shellharbour	5	8	1	Pectinidae	Mimachlamys	famigerator	Mimachlamys famigerator	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Pectinidae	Mimachlamys	gloriosa	Mimachlamys gloriosa	Lamprell and Whitehead, 1992
Shellharbour	4	8	1	Pectinidae	Mimachlamys	gloriosa	Mimachlamys gloriosa	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Mytilidae	Modiolus	peronianus	Modiolus peronianus	Lamprell and Healy, 1998
Shellharbour	1	4	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	1	4	14	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	2	4	4	Mesodesmatidae	Paphies	elongata	Paphies	Lamprell and

							elongata	Whitehead, 1992
Shellharbour	2	4	6	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	2	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	3	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	4	4	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	5	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	5	4	7	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	8	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	8	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	9	4	6	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	10	4	7	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Veneridae	Placamen	placidum	Placamen placidum	Lamprell and Whitehead, 1992
Shellharbour	9	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
Shellharbour	10	4	1	Nuculanidae	Saccella	crassa	Saccella crassa	Lamprell and Healy, 1998
Shellharbour	1	4	3	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Shellharbour	1	8	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Shellharbour	1	4	3	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
Shellharbour	2	4	1	Tellinidae	Tellina	tenuilirata	Tellina	Lamprell and

							tenuilirata	Whitehead, 1992
Shellharbour	9	4	3	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
Shellharbour	10	4	3	Tellinidae	Tellina	tenuilirata	Tellina tenuilirata	Lamprell and Whitehead, 1992
Shellharbour	1	4	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Shelly Central	8	8	1	Arcidae	Barbatia	trapezina	Barbatia trapezina	Lamprell and Healy, 1998
Shelly Central	4	4	2	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shelly Central	10	4	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shelly Central	10	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shelly Central	1	8	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Shelly Central	1	8	2	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Shelly Central	8	4	1	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Shelly Central	10	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Shelly Central	2	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Shelly Central	10	4	1	Psammobiidae	Soletellina	donacioides	Soletellina donaciodes	Lamprell and Whitehead, 1992
Shelly Central	2	4	1	Mactridae	Zenatina	victoriae	Zenatina victoriae	Lamprell and Whitehead, 1992
Shelly Central	2	8	1	Mactridae	Zenatina	victoriae	Zenatina victoriae	Lamprell and Whitehead, 1992
Shelly Central	4	4	3	Mactridae	Zenatina	victoriae	Zenatina victoriae	Lamprell and Whitehead, 1992
Shelly	4	4	4	Mactridae	Zenatina	victoriae	Zenatina	Lamprell and

Central							victoriae	Whitehead, 1992
Shelly Central	4	8	1	Mactridae	Zenatina	victoriae	Zenatina victoriae	Lamprell and Whitehead, 1992
Shelly Central	10	4	3	Mactridae	Zenatina	victoriae	Zenatina victoriae	Lamprell and Whitehead, 1992
Shelly Sunshine	6	8	1	Mytilidae	Amygdalum	glaberrima	Amygdalum glaberrima	Lamprell and Healy, 1998
Shelly Sunshine	8	4	1	Mytilidae	Amygdalum	glaberrima	Amygdalum glaberrima	Lamprell and Healy, 1998
Shelly Sunshine	6	8	1	Lucinidae	Anodontia	edentula	Anodontia edentula	Lamprell and Whitehead, 1992
Shelly Sunshine	6	8	2	Arcidae	Arca	navicularis	Arca navicularis	Lamprell and Healy, 1998
Shelly Sunshine	1	8	2	Arcidae	Arcopsis	deliciosa	Arcopsis deliciosa	Lamprell and Healy, 1998
Shelly Sunshine	6	8	2	Arcidae	Arcopsis	deliciosa	Arcopsis deliciosa	Lamprell and Healy, 1998
Shelly Sunshine	1	4	40	Noetiidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Shelly Sunshine	5	4	40	Arcidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Shelly Sunshine	6	8	3	Arcidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Shelly Sunshine	8	4	8	Arcidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Shelly Sunshine	10	4	8	Arcidae	Arcopsis	symmrica	Arcopsis symmrica	Lamprell and Healy, 1998
Shelly Sunshine	9	8	20	Arcidae	Barbatia	pistachia	Barbatia pistachia	Lamprell and Healy, 1998
Shelly Sunshine	1	8	2	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shelly Sunshine	1	8	2	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shelly	3	8	3	Mytilidae	Brachidontes	rostratus	Brachidontes	Lamprell and

Sunshine							rostratus	Healy, 1998
Shelly Sunshine	9	8	1	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Shelly Sunshine	3	8	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shelly Sunshine	5	4	19	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shelly Sunshine	6	8	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shelly Sunshine	9	8	6	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shelly Sunshine	10	4	1	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Shelly Sunshine	1	4	19	Carditidae	Cardita	variegata	Cardita variegata	Lamprell and Whitehead, 1992
Shelly Sunshine	1	4	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Shelly Sunshine	5	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Shelly Sunshine	9	8	3	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Shelly Sunshine	1	8	1	Veneridae	Dosinia	tenella	Dosinia tenella	Lamprell and Whitehead, 1992
Shelly Sunshine	1	4	6	Cardiidae	Fragum	hemicardium	Fragum hemicardium	Lamprell and Whitehead, 1992
Shelly Sunshine	8	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shelly Sunshine	9	8	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shelly Sunshine	10	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Shelly Sunshine	8	4	1	Glycymerididae	Glycymeris	hedleyi	Glycymeris hedleyi	Lamprell and Whitehead, 1992
Shelly	9	8	3	Veneridae	Granicorium	indutum	Granicorium	Lamprell and

