Illuminating the deep: an exploration of deep-sea benthic macrofaunal ecology in the Northwest Atlantic Ocean

by

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To my parents and grandparents

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Acronyms commonly used in this thesis

AIC: Akaike Information Criterion.

BEF: Biodiversity – Ecosystem Functioning.

BPI: Bathymetric Position Index.

Cefas: Centre for the Environment Fisheries and Aquaculture Science.

DDG: Depth – Diversity Gradient.

FSV/R/E: 'Functional Species Variability/Richness/Evenness'.

GAM: Generalised Additive Model.

IECS: Institute of Estuarine and Coastal Studies.

LDG: Latitudinal Diversity Gradient.

NAFO: Northwest Atlantic Fisheries Organisation.

NEREIDA: NAFO potential vulnerable marine ecosystems – impacts of deep-sea fisheries.

POC: Particulate Organic Carbon.

PSD: (Sediment) Particle Size Diversity.

PSV/R/E: 'Phylogenetic Species Variability/Richness/Evenness'.

SAI: Significant Adverse Impact.

SDM: Species Distribution Model.

SEM: Structural Equation Model.

UNGA: United Nations General Assembly.

VIF: Variance Inflation Factor.

VME: Vulnerable Marine Ecosystem.

VMS: Vessel Monitoring System.

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Declaration

I hereby declare that the work presented in this thesis was conducted by myself under the supervision of Professor Alex D. Rogers and Dr Andrew J. Kenny, with the exception of those instances where the contribution of other individuals has been specifically acknowledged. I have clearly indicated throughout the document where the work of others has been quoted, paraphrased or discussed.

I hereby confirm that this thesis has not been submitted for any other qualification or degree at this university or any other institution.



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Abstract

Understanding of the fundamental ecology of deep-sea ecosystems remains immature relative to more familiar shallow-water and terrestrial habitats, despite more than two hundred years of scientific investigation. This thesis aims to progress knowledge of deep-sea benthic ecology by the analysis of over three hundred box core samples collected from the Northwest Atlantic continental slope as part of the international NEREIDA programme. Aspects of the ecology of Peracarida (Crustacea) are studied, and this is facilitated by the coupling of a large faunal dataset with extensive environmental information. To further enhance the power of this dataset, phylogenetic and functional characteristics of assemblages are investigated. Using community phylogenetic methodology, it is demonstrated that the peracarid assemblages studied are structured more strongly by variation in environmental parameters than they are by competitive interactions. Analyses demonstrate that the intensity of bottom trawling, seafloor temperature, current speed, food availability, sediment characteristics and physical habitat heterogeneity all influence deep-sea peracarid assemblage biodiversity metrics. Further, the importance of high poriferan biomass for the promotion of peracarid assemblages of high density, biomass, richness and diversity is highlighted. Of relevance to the management of deep-sea ecosystems, the results of this thesis suggest that caution should be exercised when applying species distribution models to data-deficient environments, whilst the location of spatial closures in the NAFO Regulatory Area may not be fully optimal for the protection of all components of diverse benthic assemblages against the impacts of bottom trawling. The importance of deep-sea diversity is demonstrated by the finding of positive biodiversity – ecosystem functioning relationships. However, the form of these relationships is found to be dependent on the biodiversity and ecosystem functioning metrics employed, and a hypothesis for a generalised form of biodiversity – ecosystem functioning relationships is proposed. Finally, this thesis calls for more ambitious deep-sea ecological investigations, and it is hoped that its findings will encourage future research initiatives, helping to further illuminate this enigmatic and fascinating environment.

Chapter 1

Introduction

1.1. A brief history of deep-sea research

1.1.1 The azoic hypothesis

"*The surface of the deep ocean teems with animal life, and this is probably not less well proportionally tenanted down to depths where, for the want of necessary conditions, it ceases to exist*" (De La Beche, 1834).

This statement succinctly summarises the opinion of the scientific community with respect to the potential for deep-sea environments to host life that held for much of the 19th Century. Temperature, light and food availability were believed to be too low, and hydrostatic pressure too high for even the hardiest of life-forms to persist in the deep sea (here defined as areas underlying more than 200 metres of water), let alone for complex ecosystems to exist.

The origins of this 'azoic' hypothesis date to the early 19th Century, but the theory was propelled to prominence by the work of Edward Forbes in the 1840s. Based on studies of the ecology of terrestrial and marine gastropods (Forbes, 1840a, Forbes, 1840b), Forbes proposed a hypothesis of depth-related zones of marine life and, in 1841, launched an 18-month expedition aboard HMS *Beacon* in the eastern Mediterranean to put this theory to the test (Anderson and Rice, 2006). During this expedition, over 100 benthic samples were taken to a depth of just over 400 metres using a primitive dredging apparatus (Anderson and Rice, 2006) and, based on these samples, Forbes concluded that "*the number of species and of individuals diminishes as we descend* [through the water column]*, pointing to a zero in the distribution of animal life as yet unvisited*" (Forbes, 1844). Extrapolating

his results, Forbes hypothesised that life ceased to exist below a depth of approximately 550 m (Anderson and Rice, 2006).

Although this claim seems absurd in the present day, based on the available information, Forbes' conclusions were indeed valid. Instead, it was the dataset that Forbes based his conclusions upon that was heavily flawed, with two major weaknesses: 1), the eastern Mediterranean is highly oligotrophic, and so hosts a depressed abundance and richness of species relative to other comparable deep-sea areas. 2), the dredge utilised by Forbes was extremely inefficient; a problem only exacerbated by the relatively small average body-size of organisms found in the sampling area (because of its oligotrophic nature) (Anderson and Rice, 2006).

Otto Friedrich Muller (1730-1784) may have been the first person to use a dredge to scientifically investigate marine life (Thomson, 1873). This dredge consisted of a coarse mesh bag attached to a square metal frame, and such a simple design was liable to a large loss of fauna during hauling (Anderson and Rice, 2006). The dredge utilised by Forbes was an improvement upon this, sporting a much narrower aperture (to reduce loss of fauna) and scrapers on both long edges of the frame. However, Forbes' dredge still had a major limitation: the canvas collecting bag rapidly filled with mud upon contact with the seabed, severely compromising the dredge's filtration capabilities (Anderson and Rice, 2006).

Alternative sampling equipment was available at the time, however, and as early as 1818, soundings from HMS *Isabella* made using a 'deep-sea clamm' at a water depth of about 1100 m (Rice, 1975) in the region of Baffin Bay brought up annelids and a gorgonocephalid starfish, clearly contradicting the nascent azoic theory. Unfortunately, this evidence was never publically advertised because of controversy involving the reporting of a fictitious range of mountains blocking Lancaster Sound by Captain John Ross (Anderson and Rice, 2006).

Shortly following Forbes' expedition, upon an Antarctic expedition aboard HMS *Erebus* and HMS *Terror*, James Clark Ross successfully collected living corals, bryozoans and other invertebrates from about 730 m depth using a modified dredge, stating "*I have no doubt, that from however great a depth we may be enabled to bring up the mud and stones of the bed of the ocean we shall find them teeming with animal life*" (Ross, 1847). Following this, Michael and George Ossian Sars used modified dredges to sample hundreds of species off the Norwegian coast from depths up to 550 m between the years 1850 and 1868 (Sars, 1872). Subsequently, aboard HMS *Bulldog* in the Northeast Atlantic in 1860, George Charles Wallich retrieved a sounding line from approximately 2300 m with 13 starfish attached. However, whilst Wallich immediately recognised the significance of this finding, his reports were largely ignored by the scientific establishment because of his perceived bad character (Anderson and Rice, 2006).

It was not until 10 years later that a series of cruises headed by William Carpenter aboard HMS *Lightning* and HMS *Porcupine* in deep waters off the British Isles, Spain and in the Mediterranean finally put the azoic hypothesis to rest (Thomson, 1873). The dredges used during these cruises were similar to those utilised by Forbes, but improved upon these in several ways: the width of the frame was increased, filtration capacity was enhanced by lining a coarse outer mesh with a finer inner netting, and tangles of hemp rope were attached to the rear of the dredge to improve the sampling efficiency of smaller invertebrates (Anderson and Rice, 2006). These cruises were a great success, documenting hundreds of species from depths great enough to falsify the azoic hypothesis beyond refute.

1.1.2 Technological progression towards a modern understanding of deep-sea biology

Following the success of HMS *Lightning* and HMS *Porcupine*, in 1872, HMS *Challenger* embarked on a four year global cruise in order to systematically investigate the deep sea (Thomson et al., 1880). Other than 61 desertions, two cases of insanity and a suicide (Broad, 1997), the cruise was a great success, documenting for the first time the biological,

chemical and physical attributes of oceans at a global scale, from coastal waters to the deepest points on the globe (Rice, 2001). Indeed, this cruise is frequently cited as the origin of the science of oceanography. In the 1940s, the Danish Expedition Foundation's *Galathea* Voyage was the first to establish that life occurred at depths of more than 10 km in the Philippines trench, whilst an extensive world-wide collecting effort was undertaken by Russian scientists following World War II (Filatova, 1982).

However, it was not until the 1960s, when Robert Hessler and Howard Sanders used an epibenthic sledge (EBS) to effectively sample the deep seafloor, that the great richness of deep-sea life became truly apparent (Hessler and Sanders, 1967, Sanders, 1968). An EBS is a towed benthic sampler consisting of a frontal cutting edge and a large collecting bag of fine mesh. This bag is supported by a frame equipped with a wide set of runners, and the sledge as a whole is symmetrical so that it may land on either side and be equally effective (Hessler and Sanders, 1967). Previous to this research, species richness in the deep sea was thought to be inferior to that of shallow waters (Ekman, 1953), yet Hessler and Sanders documented a similar species density as typical for shallow tropical seas, and an average of 14.8 times as many species recovered per station (deeper than 915 m) than obtained during the *Challenger* expedition (Hessler and Sanders, 1967). The EBS is considered such an effective sampling method that it is still used, virtually unchanged, to this day (e.g. Clark and Rowden (2009)).

Box corers are another key benthic sampling apparatus, being developed in the 1960s and 1970s (Reineck, 1963, Hessler and Jumars, 1974) because of uncertainties associated with previous 'quantitative' benthic sampling equipment (Gage, 1996). The basic design of a box corer consists of a box-shaped weighted plunger mounted on a frame, armed with a hinged arm that is triggered to release and seal the base of the box as it impacts with and then is removed from the sediment. Box corers offer a quantitative method for obtaining large volumes of sediment with little loss of faunal content. Although sometimes criticised, particularly with respect to problems related to the bow-wave effect (see Section 6.3.1),

they represent the sampling device of choice for most modern deep-sea benthic macrofaunal biodiversity studies, including this thesis.

Submersibles have further enhanced our abilities to sample deep-sea environments. The first manned research submersibles were constructed in the 1960s following extensive technological development in the 1950s (the dives of *Trieste*, for example). These vehicles gave scientists the means to directly observe and survey deep-sea animals in their natural environment, whilst also facilitating exploration of newly discovered chemosynthetic environments such as hydrothermal vent fields and cold seeps (Lonsdale, 1977, Paull et al., 1984). Submersibles are now able to dive deeper and longer, take more samples with more precision, and collect more accurate physical and chemical data than ever before (Hogg et al., 2010). Development of Remotely Operated Vehicles (ROVs) since the 1970s, largely to serve the offshore oil industry, has given scientists further choice of sampling equipment, and there has been a trend over time towards ROVs with greater capacity for high-resolution visual and acoustic survey, habitat and biological sampling, and experimental manipulation at ever increasing depths (Hogg et al., 2010).

The first Autonomous Underwater Vehicles (AUVs) were developed in the 1960s (Blidberg, 2001), but have only begun to be utilised commonly for deep-water research since the 2000s (Wynn et al., 2014). As their name implies, AUVs are unmanned and able to operate independently of their surface vessel once deployed; navigating a pre-planned route and collecting data (e.g. via photography/multibeam sonar/water sampling) as programmed (Yoerger et al., 2007, Danovaro et al., 2014, Wynn et al., 2014), often for prolonged periods of time (typically in the order of hours to days in deep-sea applications (Clark et al., 2016)). AUVs therefore represent an efficient means of undertaking research tasks that do not require continued real-time human input (Danovaro et al., 2014, Wynn et al., 2014). However, this autonomy also makes AUVs inflexible and inappropriate when directed sampling is required (Yoerger et al., 2007).

Towed camera systems offer a lower-cost alternative to manned submersibles/ROVs/AUVs, and have increased in sophistication greatly over the course of the 20th Century to the present (Hogg et al., 2010). They are particularly effective for enumerating megafaunal populations and documenting substratum type, indications of human disturbance, and the abundance of habitat-forming taxa, (e.g. Clark and Rowden (2009), Durden et al. (2015)).

Most recently, sonar technology has progressed significantly. From its origin in the early 20th Century (D'Amico and Pittenger, 2009), sonar technology has increased in resolution and sophistication whilst reducing in cost and size. Techniques commonly used for deep-sea sampling include side-scan sonar (used to map large areas of seabed quickly and accurately) and multibeam echo-sounding (a multiple frequency approach used to produce shaded-relief topographic maps of the seabed and provide information on seabed texture) (Hogg et al., 2010).

The marine technological revolution that has occurred since the mid-20th Century has contributed greatly to increasing our understanding of deep-sea biology since the pioneering work of Edward Forbes (Danovaro et al., 2014). However, our knowledge is far from complete (Poore et al., 2015). Monetary, technological, and perhaps even behavioural barriers still prohibit thorough exploration of even the most accessible regions, and the vast majority of the deep sea is still yet to be sampled by humans (Rogers et al., 2015a). The deep sea is the largest habitat on Earth, covering an area of about 434 million km^2 (equivalent to 50 % of the surface of the Earth), and a water volume of over 1.34 billion km^3 (Costello et al., 2010, Danovaro et al., 2014) and sampling to date has likely covered less than 0.0001 % of total deep-sea habitat (Rogers et al., 2015a). This slightly daunting fact is amusingly summarised by Widdicombe and Somerfield (2012): "*Our knowledge of marine biodiversity* [can be] *likened to what our knowledge of rainforest biodiversity might be like if our only way of assessing it was by means of a grappling hook deployed from a hot-air balloon*".

1.2 Deep-sea diversity

1.2.1 How diverse?

Attempts to determine the total number of species on Earth have been ongoing for over 250 years (Linnaeus, 1758, Westwood, 1833, Odegaard, 2000, Costello et al., 2012). Linnaeus, in his ground-breaking text, recorded about 4400 animal species (Linnaeus, 1758, Odegaard, 2000). However, as time has progressed, this number has swelled, and recent quantitative estimates of global species richness range between about 2 million (Costello et al., 2012) and 9 million (Mora et al., 2011b), whilst estimates based on expert opinion extend up to 100 million species (May, 2010). However, confidence in all estimates remains low because of continued limitations in sampling and controversy over the assumptions employed by indirect estimation methods (Mora et al., 2011b, Pimm, 2012).

Estimates of total marine species richness are rare, and analyses often produce contradictory conclusions based on the methodology used. Estimates range from 0.3 - 0.5 million (May, 1992), to 0.5 - 1 million (Appeltans et al., 2012), to 'over 1 million' (Winston, 1992), to 1.4 - 1.6 million (Bouchet, 2006), to 2.2 million (Mora et al., 2011b), to 5 million (Poore and Wilson, 1993), to a maximal of over 10 million marine species (Grassle and Maciolek, 1992).

Attempts to calculate deep-sea species richness are even rarer, but there are indications that it may be huge. For example, based on data from 233 box core samples collected at continental slope depths in the North Atlantic, Grassle and Maciolek (1992) estimated global deep-sea macrofaunal richness to be between 1 million and over 10 million species. However, this is likely an overestimate, falling victim to the 'ecological fallacy' that results of analyses based on data that are spatially aggregated can be reliably extrapolated to alternative aggregations (Steel and Holt, 1996, Lambshead and Boucher, 2003, Poore et al., 2015), with samples being taken from a particularly diverse area that straddles a depth zonation, and analyses based on multiple higher taxa differentially responding to environmental and ecological parameters along the study transect. More recent discussions

of deep-sea faunal diversity show greater conservatism (Lambshead and Boucher, 2003), and promote a paradigm where the deep sea has modest gamma diversity (total species diversity at the regional scale (Whittaker, 1972)), despite an undeniably high alpha diversity (species diversity at the local scale (Whittaker, 1972)), through patch dynamic mechanisms (Lambshead and Boucher, 2003). It is now generally agreed that the deep sea contributes significantly to a total marine species richness of approximately 0.5 – 1.5 million (Mora et al., 2011b, Appeltans et al., 2012, Costello et al., 2012).

1.2.2 Niche and neutral theories and the distribution of diversity through the deep sea

The neutral theory of Hubbell (2001) proposes that the likelihood of death for individuals within a local community is equal and independent of species identity, and that the replacement of individuals occurs either from within the local community or from the wider metacommunity (which has a set structure) with a likelihood that is dependent on relative abundances of species (Rosindell et al., 2011). In other words, it assumes that species are demographically identical and exhibit no fitness differences. Even though these assumptions are clearly ecologically unrealistic, neutral theory has been used to good effect in explaining relative species abundances, species-area relationships and beta diversity (Zillio et al., 2005, Rosindell and Cornell, 2009, Etienne and Rosindell, 2011), and thus has been promoted as a useful starting point for an explanation of macroecological patterns (Rosindell et al. 2011).

In contrast, species differences are at the heart of niche theory, developed by Grinnell (1924), Elton (1927) and Hutchinson (1957), which represents a key pillar of ecology. Niche theory emphasises that species must differ in some dimension (e.g. physiology, behaviour, phenology) in order to coexist, and a niche can be defined as an n-dimensional hypervolume describing the place (realised or fundamental) of a species within its environment (Hutchinson, 1957). Niche theory has been used in a plethora of applications, including species distribution modelling and conservation planning, the prediction of species'

invasions and climate change impacts, and the explanation of community composition and the outcomes of competitive interactions (Gause, 1934, Pianka, 1981, Peterson, 2003, Peterson, 2006, Ashford et al., 2014).

Although neutral theory is now accepted by the wider ecological research community as a valuable null model to be applied, niche theory is recognised as the more realistic approximation of reality. Neutral processes have been investigated in the deep sea only extremely rarely (e.g. Quattrini et al. (2017)), and discussion of niche theory still dominates within deep-sea macroecological literature.

Two macroecological patterns of deep-sea diversity have received most attention in the literature: latitudinal diversity gradients, and depth - diversity relationships. Latitudinal diversity gradients (LDGs) have a long history in terrestrial ecology. For example, upon returning from his 1799 – 1804 expedition to Latin America, Alexander von Humboldt remarked that the 'organic development and abundance of vitality' of plant life greatly increased as one travelled from the poles to the equator (Anderson and Rice, 2006). Such patterns are now recognised for a myriad of terrestrial organisms (Hillebrand, 2004), including birds (Hawkins et al., 2003), mammals (Buckley et al., 2010), trees (Currie and Paquin, 1987) and mites (Maraun et al., 2007).

Explanations for LDGs are nearly as numerous as examples of the gradients themselves, but can be divided into three main groups:

1. Mid-domain effects: whereby random placement of species within a bounded space can produce a diversity peak at the mid-point of the domain (e.g. the equator) independent of any biological information or process (Colwell and Lees, 2000, Koleff and Gaston, 2001, Hillebrand, 2004).

2. Geographic range size in relation to climatic factors (e.g. 'Rapoport's Rule' (Stevens, 1989)): geographic ranges of terrestrial species are generally largest at high latitudes, where species need to adapt to seasonal extremes in conditions, and smallest at the

equator, where species are adapted to a much smaller variance in climatic conditions. A greater number of species with small geographic ranges can be packaged into a given area than species with larger geographic ranges (Gage, 1996).

3. Relative rates of diversification and extinction in the tropics: such explanations variously claim the tropics to be a cradle of diversity (high diversification rates), a museum of diversity (low extinction rates), or both (Stebbins, 1974, Jablonski et al., 2006, Rivadeneira et al., 2015).

Of these groups, theories based on equatorial diversification/extinction rates are most numerous, and reasons put forward for high tropical diversification and low extinction rates include Wright's (1983) species-energy hypothesis (greater energy availability facilitates higher faunal abundances that promote diversification (Currie, 1991, Green and Fong, 2015, Woolley et al., 2016)), that increasing biome area promotes speciation (Rosenzweig, 1995, Losos and Schluter, 2000), that changes in the intensity or specificity of ecological interactions occur with latitude (Pianka, 1966), that higher temperatures promote increased mutation rates and reduced generation times (Cardillo, 1999), and that the higher temporal stability of the tropics over geological time enhances clade persistence (Jansson and Dynesius, 2002). However, despite such a large literature, there is still an "*astonishing lack of consensus about the mechanisms leading to this spatial variation in diversity*" (Hillebrand, 2004).