Sunshine							indutum	Whitehead, 1992
Shelly Sunshine	1	4	4	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Shelly Sunshine	1	4	1	Limidae	Lima	vulgaris	Lima vulgaris	Lamprell and Whitehead, 1992
Shelly Sunshine	1	8	2	Mactridae	Mactra	antecedens	Mactra antecedens	Lamprell and Whitehead, 1992
Shelly Sunshine	1	4	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Shelly Sunshine	3	8	1	Mytilidae	Modiolus	peronianus	Modiolus peronianus	Lamprell and Healy, 1998
Shelly Sunshine	1	4	20	Anomiidae	Patro	australis	Patro australis	Lamprell and Healy, 1998
Shelly Sunshine	2	16	1	Pteriidae	Pinctada	fucata	Pinctada fucata	Lamprell and Healy, 1998
Shelly Sunshine	3	8	2	Pteriidae	Pinctada	fucata	Pinctada fucata	Lamprell and Healy, 1998
Shelly Sunshine	1	4	2	Veneridae	Pitar	bullatus	Pitar bullatus	Lamprell and Whitehead, 1992
Shelly Sunshine	1	4	1	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Shelly Sunshine	6	8	1	Veneridae	Tapes	sericeus	Tapes sericeus	Lamprell and Whitehead, 1992
Shelly Sunshine	1	4	15	Mytilidae	Trichomya	hirsutus	Trichomya hirsutus	Lamprell and Healy, 1998
Shelly Sunshine	1	8	2	Mytilidae	Trichomya	hirsutus	Trichomya hirsutus	Lamprell and Healy, 1998
Shelly Sunshine	3	8	1	Mytilidae	Trichomya	hirsutus	Trichomya hirsutus	Lamprell and Healy, 1998
Shelly Sunshine	6	8	2	Mytilidae	Trichomya	hirsutus	Trichomya hirsutus	Lamprell and Healy, 1998
Shelly Sunshine	10	4	2	Mytilidae	Trichomya	hirsutus	Trichomya hirsutus	Lamprell and Healy, 1998
Shelly	1	8	2	Mytilidae	Xenostrobus	pulex	Xenostrobus	Lamprell and

Sunshine							pulex	Healy, 1998
Tab North	9	4	7	Mytilidae	Brachidontes	rostratus	Brachidontes rostratus	Lamprell and Healy, 1998
Tab North	9	4	2	Carditidae	Cardita	excavata	Cardita excavata	Lamprell and Whitehead, 1992
Tab North	9	4	1	Donacidae	Donax	brazieri	Donax brazieri	Lamprell and Whitehead, 1992
Tab North	8	8	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Tab North	9	4	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Tab North	1	4	2	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	2	4	85	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	2	8	5	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	5	4	12	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	8	4	86	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	8	8	11	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	9	4	2	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	9	4	12	Donacidae	Donax	deltoides	Donax deltoides	Lamprell and Whitehead, 1992
Tab North	1	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tab North	2	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tab North	2	8	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tab North	5	4	2	Donacidae	Donax	veruinus	Donax	Lamprell and

							veruinus	Whitehead, 1992
Tab North	8	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tab North	9	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tab North	2	4	5	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Tab North	2	4	11	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Tab North	8	8	2	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Tab North	1	4	1	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	2	4	3	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	2	8	1	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	8	8	1	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	8	8	2	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	9	4	5	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	9	8	1	Veneridae	Gomphina	fulgida	Gomphina fulgida	Lamprell and Whitehead, 1992
Tab North	5	4	2	Hemidonacidae	Hemidonax	dactylus	Hemidonax dactylus	Lamprell and Whitehead, 1992
Tab North	1	4	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Tab North	2	4	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Tab North	2	8	1	Hemidonacidae	Hemidonax	pictus	Hemidonax pictus	Lamprell and Whitehead, 1992
Tab North	1	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and

								Whitehead, 1992
Tab North	2	4	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Tab North	8	8	1	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Tab North	9	4	3	Limidae	Lima	nimbifer	Lima nimbifer	Lamprell and Whitehead, 1992
Tab North	9	4	7	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tab North	5	4	3	Psammobiidae	Soletellina	donacioides	Soletellina donaciodes	Lamprell and Whitehead, 1992
Tab North	8	8	1	Psammobiidae	Soletellina	donacioides	Soletellina donaciodes	Lamprell and Whitehead, 1992
Tab North	9	4	3	Psammobiidae	Soletellina	donacioides	Soletellina donaciodes	Lamprell and Whitehead, 1992
Tab North	9	4	1	Tellinidae	Tellina	deltoidalis	Tellina deltoidalis	Lamprell and Whitehead, 1992
Tannum	1	4	1	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Tannum	1	8	2	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Tannum	2	4	1	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Tannum	2	4	5	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Tannum	2	8	2	Arcidae	Anadara	craticulata	Anadara craticulata	Lamprell and Healy, 1998
Tannum	2	4	3	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Tannum	2	8	19	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Tannum	2	16	4	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Tannum	4	8	1	Arcidae	Anadara	crebricostata	Anadara	Lamprell and

							crebricostata	Healy, 1998
Tannum	8	8	1	Arcidae	Anadara	crebricostata	Anadara crebricostata	Lamprell and Healy, 1998
Tannum	2	4	1	Arcidae	Anadara	gubernaculum	Anadara guvernaculum	Lamprell and Healy, 1998
Tannum	10	8	1	Arcidae	Anadara	vellicata	Anadara vellicata	Lamprell and Healy, 1998
Tannum	2	16	1	Arcidae	Barbatia	foliata	Barbatia foliata	Lamprell and Healy, 1998
Tannum	8	8	1	Chamidae	Chama	fibula	Chama fibula	Lamprell and Whitehead, 1992
Tannum	2	8	2	Pectinidae	Chlamys	curtisiana	Chlamys curtisiana	Lamprell and Whitehead, 1992
Tannum	1	4	1	Pectinidae	Chlamys	irregularis	Chlamys irregularis	Lamprell and Whitehead, 1992
Tannum	1	8	2	Pectinidae	Chlamys	irregularis	Chlamys irregularis	Lamprell and Whitehead, 1992
Tannum	2	8	6	Pectinidae	Chlamys	irregularis	Chlamys irregularis	Lamprell and Whitehead, 1992
Tannum	10	8	1	Pectinidae	Chlamys	irregularis	Chlamys irregularis	Lamprell and Whitehead, 1992
Tannum	4	8	1	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Tannum	1	4	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tannum	2	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tannum	2	4	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tannum	2	8	1	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tannum	4	8	2	Donacidae	Donax	veruinus	Donax veruinus	Lamprell and Whitehead, 1992
Tannum	1	4	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and

								Whitehead, 1992
Tannum	1	4	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	1	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	2	4	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	2	4	4	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	2	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	2	8	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	4	8	2	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	5	4	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tannum	2	4	1	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Tannum	2	8	1	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Tannum	2	8	2	Veneridae	Dosinia	nedigna	Dosinia nedigna	Lamprell and Whitehead, 1992
Tannum	2	8	1	Veneridae	Eumarcia	fumigata	Eumarcia fumigata	Lamprell and Whitehead, 1992
Tannum	1	4	3	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Tannum	1	8	3	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Tannum	6	8	2	Tellinidae	Exotica	donaciformis	Exotica donaciformis	Lamprell and Whitehead, 1992
Tannum	1	4	1	Veneridae	Gafrarium	pectinatum	Gafrarium pectinatum	Lamprell and Whitehead, 1992
Tannum	2	8	4	Psammobiidae	Gari	anomala	Gari anomala	Lamprell and

								Whitehead, 1992
Tannum	1	8	1	Psammobiidae	Gari	maculosa	Gari maculosa	Lamprell and Whitehead, 1992
Tannum	2	4	2	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Tannum	4	8	1	Psammobiidae	Gari	modesta	Gari modesta	Lamprell and Whitehead, 1992
Tannum	1	4	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	1	4	4	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	1	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	1	16	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	2	4	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	2	4	3	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	2	4	7	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	2	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	2	8	11	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	3	4	3	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	3	16	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	4	4	3	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	4	4	3	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	4	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and

								Whitehead, 1992
Tannum	4	16	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	5	4	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	5	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	10	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tannum	1	8	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tannum	2	4	1	Glycymerididae	Glycymeris	grayana	Glycymeris grayana	Lamprell and Whitehead, 1992
Tannum	3	4	6	Hemidonacidae	Hemidonax	dactylus	Hemidonax dactylus	Lamprell and Whitehead, 1992
Tannum	4	8	3	Hemidonacidae	Hemidonax	dactylus	Hemidonax dactylus	Lamprell and Whitehead, 1992
Tannum	2	8	1	Kellidae	Kellia	rotunda	Kellia rotunda	Lamprell and Healy, 1998
Tannum	2	4	4	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Tannum	5	8	1	Tellinidae	Leporimetis	spectabilis	Leporimetis spectabilis	Lamprell and Whitehead, 1992
Tannum	2	4	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Tannum	2	8	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Tannum	3	8	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Tannum	5	4	1	Tellinidae	Macoma	candida	Macoma candida	Lamprell and Whitehead, 1992
Tannum	2	4	4	Mactridae	Mactra	antecedens	Mactra antecedens	Lamprell and Whitehead, 1992
Tannum	2	4	1	Mactridae	Mactra	cuneata	Mactra cuneata	Lamprell and

								Whitehead, 1992
Tannum	1	16	2	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Tannum	1	8	1	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Tannum	2	4	1	Mactridae	Mactra	olorina	Mactra olorina	Lamprell and Whitehead, 1992
Tannum	3	4	1	Mactridae	Mactra	queenslandica	Mactra queenslandica	Lamprell and Whitehead, 1992
Tannum	1	8	1	Veneridae	Paphia	crassisulca	Paphia crassisulca	Lamprell and Whitehead, 1992
Tannum	1	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	1	8	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	1	8	8	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	2	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	2	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	2	4	7	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	2	8	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	2	8	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	2	16	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	5	8	4	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tannum	1	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Tannum	2	8	1	Semelidae	Semele	crenulata	Semele	Lamprell and

							crenulata	Whitehead, 1992
Tannum	2	16	1	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Tannum	1	4	1	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Tannum	1	4	2	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Tannum	2	4	1	Psammobiidae	Soletellina	petalina	Soletellina petalina	Lamprell and Whitehead, 1992
Tannum	2	4	1	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and Whitehead, 1992
Tannum	10	8	1	Mactridae	Spisula	aspersa	Spisula aspersa	Lamprell and Whitehead, 1992
Tannum	2	8	1	Veneridae	Tapes	belcheri	Tapes belcheri	Lamprell and Whitehead, 1992
Tannum	2	8	1	Tellinidae	Tellina	bougei	Tellina bougei	Lamprell and Whitehead, 1992
Tannum	2	8	1	Tellinidae	Tellina	robutsa	Tellina robusta	Lamprell and Whitehead, 1992
Tannum	2	4	4	Tellinidae	Tellina	staurella	Tellina staurella	Lamprell and Whitehead, 1992
Tannum	2	8	1	Tellinidae	Tellina	staurella	Tellina staurella	Lamprell and Whitehead, 1992
Tannum	2	16	1	Tellinidae	Tellina	staurella	Tellina staurella	Lamprell and Whitehead, 1992
Tannum	2	8	2	Veneridae	Timoclea	recognita	Timoclea recognita	Lamprell and Whitehead, 1992
Tannum	1	8	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Tannum	2	16	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Tannum	10	8	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Tannum	10	8	1	Lucinidae	Wallucina	assimilis	Wallucina	Lamprell and

							assimilis	Whitehead, 1992
Tully	2	8	2	Donacidae	Donax	cuneatus	Donax cuneatus	Lamprell and Whitehead, 1992
Tully	1	8	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Tully	1	8	1	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Tully	2	8	3	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Tully	10	8	2	Veneridae	Dosinia	incida	Dosinia incida	Lamprell and Whitehead, 1992
Tully	1	8	1	Veneridae	Dosinia	mira	Dosinia mira	Lamprell and Whitehead, 1992
Tully	4	8	1	Veneridae	Dosinia	sculpta	Dosinia sculpta	Lamprell and Whitehead, 1992
Tully	1	4	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	1	4	3	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	1	8	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	1	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	2	4	1	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	2	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	2	8	2	Psammobiidae	Gari	oriens	Gari oriens	Lamprell and Whitehead, 1992
Tully	1	8	5	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	1	8	16	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	1	8	29	Glycymerididae	Glycymeris	crebreliratus	Glycymeris	Lamprell and

							crebreliratus	Whitehead, 1992
Tully	1	16	1	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	1	16	3	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	1	16	10	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	2	8	3	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	2	8	26	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	2	16	3	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	3	16	6	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	4	8	7	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	4	16	3	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	8	8	3	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	9	8	9	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	10	8	9	Glycymerididae	Glycymeris	crebreliratus	Glycymeris crebreliratus	Lamprell and Whitehead, 1992
Tully	1	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	1	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	2	8	4	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	2	8	6	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	2	16	1	Glycymerididae	Glycymeris	holsericus	Glycymeris	Lamprell and