It was assumed for the majority of the 20th Century that the physical gradients that cause latitudinal diversity patterns in shallow waters and terrestrial environments could not affect the supposedly insulated communities of the deep sea (Rex et al., 1993, Lambshead et al., 2000, Rex et al., 2000, Gage, 2004). However, it is now thought that LDGs do exist in the deep sea, with Rex et al. (1993) publishing the first evidence for such gradients based on bivalve, gastropod and isopod diversity in the Atlantic Ocean. The findings of this study remain controversial, however; clear diversity gradients are demonstrable only in the North Atlantic, and only with a strong reliance on samples from the Norwegian Sea – a region that

exhibits depressed diversity as a result of ongoing re-colonisation following the quaternary glaciation and the Storegga slide (Gray, 1994, Gray, 1997, Gage, 2004). Yet, since this initial study, further analyses have confirmed deep-sea latitudinal diversity patterns (Rex et al., 2000), and extended examples to additional taxonomic groups, including benthic foraminifera (Culver and Buzas, 2000, Corliss et al., 2009), and cumaceans (Gage et al., 2004). However, this gradient does not seem to be universal (Lambshead et al., 2000, Lambshead et al., 2002), and there is some evidence that the form of LDGs may differ between upper-bathyal and lower-bathyal/abyssal environments (Woolley et al., 2016).

Three main explanations for deep-sea LDGs have found favour with the scientific community. The first is that the high seasonality of food input in high latitude bathyal habitats depresses species richness and equitability as a result of the increased dominance of opportunistic species (Culver and Buzas, 2000, Rex et al., 2000, Corliss et al., 2009). Proposed mechanisms for this include the acceleration and destabilisation of interspecific interactions as population abundances increase (Rex et al., 1993, Gage et al., 2004), and alteration to the nature and scale of habitat heterogeneity with pulsed nutrient delivery (Rex et al., 1993). The second explanation is based, in essence, on Alfred Russell Wallace's (1878) idea that the high species richness and 'mature' biodiversity of tropical latitudes is an expression of uninterrupted evolution, this contrasting with higher latitudes where climate has been most variable, so enforcing periodic checks and extinctions on the biota there (Wilson, 1998, Gage, 2004, Gage et al., 2004). Additionally, Gage et al. (2004) argue that dispersal into deeper waters and higher latitudes from tropical cradles of diversity will produce latitudinal species diversity gradients. Finally, total deep-sea benthic area in the North Atlantic decreases with increasing latitude, and this has been proposed to limit total species richness at higher latitudes (Lambshead et al., 2000).

However, it can be argued that any conclusions concerning deep-sea LDGs remain speculative at best since knowledge of the Antarctic deep sea is still developing (Gage, 2004, Rogers and Linse, 2014), there is a lack of statistically adequate replication

(Lambshead et al., 2000, Gage, 2004), the influence of glaciation (Heinrich events (Heinrich, 1988), for example) in shaping the biota of high latitudes is too great (Gage, 2004), and the division of the Atlantic into basins and its benthic area/latitudinal relationships are confounding.

Unlike latitudinal diversity gradients, depth - diversity relationships (DDRs) have no real analogue on land, save, perhaps, for elevational diversity gradients (Sanders and Rahbek, 2012). Having been recognised for a greater period of time in the deep sea, they have been subjected to a greater detail of investigation and are thus less controversial amongst the scientific community than LDGs.

Typically, DDRs are unimodal, with diversity peaking at mid-slope depths. Early attention to such patterns was centred on the western North Atlantic (the most intensively sampled region of the deep sea) and examples were qualitative in type. For instance, Rex (1973, 1976, 1981) highlighted a peak in macrofaunal diversity on the continental slope relative to shelf and abyssal depths. Quantitative examples followed, confirming these initial studies (Etter and Grassle, 1992, Paterson and Lambshead, 1995, Cosson-Sarradin et al., 1998, Wilson, 1998).

Explanations for DDRs are numerous, but, as with latitudinal diversity patterns, can be split into those based on mid-domain effects (no biological basis to the pattern), and those which promote the importance of specific ecological or physiological processes. In the case of mid-domain explanations, the boundary constraints are no longer the poles, but instead are the air-sea interface, and the deepest sea floor. Simulations whereby large sets of species with different depth ranges are randomly distributed within these boundary constraints produce unimodal species diversity patterns (Pineda, 1993, Pineda and Caswell, 1998). However, detailed analysis of the shape of the depth/diversity curves produced shows that mid-domain effects do not fully explain observed depth/diversity patterns (Pineda and Caswell, 1998, Levin et al., 2001).

Biological explanations for DDRs can be further split into those stressing the importance of ecological factors and those that promote processes acting over evolutionary timescales. For example, Rex (1973, 1981) argues that supposed higher environmental stability with increasing depth boosts diversity on continental slopes relative to the shelf, but that reduced food availability limits diversity as depth increases further (Rex et al., 2005). Cosson-Sarradin et al. (1998) invoked the 'Intermediate Productivity Theory' (Grime, 1973) in explaining a parabolic depth/diversity relationship for polychaetes in the East Atlantic, suggesting that intermediate levels of food availability at continental slope depths allows for greater species coexistence via reduced competitive displacement. Other studies emphasise the importance of habitat heterogeneity in promoting diversity. Mid-slope depths represent some of the most structurally and physically diverse environments in the oceans, with numerous canyons, cliffs, banks, ridges, mounds, gulleys and broad slopes (Levin et al., 2010), whilst sediment particle size heterogeneity is maximised (Etter and Grassle, 1992), organic matter inputs are varied (e.g. riverine, macrophytic and planktonic input) (Levin et al., 2010), turbidity flows provide periodic disturbance (Thistle et al., 1985, Gage, 1996, Levin et al., 2001, Levin et al., 2010), strongly-differentiated water masses meet (Gage, 2004), and the presence of oxygen minimum zones boosts beta diversity (the turnover of species diversity over space (Whittaker, 1972)) (Gooday et al., 2010), all promoting the formation of diverse biological communities. In short, "[continental] *margins comprise some of the most heterogeneous and dynamic real estate on the planet*" (Levin et al., 2010).

Consideration of processes acting over evolutionary timescales in the context of DDRs is rarer, but Rex and Etter (1998) suggest that the potential for evolutionary radiation in the deep sea is greatest at continental slope depths, where the bathymetric selective gradient is steeper, there is more opportunity for geographic isolation, and where food resources permit greater coexistence of species than in the abyss. This proposition is supported somewhat by work on gastropods (McClain et al., 2004, Rex et al., 2005).

1.2.3 Why is the deep sea so diverse?

"*How the deep sea – a seemingly food poor and apparently featureless habitat – provides habitat for so many different species represents one of the most intriguing and challenging problems in marine biology*" (Gage, 1996).

Following Hessler and Sander's pioneering work (1967), a flood of hypotheses have emerged, each attempting to explain high deep-sea alpha diversity. The 'Stability-Time Hypothesis' of Sanders (1968) was one of the first of these, arguing that, because physical environmental conditions in the deep sea appear relatively constant over time, niche diversification (especially in dietary terms) has occurred on a lavish scale, resulting in modern communities where competitive interactions are weak and coexistence is high. Reception to this hypothesis has been mixed, some arguing that the dietary specialisation supposed in the 'Stability-Time Hypothesis' is undemonstrated (Dayton and Hessler, 1972), and that, based on gut content analysis, most larger deep-sea benthic metazoans appear to be relatively unselective deposit feeders (Dayton and Hessler, 1972, Gage, 1996) (Appendix 4). Others promote this theory; Valentine and Jablonski (2015) argue that stability in environment may link the high diversities of the shallow tropics and deep sea.

Following this, hypotheses have progressed towards spatio-temporal heterogeneity models and interactive species co-existence at the local scale (Gage, 2004), all essentially promoting different ways to maintain ecological disequilibria and delay successional processes. For example, Dayton and Hessler (1972), Rex (1976) and Gage (2004) argue that predatory disturbance in the deep sea serves to reduce the strength of competition and species dominance, and so produces a variety of communities at different successional stages. Grant (2000) too promotes frequency-dependent predation as a mechanism to cap the abundance of common species, but downplays its role in limiting the severity of competition, since evidence from shallow-water soft sediment communities suggests that competition in the deep sea is likely to be symmetrical and weak, with limited significance to the structuring of communities (see Section 2.2) (Woodin, 1983). Conversely, some

workers (e.g. Danovaro et al. (2008)) have argued that a high level of facilitation (Connell and Slatyer, 1977) in the deep sea promotes high diversity (more species lead to the creation of more niches, which facilitates the coexistence of more species) (see Section 5.2.3).

Other theories emphasise that a combination of environmental factors and species interactions are important for producing high-diversity deep-sea communities. For example, spatially and temporally patchy food resources at a variety of scales can result in a heterogeneous community structure (Grassle and Morse-Porteous, 1987, Rice and Lambshead, 1994, Gage, 1996), whilst the disturbance mosaic theory suggests that diversity is boosted by periodic random physical disturbance coupled with relatively slow population growth rates, creating a mosaic of intermediate disturbance levels (Connell, 1978) at varying stages of community recovery (Huston, 1979, Kukert and Smith, 1992, Gage, 1996). Another hypothesis emphasises the importance of source/sink metapopulations in the deep sea, with the dispersal of pelagic water-borne larvae from a diverse set of species providing the potential for species to frequently expand their range and rapidly exploit patchy resources (Gage, 1996, Gray, 2002, Gage, 2004). Following from this, it is important to note that the relative openness of the oceans over large spatial scales provides pathways for evolutionary radiations to disperse into all ocean basins (given sufficient time) (Gage, 2004). Other ideas stress the importance of large-scale physical heterogeneity in promoting high species richness in the deep sea. For instance, it is argued that there is a high spatial and temporal heterogeneity of sediment structure in the deep sea, caused by both biological activities and hydrographic and geomorphic factors (see Section 1.2.2). Biologically-generated sediment heterogeneity (e.g. mounds, burrows, tubes and 'mud balls') may persist longer and contribute more to niche diversification in the deep sea than in shallow water (Jumars, 1975, Gage, 1996). There is also evidence that bathymetric heterogeneity may promote speciation over evolutionary timescales by restricting genetic connectivity between populations (Zardus et al., 2006, Knutsen et al., 2009). Perhaps most

simply, Gage (1996) cites well known species/area relationships to suggest that high diversity in the deep sea may be a consequence of its huge area.

Amongst this myriad of theories, a consensus is slowly forming that high deep-sea diversity is a result of a combination of several important factors and no single process is likely to emerge to provide a universal explanation (Gage, 2004). Low levels of competition, high incidence of facilitation, sufficient predation and other forms of biotic and abiotic disturbance to limit species dominance, and varied patch dynamics (food supply and biogenic and physical sediment characteristics) over small spatial scales are superimposed upon regional-scale clines in physical habitat, productivity, flow regimes, oxygen concentrations and temperature, which in turn occur in the setting of a spatially huge and relatively open system with the potential for global-scale dispersal of taxa – a near-perfect recipe for high species diversity (Grassle and Maciolek, 1992, Gage, 1996, Levin et al., 2001, Gray, 2002).

1.2.4 How can we quantify deep-sea diversity?

Historically, quantification of deep-sea diversity has been relatively rudimentary. Hessler and Sanders (1967) simply used species counts and individuals:species ratios to quantify species diversity in the deep sea. The rarefaction method, (Sanders, 1968, Hurlbert, 1971) facilitated comparison of the diversity of communities from non-quantitative samples (e.g. epibenthic sledge samples), and is thought to represent an unbiased estimator of diversity which is sensitive to the presence of rare species (Rex et al., 1993). Further, measures such as Pielou's J and Shannon diversity have historically been used to quantify community evenness and diversity, respectively, in the deep sea. These simple metrics are the standard descriptive statistical methods for biodiversity studies in the deep sea to this day.

However, these methods clearly have limitations. Rarefaction, for example, assumes that the distribution of individuals is random, and that community dominance does not vary with increasing sample size (Gray, 2002), yet benthic species typically occur in aggregations, and dominance always decreases with increasing sample spatial size (Fager, 1972, Gray, 1997).

As a result, the application of rarefaction methods to benthic datasets is of doubtful validity (Gray, 2002). Furthermore, typical diversity metrics treat all species equally. For instance, a hypothetical sample of 10 individuals representing 10 different species of the amphipod genus *Harpinia* will be recorded as being just as diverse as a sample of 10 individuals representing 10 different species of peracarid crustacean from 10 different families, when the *phylogenetic* diversity of the second sample is clearly much higher. Thankfully, additional diversity metrics that incorporate phylogenetic and functional aspects of diversity have been designed and are starting to be used more commonly in ecological studies.

Quantitative measures of community phylogenetic structure hark back to the pioneering work of Charles Elton (1946), who used species:genus ratios as a measure of taxonomic diversity (see Section 2.2.1). Current measures of phylogenetic diversity include, for example, the 'net relatedness index' (Webb, 2000) – a standardised measure of the mean pairwise phylogenetic distance of taxa in a community sample relative to a phylogeny of an appropriate species pool (Webb et al., 2002), the 'nearest taxon index' (Webb, 2000) – a standardised measure of the phylogenetic distance to the nearest taxon for each taxon in a community sample (Webb et al., 2002), and 'Phylogenetic Species Variability' (Helmus et al., 2007a) – a measure of the relative clustering of taxa in a community sample across an appropriate phylogeny. These measures of diversity attempt to quantify the average distance between species in a community based on a phylogenetic tree (Pavoine and Bonsall, 2011). The degree of phylogenetic clustering or dispersion can further be used to infer details of the key factors shaping communities (Helmus et al., 2007b). Phylogenetic clustering suggests an importance of environmental filtering in community development, whilst over-dispersion suggests a greater relative importance of competitive exclusion between closely-related taxa in a community (or phenotypic convergence by distantly-related taxa) (Webb et al., 2002, Helmus et al., 2007b, Kluge and Kessler, 2011) (see Chapter 2).

The concept of functional diversity relates to variation in the number, type and distribution of functions performed by organisms within ecosystems, and hence places functional trait combinations as the diversity unit under analysis, rather than species identity (Díaz and Cabido, 2001, Flynn et al., 2011). Its use is based upon the argument that the functional traits of species have more ecological relevance than species identity *per se* (Murray et al., 2014, Leduc et al., 2015). Assuming that functional traits are conserved within lineages, phylogenetic and functional diversity patterns should be identical (Kluge and Kessler, 2011), and similar to the case of phylogenetic diversity, the degree of clustering or dispersion of functional traits in a community can be used to investigate the ecological forces shaping the community in question (Kluge and Kessler, 2011, Kraft et al., 2015, Leduc et al., 2015, Törnroos et al., 2015), with functional diversity significantly greater than that of a randomly selected assemblage (functional over-dispersion) being suggestive of the importance of character displacement processes, whilst the opposite situation (functional clustering) is indicative of the importance of environmental filters in constraining community composition (Kluge and Kessler, 2011) (see Chapter 2).

Functional diversity can be calculated using traditional diversity metrics (simply replacing species names with functional categories), but there has been experimentation with alternative techniques. For example, 'functional attribute diversity' (Walker et al., 1999) sums species distances in multivariate trait space as a measure of total trait dissimilarity (Cadotte et al., 2009), whilst the 'functional diversity' measure of Petchey and Gaston (2002, 2006) uses the distance matrix created using 'functional attribute diversity' analysis and runs it through a clustering algorithm to create a functional dendrogram. Diversity can then be calculated following similar methods to those applied to phylogenies.

At the same time as functional and phylogenetic diversity measures have been developed, taxonomic diversity metrics have also been advanced. For example, the utility of Rao's (1982) quadratic entropy measure (a species diversity measure that combines species relative abundances and pairwise interspecies differences) has been extended (Ricotta and

Szeidl, 2009), and new methods for calculating alpha, beta and gamma diversity have been proposed based on hierarchical multispecies abundance models (Iknayan et al., 2013). The application of phylogenetic and functional diversity measures in conjunction with metrics of taxonomic diversity appears to increase our ability to tease apart the details of community diversity, structure and function (Cadotte et al., 2009, Devictor et al., 2010, Flynn et al., 2011, Kluge and Kessler, 2011, Pavoine and Bonsall, 2011, Naeem et al., 2012, Leduc et al., 2015), and many ecological studies are now employing multiple forms of diversity metric (e.g. Cadotte et al. (2009), Kluge and Kessler (2011)). However, the use of phylogenetic and functional diversity metrics is much rarer in marine environments, and this thesis particularly promotes the consideration of alternative measures of diversity in deep-sea ecological investigations.

1.2.5 Environmental factors influencing deep-sea communities

Numerous physical environmental factors have been shown to be important in shaping deep-sea benthic communities. This topic is covered in detail in Chapter 3, and reviewed briefly below.

The quantity (rate and regularity) and quality of organic matter being delivered to the seabed from surface waters represents one of the most fundamental factors structuring deep-sea communities and has been shown to have a controlling influence over benthic faunal composition, diversity, biomass, abundance, body size, and oxygen consumption, and hence ecosystem functioning (the aggregate effect of physical, chemical and biological processes associated with the flow of energy and matter within and between trophic levels, communities and ecosystems (Danovaro et al., 2008, Loreau, 2008, Paterson et al., 2012)) and the provision of ecosystem services (the benefits that people obtain from ecosystems (Armstrong et al., 2012, Thurber et al., 2014)) (Gooday and Turley, 1990, Flach and Thomsen, 1998, Ruhl and Smith, 2004, Johnson et al., 2007, Smith et al., 2008, Corliss et al., 2009, De Leo et al., 2010, Beazley et al., 2013, Smith et al., 2013, Woolley et al., 2016) (see sections 3.2.3 and 3.5.3). As a result, temporal changes in surface phytoplankton

communities can have considerable influence over ecological processes in the deep sea (Graf, 1989, Smith et al., 2006, Johnson et al., 2007, Corliss et al., 2009, Smith et al., 2013). When food availability is low, diversity is predicted to be depressed because insufficient resources are available to support viable populations of species (Levin et al., 2001, Rex et al., 2005). However, when food availability is high, diversity may also be supressed because of reduced habitat heterogeneity, increased species dominance, and greater potential for physiological stress linked to oxygen limitation and/or sulphide toxicity. Thus, the relationship between food availability and diversity in the deep sea is suggested to conform with the terrestrially-developed 'Intermediate Productivity Theory' (Grime, 1973) (see Section 1.2.2).

Sediment characteristics also appear to be important in shaping deep-sea communities, and benthic diversity has been shown to relate significantly to particle size diversity (Etter and Grassle, 1992, Leduc et al., 2012, Pape et al., 2013). This has largely been attributed to interspecific differences in particle size preference between abundant deposit feeding taxa (Etter and Grassle, 1992, Flach and Thomsen, 1998, Barrio Froján et al., 2012) (see sections 3.2.2 and 3.5.2).

Current flow is a form of disturbance that can further influence sediment structure, faunal recruitment potential, food availability and other environmental parameters, and thus can have a large influence over benthic community structure (Smith and Brumsickle, 1989, Flach and Thomsen, 1998) (see sections 3.2.4 and 3.5.4). For instance, Paterson and Lambshead (1995) reported a strong linear relationship between the frequency of current speeds of over 15 cm/s in the Rockall Trough and the level of polychaete species dominance, whilst Murillo et al. (2012) found the position of the Labrador current to be an important factor influencing the distribution of sponges around the Flemish Cap. At the extreme end of the spectrum, benthic storms represent agents of disturbance that can modify the diversity and structure of benthic communities (Hall, 1994, Gage et al., 1995, Gage, 1997).

Oceanographic variables such as temperature, salinity, oxygen concentration and pH have further influence over benthic community structure (Levin et al., 2001). The importance of temperature in shaping marine communities is fundamental because of its powerful control over the metabolic rate of organisms (Brown et al., 2004). Temperature has direct importance in determining faunal distributions, recruitment, growth rates and species interactions (Timofeev, 2001, Perez-Rodriguez et al., 2012, Widdicombe and Somerfield, 2012, Poloczanska et al., 2013), and thus has been shown to have a significant influence on benthic macrofaunal composition in multiple systems (Yasuhara et al., 2008, Barrio Froján et al., 2012, Yasuhara and Danovaro, 2014, Yasuhara et al., 2014) (see sections 3.2.6 and 3.5.6). As a result of its important influence over solute concentrations in marine organisms, salinity has been shown to significantly influence benthic community composition (Beazley et al., 2013). Physiological constraints dictate the structure and diversity of communities found in locations of differing oxygen concentration (Gooday et al., 2010, Moffitt et al., 2015) (see Section 6.3.2). For example, sponges appear to require significant oxygenation and so are largely absent from oxygen minimum zones (OMZs) (Buhl-Mortensen et al., 2010). As a result, variation in oxygen concentration can influence ecosystem functioning (Woulds et al., 2007). Variation in pH can further influence community structure. For example, calcifying taxa are vulnerable to dissolution in areas of depressed pH , but other taxa may not be similarly affected (Bernhard et al., 2009). Another mechanism relates to surface productivity – in areas of depressed pH, iron availability is reduced (Shi et al., 2010), leading to decreased primary production, with consequences for deep-sea communities as outlined above (also see Section 6.3.2).

Of large and increasing significance is the impact of humans on all marine systems. Even small human populations can have severe impacts on marine biodiversity (Jackson, 2008), and so the potential consequences of the recent human population explosion are great. Indeed, the unsustainable use of marine resources has already resulted in significant changes to the diversity and composition of biological communities, with consequences for

ecosystem functioning (Worm et al., 2006, Loreau, 2008, Coll et al., 2012, Holt et al., 2012, Widdicombe and Somerfield, 2012). As a result, the capacity of oceans to provide key ecosystem services may be becoming increasingly impaired (Coleman and Williams, 2002, Worm et al., 2006, Loreau, 2008, Doney et al., 2012). For example, overfishing is leading to a reduction in diversity and changes to ecosystem functioning in marine environments (Thrush et al., 1998, Coleman and Williams, 2002, Bailey et al., 2009, Worm et al., 2009, Mangano et al., 2014), and the loss of large predatory fish and marine mammals and reptiles has been particularly pronounced, resulting in changes to predation regime, reduction in average body size and trophic level, and typically faster growth rates in marine ecosystems (Jackson et al., 2001, Myers and Worm, 2003, Worm et al., 2009, Duffy et al., 2012). Anthropogenic impacts are now extending further into the deep sea (Benn et al., 2010). Bottom trawling, energy extraction and waste disposal now occur at bathyal and even abyssal depths, and resultant localised impacts can be severe (Bailey et al., 2009, Buhl-Mortensen et al., 2010, Ramirez-Llodra et al., 2011, Widdicombe and Somerfield, 2012). When this is coupled with the potential impacts of climate change (Doney et al., 2012, Howes et al., 2015, Sweetman et al., 2017), it becomes clear that it is now a management and conservation imperative to increase our understanding of how multiple anthropogenic stressors are influencing deep-sea environments (Buhl-Mortensen et al., 2010, Ramirez-Llodra et al., 2011, Doney et al., 2012). This thesis focusses particularly on the impacts of bottom trawling and rising temperatures in the deep sea.

1.3 Anthropogenic threats to marine environments

1.3.1 A brief history of bottom trawling

Concerns over the effects of trawling on marine ecosystems, with claims that trawling markedly reduces benthic habitat diversity (Coleman and Williams, 2002, Rogers et al., 2008, Rogers and Gianni, 2009, Grabowski et al., 2014), reduces community biodiversity and biomass (Thrush et al., 1998, Coleman and Williams, 2002, Rogers et al., 2008, Worm et al., 2009, Levin et al., 2010, Barrio Froján et al., 2012, Duffy et al., 2012, Howarth et

al., 2013), causes trophic cascades and changes to community structure (Snelgrove, 1997, Thrush et al., 1998, Kaiser et al., 2000, Coleman and Williams, 2002, Fisher and Frank, 2002, Micheli et al., 2004, Rogers et al., 2008, Worm et al., 2009, Barrio Froján et al., 2012, Duffy et al., 2012, Widdicombe and Somerfield, 2012, Howarth et al., 2013, Ingels et al., 2014), decreases ecosystem resilience (Jackson et al., 2001, Coleman and Williams, 2002, Howarth et al., 2013) and reduces ecosystem functioning (Worm et al., 2006, Worm et al., 2009) are commonly thought to have arisen relatively recently – perhaps in the second half of the 20th Century. However, concerns over the impacts of trawling in fact date back to its introduction in the 13th Century in Northwest Europe (de Groot, 1984). For instance, a fascinating complaint made to King Edward III in 1376 reads:

> "*The commons petition the king, complaining that where in creeks and havens of the sea there used to be plenteous fishing, to the profit of the Kingdom, certain fishermen for several years past have subtly contrived an instrument called 'wondyrechaun' made in the manner of an oyster dredge, but which is considerably longer, upon which instrument is attached a net so close meshed that no fish be it ever so small which enters therein can escape, but must stay and be taken. And that the great and long iron of the wondyrechaun runs so heavily and hardly over the ground when fishing that it destroys the flowers of the land below water there, and also the spat of oysters, mussels and other fish upon which the great fish are accustomed to be fed and nourished. By which instrument in many places, the fishermen take such quantities of small fish that they do not know what to do with them; and that they feed and fat their pigs with them, to the great damage of the commons of the realm and the destruction of the fisheries, and they pray for a remedy*" (Roberts (2007), p136-137).

These initial protests were remarkably successful, with acts passed in parliament to ban the use of trawls as early as 1350 (de Groot, 1984). However, a cycle of complaint and contest has continued since; complaints emphasising the effect of trawling on habitat and food availability for fish, and contests being based on the paradigm of oceans as an inexhaustible source of food. For example, in a request to Prince William of Orange by Dutch fishermen dated 19th April, 1583, it is argued that the physical damage that occurs to the seabed following the passage of a trawl reduces the likelihood of catching fish into the future (de Groot, 1984). In contrast to this, Thomas Henry Huxley stated that "*Probably all the great sea-fisheries, are inexhaustible…*" (Huxley, 1884).

Investigation of trawling impacts began in earnest in the 20th Century. For example, in 1938, Michael Graham investigated the effect of the use of tickler chains on benthic fauna in plaice fisheries in the North Sea. He concluded that damage to benthic fauna as a result of trawling was not great since catches of benthic fauna and plaice were similar in trawled and non-trawled areas (Graham, 1955). However, following the adoption of Resolution 1970/S/1 at 58th Council Meeting of The International Council for the Exploration of the Sea (ICES) in 1970, the potential severity of anthropogenic impacts on the world's oceans began to gain acceptance, and several papers were published detailing this (e.g. Houghton et al. (1971), Bridger (1972)). Investigations of the impacts of trawling, and fishing in general, continued throughout the 1980s and 1990s (Bradstock and Gordon, 1983, de Groot, 1984, Jones, 1992), yet a global crisis in fisheries was regarded with scepticism by many until as recently as the mid-1990s (Morato et al., 2006).

Trawling in the deep sea has a much shorter history than in shallow water, with all major deep-water fisheries being developed post World War II, and major expansion only occurring in the 1950s and 1960s (Rogers, 1994, Koslow et al., 2000, Roberts, 2002, Morato et al., 2006, Davies et al., 2007, Ramirez-Llodra et al., 2011). This expansion into deeper waters reflected the relative exhaustion of shallow-water stocks, and so represents a late stage of the 'fishing up' process (Deimling and Liss, 1994, Koslow et al., 2000, Roberts, 2002, Davies et al., 2007, Ramirez-Llodra et al., 2011, Norse et al., 2012). The most significant expansion of deep-water fisheries occurred following the discovery of habitats, like seamounts, that naturally support substantial concentrations of benthopelagic fish such as orange roughy and *Sebastes* spp. (Koslow et al., 2000, Ramirez-Llodra et al., 2011). Further, deep-sea fishing only became possible following technological developments including large refrigerated vessels, more powerful winches, stronger cables and new types of trawling gear (such as 'Rockhopper' rigs) (Roberts, 2002, Davies et al., 2007). Following this initial expansion into the deep sea, the mean depth of fishing for demersal fish has increased globally at a rate of 22 metres per decade, with rates ranging from 1 metre per decade in the North Pacific to 180 metres per decade for Antarctic fisheries (Morato et al.,

2006). Currently, technology and economics restricts most commercial fisheries to maximum depths of approximately 1600 metres (Basson et al., 2002).

1.3.2 Impacts of bottom trawling

The impacts of trawling on benthic ecosystems have been relatively well examined in shallow waters. Commonly it is concluded that the passage of a trawl tends to excavate and damage benthic organisms (Houghton et al., 1971, Thrush et al., 1998), and, as a result, chronic trawling has been shown to cause a shift in benthic community structure. This is typically characterised by a relative increase in the abundance of smaller and soft-bodied species, and an associated reduction in the abundance of larger and more fragile species (Thrush et al., 1998, Kaiser et al., 2000, Jennings et al., 2002, van Denderen et al., 2013, Ingels et al., 2014, Mangano et al., 2014, Johnson et al., 2015). For example, bottom trawling is found to result in an increased dominance of burrowing deposit-feeding worms, small bivalves and scavenging biota, and a concomitant reduction in fragile epifauna and bioturbating infauna (Reise, 1982, Thrush et al., 1998, Mangano et al., 2014, van der Grient, 2016). As well as direct mortality from the passage of a trawl, some of this change in community structure reflects a reduction in substratum heterogeneity following trawling. For instance, biologically- and physically-generated sediment heterogeneity may be reduced or eliminated by the passage of a trawl (Thrush et al., 1998), with trawls penetrating up to 80 mm into the seabed (Paschen et al., 2000). The removal of large epifauna, such as sponges and corals, by trawling (Auster et al., 1996, Thrush et al., 1998) also reduces habitat quality, space and complexity for other benthic taxa, and has been likened to forest clear-cutting on land (Watling and Norse, 1998). Changes in community structure may also occur via food-web processes such as trophic cascades following the depletion of target species populations (e.g. Snelgrove, 1997, Pauly et al., 1998, Auster and Shackell, 2000, Bundy, 2001, Coleman and Williams, 2002, Jennings et al., 2002, Myers and Worm, 2003, Micheli et al., 2004, Berkes et al., 2006, Worm et al., 2006, Worm et al., 2009, Frank et al., 2011, Duffy et al., 2012, Widdicombe and Somerfield, 2012, Perez-Rodriguez et al., 2012, Howarth et al., 2013, Watson et al., 2013, Buren et al., 2014, Foster

et al., 2015). Typically, food chain length is reduced following trawling, and communities are shifted towards dominance by small-bodied, fast-maturing and ecologically generalised omnivores and detritivores (Duffy et al., 2012, Foster et al., 2015). For example, following the collapse of cod stocks in the Northwest Atlantic in the early 1990s, planktivorous forage fish (like capelin) and macroinvertebrates (such as lobster) came to dominate (Frank et al., 2011, Nogueira et al., 2016). Nutrient release as a result of sediment re-suspension and disposal of by-catch is another impact of trawling and can cause disturbance to natural carbon cycling and oxygen concentrations (Snelgrove, 1997, Pusceddu et al., 2005). Combining these impacts, the end product of chronic trawling in shallow waters is typically a reduction in the average body size, species richness, abundance and diversity of benthic communities (Thrush et al., 1998, Kaiser et al., 2000, Jennings et al., 2002, Mangano et al., 2014).

The impacts of trawling are potentially greater in the deep sea relative to shallow-water, yet few studies have directly investigated this (Rogers et al., 2008, Clark and Rowden, 2009). Those studies that have been conducted suggest similar consequences of trawling as in shallow water, but at an even greater magnitude of severity (Koslow et al., 2000, Koslow et al., 2001, Hall–Spencer et al., 2002, Althaus et al., 2009, Clark and Rowden, 2009, Williams et al., 2010, Barrio Froján et al., 2012, Murillo et al., 2012, Pusceddu et al., 2014). Deep-sea ecosystems are typically more fragile than their shallow-water counterparts as a consequence of low levels of natural disturbance and mortality, and component species are easily damaged or killed by mechanical force (Rogers et al., 2008, Clark and Rowden, 2009, Rogers and Gianni, 2009). As such, the vulnerability of deep-sea ecosystems to trawl disturbance is clear. As in shallow-water, trawling results in considerable incidental damage and removal as by-catch of epibenthic fauna. This can cause habitat modification following the removal of key framework-forming foundation species, with knock-on effects for other benthic taxa (Koslow et al., 2000, Koslow et al., 2001, Hall–Spencer et al., 2002, Roberts, 2002, Rogers et al., 2008, Clark and Rowden, 2009, Buhl-Mortensen et al., 2010, Hogg et al., 2010, Barrio Froján et al., 2012) (see

Chapter 4). For example, Koslow and Gowlett-Holmes (1998) documented a reduction in benthic biomass and species richness per sample of 83 % and 59 % respectively on fished relative to unfished seamounts off southern Tasmania, whilst Anderson and Clark (2003) noted that high levels of epifaunal by-catch associated with the opening of an orange roughy fishery south of Tasmania declined rapidly within two years, highlighting the speed at which sponges, corals and other epifaunal organisms can be removed following the onset of trawling. Further to the removal of epifauna, the physical action of trawling can lead to smoothing of the seafloor over large spatial scales (Clark and Rowden, 2009, Puig et al., 2012); the net result of this and the by-catch of epifauna being an overall reduction of substratum heterogeneity with trawling (Rogers et al., 2008, Clark and Rowden, 2009). Deep-sea fisheries may also result in an increase in particle density and reduction in organic carbon concentration in surface sediments (Martín et al., 2014), whilst, on steep slopes and canyon flanks, trawling can cause an increased probability of sediment gravity flows, engulfing fauna in their wake (Snelgrove, 1997, Palanques et al., 2006, Hogg et al., 2010, Martín et al., 2014).

As in shallow water, changes to deep-sea community structure may also occur as a result of food-web mediated impacts and trophic cascades. Deep-sea fish species exhibit very low productivity (Norse et al., 2012) and are particularly susceptible to stock depletion because of their high longevity (Koslow et al., 2000, Roberts, 2002, Morato et al., 2006, Rogers et al., 2008, Ramirez-Llodra et al., 2011, Norse et al., 2012) (orange roughy, for example, can live for over 100 years (Tracey and Horn, 1999)), slow growth rates (Koslow et al., 2000, Morato et al., 2006, Rogers et al., 2008, Ramirez-Llodra et al., 2011, Norse et al., 2012), low natural mortality (Koslow et al., 2000, Rogers et al., 2008), late-maturation (often first reproducing at over 20 years of age) (Koslow et al., 2000, Roberts, 2002, Morato et al., 2006, Rogers et al., 2008, Ramirez-Llodra et al., 2011, Norse et al., 2012), low fecundity (most deep-water teleosts have eggs about two times larger than comparable shallow water species) (Koslow et al., 2000, Morato et al., 2006, Rogers et al., 2008, Norse et al., 2012) and episodic recruitment (Koslow et al., 2000, Rogers et al., 2008, Norse et al., 2012).

Further, the aggregation behaviour around discrete topographic features displayed by some target species makes them particularly easy to locate and exploit (Rogers et al., 2008, Norse et al., 2012). It is likely that stock depletion in deep waters will be associated with trophic effects (Rogers et al., 2008, Bailey et al., 2009), but these are not yet well documented, and their relative strength compared to shallow-water systems remains unclear.

Further to the severity of these impacts, recovery times of benthic communities from trawling appear to be far greater in the deep sea relative to shallow water – in the region of decades or more rather than years (Hall–Spencer et al., 2002, Williams et al., 2010). The benthic epifauna conspicuously impacted by deep-sea trawling generally consists of species that are long-lived, slow-growing and late-maturing, and hence it takes long periods of time for areas of seabed to be recolonised following the passage of a trawl (Freese, 2001, Rogers et al., 2008, Clark and Rowden, 2009, Hogg et al., 2010, Murillo et al., 2012, Hansen et al., 2013). For example, evidence for sponge recovery at about 200 m water depth off Canada was minimal one year after experimental trawling (Freese, 2001). Overall, deep-sea trawling has been claimed to result in a long-term reduction in benthic species diversity and biomass and a change in community composition (Koslow and Gowlet-Holmes, 1998, Koslow et al., 2001, Rogers et al., 2008, Clark and Rowden, 2009, Barrio Froján et al., 2012, Pusceddu et al., 2014, van der Grient, 2016). Justly so, bottom trawling continues to be recognised as the single most serious threat to deep-sea ecosystems globally (Benn et al., 2010, Hogg et al., 2010, Gianni et al., 2011). The impacts of bottom trawling on peracarid communities are explored in Chapter 3.

1.3.3 Other direct threats to deep-sea ecosystems

Further direct threats to deep-sea ecosystems include oil and gas extraction/exploration, and seabed mining. The environmental impacts of oil and gas extraction and exploration on deep-sea ecosystems take three main forms: smothering and toxin-related impacts due to accidental spillage of oil, physical damage as a result of installation and equipment use,

and smothering as a result of drilling mud release. The *Deepwater Horizon* disaster of April 2010 serves well to illustrate the potential impacts of accidental oil release (Redmond and Valentine, 2012, White et al., 2012), whilst use of heavy equipment during exploration and installation activity may physically damage fragile deep-sea ecosystems (Rogers et al., 2008), and the release of drilling muds and cuttings can directly impact suspension-feeding taxa as a result of smothering and covering of areas of suitable substratum (Jones et al., 2007, Hogg et al., 2010). Although extraction of hydrocarbons along continental slopes, and the associated likelihood of accidental spillage of oil, continues to grow (Davies et al., 2007, Rogers et al., 2015a), the oil and gas industry does generally show a high level of environmental responsibility, and the spatial extent of the direct impacts of extraction is relatively small (Benn et al., 2010, Rogers et al., 2015a).

Mining represents an emerging threat in the deep sea, but one with potentially serious consequences for associated ecosystems (Thurber et al., 2014). Five major forms of deep-sea mineral resources have been considered for exploitation: abyssal manganese and iron nodule fields, cobalt-rich crusts on seamounts, hydrothermal vent polymetallic sulphide deposits, metal-rich muds and marine phosphates (Rona, 2003, Baker and German, 2009, ISA, 2014, Rogers et al., 2015a). Manganese and iron nodules commonly represent the only hard substratum over large areas of the abyssal seafloor, and have been shown to host a distinct fauna (Thiel et al., 1993, Gooday et al., 2017). Because of the fragility of organisms and scale of mining proposed, faunal mortality following contact with harvesting equipment will likely be very high (Ramirez-Llodra et al., 2011, Jones et al., 2017), whilst mining operations are predicted to re-suspend huge volumes of sediment, with associated smothering and toxin-related impacts (Oebius et al., 2001). Cobalt-rich ferromanganese crusts grow to greatest dimensions on seamounts in the Pacific Ocean (Hein et al., 2010), and, although ecosystem-level impacts of the mining of these crusts have not been well documented, it is predicted that impacts will be more localised than for nodule mining. However, a similar destruction of sessile epifauna is expected, as well as impacts resulting from the discharge of contaminated waste water from processing ships (Glover and Smith,

2003). Potential impacts of the mining of hydrothermal vents include the total destruction of vent sites and their associated fauna, the production of toxic sediment plumes, and impacts from the discharge of contaminated waste water from processing ships (Ramirez-Llodra et al., 2011, Rogers et al., 2015a). Metal-rich muds represent an extreme deep-sea environment, typically being highly saline, anoxic and acidic, yet there are hints that they host a diverse fauna (Vestheim and Kaartvedt, 2016). At present the potential impacts of mining on these communities is not well understood (Rogers et al., 2015a). Communities associated with marine phosphate deposits have been better studied, particularly off the coast of Namibia, and on the Chatham Rise (Rogers et al., 2015a). Consent to mine these deposits has been refused or put on hold to date because of concerns over associated impacts on fisheries and surrounding benthic fauna (N.Z.Government, 2015, Rogers et al., 2015a). This thesis does not directly investigate the impacts of oil and gas extraction or mining on deep-sea environments, and so these threats are not discussed further.

1.3.4 Indirect threats to marine ecosystems: climate change

Climate change, resulting from artificially elevated concentrations of greenhouse gasses (particularly carbon dioxide) in the atmosphere, increasing its insulatory potential (IPCC, 2013), represents an insidious anthropogenic threat to deep-sea ecosystems. Historically, the deep sea was thought to be buffered against surface-driven climate cycles (Menzies, 1965), but it is now recognised that the effects of climate change will manifest in the deep sea via three pathways: changes to water temperature, pH, and oxygen concentrations. The combined consequences of these pathways have been argued to represent the greatest threat to deep-sea ecosystems over the current century and into the next (Ramirez-Llodra et al., 2011).

Mean global sea surface temperature has risen by over 0.4 ^{o}C since the mid-20th Century (Levitus et al., 2009), and is predicted to increase by a further 1.8 ^{o}C - 4 ^{o}C this century (IPCC, 2013), depending on emission scenarios. Expansions and contractions in the geographical ranges of species (both vertically and horizontally), and changes in the

relative abundance and growth rate of populations represent perhaps the most overt consequences of such temperature change (Perry et al., 2005, Ramirez-Llodra et al., 2011, Doney et al., 2012, Beaugrand et al., 2014, Howes et al., 2015). Distributional shifts appear to be occurring faster in marine systems than terrestrial (Poloczanska et al., 2013), a situation attributed to the greater 'openness' of marine systems. Distributional shifts are predicted to be particularly marked in areas where organisms are already physiologically stressed (e.g. by low pH or oxygen concentrations) (Portner and Farrell, 2008, Widdicombe and Somerfield, 2012). Examples of changes in species' distributions as a result of climate change already exist. For instance, the diatom *Neodenticula seminae* became abundant in the Atlantic Ocean seemingly for the first time in 800000 years in 1999 following a winter of ice-free water around the Canadian Arctic (Reid et al., 2007), whilst North Sea fish species richness increased by about 50 % between 1986 and 2005 concurrent with increasing water temperatures (Perry et al., 2005). Further to influencing species' distributions via changes in water temperature, climate change is predicted to alter regional wind patterns and thus ocean circulation patterns, potentially affecting distributions as a result of altered organism dispersal (Doney et al., 2012). Further, it is predicted that invasion intensity (number of species invasions relative to the current species richness at a site) will increase as a result of climate change, potentially reaching a global average of 55 % by 2050 (Cheung et al., 2009).

Changes to phytoplankton community composition with increasing temperature are predicted to occur over the current century (Acevedo-Trejos et al., 2014, Howes et al., 2015), with an increased representation of picoplankton in surface waters (Moran et al., 2010). Greater water column stratification with increasing temperature may also result in reduced nutrient availability in surface waters, leading to depressed primary productivity (Behrenfeld et al., 2006, Chavez et al., 2011), although the fertilising effect of increased CO_2 concentration may offset this to some extent (Doney et al., 2012). Potentially reduced productivity in the photic zone and more rapid re-mineralisation of sinking primary production is likely to have significant impacts on the structure of deep-sea communities

(Levin et al., 2001, Ruhl and Smith, 2004, Corliss et al., 2009, Howes et al., 2015, Pilditch et al., 2015) (see Section 1.2.5). However, increased pressure gradients between land and sea as a result of climate warming may cause the intensification of upwelling winds (Bakun et al., 2010), promoting increased nutrient concentrations and thus primary productivity in upwelling zones (Smith et al., 2013).