							holsericus	Whitehead, 1992
Tully	4	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	4	16	1	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	9	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	9	16	1	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	10	8	2	Glycymerididae	Glycymeris	holsericus	Glycymeris holsericus	Lamprell and Whitehead, 1992
Tully	1	8	4	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	1	8	26	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	1	16	5	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	2	8	2	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	2	8	11	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	2	16	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	4	8	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	4	16	5	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	5	4	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	8	8	4	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	9	8	3	Glycymerididae	Glycymeris	queenslandica	Glycymeris queenslandica	Lamprell and Whitehead, 1992
Tully	9	16	1	Glycymerididae	Glycymeris	queenslandica	Glycymeris	Lamprell and

							queenslandica	Whitehead, 1992
Tully	2	16	1	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Tully	10	16	1	Gryphaeidae	Hyotissa	hyotis	Hyotissa hyotis	Lamprell and Healy, 1998
Tully	3	16	1	Veneridae	Lioconcha	castrensis	Lioconcha castrensis	Lamprell and Whitehead, 1992
Tully	1	8	2	Tellinidae	Macoma	dispar	Macoma dispar	Lamprell and Whitehead, 1992
Tully	1	4	1	Tellinidae	Macoma	praetexta	Macoma praetexta	Lamprell and Whitehead, 1992
Tully	1	8	2	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Tully	1	16	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Tully	1	16	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Tully	9	8	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Tully	9	16	1	Mactridae	Mactra	dissimilis	Mactra dissimilis	Lamprell and Whitehead, 1992
Tully	1	8	2	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Tully	9	8	1	Glycymerididae	Melaxinaea	vitrea	Melaxinaea vitrea	Lamprell and Whitehead, 1992
Tully	1	4	1	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tully	5	4	2	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tully	9	8	3	Mesodesmatidae	Paphies	elongata	Paphies elongata	Lamprell and Whitehead, 1992
Tully	1	4	1	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and Whitehead, 1992
Tully	1	8	2	Mesodesmatidae	Paphies	striata	Paphies striata	Lamprell and

								Whitehead, 1992
Tully	1	8	1	Veneridae	Placamen	tiara	Placamen tiara	Lamprell and Whitehead, 1992
Tully	9	8	1	Ostreidae	Saccostrea	cucullata	Saccostrea cucullata	Lamprell and Healy, 1998
Tully	8	16	2	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Tully	10	16	2	Semelidae	Semele	crenulata	Semele crenulata	Lamprell and Whitehead, 1992
Tully	10	16	2	Mactridae	Spisula	coppingeri	Spisula coppingeri	Lamprell and Whitehead, 1992
Tully	2	8	1	Veneridae	Tawera	subnodulosa	Tawera subnodulosa	Lamprell and Whitehead, 1992
Tully	9	4	1	Tellinidae	Tellina	casta	Tellina casta	Lamprell and Whitehead, 1992
Tully	4	8	1	Tellinidae	Tellina	serricostata	Tellina serricostata	Lamprell and Whitehead, 1992
Tully	10	8	1	Tellinidae	Tellina	serricostata	Tellina serricostata	Lamprell and Whitehead, 1992
Tully	4	8	1	Tellinidae	Tellina	staurella	Tellina staurella	Lamprell and Whitehead, 1992
Tully	1	8	1	Veneridae	Timoclea	recognita	Timoclea recognita	Lamprell and Whitehead, 1992
Tully	8	8	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Tully	9	8	1	Veneridae	Timoclea	scabra	Timoclea scabra	Lamprell and Whitehead, 1992
Tully	1	4	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Tully	1	4	3	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Tully	1	8	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Tully	1	8	7	Lucinidae	Wallucina	assimilis	Wallucina	Lamprell and

							assimilis	Whitehead, 1992
Tully	2	8	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Tully	4	8	2	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992
Tully	5	4	1	Lucinidae	Wallucina	assimilis	Wallucina assimilis	Lamprell and Whitehead, 1992

5. **Measurements made of bivalves, used in Chapter Five. All bivalves listed here were collected by MRK for the work carried out for this thesis.**

site	quadrat	fraction	species	length	height	size
Cannonvale	5	16	Anadara crebricostata	22.66	29.99	4.201802
Cannonvale	9	8	Anadara guvernaculum	10.42	13.35	3.074796
Cannonvale	10	8	Andara dautzenbergi	16.15	20.13	3.702008
Cannonvale	7	8	Arcopsis symmrica	8.64	11.93	2.807692
Cannonvale	10	8	Barbatia foliata	16.73	22.66	3.735225
Cannonvale	10	8	Barbatia pistachia	10.16	14.19	3.019719
Cannonvale	5	16	Cardita crassicosta	43.12	33.76	4.537847
Cannonvale	10	16	Chama fibula	29.7	23.69	4.393323
Cannonvale	10	8	Donax cuneatus	15.53	20.71	3.465397
Cannonvale	10	16	Dosinia mira	25.48	27.03	4.183485
Cannonvale	6	8	Fragum hemicardium	15.05	11.12	3.295009
Cannonvale	10	8	Gafrarium pectinatum	19.98	20.93	3.711864
Cannonvale	8	8	Limaria fragilis	10.23	14.74	2.962388
Cannonvale	10	8	Lioconcha annettae	12.74	14.56	3.08444
Cannonvale	5	16	Lioconcha castrensis	30.19	36.68	4.497606
Cannonvale	7	8	Lioconcha fastigiata	12.55	14.18	3.087332
Cannonvale	7	8	Mactra abbreviata	14.87	18.82	3.461846
Cannonvale	10	8	Mactra dissimilis	9.65	15.34	3.122266
Cannonvale	10	16	Mactra dissimilis	26.77	45.03	4.400843
Cannonvale	3	16	Mactra olorina	22.39	26.19	4.006492
Cannonvale	3	4	Marcia hiantina	10.89	14.32	2.938654
Cannonvale	10	8	Meropesta nicobarica	16.94	20.54	3.642718
Cannonvale	8	8	Paphies striata	10.48	13.52	2.924732
Cannonvale	1	8	Patro australis	27.3	20.66	3.896011
Cannonvale	6	4	Pitar nipponica	9.14	10.23	2.777842
Cannonvale	10	4	Pitar subpellucidus	7.9	8.54	2.471742
Cannonvale	10	8	Placamen tiara	10.72	15.82	3.200419
Cannonvale	10	8	Semele crenulata	12.36	11.55	3.195011
Cannonvale	7	8	Semele lamellosa	18.01	27.47	3.811979