Further biological consequences of rising temperatures in the marine realm include increased faunal basal metabolic rates (Brown et al., 2004), resulting in increased respiratory demand, and potentially reduced aerobic scope for activity (Doney et al., 2012). When this is coupled with reduced food availability in the deep sea, a reduction in faunal biomass may result, supressing carbon storage potential. This is of particular significance considering the importance of continental slopes for global carbon storage (Muller-Karger et al., 2005, Trueman et al., 2014, Rogers et al., 2015b) (see Section 3.5.6). Disease dynamics may be affected too by climate change (Doney et al., 2012), and sponge grounds in shallow and deep water may be particularly vulnerable to disease outbreaks with changing water temperature as a result of community shifts in associated bacteria (Hogg et al., 2010). Importantly, changes in the timing and intensity of episodic events (such as seasonal ice melt) may disrupt the population dynamics of commercially exploited species (Buren et al., 2014).

Of real concern is that consequences of a changing climate for marine organisms may form part of a positive feedback cycle. As temperature increases, CO_2 solubility decreases, and CO_2 uptake by the oceans may decrease by as much as 9-15 % by 2100 (Riebesell et al., 2009). Further, with increased ocean stratification, the drawdown of carbon dioxide via the biological pump may decrease by as much as 31 % over temperature increases of 2-6 ^{o}C (Wohlers et al., 2009). As a worst case scenario, continued increases in seafloor temperature could lead to the accelerated release of methane from gas hydrates buried under surface sediments, resulting in catastrophic climate warming (Reagan and Moridis,

2007), with similarities to the Paleocene/Eocene Thermal Maximum 55.5 million years ago (Schmidt and Shindell, 2003).

Closely associated with increasing atmospheric carbon dioxide concentration is a reduced pH in the oceans. The oceans have absorbed about a third of anthropogenic CO_2 emissions to date (Orr et al., 2005), and as the rate of formation of carbonic acid is greater than the ability of the oceans to buffer against it, the pH of seawater has declined by about 0.1 units since the beginning of the Industrial Revolution (Sabine et al., 2004, Cao and Caldeira, 2008, Howes et al., 2015). Expected impacts of ocean acidification include increased metabolic costs of calcium carbonate skeleton construction (Fabry et al., 2008, Jackson et al., 2014), developmental abnormalities in larvae (Kurihara, 2008), metabolic suppression (Fabry et al., 2008), changes to predator/prey dynamics (Cripps et al., 2011, Dixson et al., 2015, Howes et al., 2015), increased representation of picoplankton in phytoplankton communities (with relevance to food export to the deep sea (Smith et al., 2013, Howes et al., 2015)), and disruption to the oceanic nitrogen cycle (Beman et al., 2011, Laverock et al., 2013). However, as the influence of variation in pH on benthic communities is not investigated in this thesis (because of a lack of data), the potential impacts of ocean acidification on marine communities are not discussed further here (although see Section 6.3.2).

Marine oxygen concentrations will also be affected by climate change. Indeed, oxygen concentrations have been declining in the oceans since the mid-20th century, and a further decline of 1-7 % is expected by 2100 (Shaffer et al., 2009, Keeling et al., 2010), with an associated expansion of oxygen minimum zones (OMZs) particularly at depths between 200 m and 700 m in the tropics and sub-tropics (Stramma et al., 2008, Stramma et al., 2010). This results primarily from depressed oxygen solubility in warm surface waters, elevated organismal respiration rates under warmer temperatures and physiological stress (Brown et al., 2004, Hofmann and Schellnhuber, 2009), increased ocean stratification (Polovina et al., 2008), and reduced oxygen production by phytoplankton (Behrenfeld et al.,

2006). Expected impacts of ocean deoxygenation include depressed growth and reproduction rates as a result of altered metabolism and behaviour (Wu, 2002), large-scale habitat compression (Prince et al., 2010, Seibel, 2011), and major changes to pelagic and benthic community structure (Levin, 2003, Rosa and Seibel, 2010, Moffitt et al., 2015). Again, however, as the influence of variation in oxygen concentration on benthic communities is not investigated in this thesis (because of a lack of data), the potential impacts of ocean deoxygenation are not discussed further here, (although see Section 6.3.2).

To combine these threads, it is likely that warming, acidification and increasing hypoxia in the oceans will result in a profound change to the structure of marine ecosystems (Howes et al., 2015, Nagelkerken and Connell, 2015). Some taxa, such as OMZ-specialists and picoplankton (Levin, 2003, Moran et al., 2010) may benefit, increasing in abundance as a result of reduced competition/predation, or increased nutrient/food availability (Doney et al., 2012, Widdicombe and Somerfield, 2012, Howes et al., 2015). However, many others may be negatively impacted, including large predatory fish (Stramma et al., 2012) and cold water corals and sponges (Thresher et al., 2015). As a result, the emergence of novel climate-adapted biomes (with new combinations of biotic and abiotic conditions) is highly likely (Heller and Zavaleta, 2009, Doney et al., 2012). Shifts in the size structure, spatial range, phenology, and seasonal and absolute abundances of populations will lead to an altered strength, synchrony, and potentially direction of trophic pathways (Levin, 2003, Smith et al., 2008, Brander, 2010, Beaugrand et al., 2014, Buren et al., 2014, Howes et al., 2015), with climate signals propagating both up and down food webs (Doney et al., 2012). The functional properties of ecosystems will be significantly altered, including changes to biogeochemical cycles (Zondervan et al., 2001, Heinze, 2004, Beman et al., 2011), and potential reductions in the transfer of primary production to higher trophic levels (with relevance to fishery yields) (Davies et al., 2007, Smith et al., 2008, Wohlers et al., 2009). Although the actual magnitude of these changes will depend on a complex and varied suite of factors, including the extent of functional redundancy, rate of climatic change, and

sequence of community change (Doney et al., 2012), it is likely that climate change impacts will act synergistically with other anthropogenic threats in the marine realm (Ramirez-Llodra et al., 2011). The influence of temperature variation on deep-sea peracarid populations is investigated in Chapter 3.

1.4 Marine Protected Areas and Vulnerable Marine Ecosystems

1.4.1 Marine Protected Areas

Discussion of 'Marine Protected Areas' (MPAs), hereby defined as '*clearly defined geographic spaces with economic and cultural value, that are recognised by all relevant parties, and that aim to protect, preserve and/or restore the natural structure and functioning of marine ecosystems*' as a management/conservation tool is highly popular because of the myriad of claimed conservation and fishery benefits associated with their use. These include increased/stabilised species and genetic diversity (Auster and Shackell, 2000, Russ et al., 2004, Worm et al., 2006, Worm et al., 2009, Anon, 2013), elevated abundance of commercially exploited species (Auster and Shackell, 2000, Fisher and Frank, 2002, Davies et al., 2007), enhanced ecosystem productivity (Worm et al., 2006, Davies et al., 2007, Worm et al., 2009, Coll et al., 2012, Anon, 2013, Guénette et al., 2014), the maintenance/restoration of natural ecosystem structure (Micheli et al., 2004, Russ et al., 2004, Coll et al., 2012, Anon, 2013), the 'spillover' of adult fish and a net export of propagules to surrounding areas (Fisher and Frank, 2002, Micheli et al., 2004, Russ et al., 2004, Davies et al., 2007, Anon, 2013, Colléter et al., 2014, Guénette et al., 2014), the protection of important ecosystem habitat features (Auster and Shackell, 2000, Micheli et al., 2004, Davies et al., 2007, Worm et al., 2009, Buhl-Mortensen et al., 2010, Anon, 2013), increased ecosystem resilience (Worm et al., 2009, Anon, 2013), and even increased tourism revenue (Russ et al., 2004, Worm et al., 2006). The use of intelligently designed and policed protected areas in the high seas is promoted in order to protect areas of vulnerable habitat and fish stocks from the impacts of deep-sea fisheries and future climate

change (Roberts, 2002, Davies et al., 2007, FAO, 2009, Baker et al., 2012, Coll et al., 2012, Rochette et al., 2014, Gianni et al., 2016, Sweetman et al., 2017).

As such, examples of MPAs are numerous; from temperate regions (e.g. large areas of the Scotian Shelf (Fisher and Frank, 2002)) to the tropics (e.g. the Banc d'Arguin National Park in Mauritanian waters (Guénette et al., 2014)), and shallow water (e.g. MPAs cover 5% of the continental shelf area in the Mediterranean Sea (Coll et al., 2012)) to the deep sea (e.g. 14 seamounts off Tasmania were designated marine reserves in 1995 (Koslow et al., 2001)). However the total ocean area covered by MPAs (~3.5 %) is still relatively low compared to the area protected on land (~12.9 %) (Wood et al., 2008, Jenkins and Joppa, 2009, Rochette et al., 2014, Thomas et al., 2014, McCauley et al., 2015).

A number of meta-analyses and synthesis studies have been conducted in an attempt to determine the true effectiveness of MPAs. On average, protection promotes increased faunal biomass, numerical density, taxonomic richness, body size, and fecundity (Auster and Shackell, 2000, Micheli et al., 2004, Worm et al., 2006, Lester et al., 2009, Scriberras et al., 2013). Catch per unit effort is typically enhanced around reserves, and tourism revenue can be elevated within MPAs (Worm et al., 2006). The magnitude of these effects seems to be independent of latitude, and even small reserves can be highly effective (Lester et al., 2009). However, the influence of MPAs does vary with taxonomic group and trophic level considered, with some species being negatively affected by protection as a result of increased competition or predation (Auster and Shackell, 2000, Micheli et al., 2004, Lester et al., 2009). Reserve characteristics and context, fishing intensity outside the reserve and inside the reserve prior to protection, and the degree of protection enforced, are important factors in determining the direction and magnitude of faunal response in MPAs (Lester et al., 2009, Scriberras et al., 2013, Ban et al., 2014).

MPAs represent an important device for the management and conservation of marine resources. However, it is to be stressed that the installation of MPAs requires extensive

planning, effective design, and efficient policing and monitoring. Protected areas should be used as part of a wider adaptive management framework that is sensitive to changes in both the natural environment and the prevailing socio-economic climate (Ban et al., 2014, Weigel et al., 2014, Mills et al., 2015).

1.4.2 Protecting the deep sea – the UNGA resolutions

Spatial closures have been used to manage human impacts on the deep sea for at least 20 years (e.g. Koslow and Gowlet-Holmes (1998)). However, a formal policy framework to identify and protect vulnerable deep-sea habitats was created only in the mid-2000s with the introduction of United Nations General Assembly (UNGA) resolution 59/25. This resolution called for states and Regional Fisheries Management Organisations (RFMOs) to prohibit destructive fishing practices that impact deep-sea coral reefs and other fragile habitats. This was followed in December 2006 by UNGA resolution 61/105, which called for the formal recognition of the immense importance and value of deep-sea ecosystems and the biodiversity that they contain by following the precautionary principle and ecosystem approach when harvesting biological products from the deep sea (Gianni et al., 2016). In particular, this resolution called for the closure of areas where 'Vulnerable Marine Ecosystems' (VMEs) are known to exist to bottom-contact fishing until measures to prevent 'Significant Adverse Impacts' (SAIs) are in place (see Section 1.4.3). Fishing activities should be stopped immediately if contact with a VME is recognised, and the encounter should be reported to the relevant RFMO. An effort should be made to identify all areas where VMEs are likely to occur, and to ensure the long-term sustainability of deep-sea fish stocks. Appropriate and continuing monitoring and surveillance mechanisms should be emplaced, and impact assessments should be carried out prior to the commencement of fishing activities (Auster et al., 2011, Gianni et al., 2016). UNGA resolution 61/105 called for such measures to be implemented by December 31st 2008, or else high-seas bottom fishing not to be authorised.

By mid-2008 it was clear that the majority of states and RFMOs were slow in implementing UNGA 61/105. Thus a further resolution was drawn up – UNGA 64/72. This was adopted in 2009 and reaffirmed and strengthened, with a sense of urgency, the call for action to utilise deep-sea habitats in a sustainable manner. In 2011, an updated set of resolutions (66/68) was drawn up, noting that although progress was made between 2004 and 2011 in the management of deep-sea fishery resources, the above resolutions still had not been fully implemented. UNGA 66/68 again reaffirmed the need to subscribe to and realise the measures outlined in the previous resolutions, but further encouraged collaboration with scientific research to identify VMEs and the occurrence of SAIs (Gianni et al., 2016).

To aid in the implementation of these resolutions, the Food and Agriculture Organisation (FAO) sponsored a series of expert consultations involving delegates from over 50 nations, as well as inter- and non-governmental organisations, to draw up a set of guidelines for the management of deep-sea fisheries in the high seas (FAO, 2009). These guidelines apply to all fisheries in the high seas where catches include species that can only sustain low exploitation rates and where bottom-contact fishing occurs on a regular basis. Hence the slow rate of progress in the implementation of the UNGA resolutions does not appear to result from insufficient direction, but rather from significant inertia to change within the high seas fishing community.

1.4.3 'Vulnerable Marine Ecosystems' and 'Significant Adverse Impacts'

Before continuing, it is necessary to suitably define what a 'VME' is, and what constitutes a 'SAI'. VMEs can be defined as distinct, diverse benthic assemblages that are limited and fragmented in their spatial extent, and dominated by rare, endangered or endemic component species that are physically fragile, and so vulnerable to damage (or structural/biological alteration) by human activities, especially those that contact the seabed (Fuller et al., 2008, Rogers et al., 2008, FAO, 2009, Parker et al., 2009, Rogers and Gianni, 2009, Hogg et al., 2010, Auster et al., 2011, Hansen et al., 2013, Penney, 2014). VMEs are recognised as hotspots of biodiversity and ecosystem functioning (see Chapter 4),

but they are also easily disrupted or degraded, and, since their component species typically exhibit traits of slow growth, late maturity, low fecundity, unpredictable recruitment and high longevity, VMEs may be extremely slow to recover from disturbance (Fuller et al., 2008, Rogers et al., 2008, FAO, 2009, Parker et al., 2009, Hogg et al., 2010, Auster et al., 2011, Hansen et al., 2013, Penney, 2014). Examples of taxa considered indicators of VMEs include a myriad of deep-sea corals, hydrozoans, cerianthids, poriferans, ophiuroids, stalked crinoids, ascidians, bryozoans, brachiopods, xenophyophores, and deep-water serpulid and oyster reefs, and chemosynthetic species (Fuller et al., 2008, Parker et al., 2009, Rogers and Gianni, 2009, Gianni et al., 2011, Murillo et al., 2012).

A SAI occurs following any disturbance to a VME that impairs the ability of impacted VME constituent populations to replace themselves, that degrades the long-term productivity of the habitat, and that causes a significant loss of species richness and habitat diversity and structure on more than a temporary basis (i.e. if the average interval between disturbance events is shorter than the recovery time of the habitat) (Hogg et al., 2010).

Accurate mapping of VMEs, and the identification of areas that are under most acute threat from bottom-contact activities, requires reliable knowledge of seabed geological and oceanographic characteristics, the communities found there, and the historical and current spatial distribution and intensity of fishing effort (Duran Munoz et al., 2012). The information sources most commonly utilised to aid in the mapping of VMEs are fisheries by-catch data, scientific survey data, acoustic survey data, and species distribution models (SDMs).

The use of fisheries by-catch data is a relatively cheap and quick method to identify VME locations, and so is useful as an initial assessment method. This involves the collation of historical (via logbooks and reports) and current (via fisheries observers) VME-indicator taxa by-catch statistics, and the plotting of these to produce a map of the distribution of VMEs in a given area. However, the spatial resolution of such an approach is limited – trawls may

be towed a number of kilometres over the seabed, hauling up VME taxa collected from any location along this trawl path, and the taxonomic accuracy and resolution of the resultant data are highly dependent on the expertise of the fishermen and fishery observers (Rogers et al., 2008). There is also significant error associated with the use of fishing gear to sample the seabed (see Section 1.4.4), typically leading to an underestimation of VME distributions (Rogers et al., 2008, Parker et al., 2009, Duran Munoz et al., 2012, Vierod et al., 2014).

Scientific surveys, involving standardised trawls, deep-water photography and video, submersible deployment, acoustic surveys utilising sonar techniques (see Section 1.1.2) and detailed statistical analyses, can provide greater detail (spatial, temporal and taxonomic) of VME distributions than fisheries by-catch data (Rogers et al., 2008), and represent the trusted methodology in many areas (Kenchington et al., 2014, Gianni et al., 2016). However, such surveys are expensive, requiring dedicated sea-time and specialist equipment, and require a high level of technical expertise (Rogers et al., 2008).

Species distribution models, represent a promising low-cost method to map predicted VME distributions over large spatial scales based on known occurrences and associated environmental information (Ashford et al., 2014). However, SDMs are greatly influenced by data quantity and quality, both of which are commonly limited in deep-sea environments. SDMs have been used to good effect on both global (Yesson et al., 2012, Ashford et al., 2014) and regional scales (Ross and Howell, 2012, Knudby et al., 2013a, Knudby et al., 2013b), but do require ground-truthing before important management decisions are based on their findings (Rogers et al., 2008, Hansen et al., 2013, Ashford et al., 2014, Vierod et al., 2014). The use of SDMs to inform management decisions in the deep sea is investigated and discussed further in Chapter 4.

1.4.4 Problems with enforcing the UNGA resolutions

A key aspect of the UNGA resolutions is the cessation of bottom fishing activities if contact with a VME is recognised. Many RFMOs utilise a 'move-on rule' to manage the behaviour of fishing vessels in this situation. Typically, this rule requires that fishing activities are stopped if a set weight of VME-indicator taxa is caught as by-catch during operations, followed by relocation to alternative fishing grounds, the filing of a report to the relevant RFMO, and closure of the apparent VME area (see Section 1.4.5) (Gianni et al., 2016, NAFO, 2017b). Since no specific VME by-catch threshold parameters were given in the UNGA regulations, it is the responsibility of RFMOs and flag states to tailor move-on rules to specific locations so that they are practical and effective (Auster et al., 2011, Hansen et al., 2013, Penney, 2014). Such a system appears sensible, but has been hindered by a variety of issues in practice. For example, the majority of by-catch weight thresholds used to trigger the move-on rule are not supported by any explicit biological definition of the presence of a VME (Rogers et al., 2008, Auster et al., 2011, Penney, 2014), and many of the current threshold weights are far removed from ecological realities (Auster et al., 2011). Commonly, implemented weight thresholds are based on data from research trawls, rather than commercial trawls, and it is well documented that commercial trawls do not represent effective sampling devices for fragile epibenthic taxa (Auster et al., 2011, Hansen et al., 2013). Thus, what arrives on deck likely represent only a small portion of what was damaged or killed on the seafloor (Freese et al., 1999, Mortensen et al., 2008). Further, many VME by-catch thresholds are based on extrapolations of 30-minute research trawl data. This approach has been severely criticised predominantly because of its assumption that VMEs are not patchily distributed, and hence that increasing the duration of a trawl will result in a proportionally greater catch of VME-indicator taxa (Parker et al., 2009, Hogg et al., 2010, Auster et al., 2011, Hansen et al., 2013). As a result, VME by-catch thresholds implemented by RFMOs and flag states are variable, and generally set too high (Rogers and Gianni, 2009, Hogg et al., 2010, Auster et al., 2011, Gianni et al., 2011, Gianni et al., 2016).

Move-on protocols also typically suffer from the use of inappropriate taxonomic units. For example, protocols are often applied only to live corals and sponges, and at no greater taxonomic resolution than that. This disregards both the huge diversity (e.g. functional/morphological/ecological) that is contained within these units, and the great importance of dead coral and sponge habitat (Bett and Rice, 1992, Rogers and Gianni, 2009, Auster et al., 2011, Hansen et al., 2013, Penney, 2014). Further, the same move-on thresholds are sometimes applied to very different types of fishing gear (e.g. long-line vs bottom trawl) (Gianni et al., 2016), whereas a range of thresholds specific to gear configuration would be preferable (Rogers and Gianni, 2009).

There are also frequently problems with the protocols in place for action if move-on rules are triggered. Commonly, following triggering of the move-on rule, vessels are required to move at least 2 nm from the start or end point of the offending trawl before recommencing fishing activities (Gianni et al., 2016). However, with trawl lengths of up to 20+ nm, and the exact location of VME contact often being unknown, such a move-on distance will cover only a small portion of the trawl length, potentially leaving the impacted VME(s) open to subsequent fishing activity (Rogers and Gianni, 2009, Gianni et al., 2011, Hansen et al., 2013). Perhaps the most fundamental issue with the move-on protocol, however, is that where associations between seabed features and both VMEs and fish aggregations occur, triggering of the move-on rule is likely to result simply in a movement away from one VME area to another (Auster et al., 2011).

A second key aspect of the UNGA resolutions is the requirement to conduct thorough impact assessments *prior* to engagement in bottom fishing. Implementation of this requirement has been uneven at best. Some RFMOs, such as the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), now have a functioning impact assessment framework in place, but others, such as the Northwest Atlantic Fisheries Organisation (NAFO), are yet to progress so far (Gianni et al., 2016). Lack of action in implementing impact assessments is often attributed to the 'prohibitive' costs associated – especially in

relation to the collection of baseline information on ecosystem state, and the mapping of VMEs. However, such a position is weak, especially considering that profit is potentially being made by fishing high seas areas, and becomes untenable when it is considered that states often subsidise fleets to fish in such areas (Gianni et al., 2011).