Cannonvale	6	8	Septifer bilocularis	18.09	11.59	3.428273
Cannonvale	7	8	Tapes literatus	19.37	23.38	3.812162
Cannonvale	7	8	Tellina casta	11.47	12.82	2.989963
Cannonvale	7	8	Tellina staurella	17.35	26.23	3.701672
Cape Pall	10	8	Anadara craticulata	16.35	20.49	3.746022
Cape Pall	4	8	Anadara crebricostata	18.52	24.87	3.979964
Cape Pall	8	16	Anadara guvernaculum	21.73	20.55	4.052002
Cape Pall	8	4	Barbatia foliata	7.8	14.82	2.78797
Cape Pall	9	8	Cardita crassicosta	17.35	9.59	3.245784
Cape Pall	2	8	Chama fibula	20.06	17.68	3.918073
Cape Pall	1	8	Donax cuneatus	12.17	16.78	3.133586
Cape Pall	8	4	Donax veruinus	6.95	12.07	2.277991
Cape Pall	4	8	Dosinia incida	11.72	11.79	2.95008
Cape Pall	10	8	Dosinia mira	15.03	16.01	3.383154
Cape Pall	4	8	Exotica donaciformis	12.63	13.91	3.203546
Cape Pall	5	16	Exotica obliquaria	27.92	26.32	4.430009
Cape Pall	4	8	Gari modesta	11.3	16.79	3.077421
Cape Pall	8	16	Glycymeris crebreliratus	28.67	27.57	4.226536
Cape Pall	4	16	Glycymeris holsericus	26.14	26.58	4.107374
Cape Pall	4	16	Glycymeris queenslandica	28.23	30.76	4.300428
Cape Pall	8	4	Kellia rotunda	9.98	13.05	3.061764
Cape Pall	2	4	Leporimetis spectabilis	5.75	7.14	2.117418
Cape Pall	4	8	Lima vulgaris	20.15	18.51	3.766655
Cape Pall	8	8	Lioconcha fastigiata	12.04	13.8	3.040174
Cape Pall	8	4	Macoma candida	7.06	9.94	2.342739
Cape Pall	2	8	Mactra abbreviata	13.96	15.39	3.366824
Cape Pall	9	8	Mactra abbreviata	17.29	24.6	3.749489
Cape Pall	2	8	Mactra dissimilis	11.73	15.39	3.256025
Cape Pall	2	8	Mactra dissimilis	16.61	23.49	3.672222
Cape Pall	2	4	Mactra turgida	8.29	8.78	2.618207

Cape Pall	2	8	Melaxinaea vitrea	15.45	16.73	3.480502
Cape Pall	8	4	Paphies elongata	8.65	14.98	2.785601
Cape Pall	4	4	Paphies striata	5.76	6.66	1.997591
Cape Pall	5	4	Paphies striata	7.81	12.48	2.559086
Cape Pall	4	4	Pitar bullatus	10.59	12.87	3.019246
Cape Pall	8	4	Pitar nipponica	7.97	9.77	2.586008
Cape Pall	2	8	Pitar subpellucidus	10.26	11.03	2.782796
Cape Pall	10	8	Septifer bilocularis	24.32	14.45	3.683076
Cape Pall	4	4	Soletellina petalina	4.72	9.33	2.021578
Cape Pall	4	8	Spisula aspersa	11.82	16.43	3.093164
Cape Pall	4	4	Tellina bougei	13.91	19.6	3.185167
Cape Pall	4	8	Tellina casta	12.9	14.71	3.226352
Cape Pall	1	4	Tellina radians	7.22	10.76	2.44075
Cape Pall	10	8	Tellina serricostata	12.11	18.77	3.221469
Cape Pall	8	8	Timoclea recognita	16.61	16.89	3.625413
Cape Pall	8	8	Wallucina assimilis	10.89	11.89	2.931606
Hat Head	7	16	Anadara trapezia	22.44	22.84	4.039729
Hat Head	8	8	Barbatia pistachia	10.98	13.99	3.158047
Hat Head	9	8	Bassina pachyphylla	9.57	13.4	2.83619
Hat Head	8	4	Brachidontes rostratus	17.27	10.74	3.317319
Hat Head	5	4	Cardita excavata	11.86	8.13	2.809071
Hat Head	4	4	Donax deltoides	9.56	12.14	2.858932
Hat Head	9	8	Donax faba	11.57	13.57	3.065901
Hat Head	4	4	Donax veruinus	5.87	8.89	2.020563
Hat Head	6	8	Dosinia nedigna	16.63	18.85	3.468859
Hat Head	3	8	Gari livida	14.35	24.31	3.565806
Hat Head	8	8	Gari oriens	11.94	20.98	3.330051
Hat Head	9	4	Hemidonax dactylus	9.22	13.51	2.727017
Hat Head	6	8	Hemidonax pictus	10.49	16.94	3.100375
Hat Head	4	16	Lima nimbifer	31.27	22.67	4.066143
Hat Head	4	4	Mactra contraria	8.12	12.05	2.612983
Hat Head	3	8	Paphies elongata	18.22	27.35	3.721896

Hat Head	7	8	Paphies elongata	11.73	18.93	3.309652
Hat Head	9	16	Plagiocardium setosum	33.4	44.64	4.813094
Hat Head	4	4	Saccella crassa	6.17	10.55	2.326833
Hat Head	10	4	Tellina deltoidalis	7.23	10.23	2.40291
Hat Head	10	4	Tellina deltoidalis	5.96	11.6	1.964591
Hat Head	5	8	Tellina lilium	12.49	20.1	3.198252
Hat Head	3	4	Tellina tenuilirata	5.15	8.63	2.112624
Hat Head	1	4	Timoclea scabra	7.23	7.98	2.309209
Lucinda	1	4	Anadara craticulata	9.2	11.38	2.809383
Lucinda	2	4	Anadara guvernaculum	5.26	5.13	1.936868
Lucinda	9	8	Anodontia omissa	15.09	18.41	3.260807
Lucinda	2	8	Antigona persimilis	10.75	12.5	2.933768
Lucinda	1	4	Cardita crassicosta	8.87	9.15	2.666019
Lucinda	1	4	Cardita variegata	7.46	8.04	2.369335
Lucinda	1	4	Circe mistura	8.48	7.29	2.49865
Lucinda	4	4	Donax veruinus	4.11	8.44	1.685829
Lucinda	9	16	Dosinia incida	23.92	24.37	3.959571
Lucinda	3	8	Dosinia mira	15.3	16.15	3.310258
Lucinda	2	8	Dosinia sculpta	18.33	21.87	3.60778
Lucinda	1	4	Fragum hemicardium	8.31	6.22	2.472865
Lucinda	4	4	Gafrarium catillus	8.64	9.71	2.068693
Lucinda	1	4	Gafrarium equivocum	9.88	11.53	2.7655
Lucinda	2	8	Gari anomala	13.72	22.74	3.211955
Lucinda	8	8	Gari modesta	10.21	19.77	3.061074
Lucinda	4	8	Gari oriens	12.98	17.78	3.344365
Lucinda	4	4	Gari weinkauffi	6.07	11.59	2.193371
Lucinda	3	16	Glycymeris crebreliratus	27.89	27.52	4.155902
Lucinda	4	8	Glycymeris holsericus	18.37	19.39	3.643566
Lucinda	2	8	Limopsis multistriatus	15.05	15.06	3.094591
Lucinda	1	4	Lioconcha annettae	5.07	5.4	1.384486
Lucinda	2	8	Macoma candida	11.31	15.6	2.94159