A further interesting issue in enforcing the UNGA resolutions is that of 'flags of convenience' (Gianni and Simpson, 2005). Currently, conservation and management measures adopted by RFMOs are binding only for contracting parties, meaning that other fishing nations can ignore these rules without consequence (Anon, 2013, Hansen et al., 2013). Thus, it is possible for fishing vessels to avoid or violate management regulations by operating under flags of convenience from countries not contracted to the relevant RFMO (Davies et al., 2007).

Indeed, even when areas known to house VMEs are closed to bottom fishing, policing these closures can be a complex task. Spatial closures may be large, far from land and geo-spatially complex, and thus determining compliance via patrol vessels or overflight is typically prohibitively expensive and time consuming (Davies et al., 2007, Hogg et al., 2010, Anon, 2013, Hansen et al., 2013, Arias et al., 2014). Alternative policing measures include buoy-based radar, and satellite surveillance (Hallwood, 2004). Most popular, however, is the use of on-board fisheries-independent observers and Vessel Monitoring Systems (VMS). On-board observers can be used to verify boat operation and catch, and check compliance with management measures (Auster and Shackell, 2000, Hogg et al., 2010, Hansen et al., 2013). VMS systems use GPS trackers to relay the location of fishing vessels at high spatial and temporal resolutions to flag states and RFMOs, and can also be used to warn fishermen if they are about to enter a restricted area (Davies et al., 2007). However, VMS signals can be blocked or falsified, reporting frequency can be low, there may be uncertainty regarding the activity of the vessel in question (Davies et al., 2007, Rogers and Gianni, 2009). A more fundamental way to increase compliance with regulations is via education concerning the biological and economic damage that illegal fishing activities can cause (Auster and

Shackell, 2000, Hallwood, 2004). Finally, it has been suggested that the redirection of harmful subsidies, pervasive in many fisheries at present, towards the enforcement of conservation and management regulations could help offset policing costs (Anon, 2013).

1.4.5 Current extent of subscription to the UNGA resolutions

Progress towards the fulfilment of the UNGA resolutions has been variable. CCAMLR have arguably made best progress towards fully adopting the resolutions. Commercial bottom trawling and the use of gillnets in the Convention Area are prohibited, leaving less destructive longlining (Pham et al., 2014) as the only bottom-contact fishing method permitted (Gianni et al., 2016). Any Contracting Parties that wish to participate in bottom-contact fishing are required to submit an impact assessment, and in the toothfish fishery (the most important in the area), coverage by fisheries-independent observers is now 100 % (Gianni et al., 2016). A functional move-on rule is also in place, based upon published lists of VME-indicative taxa at an appropriate taxonomic resolution, with a suitable, gear-specific weight threshold, and effective closure protocols following its triggering (Gianni et al., 2016). Such a rule has proven highly effective, resulting in the closure of multiple areas, whilst a large area to the south of the South Orkney Islands has also been closed entirely to bottom-contact fishing (Gianni et al., 2016). Quotas for toothfish are well established, but stocks are currently considered fully- or over-exploited. This may in part be the result of past illegal, unreported and unregulated (IUU) fishing in the area (Gianni et al., 2011). However, it should be noted that the CCAMLR Convention Area is relatively easy to manage effectively compared to other areas of beyond national jurisdiction because of its comparative isolation, the relatively short history of fishing in Antarctic waters (there are no native fishing populations), the ability to raise funds for management and conservation via the taxation of high-value fish, and the ability to catch toothfish with longline gear rather than by trawling, in particular.

At the other end of the spectrum, large areas of the high seas remain essentially unmanaged, with no RFMO, or only a 'regional fisheries arrangement'. For example, there is currently no RFMO or any interim measures to regulate deep-water fisheries in international waters in the South West Atlantic, nor are negotiations underway to establish an RFMO in the area (Gianni et al., 2016). A move-on rule is yet to be developed and implemented, no quotas are in place, and the extent of by-catch is unknown (Gianni et al., 2016). Spanish fleets do voluntarily adhere to a restriction of bottom fishing in the region to depths less than 300 metres, but no other flag states recognise this restriction (Portela et al., 2015, Gianni et al., 2016). Recently, however, there have been some efforts to determine the extent of VMEs in the region (Portela et al., 2015).

A more typical situation is that of the Northeast and Southeast Atlantic Ocean. Both these regions have RFMOs (the 'North East Atlantic Fisheries Commission' (NEAFC), and 'South East Atlantic Fisheries Organisation' (SEAFO), respectively), impact assessments are required to be submitted, and move-on protocols are in place for both areas (Gianni et al., 2016). However, move-on threshold weights are arguably set too high (NEAFC: 30 kg of live coral, and 400 kg of live sponges in a single trawl. SEAFO: 60 kg of live coral, and 600/400 kg of live sponges in currently fished/exploratory areas, respectively, in a single trawl (NEAFC, 2014, SEAFO, 2014, Gianni et al., 2016)). Upon triggering the move-on rule, the NEAFC protocol is quite effective, with a 2 nm wide band on both sides of the total trawl length, plus an extension of 2 nm at the start and end of the trawl track, being closed to all bottom fishing activity pending further investigation (NEAFC, 2014, Gianni et al., 2016). The move-on protocol of SEAFO is less effective, simply requiring vessels to move 2 nm from the endpoint of the tow in a direction least likely to result in further VME encounters (SEAFO, 2014, Gianni et al., 2016). In both regions several areas where VMEs have historically been known to occur have been closed to bottom-contact fishing (NEAFC, 2014, SEAFO, 2014, Gianni et al., 2016), and for both RFMOs these closures include representative regions of the Mid Atlantic Ridge. Both RFMOs now implement a prohibition on gillnet

fishing (complete for SEAFO, and for their use below 200 metres depth for NEAFC), but the status of exploited fish stocks in both regions is poorly known (Gianni et al., 2016).

Details of the subscription of NAFO to the UNGA resolutions are reviewed in Section 1.6.1 and discussed further in chapters 4 and 6.

1.5 Biodiversity - ecosystem functioning research

1.5.1 What is BEF and why study it?

Here, 'biodiversity' is defined, following DeLong (1996), as '*a concept that specifically refers to the magnitude of biological variety within and among communities of organisms at any spatial scale – from microsites to the entire biosphere*', whilst ecosystem functioning is defined as '*the aggregate effect of physical, chemical and biological processes associated with the flow of energy and matter within and between trophic levels, communities and ecosystems*', following Danovaro et al. (2008), Loreau (2008) and Paterson et al. (2012).

Biodiversity – ecosystem functioning (BEF) research aims to uncover the fundamental form of the relationship between the magnitude of diversity in a biological system and the rate at which ecosystem functioning occurs in that system (Naeem, 2012). Since different species play different functional roles in ecosystems, it is hypothesised that increasing biodiversity will promote elevated ecosystem functioning, and the link between biodiversity and ecosystem functioning has been shown to be positive in many environments (Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006, Danovaro et al., 2008, Naeem et al., 2012, Soliveres et al., 2016). The cumulative influence of ecosystem functioning is the provision of ecosystem services, and as such, BEF research has been termed the "*utilitarian rationale for biodiversity conservation*" (Magurran, 2012).

Oceans account for about two thirds of the monetary value of global ecosystem services (Costanza et al., 1997) and important marine services include decomposition and nutrient regeneration (Huettel and Gust, 1992, Costanza et al., 1997, Snelgrove, 1997, Solan et al., 2004, Danovaro et al., 2008, Smith et al., 2008, Levin et al., 2010, Danovaro, 2012, Doney et al., 2012, Thrush and Lohrer, 2012, Anon, 2013, Laverock et al., 2013, Snelgrove et al., 2014, Dell'Anno et al., 2015, Rogers et al., 2015b), secondary biomass production (Costanza et al., 1997, Snelgrove, 1997, Worm et al., 2006, Danovaro et al., 2008, Danovaro, 2012, Doney et al., 2012, Duffy et al., 2012, Thrush and Lohrer, 2012, Snelgrove et al., 2014, Rogers et al., 2015b), catalysis of biogeochemical cycles associated with climate regulation (such as the carbon cycle) (Costanza et al., 1997, Snelgrove, 1997, Danovaro et al., 2008, Smith et al., 2008, Levin et al., 2010, Anon, 2013, Snelgrove et al., 2014, Thurber et al., 2014, Rogers et al., 2015b), the maintenance of water quality (Newell, 1988, Costanza et al., 1997, Snelgrove, 1997, Worm et al., 2006, Doney et al., 2012, Anon, 2013, Snelgrove et al., 2014, Thurber et al., 2014, Rogers et al., 2015b), sediment stability/trapping/transport (Snelgrove, 1997, Doney et al., 2012, Thrush and Lohrer, 2012, Snelgrove et al., 2014), habitat formation and the provision of settlement sites (Bett and Rice, 1992, Buhl-Mortensen et al., 2010), the provision of food (Levin et al., 2010, Doney et al., 2012, Anon, 2013, Zhou et al., 2014, Snelgrove et al., 2014, Rogers et al., 2015b), oxygen production (Anon, 2013, Rogers et al., 2015b), detoxification (Snelgrove, 1997, Anon, 2013, Snelgrove et al., 2014, Thurber et al., 2014, Rogers et al., 2015b), and cultural services (e.g. European coastal and maritime tourism is worth 183 billion euros (ECORYS, 2013)), amongst others – see Rogers et al. (2015b) for a thorough list.

There is a pressing need to quantitatively evaluate the relationship between biodiversity and the provision of these ecosystem services in marine environments so that the negative consequences of the current global biodiversity crisis can be minimised as far as possible (Biles et al., 2002, Cardinale et al., 2012, Naeem, 2012, Naeem et al., 2012, Snelgrove et al., 2014, McCauley et al., 2015).

1.5.2 A short history of BEF research and alternative investigative approaches

Following Darwin's observation that plant communities containing a greater variety of species are likely to be more productive than monocultures (Darwin, 1859), BEF research as a concept first emerged in the 1970s (e.g. Gardner and Ashby (1970) and De Angelis (1975)). However, it was not until the mid-1990s that BEF relationships were considered in detail and significant advances were made (Lawton, 1994, Naeem et al., 1994, Naeem et al., 1995). Initial BEF studies were generally small in scale (both spatially and temporally), highly controlled, and experimental in type, investigating a limited number of species (often representing a restricted trophic and taxonomic portion of the wider community (Duffy et al., 2007)) and simple ecosystem functioning metrics (Duffy et al., 2012, Naeem et al., 2012), and thus had unclear relevance to natural systems (Lawton, 1994, Loreau, 2008, Bremner, 2012, Duffy et al., 2012, Emmerson, 2012, Godbold, 2012, Magurran, 2012). The vast majority of this early BEF research occurred in terrestrial systems (particularly temperate grasslands (Balvanera et al., 2006)).

Marine BEF research has focussed predominantly on shallow-water environments and has been experimental in type. These shallow-water marine studies are quite well developed, with examples of in-situ manipulations of species diversity (Griffin et al., 2010), incorporation of habitat or resource heterogeneity (Dyson et al., 2007, Weis et al., 2008), analysis of multiple trophic levels (Duffy et al., 2007) and investigation across varying spatial and temporal scales (O'Connor and Crowe, 2005, Stachowicz et al., 2008, Godbold, 2012). However, relative to nature, again these investigations typically examine a depauperate fauna, with simple ecological structure, over only small geographic areas and short time periods (Naeem et al., 2012, Leduc et al., 2013, Mora et al., 2014).

Meta-analysis methods have been applied to BEF research in an attempt to produce more generalisable conclusions (Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006, Lefcheck et al., 2015). The results of these analyses suggest that BEF relationships are relatively consistent over multiple trophic levels and ecosystem types (Loreau, 2008,

Lefcheck et al., 2015), with reductions in ecosystem resilience, stability and ability to provide multiple services with declining diversity (Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006, Lefcheck et al., 2015, Shanafelt et al., 2015).

In an attempt to reveal BEF relationships at temporal and spatial scales larger than would be possible with experimental studies, correlational studies are now being promoted (Loreau, 2008, Mora et al., 2011a, Duffy et al., 2012, Snelgrove et al., 2014, Hodapp et al., 2015). This approach further facilitates BEF research in environments where experimental studies are difficult to undertake (Loreau, 2008), and all published deep-sea BEF research to date (see Section 5.2.3) has been based on a correlational approach (Danovaro et al., 2008, Leduc et al., 2013, Narayanaswamy et al., 2013, Pape et al., 2013, Zeppilli et al., 2016).

There are advantages and disadvantages to both experimental and correlational approaches to BEF research. The experimental approach gives precise control over both the taxa included and the environmental conditions of an investigation (Godbold, 2012, Raffaelli and Friedlander, 2012), and high levels of replication can be achieved, this providing the statistical power that is so persuasive in the scientific community (Raffaelli and Friedlander, 2012). However, controlled experimental manipulations are inherently constrained in the number of driver variables that can be tested at any one time (Godbold, 2012). As a result, these experiments are usually limited in extent (spatially and temporally), biodiversity, and scope (Naeem et al., 2012). Further, the biodiversity and ecosystem functioning metrics that are appropriate to small-scale experimental systems are often difficult to translate to natural ecosystems (Raffaelli and Friedlander, 2012). As a result, it is often problematic to apply experimental findings to a broader context, and, indeed, it has been argued that experimental studies are likely to underestimate the importance of biodiversity to ecosystem functioning in natural systems (Mora et al., 2011a, Bremner, 2012, Godbold, 2012, Raffaelli and Friedlander, 2012, Mora et al., 2014).

In contrast, a correlational approach facilitates the investigation of BEF patterns directly in natural systems and in situations relevant to management and policy (Loreau, 2008, Duffy et al., 2012, Holt et al., 2012, Naeem et al., 2012, Snelgrove et al., 2014). Observational data provides the information required, whilst environmental factors can be incorporated into statistical models (Loreau, 2008, Raffaelli and Friedlander, 2012, Naeem et al., 2012, Leduc et al., 2013, Hodapp et al., 2015). This gives the opportunity to investigate greater levels of complexity, and so correlational studies have the potential to add insight and relevance to experimental studies (Raffaelli and Friedlander, 2012, Thrush and Lohrer, 2012, Snelgrove et al., 2014, Mora et al., 2014). However, correlation does not necessarily imply causation, and there is a perceived weaker inferential power of correlational studies relative to the experimental approach (Raffaelli and Friedlander, 2012). In addition, the great complexity that correlational studies intend to encompass often makes it difficult to disentangle interactions and pin-down the most important shaping factors (Raffaelli and Friedlander, 2012).

1.5.3 Alternative forms of the BEF relationship

In theory, the form of the relationship between biodiversity and ecosystem functioning could take a variety of shapes – positive/negative/idiosyncratic, linear/exponential/logarithmic etc. However, three generalised forms are typically distinguished as the most common shapes for natural BEF relationships: 1) an asymptotic curve of increasing ecosystem functioning with increasing biodiversity, 2) a linear relationship between biodiversity and ecosystem functioning, and 3) an accelerating relationship between biodiversity and ecosystem functioning (Naeem et al., 1994, Naeem et al., 1995, Hector et al., 1999, Tilman et al., 2001, Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006, Danovaro et al., 2008, Mora et al., 2011a, Naeem, 2012) (see Figure 5.1 and Section 5.2.1).

In each of these forms there is a positive relationship between biodiversity and ecosystem functioning, and so all predict that a loss of biodiversity will result in a reduction in the magnitude of ecosystem functioning. However, the intricacies of each of these forms have contrasting implications for the rate at which ecosystem functioning decreases with declining biodiversity and for the dominant biological interactions in the system in question (Hooper et al., 2005, Worm et al., 2006, Cardinale et al., 2012, Naeem, 2012) (see Figure 5.2 and Section 5.2.2).

In this thesis, what limited deep-sea BEF research has been conducted (see Section 5.2.3) is expanded upon and clarified via a correlational-style analysis of the largest deep-sea BEF dataset yet produced. There are a wide range of approaches for the measurement of ecosystem functioning, and the choice of approach represents a balance between what can be measured relatively easily and what is of greatest relevance to the hypotheses being tested (Bremner, 2012, Paterson et al., 2012). Chapter 5 utilises multiple measures of ecosystem functioning (limited by the scope of NEREIDA sampling (see sections 1.6.2 and 6.3.3)) at different levels of specificity to the faunal assemblages in question in an attempt to capture the multi-faceted nature of the concept (see Table 5.1). Similarly there are a large number of options available for the quantification of biodiversity (see Section 1.2.4), and, although initial BEF studies focused simply on species richness (Naeem et al., 2012), and relatively little attention has been given to measures of functional and phylogenetic diversity to date (Bremner, 2012), it is now understood that the greater the focus on multiple integrated and complimentary dimensions of biodiversity, the more useful the conclusions that can be drawn from a study (Devictor et al., 2010, Naeem et al., 2012, Leduc et al., 2015). In recognition of this, Chapter 5 investigates taxonomic, functional and phylogenetic metrics of diversity (see Table 5.1).

1.6 The NAFO Regulatory Area and NEREIDA programme

The NAFO Regulatory Area in the Northwest Atlantic (Figure 1.1) is the focal study area of this thesis, and thus deserves a detailed review of its attributes and management strategies.

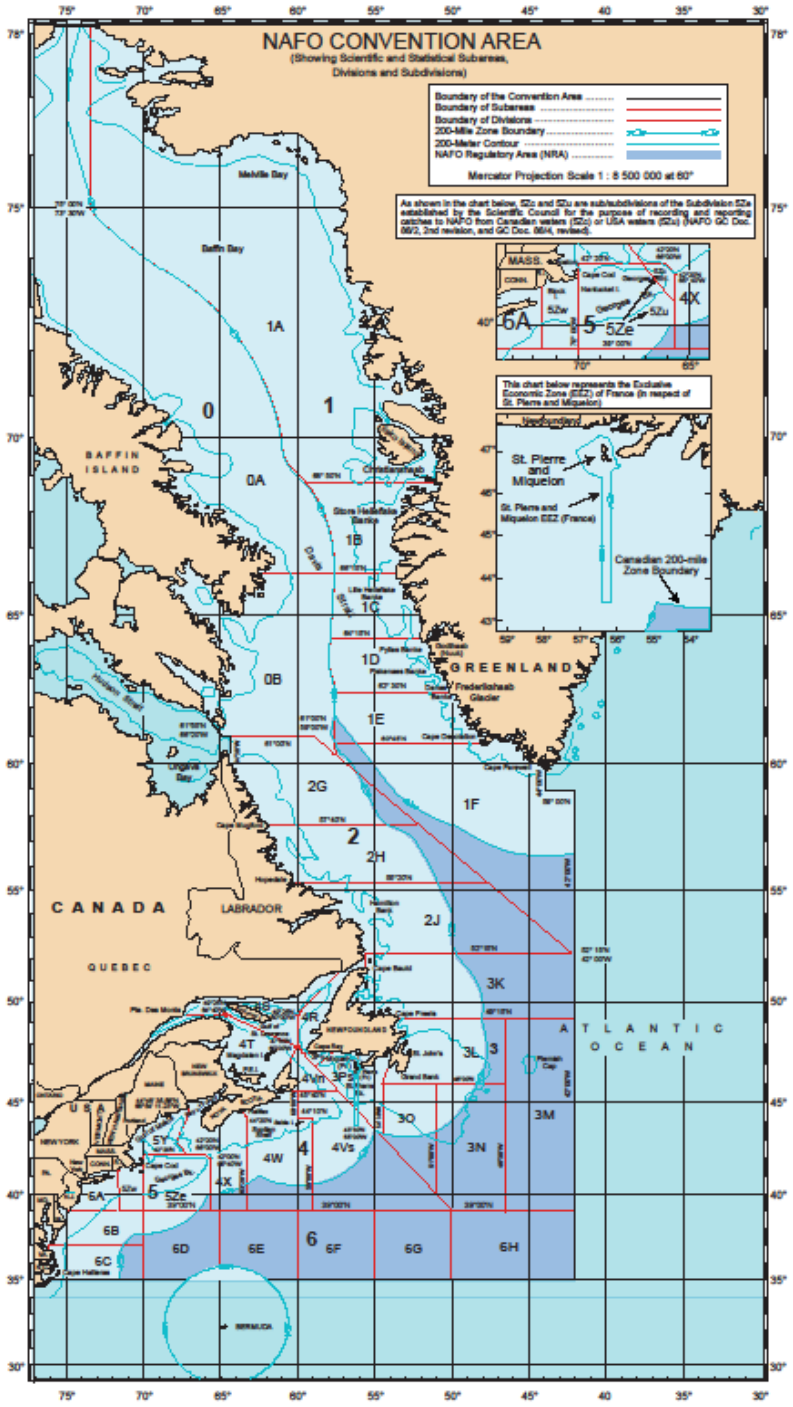


Figure 1.1: Geographic delineations of the Northwest Atlantic Fisheries Organisation convention area. ©Northwest Atlantic Fisheries Organisation. Obtained from https://www.nafo.int/About-us on 15/03/2017.