Lucinda	4	4	Macoma praetexta	5.93	8.53	2.174839
Lucinda	4	8	Mactra abbreviata	13.64	19.66	3.398199
Lucinda	2	8	Mactra dissimilis	9.99	16.68	3.098366
Lucinda	4	16	Mactra dissimilis	27.11	37.2	4.34601
Lucinda	1	4	Mactra queenslandica	6.87	7.67	2.335473
Lucinda	4	4	Marcia hiantina	6.66	7.57	2.114292
Lucinda	9	8	Melaxinaea vitrea	11.98	12.4	3.050723
Lucinda	7	16	Paphia crassisulca	18.39	23.4	3.725631
Lucinda	10	16	Paphies elongata	11.68	18.89	3.150001
Lucinda	2	8	Paphies striata	14	20.14	3.353848
Lucinda	7	4	Paphies striata	8.67	9.92	2.605313
Lucinda	1	4	Pitar bullatus	8.02	10.09	2.57784
Lucinda	4	8	Semele crenulata	12.36	10.94	3.17248
Lucinda	2	8	Semele lamellosa	16.9	26.27	3.715873
Lucinda	2	8	Solen roseomaculatus	50.28	11.17	3.653763
Lucinda	4	4	Soletellina petalina	5.66	12.3	2.397259
Lucinda	1	4	Strigilla tomlini	7.21	8.66	2.422959
Lucinda	2	8	Tellina casta	13.9	14.89	3.259116
Lucinda	5	4	Tellina radians	4.4	6.37	1.831953
Lucinda	2	4	Tellina vernalis	6.13	7.61	2.141163
Lucinda	2	8	Wallucina assimilis	14.54	14.7	3.186456
One Mile	9	8	Barbatia trapezina	11.53	15.32	3.256392
One Mile	5	4	Bassina pachyphylla	7.94	9.42	2.401021
One Mile	8	8	Cardita excavata	18.32	11.57	3.354649
One Mile	2	8	Chlamys aktinos	12.06	10.74	2.686575
One Mile	10	16	Donax brazieri	35.12	49.92	4.677089
One Mile	4	4	Gari truncata	4.9	8.58	1.912863
One Mile	10	4	Glycymeris queenslandica	5.12	5.42	1.685824
One Mile	1	8	Granicorium indutum	12.32	10.15	2.873897
One Mile	6	4	Kellia rotunda	9.23	7.64	2.36532
One Mile	1	4	Limatula strangei	8.68	5.35	2.297793

One Mile	1	8	Lutraria rhynchaena	11.11	20.65	3.284212
One Mile	1	4	Mactra contraria	6.24	6.85	2.144002
One Mile	3	16	Mactra contraria	25.39	35.23	4.229514
One Mile	1	8	Mactra jacksonensis	11.77	13.74	2.944349
One Mile	10	8	Modiolus peronianus	13.2	13.1	2.928153
One Mile	8	4	Paphies elongata	8.22	13.02	2.580599
One Mile	9	4	Paphies elongata	5.77	9.03	2.217299
One Mile	8	8	Placamen placidum	8	10.06	2.531198
One Mile	NA	4	Placamen tiara	7.84	10.22	2.443791
One Mile	7	4	Saccella crassa	7.48	13.12	2.640415
One Mile	4	8	Spisula trigonella	12.16	13.59	3.175196
One Mile	6	4	Tellina deltoidalis	6.49	13.37	2.350893
One Mile	1	4	Tellina modestina	5	8.86	1.945535
One Mile	1	4	Tellina tenuilirata	7.35	11.78	2.615813
Palm Beach	10	8	Antigona persimilis	17.48	20.2	3.7693
Palm Beach	9	4	Cardita excavata	11.95	8.2	2.764212
Palm Beach	2	4	Chlamys aktinos	8.65	7.06	2.018899
Palm Beach	1	8	Donax brazieri	10.5	13.11	2.952554
Palm Beach	7	16	Donax faba	21.84	32.03	4.018898
Palm Beach	3	4	Epicodakia gunnamatta	6.87	8.44	2.413868
Palm Beach	3	4	Fulvia tenuicosta	4.92	5.6	1.890537
Palm Beach	3	4	Gari modesta	8.52	15.67	2.669796
Palm Beach	10	8	Glycymeris grayana	14.41	15.32	3.258494
Palm Beach	10	16	Glycymeris queenslandica	23.68	23.91	4.034351
Palm Beach	10	16	Kellia rotunda	31.58	21.95	4.022343
Palm Beach	10	4	Limatula strangei	7.73	4.99	2.089836
Palm Beach	3	8	Lutraria rhynchaena	13.31	26.41	3.608274
Palm Beach	8	8	Mactra contraria	13.56	13.56	3.111347
Palm Beach	3	8	Mactra jacksonensis	18.93	24.1	3.757286
Palm Beach	3	8	Paphies elongata	12.14	19.5	3.166877
Palm Beach	10	4	Placamen placidum	7.16	8.03	2.327621

Palm Beach	10	4	Saccella crassa	6.5	11.3	2.369808
Palm Beach	1	8	Timoclea scabra	12.05	13.26	3.008281
Palm Cove	10	8	Anadara craticulata	14.35	20.41	3.603357
Palm Cove	10	16	Anadara crebricostata	22.39	27.52	4.165593
Palm Cove	4	8	Anadara guvernaculum	20.95	19.59	3.987293
Palm Cove	10	4	Donax veruinus	4.52	7.52	1.854047
Palm Cove	10	4	Exotica donaciformis	6.16	10.18	2.256561
Palm Cove	10	4	Exotica obliquaria	5.27	7.06	2.060315
Palm Cove	6	8	Gari oriens	12.81	18.15	3.309349
Palm Cove	10	16	Glycymeris queenslandica	20.13	20.84	3.768239
Palm Cove	9	4	Hemidonax pictus	9.41	12.73	2.903903
Palm Cove	10	4	Hyotissa hyotis	9.5	6.15	2.394887
Palm Cove	6	4	Leporimetis spectabilis	9.47	12.47	2.92376
Palm Cove	10	4	Lioconcha annettae	8.98	9.76	2.452212
Palm Cove	6	16	Lioconcha castrensis	25.66	26.8	4.184415
Palm Cove	10	8	Macoma dispar	10.33	12.04	2.802478
Palm Cove	10	4	Macoma praetexta	7.19	10.21	2.429585
Palm Cove	6	4	Mactra abbreviata	8.92	12.06	2.718398
Palm Cove	10	8	Meropesta nicobarica	13.67	16.25	3.266304
Palm Cove	6	4	Paphies striata	8.52	12.01	2.622017
Palm Cove	9	4	Paphies striata	6.74	8.71	2.224836
Palm Cove	10	8	Pitar bullatus	11.6	14.61	3.161865
Palm Cove	6	4	Pitar nipponica	8.28	9.82	2.663839
Palm Cove	10	8	Saccostrea cucullata	26.04	14.3	3.763736
Palm Cove	10	16	Semele crenulata	26.47	28.82	4.42376
Palm Cove	10	4	Spisula aspersa	6.16	8.82	2.153234
Palm Cove	9	4	Standella pellucida	7.11	8.64	2.445315
Palm Cove	9	16	Striarca olivacea	21.23	34.5	4.132741
Palm Cove	10	8	Tellina casta	12.1	13.53	3.121935
Palm Cove	8	8	Wallucina assimilis	12.38	12.41	3.07438
Rainbow	3	8	Anadara trapezia	20.57	23.92	3.993918

Rainbow	10	8	Barbatia trapezina	10.91	14.51	3.131339
Rainbow	5	4	Bassina jacksoni	7.45	10.67	2.602808
Rainbow	4	8	Bassina pachyphylla	14.86	19.28	3.428908
Rainbow	10	16	Brachidontes rostratus	39.04	25.38	4.516081
Rainbow	5	4	Cardita excavata	12.05	6.79	2.727397
Rainbow	8	8	Donax brazieri	17.21	25.12	3.667956
Rainbow	10	4	Donax cuneatus	9.89	12.09	2.879078
Rainbow	5	4	Donax deltoides	7.3	8.26	2.378123
Rainbow	9	16	Donax faba	15.55	22.45	3.543393
Rainbow	9	16	Donax veruinus	14.53	24.17	3.598415
Rainbow	7	8	Dosinia nedigna	17.14	18.23	3.497435
Rainbow	4	8	Gari livida	11.55	19.72	3.319681
Rainbow	3	8	Gari oriens	12.24	21.26	3.307592
Rainbow	8	8	Glycymeris grayana	10.91	11.89	2.827975
Rainbow	8	16	Glycymeris queenslandica	28.55	29.85	4.237147
Rainbow	10	8	Hemidonax pictus	11.56	19.45	3.196992
Rainbow	8	8	Mactra antecedens	11.71	19.5	3.289057
Rainbow	8	16	Mactra contraria	43.48	63.14	4.923948
Rainbow	10	8	Mactra cuneata	11.88	13.92	3.124384
Rainbow	1	4	Paphies elongata	10.01	16.79	3.059832
Rainbow	7	8	Paphies elongata	10.75	18.1	3.012381
Rainbow	7	8	Plagiocardium setosum	16.25	20.59	3.780145
Rainbow	1	4	Timoclea scabra	7.44	7.98	2.386908
Rainbow	6	16	Vepicardium multispinosum	23.43	26.89	4.169059
Rainbow	5	4	Wallucina haddoni	8.79	7.79	2.447458
Saltwater	1	4	Antigona persimilis	9.44	12.39	2.852317
Saltwater	1	4	Bassina pachyphylla	10.45	11.43	2.719065
Saltwater	10	4	Cardita excavata	11.32	7.58	2.67569
Saltwater	10	4	Chlamys aktinos	10.16	8.57	2.316672
Saltwater	1	4	Donax deltoides	8.71	9.94	2.556193

Saltwater	10	4	Glycymeris grayana	7.54	7.97	2.344491
Saltwater	4	4	Glycymeris queenslandica	10.43	10.73	2.792236
Saltwater	4	4	Katelysia rhytiphora	9.46	11.49	2.748137
Saltwater	1	4	Limatula strangei	13.75	8.17	2.826908
Saltwater	1	4	Lutraria rhynchaena	6.48	10.34	2.360171
Saltwater	4	4	Mactra contraria	9.6	9.11	2.550706
Saltwater	4	4	Mactra jacksonensis	5.85	7.77	2.076272
Saltwater	4	4	Modiolus peronianus	14.89	9.56	2.930066
Saltwater	1	4	Neocardium thetidis	3.37	3.82	1.354944
Saltwater	10	4	Paphies elongata	7.4	12.73	2.457754
Saltwater	4	4	Placamen placidum	11.09	14.2	2.989344
Saltwater	1	4	Saccella crassa	8.3	11.33	2.660931
Shellharbour	3	4	Antigona persimilis	10.15	10.25	2.77463
Shellharbour	4	8	Barbatia trapezina	17.36	20.03	3.889431
Shellharbour	4	8	Bassina pachyphylla	19.34	25.88	3.817569
Shellharbour	6	16	Brachidontes rostratus	48.04	23.98	4.524852
Shellharbour	9	4	Cardita excavata	12.03	7.39	2.783306
Shellharbour	3	16	Chlamys aktinos	28.78	24.99	3.796483
Shellharbour	4	4	Donax brazieri	8.94	11.51	2.767776
Shellharbour	10	4	Donax faba	9.81	14.51	2.834575
Shellharbour	1	4	Epicodakia gunnamatta	8.36	13.08	2.801687
Shellharbour	3	4	Fulvia tenuicosta	7.44	7.36	2.22858
Shellharbour	5	8	Gari modesta	8.98	19.16	2.779158
Shellharbour	9	4	Glycymeris grayana	5.16	5.99	1.757285
Shellharbour	7	16	Glycymeris queenslandica	27.39	30.17	4.295323
Shellharbour	4	8	Granicorium indutum	17.88	14.5	3.316016
Shellharbour	2	8	Kellia rotunda	25.01	18.29	3.68281
Shellharbour	3	16	Lima nimbifer	37.5	25.4	4.239775
Shellharbour	7	16	Limatula strangei	35.08	19.16	4.135653
Shellharbour	4	8	Lutraria rhynchaena	19.15	11.16	3.364287