1.6.1 Current fishing practices and subscription to the UNGA Resolutions in the NAFO Regulatory Area

Total allowable catch for 2017 in the NAFO convention area was set at 127322 tonnes divided variably between 19 commercially exploited stocks comprised of 11 managed species: Atlantic cod (*Gadus morhua*), Atlantic redfish species (*Sebastes* spp.), American plaice (*Hippoglossoides platessoides*), witch flounder (*Glyptocephalus cynoglossus*), yellowtail flounder (*Limanda ferruginea*), greenland halibut (*Reinhardtius hippoglossoides*), white hake (*Urophycis tenuis*), thorny skate (*Amblyraja radiata*), capelin (*Mallotus villosus*), shortfinned squid (*Illex illecebrosus*), and northern shrimp (*Pandalus borealis*) (NAFO, 2017a). Species exploited but unmanaged include roundnose (*Coryphaenoides rupestris*) and rough-head (*Macrourus berglax*) grenadier, species of wolf fish, and porbeagle shark (*Lamna nasus*). No measures have yet been taken to assess the impacts of fishing on these species (Gianni et al., 2016). Fishing nations active in the Regulatory Area include Spain, Portugal, Estonia, Latvia, Lithuania, Poland, the Russian Federation, Iceland, Norway, Canada, Denmark, Ukraine, the United States of America, the Republic of Korea, Japan and Cuba (NAFO, 2013, Gianni et al., 2016). Fishing for Greenland Halibut takes place in water depths >700 metres using a net mesh size of 130 mm, and is concentrated along the continental slope to the Northeast of the Grand Banks, as well as along the southern end of the Flemish Pass and around the 'tail' of the Grand Banks (Campanis et al., 2008, González-Costas and González-Troncoso, 2009). The thorny skate fishery operates in shallower water (<200 metres), uses 280 mm mesh nets, and is focussed around the 'tail' of the Grand Banks (Del Río et al., 2003, González-Costas and González-Troncoso, 2009). The northern shrimp fishery (currently under moratorium) operates at 300 - 700 metres depth to the north of the Flemish Cap, and at 300 - 400 metres depth on the 'nose' of the Grand Banks using a mesh size of 40 mm (Casas, 2008, González-Costas and González-Troncoso, 2009). The redfish fishery operates at 250 - 1000 metres to the southeast of the Grand Banks, and between 200 and 700 metres on the Flemish Cap, and uses a mesh size of 130 mm (Vinnichenko and Skylar, 2008, González-Costas and González-Troncoso, 2009). The cod fishery of the region was only reopened in 2010 following a ten year hiatus, but is now

active again on the Flemish Cap between 100 and 400 metres water depth (Gonzalez-Costas et al., 2011).

A number of VME – indicative taxa have been identified in the NAFO convention area, including sponge species of all three classes (Calcarea, Desmospongiae, and Hexactinellidae), a number of coral taxa (such as zoanthids, antipatharians, gorgonians, pennatulaceans and scleractinians), hydrozoans, cerianthids, brachiopods, cirripedians, ascidians, crinoids, ophiuroids, holothurians, cidaroids, upright bryozoans (like phidolopoids) and xenophyophores (Fuller et al., 2008, Barrio Froján et al., 2012, Kenchington et al., 2014). These taxa elevate habitat heterogeneity in the area, playing an important role as ecosystem engineers (see Section 4.2.1.2).

In terms of minimising SAIs to VMEs, NAFO employs the use of impact assessments, a move-on protocol, and spatial closures. The submission of impact assessments by all parties wishing to participate in bottom fishing was proposed by NAFO in 2008. In the following year, no such assessments were received, although Japan and Iceland submitted fishery plans. Thus, in 2010, it was agreed that 'reassessments' of the impact of bottom-fisheries in the Regulatory Area must be completed by 2016, these consisting of a review of fishing activities, known densities of VME-indicator taxa, and the current level of protection provided to these taxa by spatial closures (Gianni et al., 2016). Any proposals for fishing outside the historical trawl footprint (that portion of the Regulatory Area where bottom fishing has historically occurred (NAFO, 2017b)) require a prior impact assessment before they can proceed (Gianni et al., 2016).

NAFO has employed a move-on rule since 2008 and, initially, VME weight thresholds were set to 100 kg of live coral or 1000 kg of sponges in a single gear deployment. These values were based on extrapolation from 30 minute research trawl data (see Section 1.4.4), did not distinguish between the gear type being used, and disregarded the biological importance of dead coral structures (Hansen et al., 2013, Gianni et al., 2016). In 2009,

these thresholds were reduced to 60 kg of live coral and 800 kg of live sponges, but these values were still criticised for being too high – of a magnitude unlikely ever to be obtained in a commercial tow within the historic fishing footprint. As a result, in 2012, thresholds were set to 60 kg of live coral and 300 kg of live sponges, and a limit of 7 kg for sea pens was added (Hansen et al., 2013, Gianni et al., 2016). These same values have been maintained into 2017 (NAFO, 2017b). If the move-on rule is triggered, the incident must be reported to the NAFO Executive Secretary (including details of location, by-catch species and weight of by-catch), and the vessel must move at least 2 nm from the endpoint of the tow in the direction least likely to result in further encounters with VMEs (NAFO, 2017b). A temporary closure of 2 nm radius from the location of the report is then adopted, pending review (NAFO, 2017b).

The first VME spatial closures were enforced by NAFO in 2006 when four seamount areas were closed to bottom-contact fishing. This was followed in 2007 by the closure of an area of continental slope in NAFO area 3O for the protection of deep-water coral habitat (Gianni et al., 2011). In 2008, two additional seamount areas were closed to bottom fishing, and in 2009, NAFO revised its spatial closures following further information from research trawls conducted by Spain and Canada. 11 additional closures were proposed around the Flemish Cap, Flemish Pass and 'tail' of the Grand Banks for the protection of sponge- and coral-dominated VMEs, although these closures only influenced about 0.7 % of fishery activities in the Convention Area (Gianni et al., 2011). In 2012, further closures of seamounts, including Orphan Knoll, were announced (Baker et al., 2012). At present, 21 areas covering a depth range of less than 500 m to over 5400 m, and a total area of over 390000 km^2 have been identified as housing VMEs (Baker et al., 2012, Hansen et al., 2013, NAFO, 2017b). However, no canyon areas have yet been closed (even though they have been identified as VMEs), and it is debatable whether the current closures are optimally placed, a topic that is discussed in chapters 4 and 6.

NAFO's conservation and management strategies are currently policed by a combination of the use of VMS, independent scientific observers, at sea and port inspection and surveillance, and an annually published compliance review. All vessels fishing in the NAFO Regulatory Area are required to be equipped with a VMS system in order to provide vessel location data (at a frequency of at least once per hour) and handle catch and activity reports. These reports include details of catch upon entry into the NAFO area, daily catch reports within the NAFO area, and catch upon exit from the NAFO area. The reports are then archived by the NAFO Secretariat and forwarded to contracting parties with an inspection presence in the Regulatory Area (NAFO, 2017b). All vessels fishing in the NAFO area are further required to carry at least one independent and impartial observer. Observers record the position of their vessel and any entries made into the logbook, and monitor catch composition and quantity, any discards, and the presence of by-catch and undersized fish. Upon evidence of infringement of the NAFO conservation and management measures, the observer is required to report their findings to an inspection vessel within 24 hours, and provide a written report to the NAFO Secretariat within 30 days of returning to port (NAFO, 2017b). Contracting Parties with an inspection and surveillance presence in the NAFO Regulatory Area must provide ships and/or aircraft to monitor the activities of fishing vessels. In turn, fishing vessels must provide full and open access to inspectors, including facilitating boarding at sea and in port. The Annual Compliance Review represents a compilation of all fishery reports received from the Contracting Parties by the NAFO Secretariat (NAFO, 2017b).

1.6.2 The NEREIDA programme

The NEREIDA (NAFO potential vulnerable marine ecosystems – impacts of deep-sea fisheries) study programme represents a research collaboration between fishery scientists, geologists and marine ecologists from Canada, Spain, the UK and Russia, with an overarching objective of furthering understanding of the ecology of VMEs in the NW Atlantic, with application to the refinement of current fishery closures and furthering of knowledge regarding the impact of bottom trawling on benthic fauna (Duran Munoz et al., 2012). This programme

was initiated in response to UNGA Resolution 61/105, with six research cruises being run over the spring and summer of 2009 and 2010. A total of 68385 km^2 of the NAFO Regulatory Area was surveyed during these cruises, with a focus on the Flemish Cap, Flemish Pass and the continental slopes of the Grand Banks (see Figure 1.2). During these cruises, acoustic data (~68000 km^2 of multibeam bathymetry and ~18600 km^2 of high-resolution seismic surveys), faunal samples (~2500 scientific trawl sets, 104 rock dredge samples and over 300 box cores), ROV surveys (photographic and video data) and oceanographic data (414 CTD drops) were collected (Duran Munoz et al., 2012).

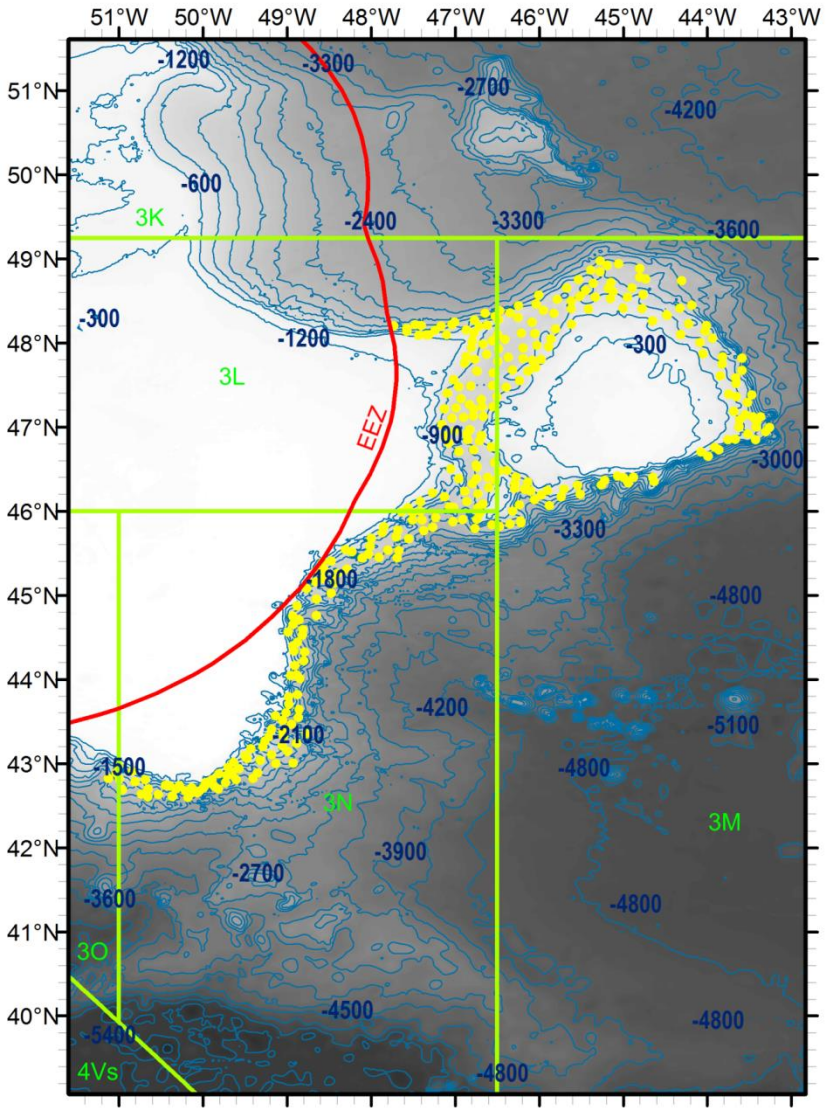


Figure 1.2: NEREIDA box core sampling locations (yellow dots) and bathymetry of the study area. Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used. Red line shows the extent of the Canadian Exclusive Economic Zone (EEZ). Green boxes show locations of Northwest Atlantic Fisheries Organisation subarea divisions (see Figure 1.1).

The bathymetry of the NEREIDA study area is dominated by four key features (see Figure 1.2). To the north (latitude ~48 ºN), the Sackville Spur forms a north-eastward extension of the Grand Banks continental slope between 900 and 2500 metres water depth, and represents a sediment drift feature (Kennard et al., 1990). The wedge-like shape of the spur results in the acceleration of the deep component of the Labrador Current, eroding away finer sediments and so exposing harder substrata that are highly suitable for attachment by epifauna, at the same time as delivering suspended food particles at a high rate (Genin et al., 1986). To the east of the Sackville Spur, the Flemish Cap (latitude 46-49 ºN, longitude 43-47 ºW) represents a large, isolated deep-water dome-shaped bank. The cap has a total area of ~27330 km^2 and a depth range of between about 120 and 800 metres (Pérez-Rodríguez et al., 2013). Separating the Flemish Cap from the Grand Banks continental shelf is the Flemish Pass – a channel reaching depths of over 1100 metres, and so representing a major dispersal barrier to shallower demersal fish species such as American Plaice (Morgan and Bowering, 2006). To the south of the Flemish Pass runs the continental slope of the Grand Banks, descending rapidly to about 2500 metres before levelling out onto the abyssal plain.

Oceanographically, the water mass in the NEREIDA study area is dominated by two distinct sources. The Labrador Current (temperature between 3 and 4 ºC, salinity between 34 and 35 ‰) flows southward from the north, whilst to the south, the area is bounded by the Gulf Stream (temperature above 4 ºC, salinity above 34.8 ‰) (Rogers and Gianni, 2009, Murillo et al., 2012). Where the Labrador Current meets the northern extent of the Flemish Pass, it bifurcates. Here the major branch flows southwards towards the southeast slopes of the Grand Banks. The remaining minor branch cycles as a semi-permanent anticyclonic gyre around the Flemish Cap (Murillo et al., 2012, Perez-Rodriguez et al., 2012). Thus, the region is characterised by latitudinal temperature gradients, as well as areas of high primary productivity as a result of strong tidal mixing and localised upwelling (Rogers and Gianni, 2009).

1.7 Overview of thesis structure

The four data chapters of this thesis further explore and extend upon the themes covered in this introductory chapter via the analysis of peracarid crustacean (see Appendix 1) assemblages contained within over 300 box cores collected as part of the NEREIDA programme (Figure 1.2).

Chapter 2, entitled '*Is competition a significant structuring agent in the deep sea?*' investigates the relative importance of biological and environmental factors in determining the structure of deep-sea peracarid assemblages. This is achieved by the consideration of phylogenetic and functional community dispersion metrics following the construction of both a 'supertree' and a functional dendrogram.

Following this analysis, Chapter 3, entitled '*Influence of the physical environment on deep-sea peracarid communities: refining prevailing paradigms'* investigates the role of a selection of physical environmental variables in defining the magnitude of various facets of peracarid biodiversity, including taxonomic, functional and phylogenetic metrics of diversity.

Chapter 4 is entitled '*On the importance of Vulnerable Marine Ecosystem habitats for deep-sea macrofaunal communities'* and considers the influence of the density of three VME-indicator taxa (Porifera, Pennatulacea and gorgonian corals) on peracarid communities in the NAFO Regulatory Area. It also investigates the optimality of current NAFO spatial closures for the protection of macrofaunal biodiversity, and discusses the use of SDMs in deep-sea contexts.

Chapter 5 considers the value of deep-sea biodiversity for the promotion of ecosystem functioning, and is entitled '*What is the form of deep-sea biodiversity - ecosystem functioning relationships?*'. A theory is developed that all positive BEF relationships take the same general form, but that different portions of the BEF curve are

enhanced/supressed depending on the average 'interaction frequency' of organisms contributing to the ecosystem function in question.

The broader-scale implications of the conclusions of these chapters are discussed in Chapter 6, as well as the potential limitations of this thesis and proposed future research directions.

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Chapter 2

'Is competition a significant structuring agent in the deep sea?'

2.1 Abstract

The magnitude of competitive interactions between organisms has classically been recognised as an important factor in determining the diversity and structure of biological communities. However, this topic has remained a subject for debate amongst deep-sea biologists ever since the publication of Hessler and Sanders' 'Stability Time Hypothesis' over fifty years ago, with no clear resolution to date. As such, further study of the role of competition in structuring deep-sea communities has recently been described by McClain and Schlacher as of "*fundamental importance and excitement*".

This study investigates the influence of competition in the deep sea by examining the phylogenetic and functional structure of peracarid assemblages. Specifically, the hypothesis that competition is not a significant structuring agent in deep-sea benthic macrofaunal assemblages is tested. This is achieved via the application of community phylogenetic methodology to a dataset consisting of macrobenthic peracarid crustaceans sampled from the Northwest Atlantic continental slope using box cores. This represents the first example of such an approach for deep-sea macrofauna. Analyses are based on examination of the distribution of sampled genera across a constructed supertree, and the distribution of sampled families across a functional dendrogram produced from an assembled trait database. These complementary phylogenetic and functional analyses provide no evidence that competition plays a central role in structuring deep-sea assemblages at the spatial scale investigated. Instead, they provide strong evidence that the environment is most important in structuring continental slope peracarid assemblages, and hint at a potentially high sensitivity of deep-sea taxa to environmental variation.

2.2 Introduction

The study of inter-specific competition, hereby defined as mutually negative interactions between taxa for a biologically important resource, has "*long been one of ecology's most fashionable pursuits*" (Schoener, 1983), and the magnitude of competition has classically being recognised as an important factor determining the diversity and structure of organismal communities (Lotka, 1932, Gause, 1934, Elton, 1946, Hardin, 1960, Diamond, 1975). For example, significant levels of competition within communities can result in high levels of dominance, and potentially the exclusion of competitively inferior taxa (Gause, 1934, Hardin, 1960), shaping species' realised niches and distributions, and even influencing ecosystem functioning (Riginos, 2009, Leduc et al., 2015).

Examples of competitive interactions are numerous in the literature, having been reported in a range of habitats and for a variety of taxa. For example, competitive interactions have been reported in terrestrial habitats amongst trees (Seidel et al., 2011), amphibians (Jaeger, 1972) and nematodes (Alatorre-Rosas and Kaya, 1990), in fresh water amongst fishes (Zaret and Rand, 1971), and fish and water fowl (Eriksson, 1979), on rocky shores amongst species of barnacle (Connell, 1961, Dayton, 1971), and barnacles and algae (Dayton, 1971), on shallow-water tropical reefs between coral and algae (McCook et al., 2001), and on mud flats amongst polychaete species (Woodin, 1974, Levin, 1982) and amphipods (Grant, 1981). These competitive interactions are typically manifested by changes in organismal growth (Levin, 1982, Seidel et al., 2011), distributions (Connell, 1961, Dayton, 1971, Jaeger, 1972, Woodin, 1974, Eriksson, 1979, Grant, 1981, McCook et al., 2001), reproductive success (Woodin, 1974, Alatorre-Rosas and Kaya, 1990, McCook et al., 2001) and feeding strategies (Zaret and Rand, 1971, Levin, 1982).

The importance, or not, of competition in shaping deep-sea communities has been a subject of debate for nearly fifty years. Implicit in the 'Stability-Time Hypothesis' (STH) (Hessler and Sanders, 1967, Sanders, 1968) (see Section 1.2.3), is the idea that long-past competitive interactions, coupled with an environment thought at the time to be stable

over long periods, have favoured a high degree of specialisation and niche differentiation amongst taxa, resulting in modern communities where competitive interactions are weak (McClain and Schlacher, 2015).

Theoretical support for competition being a weak structuring agent in deep-sea communities is mixed. The conceptual framework of Huston (1979) predicts that in food-limited environments, such as the deep sea, competitive exclusion will be rare, and of limited importance in determining community structure. Wilson (1990) and Grant (2000) too agree that competition has a limited role in structuring soft sediment assemblages. Wilson developed a paradigm whereby the importance of competition in communities is dependent on the prevailing environmental conditions, concluding that competitive exclusion of taxa in soft-sediments is unlikely. Grant argued that the low density of fauna, coupled with the huge spatial extent of the deep sea mean that competitive interactions between taxa are weak and symmetric, and thus that competition is of limited significance in structuring communities in this environment.

However, others promote a view that competition, particularly when coupled with predation, is of great importance in maintaining diversity and structuring faunal assemblages in the deep sea. For instance, Rex (1976, 1981) proposed that the diversity of deep-sea communities is maintained by a dynamic balance between predation and competition (see Section 1.2.3), arguing that high levels of competition act to supress diversity by competitive displacement and subsequent dominance, whilst moderate density-dependent predation serves to increase diversity by limiting dominance.

Hard evidence to support either of these opinions is limited. Rex and Waren (1981) studied species:genus ratios in gastropods along a gradient from shelf to abyssal depths in the Northwest Atlantic. Assuming that co-geners will be ecologically similar, a situation of a low average number of species per genus is suggestive of an importance of competitive displacement. Rex and Waren recovered such a pattern at shelf depths. However, as depth

increased towards the lower slope, the average number of species per genus increased to a maximal, hinting at a greater role of the environment over competition in structuring assemblages at these depths. Progressing towards the abyss, the ratio again declined, perhaps reflecting chronic extinction pressure (Rex et al., 2005).

McClain (2005) approached the question of the role of competition from a different perspective, considering similarity in gastropod shell morphology in the western North Atlantic. Interestingly, at all depths, shell morphologies were found to be statistically more different from one another than would be expected by chance. This was found to be particularly strong at mid-slope depths - suggesting a potential role of competitive exclusion. However, this result is complicated by a failure to unlink the magnitude of morphological dispersion observed from the species richness of a sample, with high species richness being positively correlated with over-dispersion in shell morphology. Further, the variance and nearest-neighbour distances obtained by McClain (2005) are more suggestive of a situation of closely similar species clumps that are patchily distributed in morphological space, perhaps indicative of exclusion occurring at taxonomic levels higher than species. It should also be noted that competition is not the only process that can lead to this type of character dispersion (Grant, 1972).

Laakmann et al. (2009) provided evidence that competition may play an important role in structuring deep-sea pelagic copepod assemblages. Closely related species were found to be partitioned into different depth bands, and species that did occur in the same depth band belonged to different genera and utilised different food resources.

Levin et al. (2013) investigated dorvilleid polychaete assemblages at cold seep habitats off California and Oregon. Here they documented environmental selection for these hydrogen sulphide-resistant polychaetes in seep environments, with trophic partitioning limiting competitive interactions between co-geners.

Quattrini et al. (2017) applied community phylogenetic methodology to deep-sea megafaunal populations for the first time, investigating octocoral assemblages in the Gulf of Mexico. Phylogenetic relatedness of octocorals within the shallower assemblages analysed (250 – 2000 m depth) was found to be random, suggesting a dominance of neutral processes in community assembly. However, at depths >2000 m, octocoral assemblages were found to be more closely related than would expected by chance, suggesting a growing importance of environmental filtering with increasing depth.

From this small number of studies, it appears that the question of the significance of inter-specific competition in structuring deep-water assemblages is still far from answered, prompting McClain and Schlacher (2015) to claim that a research programme specifically examining the role of competition in the deep sea to be "*of fundamental importance and excitement*".

2.2.1 A novel approach to identifying competition in the deep sea

A novel approach to determining the importance of competition in environments where the logistic difficulties of conducting experiments are prohibitive, such as the deep sea, is to examine the phylogenetic relationships between taxa present (Webb et al., 2002). As phylogenetically close taxa are likely to be ecologically similar, signatures of the ecological determinants of assemblage composition may be apparent in community phylogenetic patterns (Elton, 1946, Webb et al., 2002, Helmus et al., 2007b). Phylogenetic clustering (or 'under-dispersion'), whereby taxa in an assemblage are more closely related to each other than would be expected by a random draw from the available taxa pool, is suggestive of a dominance of environmental filtering in community development. In this situation, the prevailing environment selects for particular phenotypic traits, and these traits are more likely to be shared between closely related taxa than between more distantly related taxa (Webb et al., 2002). In contrast, phylogenetic over-dispersion, whereby taxa in an assemblage are more distantly related to each other than would be expected by a random draw from the available taxa pool, hints at a dominance of competitive exclusion (or

phenotypic convergence by distantly-related taxa) in determining assemblage structure (Webb et al., 2002, Helmus et al., 2007b, Kluge and Kessler, 2011).

The pioneering work of Elton (1946), based on the use of species:genus ratios as a proxy for phylogenetic clustering/over-dispersion, represents the first example of an attempt to study the quantitative taxonomic structure of assemblages in order to determine the ecological processes at work. However, it was not until the mid-1990s (e.g. Winston (1995)) that sufficiently accurate phylogenies became available to be applied to this problem. The origins of the modern field of community phylogenetics can be traced to the work of Webb (Webb, 2000, Webb et al., 2002), who developed the framework and hypotheses of the discipline. This approach has subsequently been applied to a wide variety of assemblages, including microbial (Horner-Devine and Bohannan, 2006, Bryant et al., 2012), avian (Lovette and Hochachka, 2006), plant (Slingsby and Verboom, 2006, Kluge and Kessler, 2011), fish (Helmus et al., 2007a, Helmus et al., 2007b), insect (Vamosi and Vamosi, 2007), and coral (Quattrini et al., 2017) amongst others, but never before have community phylogenetic methods been applied to the study of deep-sea macrofauna.

There are limitations to this approach, however; phylogeny is only a proxy for ecological similarity, and the traits important in determining co-existence of taxa in a particular environment may not necessarily correlate with phylogenetic similarity (Helmus et al., 2007b, Swenson and Enquist, 2009).

An alternative approach is to use the functional similarity of taxa as a more direct metric of ecological similarity. Again, the same clustering/over-dispersion framework outlined above can be applied to the problem, but here we are considering community assembly in functional rather than phylogenetic space.

Examples of this functional approach are dominated by studies of tropical plant assemblages (Kraft et al., 2008, Swenson and Enquist, 2009, Kraft and Ackerly, 2010,

Lebrija-Trejos et al., 2010, Kluge and Kessler, 2011, Baraloto et al., 2012, Swenson, 2013), and this method has been applied in the marine realm only rarely. For example, Ingram and Shurin (2009) considered the distribution of morphological traits amongst Pacific rockfish (*Sebastes* spp.) assemblages. Signatures of functional over-dispersion were uncovered for some traits, whilst other traits appeared to be under-dispersed, suggesting a complex balance of biotic and abiotic factors influencing assemblage structure. Bryant et al. (2012) investigated changes in microbial trait dispersion along a gradient of oxygen concentration in the eastern tropical South Pacific, finding evidence for functional over-dispersion in oxygenated waters, but functional under-dispersion within an oxygen minimum zone. This study neatly demonstrates a transition from the importance of competition to that of the environment in determining assemblage structure as abiotic conditions become more extreme. Never before has functional dispersion been investigated in deep-sea macrofauna.

This study aims to test the hypothesis that competition is not a significant structuring agent of deep-sea benthic macrofaunal assemblages. In order to achieve this with the greatest possible confidence, both the phylogenetic and functional dispersion of peracarid assemblages are investigated. Dendrograms describing both phylogenetic and functional relationships between sampled peracarid taxa are constructed, and these are coupled with extensive assemblage composition data to search for signatures of competition in Northwest Atlantic continental slope macrofaunal assemblages.

2.3 Methods

2.3.1 Peracarid assemblage composition

312 box cores (USNEL (United States Naval Electronics Laboratory) – type box corer, area 0.25 m^2) were collected from the Flemish Pass, the continental slopes of the Grand Banks and the slopes of the Flemish Cap (Northwest Atlantic Ocean) over spring and summer research cruises in 2009 and 2010 as part of the international NEREIDA programme (see Section 1.6.2 and Figure 1.2). On-board the research vessel *Miguel Oliver*, box cores were

drained of excess water and sediment subsamples were taken to a depth of 2 cm for particle size analysis and geochemical processing. The remaining sediment was split into top 5 cm and 5 cm and below portions and washed over a 0.5 mm mesh sieve. Material retained on this sieve was fixed in 4 % formaldehyde.

Initial processing of the box core samples was undertaken by the Institute of Estuarine and Coastal Studies (IECS), University of Hull, UK. Formaldehyde was drained over a 1 mm mesh sieve (see Section 6.3.1) and retained specimens were sorted to major taxonomic groups (e.g. annelids, crustaceans etc.) and transferred to 70 % industrial methylated spirits (IMS). Upon arrival at the Department of Zoology (University of Oxford), specimens of peracarid crustacean were identified to genus under Leica EZ5 and Motic SMZ-171T binocular microscopes, enumerated, labelled and stored in 80 % IMS. The resulting dataset contains information on the abundance of all sampled peracarid genera in each box core (see Appendix 2).

2.3.2 Supertree construction

Phylogenetic relationships between all sampled genera were determined by the construction of a 'supertree' (figures 2.1, 2.2 and A8.1) (phylogenetic tree produced by the combination of a number of source trees with overlapping, but not necessarily identical taxon sets (Bininda-Emonds, 2004)). This was achieved via the methodology outlined below.

2.3.2.1 Collation of published phylogenies

Google Scholar was used to search for all publications containing evolutionary trees (published up to 1st May 2016) that satisfied the following three criteria: 1) publications must contain original trees, 2) the trees must contain two or more marine peracarid families, and 3) the trees must have been analysed using a recognised phylogenetic optimality criterion. This search yielded 59 studies. From these studies, a single tree for each unique combination of taxa set analysed, character type analysed (e.g. gene(s) used or morphological characters considered), weighting scheme employed and phylogenetic

optimality criterion selected was retained for analysis in order to reduce the likelihood of data replication (which may otherwise unfairly weight the analysis, although see Bininda-Emonds (2004) for an alternative viewpoint). Following application of these requirements, 127 evolutionary trees were retained for analysis.

Tree topologies were extracted from publications by taking screenshots. Images were cleaned to remove unnecessary background graphics using Microsoft Paint 6.1, and saved as JPEG files. TreeSnatcher Plus (Laubach et al., 2012) was used to generate Newick expressions of the tree topologies depicted in the images. These Newick expressions were then imported into Archaeopteryx 0.9901b (Han and Zmasek, 2009, Zmasek, 2014) where all monophyletic groups were labelled (including interior nodes) following World Register of Marine Species (WoRMS) systematic nomenclature (Mees et al., 2015). The labelled Newick expressions were then imported into Supertree Toolkit 2.14 (Hill and Davis, 2014) where details relating to the origin of each tree were added, and summary Nexus files were produced.

2.3.2.2 Construction of supertree topology

Supertrees were constructed using the program MultiLevelSupertree (MLS) 1.0 (Berry et al., 2013). Typical supertree construction methods, such as Matrix Representation with Parsimony (MRP), or Bayesian/maximum likelihood methods (Akanni et al., 2015) require terminal taxa to be non-nested across source trees and hence only account for horizontal overlap between trees (Bininda-Emonds, 2014). This can be extremely restrictive where potential input trees are resolved at varying taxonomic levels. MLS is able to accommodate source trees where terminal taxa are at varying taxonomic levels (i.e. nested source trees), and makes use of vertical overlap between source trees to inform tree construction.

MLS was run on the Oxford University Advanced Research Computing supercomputer 'ARCUS (Phase B)' (http://www.arc.ox.ac.uk/content/home). However, even using this high-performance computer, the run time for the complete dataset was prohibitively long,

exceeding that permitted by the system. As such (and since the monophyletic status of amphipods, isopods, cumaceans and tanaidaceans is well supported by both morphological and molecular datasets (Richter and Scholtz, 2001, Poore, 2005, Spears et al., 2005, Meland and Willassen, 2007, Wilson, 2009, Drumm, 2010), and these taxa are particularly well defined by synapomorphies (see Appendix 1)), supertree construction was split into five separate runs. Firstly, the program was run individually for Amphipoda, Isopoda, Tanaidacea and Cumacea using reduced datasets containing only those source trees that focus primarily on each of the taxa. For each of these runs a taxonomy tree was used to guide the program. For the case of Amphipoda, Isopoda and Tanaidacea, this taxonomy tree was down-weighted by 10 times relative to the other input trees to ensure it did not have undue influence over the resulting supertree (which would negatively influence resolution). For the case of Cumacea, where fewer input trees were available, the taxonomy tree was down-weighted as far as possible (by four times relative to the other input trees). All other options were kept constant for each of these four runs, these being "treestransform = GeneralAB, ArcsWeight = 1, AllMC = true, Taxonomy = true, FromTaxonomyDeduction = true, PhyloTree = true, FreeAllVert = true, FullGraph = false" (see Berry et al. (2013) and program documentation for a full explanation of these options).

Prior to undertaking the fifth run of supertree construction, a further two phylogenetic trees were constructed *de novo* using Maximum Likelihood (ML) and Bayesian methodology based on 18S SSU rDNA, 28S LSU rDNA, 16S rDNA, cytochrome c oxidase 1 (COI) and Histone H3 gene sequences downloaded from GenBank (Benson et al., 2015). For peracarid families sampled by the NEREIDA box cores, all 18S, 28S, 16S, COI and H3 sequences available on GenBank were downloaded and collated using MEGA 7 (Kumar et al., 2016). In cases where multiple copies of a gene were available per species, the longest available sequence was chosen. In addition, sequence data for a selection of malacostracan outgroup taxa were obtained from GenBank in order to root the resultant phylogenies in a broader taxonomic context. The final dataset contained 483 species, with 18S data available for 310 species,

28S for 165 species, 16S for 144 species, COI for 340 species and Histone H3 for 77 species (see Appendix 6).

Genes were aligned individually using MAFFT v7.273 (Katoh and Standley, 2013) running on the MAFFT online server (http://mafft.cbrc.jp/alignment/server/). Sequences were first checked to confirm directionality using LAST plots produced by MAFFT. For protein-coding sequences (COI and H3), the G-INS-I alignment strategy was selected. This is an iterative method that is highly accurate for alignments of sequences with global homology. For 18S, 28S and 16S the E-INS-I alignment strategy was selected. This is also an iterative method, but is more appropriate for sequences with several conserved motifs that are embedded in long unalignable regions. In all cases default parameters were selected. Initial alignments of 28S revealed three primer sets covering non-overlapping sections of the gene. The primer set used for the majority of sequences for which data was available (66.5 %) was selected for use, the remaining sequences were removed, and the gene re-aligned using options as above.

Alignments were scrutinised using trimAl v1.2 (Capella-Gutiérrez et al., 2009) in order to identify highly variable regions where alignments were unlikely to be reliable. This approach has been shown to improve signal to noise ratios, resulting in more reliable estimates of phylogeny (Talavera and Castresana, 2007). trimAl was used in preference to other available alignment masking software (e.g. GBlocks) since it is able to automatically select (via the 'Automated 1' method) the most appropriate parameters to be used to maximise the signal to noise ratio (Capella-Gutiérrez et al., 2009).

This resulted in the trimming of alignments from 7570 base pairs (bp) to 1271 bp for 18S, from 5342 bp to 1360 bp for 28S, from 921 bp to 494 bp for 16S, from 1629 bp to 444 bp for COI, and from 422 bp to 327 bp for H3. Such extensive masking resulted from three main factors – 1) large portions of the alignment were removed as a result of limited primer overlap between particular pairings of taxa, 2) the large genetic distances involved across

the full alignment meant that saturation in particularly fast-evolving sections of genes (e.g. variable regions of 18S) made alignment of these areas essentially impossible, and 3) crustaceans have been shown to exhibit highly fluid genomes (Shen et al., 2015) and this can make alignment in cases of large genetic distances particularly problematic.

All missing data for taxa was coded as '?', and those taxa which lacked data for 50 % or more of the length of the alignment were removed. Upon applying this rule, retention of the 28S data resulted in an alignment of 3897 bp total length and 98 taxa. Removal of the 28S portion resulted in a shorter final alignment (2536 bp), but 285 taxa could be retained, covering a much larger portion of malacostracan phylogeny. Therefore, it was decided that the 28S data should be removed. This final alignment (18S, 16S, COI and H3) was concatenated using SequenceMatrix 1.8 (Vaidya et al., 2011).

PartitionFinder v1.1.1 (Lanfear et al., 2012) was used to select the most appropriate model of evolution and partitioning scheme for the concatenated alignment using the following settings: "branchlengths: unlinked, models of evolution: raxml/mrbayes (depending on phylogenetic program used subsequently), model selection: BIC (arguably the most appropriate metric of model performance (Minin et al., 2003, Abdo et al., 2005)), scheme: all". For subsequent RAxML and MrBayes analyses, the most appropriate model of nucleotide substitution was found to be the General Time Reversible Model (Tavaré, 1986) + invariable site proportion + gamma-distributed rate variation among sites (GTR+I+G) applied across two partitions: 1) 16S, COI, and 3rd codon position of H3, and 2) 18S and 1st and 2nd codon positions of H3 (BIC score = 191772.795).

ML and Bayesian topologies were estimated using RAxML v8.2.8 (Stamatakis, 2014) and MrBayes v3.2.6 (Ronquist et al., 2012), respectively, on the 'CIPRES science gateway v3.3' online server (Miller et al., 2010). The CIPRES gateway offers full implementations of the RAxML and MrBayes programs using high-performance computers that can be accessed free of charge via a web portal. RAxML-HPC v.8 on XSEDE was selected and all parameters were

left as default other than the following: "Maximum hours to run: 12, Outgroup: *Nebalia_sp*, *Paranebalia_longipes* (the most basal members of the analysis), Mixed/partitioned model: specified as per PartitionFinder results, Estimate proportion of invariable sites: yes, Analysis type: Rapid bootstrap analysis/search for best-scoring ML tree, Model for bootstrapping phase: GTRGAMMA, Bootstrapping type: rapid bootstrapping with RAxML halting bootstrapping automatically based on the autoMRE criterion". See Figure A7.2.

For the MrBayes run, MrBayes on XSEDE (3.2.6) was selected. Other than maximum hours to run (168), all options were specified via a MrBayes data block. Partitions were set as per PatitionFinder results, with parameters unlinked and rates allowed to vary such that each of the two partitions could evolve under independent scenarios. Two runs of 100,000,000 generations were conducted, with trees being sampled every 2000 generations using eight Markov chains with a heating value of 0.12. Trace plots of log-likelihood scores were examined using Tracer v1.6 (Rambaut et al., 2013), and the two runs were considered to have converged after 95,720,000 generations when the standard deviation of split frequencies fell below a value of 0.01. A burn-in of 20 % was selected since this corresponded to the relative stabilisation of sample probabilities, and the remaining trees were used to construct a 50 % majority rule consensus tree (see Figure A7.1).

The output trees of the four MLS runs and the ML and Bayesian analyses of the GenBank-derived sequence data were combined, using MLS, during the fifth round of supertree construction with all source trees focussing primarily on higher-level relationships within Peracarida and Malacostraca to produce the final supertree. Again, a taxonomy tree was employed to guide the program, and this was down-weighted by four times relative to the standard input trees, whilst the supertrees for Amphipoda, Isopoda, Tanaidacea and Cumacea, and the original ML and Bayesian trees derived from GenBank sequences were up-weighted by 4.5 times (maximally) relative to the standard input trees. All other options were left as above. The resulting supertree has 1487 terminal taxa (see figures 2.1, 2.2 and A8.1).

2.3.2.3 Mapping of branch lengths onto supertree topology

Whilst the supertree produced describes relationships between all included taxa, its branch lengths are arbitrary. In order to add meaningful branch lengths, the methodology outlined below was employed.

Supertree topology was trimmed to include only those taxa present in the GenBank alignment. Maximum likelihood branch lengths were estimated for this topology using RAxML v8.2.8 (Stamatakis, 2014) running on the 'CIPRES science gateway v3.3' online server (Miller et al., 2010). RAxML-HPC v.8 on XSEDE was selected and all parameters were left as default other than the following: "Maximum hours to run: 12, Outgroup: *Nebalia_sp*, *Paranebalia_longipes*, Constraint tree: Yes (supertree topology trimmed to only taxa present in the GenBank alignment), Mixed/partitioned model: specified as per PartitionFinder results, Estimate proportion of invariable sites: yes, Analysis type: Rapid hill-climbing algorithm, Model for bootstrapping phase: GTRGAMMA".

Next, following Strauss et al. (2006), common nodes between the supertree and ML branch length tree were labelled using the 'COMNODE' function of PhyloCom 4.2 (Webb et al., 2008). This labelled ML branch length tree was used as an input for the program R8s 1.8 (Sanderson, 2003) in order obtain a chronogram of taxa relationships. 22 nodes were constrained with age estimates based on fossil data (see Table 2.1) in order to calibrate the chronogram. The root node of the phylogeny (representing Malacostraca) required a maximum age constraint in order for divergence times to be estimated, and this was set to 550 Ma (million years before present) based on evidence from fossil data and previous molecular sequence-based estimates (Porter et al., 2005, Collette and Hagadorn, 2010, Sanders and Lee, 2010, Rehm et al., 2011). Non-Parametric Rate Smoothing (NPRS) with Powell optimisation was selected as the analysis method. NPRS is a non-parametric method that relaxes the stringency of molecular clock assumptions, being particularly appropriate in cases of relatively high rate variation among linages (Sanderson, 1997) (see figures A7.1 and A7.2 and Verheye et al. (2015)). NPRS uses least-squares smoothing methods to smooth

the rapidity of rate change among lineages (minimising local rate changes) and estimate unknown divergence times among lineages (Sanderson, 2003). 10 runs of the program were conducted, with 20 perturbed restarts per run and a maximum of 100,000 iterations permitted in order to provide an effective search strategy that is most likely to terminate at the global optimum (Sanderson, 2003). The CheckGradient option was specified as an additional check that the global optimum had been found.

Table 2.1: Details of nodes constrained with age estimates based on fossil data in order to calibrate the supertree chronogram.