Shellharbour	6	8	Mactra contraria	12.42	11.65	2.973671
Shellharbour	3	4	Mactra jacksonensis	9.13	12.7	2.766993
Shellharbour	4	4	Mactra parkesiana	5.92	6.7	2.007818
Shellharbour	9	8	Mimachlamys famigerator	12.04	10.18	2.636094
Shellharbour	8	8	Mimachlamys gloriosa	11.64	9.52	2.455764
Shellharbour	3	8	Modiolus peronianus	35.33	19.88	4.234665
Shellharbour	7	8	Paphies elongata	15	23.37	3.477224
Shellharbour	9	4	Paphies elongata	7.17	10.79	2.40239
Shellharbour	3	4	Placamen placidum	6.68	7.92	2.125371
Shellharbour	3	4	Saccella crassa	8	11.28	2.607794
Shellharbour	3	4	Tellina tenuilirata	6.02	9.87	2.295194
Shellharbour	1	4	Timoclea scabra	8.44	9.44	2.436266
Tannum	1	8	Anadara craticulata	15.49	19.11	3.611597
Tannum	7	16	Anadara crebricostata	32.44	40.15	4.712948
Tannum	10	4	Anadara guvernaculum	9.24	9.08	2.800455
Tannum	10	8	Anadara vellicata	10.51	13.94	3.116218
Tannum	10	16	Barbatia foliata	24.33	42.61	4.392686
Tannum	2	8	Chama fibula	18.69	13.6	3.627697
Tannum	10	8	Chlamys irregularis	22.89	20.36	3.536157
Tannum	8	8	Donax cuneatus	15.7	22.9	3.564912
Tannum	8	8	Donax veruinus	10.35	14.49	2.97336
Tannum	10	4	Donax veruinus	4.11	9.08	1.651005
Tannum	10	8	Dosinia mira	17.47	17.07	3.532903
Tannum	10	8	Dosinia nedigna	18.96	18.75	3.630182
Tannum	10	8	Eumarcia fumigata	8.51	11.23	2.701505
Tannum	6	8	Exotica donaciformis	15.46	21.85	3.499214
Tannum	1	4	Gafrarium pectinatum	10.87	10.75	2.648596
Tannum	10	8	Gari anomala	12.85	22.78	3.300894
Tannum	8	8	Gari modesta	11.27	21.9	3.199346
Tannum	7	16	Gari oriens	18.28	26.63	3.917653
Tannum	5	8	Glycymeris	21.21	21.07	3.814341

			crebreliratus			
Tannum	10	4	Glycymeris queenslandica	6.7	7.16	2.177574
Tannum	7	8	Hemidonax dactylus	16.86	27.15	3.702482
Tannum	10	8	Kellia rotunda	12.6	14.49	3.212222
Tannum	10	8	Leporimetis spectabilis	12.73	15.43	3.244065
Tannum	7	8	Macoma candida	16.88	23.29	3.606839
Tannum	10	4	Mactra antecedens	6.68	10.68	2.477232
Tannum	10	4	Mactra cuneata	9.71	11.59	2.88876
Tannum	1	16	Mactra dissimilis	29.59	40.52	4.486754
Tannum	1	8	Mactra olorina	18.73	23.13	3.790835
Tannum	10	4	Mactra olorina	7.12	9.59	2.286314
Tannum	1	8	Paphia crassisulca	13.17	16.96	3.343252
Tannum	1	8	Paphies elongata	16.68	26.63	3.708529
Tannum	10	8	Paphies elongata	9.78	15.21	2.935515
Tannum	1	4	Paphies striata	6.58	7.04	2.094041
Tannum	1	4	Soletellina petalina	5.99	13.61	2.506359
Tannum	4	8	Spisula aspersa	12.51	18.07	3.186794
Tannum	10	8	Tapes belcheri	10.54	11.99	2.92272
Tannum	10	8	Tellina bougei	12.72	17.72	3.1796
Tannum	10	8	Timoclea recognita	13.14	16.84	3.398569
Tannum	10	16	Timoclea scabra	24.83	25.31	3.927883
Tannum	4	8	Wallucina assimilis	17.51	17.88	3.581519
Tully	10	8	Donax cuneatus	11.31	16.31	3.110146
Tully	4	8	Dosinia incida	17.18	17.69	3.468188
Tully	5	8	Dosinia mira	20.94	18.51	3.706491
Tully	8	8	Dosinia sculpta	15.48	16.01	3.361389
Tully	5	8	Gari oriens	12.47	19.87	3.373208
Tully	7	16	Glycymeris crebreliratus	30.92	31.04	4.423232
Tully	8	16	Glycymeris holsericus	24.28	24.89	3.967132
Tully	8	16	Glycymeris queenslandica	25.13	25.41	4.148215

Tully	2	16	Hyotissa hyotis	30.56	38.04	4.54088
Tully	7	16	Lioconcha castrensis	35.84	43.74	4.727876
Tully	1	16	Mactra dissimilis	23.41	28.29	4.143774
Tully	1	8	Melaxinaea vitrea	14.26	15.98	3.372993
Tully	3	8	Paphies elongata	11.46	20.07	3.239116
Tully	1	8	Paphies striata	12.77	18.28	3.101725
Tully	1	8	Placamen tiara	10.54	14.59	3.200331
Tully	3	8	Saccostrea cucullata	25	13.78	3.556733
Tully	2	16	Semele crenulata	23.76	23.28	3.923041
Tully	4	16	Spisula coppingeri	32.69	35.49	4.442475
Tully	4	8	Tellina serricostata	16.25	19.7	3.491017
Tully	8	8	Tellina staurella	13.9	18.95	3.15266
Tully	1	8	Timoclea recognita	13.08	15.13	3.169445
Tully	2	8	Timoclea scabra	20.11	20.73	3.642304
Tully	1	8	Wallucina assimilis	15.02	16.03	3.375213