Node	Minimum age of divergence (Ma)	Strata	Reference
Phyllocarida - other Malacostraca	489.5	Jiangshanian	(Collette and Hagadorn, 2010)
Hoplocarida - Euphausicea	313.0	Moscovian	(Jenner et al., 1998)
Peracarida - other Malacostraca	358.9	Famennian	(Jones et al., 2016)
Lophogastrida - other Peracarida	307.0	Moscovian	(Brooks, 1962)
Eucopia* - *Gnathophausia	163.5	Callovian	(Secrétan and Riou, 1986)
Mysida - other Peracarida	163.5	Callovian	(Secrétan and Riou, 1986)
'Gammaridae type' - other Gammaroidea	45.0	Lutetian	(Jażdżewski and Kupryjanowicz, 2010)
Phreatoicidea - Asellota	307.0	Moscovian	(Schram, 1970)
Cymothoida - Valvifera	166.1	Bathonian	(Jones et al., 2014)
Cirolanidae – Anthuroidea	170.3	Aalenian	(Etter, 2014)
***Cirolana* – other Cirolanidae**	125.0	Barremian	(Wieder and Feldmann, 1992)
Tanaidacea – other Peracarida	326.4	Serpukhovian	(Peach, 1882)
Apseudomorpha - Tanaidomorpha	170.3	Aalenian	(Etter, 2004)
Cumacea – other Peracarida	323.2	Serpukhovian	(Schram et al., 2003)
Diastylidae – Bodotriidae	252.2	Changhsingian	(Gerken, 2001)
Pleocyemata – other Decapoda	358.9	Famennian	(Schram et al., 1978)
Brachyura – other Pleocyemata	185.0	Pliensbachian	(Haug and Haug, 2014)
Astacidae – other Astacoidea	145.0	Tithonian	(Van Straelen, 1928)
Penaeidae – other Dendrobranchiata	145.0	Tithonian	(Dall et al., 1990)
Atyoidea - Bresilioidea	125.0	Barremian	(Rabadá, 1993)
Stenopodidea - Axiidea	93.9	Cenomanian	(Garassino, 2001)
Chirostyloidea - Hippoidea	66.0	Maastrichtian	(Schweitzer and Feldmann, 2000)

Following this, the BLADJ function of PhyloCom 4.2 was used to set the common labelled internal nodes between the supertree and dated R8s chronogram to the same ages, and then interpolate these ages across the remainder of the supertree to obtain a fully-dated phylogeny. This method is clearly influenced by taxon sampling, and the GenBank sequences targeted do show gaps in coverage across the supertree (Figure 2.1). However the gaps occurred, in general, in regions of the supertree not relevant to this study – e.g. amongst the Talitrida, Crangonyctidira, Oniscidea and Sphaeromatidea which do not occur in the box core samples.

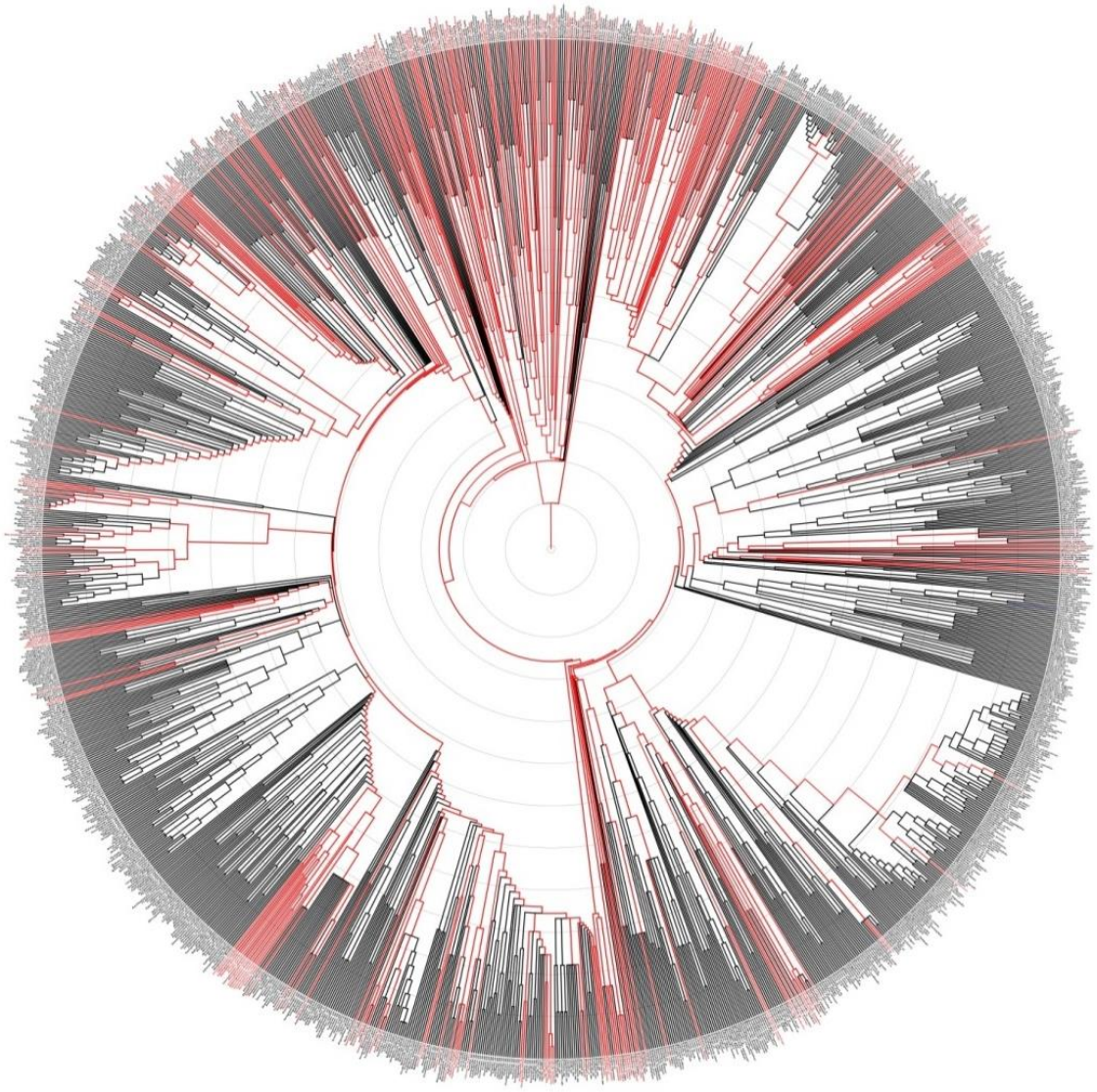


Figure 2.1: Supertree chronogram of Peracarida, including other malacostracan taxa as outgroups. Red highlights show distribution of GenBank-derived branch length information across the supertree topology. 1487 terminal taxa. Produced from 129 source trees, including *de novo* maximum likelihood and Bayesian phylogenies (Appendix 7), using MultiLevelSupertree 1.0 run on Oxford's Advanced Research Computing facility. Root at 600 Ma, concentric circles representing 50 Ma steps to present (tips).

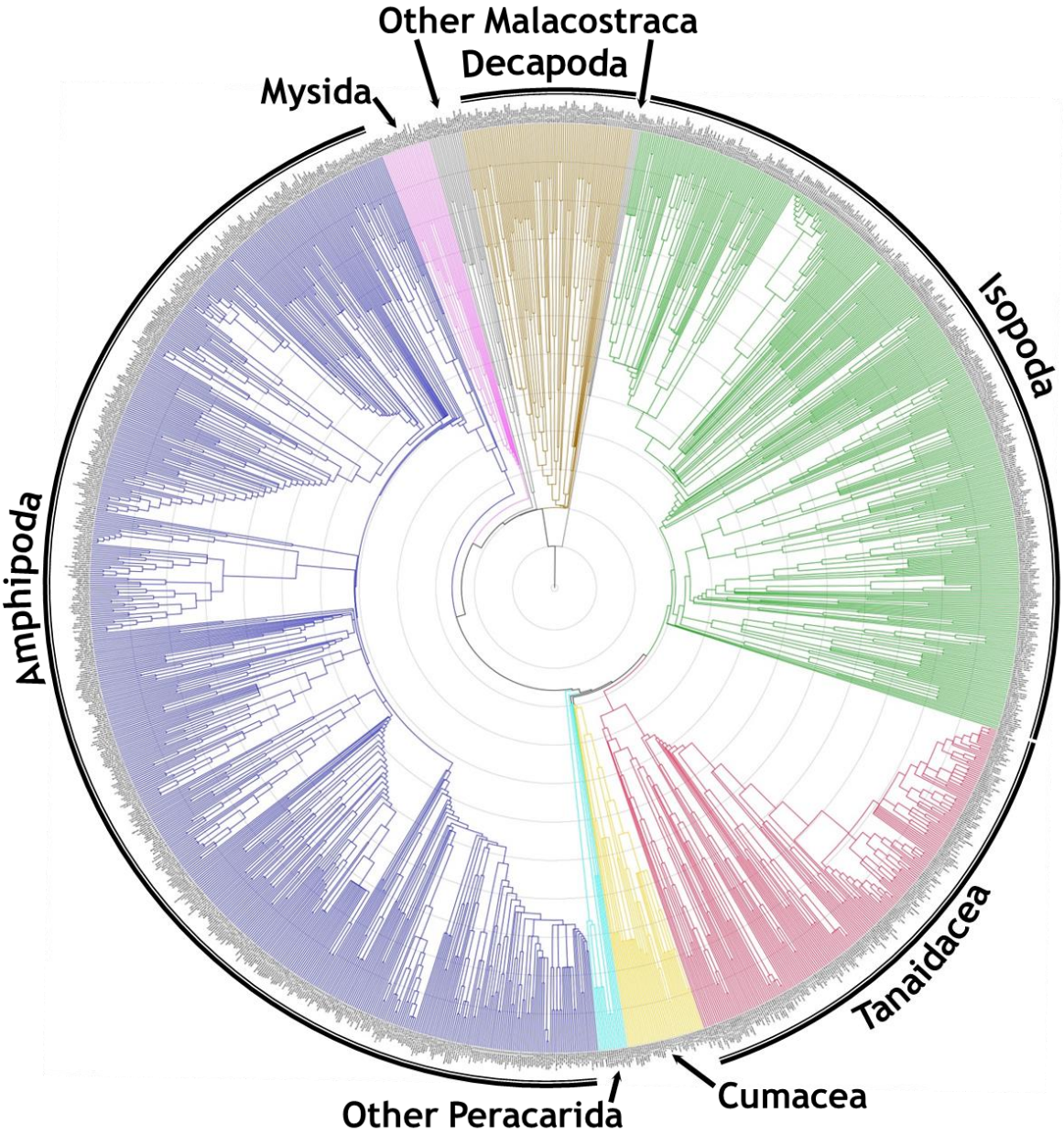


Figure 2.2: Supertree chronogram of Peracarida, including other malacostracan taxa as outgroups. 1487 terminal taxa. Produced from 129 source trees, including *de novo* maximum likelihood and Bayesian phylogenies, using MultiLevelSupertree 1.0 run on Oxford's Advanced Research Computing facility. Root at 600 Ma, concentric circles representing 50 Ma steps to present (tips).

2.3.3 Functional dendrogram construction

To gain an understanding of the functional similarity between sampled taxa, a functional dendrogram was produced (Figure 2.3) based on the relative scoring of sampled families for a selection of traits.

Functional traits were characterised at family-level (except for Tanaidacea '*incertae sedis*', which had to be scored at genus level) because of a paucity of data at higher taxonomic resolutions. Trait groupings and traits (see Table 2.2) were chosen based on ecological relevance and data availability. Proposed traits were reviewed by taxonomic experts prior to data collection (Prof. Angelika Brandt, Dr Tammy Horton and Dr Graham Bird).

Table 2.2: Trait groupings and trait modalities used to quantify functional attributes of sampled peracarid families.

Trait grouping	Trait modalities	Comments
Maximum adult length	Very small (0 to <4.7 mm)	Maximum adult length attained. Categories based on K-means clustering of continuous data – see Section 2.3.3
	Small (4.7 to <9.5 mm)	
	Medium (9.5 to <22.2 mm)	
	Large (22.2 to <45 mm)	
	Very large (>45 mm)	
Fragility	Fragile	Typically missing antennae, some pereopods and uropods upon collection - may be dis-articulated
	Medium	Typically with damaged antennae, some incomplete pereopods, and may have lost uropods upon collection
	Robust	Essentially complete specimens upon collection
Maximum fecundity	Very low (0 to <18)	Maximum number of eggs produced in a single brood. Categories based on K-means clustering of continuous data – see Section 2.3.3
	Low (18 to <31)	
	Medium (31 to <65)	
	High (65 to <135)	
	Very high (>135)	
Feeding group	Deposit feeder	Semi-selective sedimented particle feeder
	Suspension feeder	Semi-selective suspended particle feeder
	Active predator (including foraminifera)	Active selection of live prey
	Scavenger	Opportunistic feeder on recently dead material
	Parasitic	Prolonged feeding from another live organism in a non-mutually beneficial manner
Habitat space	Infaunal	Below substratum/water interface
	Epibenthic	On surface of substratum
	Benthopelagic	Near bottom/pelagic habitat
	Epibiotic (benthic)	Living on another benthic organism
Living habit	Free	Free moving
	Tube/burrow dweller	Use of constructed tube/burrow
	Parasite/direct commensal	Close relationship with another organism (obligate or facultative)

Trait grouping	Trait modalities	Comments
Motility	Fast swimmer	Able to make rapid, significant progress through water e.g. as an escape mechanism
	Slow swimmer/crawler	Able to swim, but not at a significant speed. Able to move by crawling across substratum
	Crawler/limited swimmer	Movement predominantly by crawling across substratum. Are able to move in the water column if necessary
	Crawler (no swim)	Constrained to crawling across substratum
	Burrower	Able to burrow into and make way through substratum
Bioturbation/sediment transport potential	Limited	Limited sediment movement capacity
	Low-level incidental diffusive mixing	Incidental sediment transport/mixing e.g. by movement of limbs across substratum
	Active significant sediment transport	Significant sediment transport/mixing due to active working of sediment e.g. burrowing
Sociability	Solitary	Lives individually
	Gregarious	Lives in groups
	Swarming	Can congregate in large abundances
Parental care	Limited	No interaction with young following release from brood pouch
	Extended	Active feeding and/or defence of young following release from brood pouch

A fuzzy coding (Chevenet et al., 1994) method was utilised for trait scoring to enable the coding of variability in trait scores within a family/individual, whereby a score of 0 reflects no affinity of the taxon with the trait in question, and a score of 5 represents complete affinity. To ensure equal weighting of trait groupings, the total score for a taxon for each trait group was set to 5. For example, in the case of the amphipod family Ampeliscidae, individuals mainly gather food via suspension feeding, but occasionally partake in deposit feeding (Enequist, 1949, Dauby et al., 2001, Nyssen et al., 2002, MarLIN, 2006, Dauvin and Bellan-Santini, 2009, Legeżyńska et al., 2012, Scipione, 2013, Guerra-García et al., 2014). Thus, the taxon was scored 4 for the trait 'suspension feeding', and 1 for the trait 'deposit feeding' under the trait grouping 'feeding group' (Appendix 4).

Where continuous trait data were available for families (e.g. the trait groupings 'maximum body length' and 'maximum fecundity'), natural breaks suitable for splitting the data into

distinct categories were identified via k-means clustering (MacQueen, 1967) (Sturges' formula used to determine an appropriate number of categories (Sturges, 1926)) in R 3.0.2 (R-CoreTeam, 2013) using the package 'classInt' 0.1-22 (Bivand et al., 2015), based on the maximal values for each family.

Trait scorings (77 taxa, 38 traits in 10 trait groupings) were based on available literature where possible (93 sources, 58.0 % of trait groupings) (see Appendix 4). In cases where literature was insufficient, taxa were scored based on personal observations, and these were reviewed and refined by expert opinion (42.0 % of scores). The chosen taxonomic experts were Dr Tammy Horton – Amphipoda, Prof. Angelika Brandt – Isopoda, Dr Graham Bird – Tanaidacea, and Dr Sarah Gerken – Cumacea.

The trait database was converted into a dendrogram describing functional similarity between taxa via hierarchical clustering methodology. Following Petchey and Gaston (2007) and Mouchet et al. (2008), the most appropriate distance metric and clustering method was selected by comparison of cophenetic correlation coefficient values (Sokal and Rohlf, 1962). Using the methodology of Mouchet et al. (2008), Gower and Euclidean distance metrics, and the following clustering methods, were analysed: single linkage, complete linkage, unweighted pair group method using arithmetic averages (UPGMA), weighted pair group method using arithmetic averages (WPGMA), unweighted pair group centroid method (UPGMC), weighted pair group centroid method (WPGMC), and Ward's. Further, all potential consensus tree combinations were analysed, giving a total of 254 combinations of distance and clustering methods. Analyses were conducted in R (R-CoreTeam, 2013) using a script provided by Dr Maud Mouchet. The distance and clustering method that was found to perform best was Euclidean distance and UPGMA clustering, and these methods were utilised to produce the functional dendrogram using the R package 'stats' (R-CoreTeam, 2013).

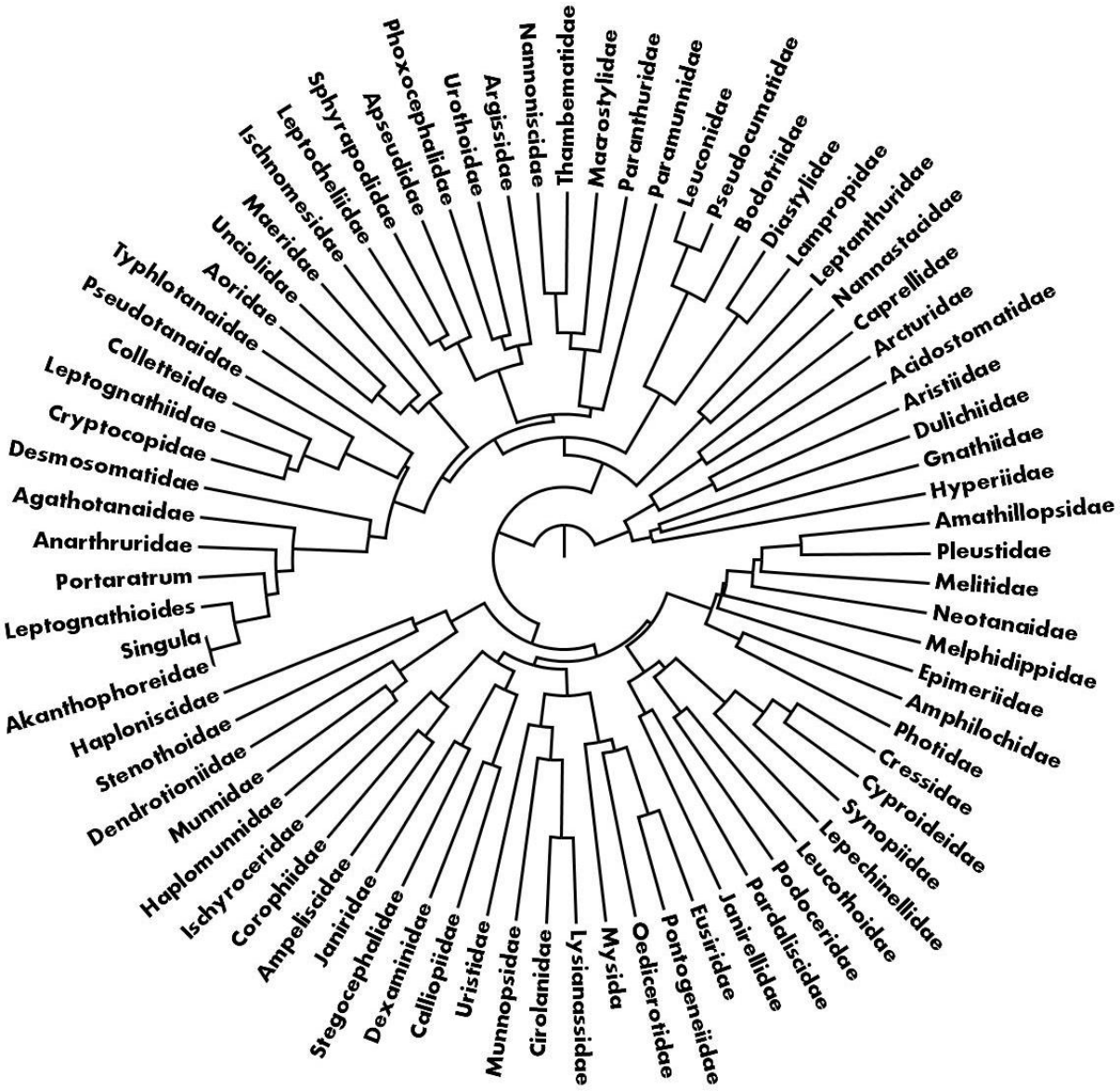


Figure 2.3: Functional dendrogram of 77 peracarid taxa sampled by NEREIDA box cores (clustering taxa are functionally similar). Produced via clustering (Euclidean distance, UPGMA) of a database of 38 traits.

2.3.4 Testing for phylogenetic structure

Phylogenetic structure was investigated across all box core samples using the constructed supertree (figures 2.1, 2.2 and A8.1) and genus-level assemblage matrix. Box cores 250 and 350 were removed from the analysis since they were erroneously combined during initial sample processing. The assemblage matrix was reduced to contain only those box cores which had two or more peracarid taxa present.

Further, seven box core subsets were produced, each consisting of 30 box cores chosen at random from within a set radius (50, 100, 200, 300, 400, 500 and 600 km) of the central-most box core sampled. This central-most box core was identified using the 'Central Feature' tool (Euclidean distance), and buffers were created using the 'Buffer' tool, in ESRI ArcGIS 10.1.

The *phylostruct* function of the R package 'picante 1.6-2' (Kembel et al., 2014) was used to test for phylogenetic structure across all box cores and within the box core subsets. 'Phylogenetic Species Variability' (PSV) (Helmus et al., 2007a) was calculated for each box core retained in the dataset based on a phylogenetic covariance matrix describing anticipated covariance between the sampled genera in the values of a hypothetical trait under 'Brownian motion' evolution. This provides a means to translate a phylogeny into a statistical measure of phylogenetic relatedness (Garland and Ives, 2000, Helmus et al., 2007a, Helmus et al., 2007b). PSV was selected as the metric of phylogenetic dispersion since it represents a pure measure of phylogenetic signal not confounded by species richness or abundance. It also has advantageous statistical properties when used in permutation tests for phylogenetic structure (Helmus et al., 2007a, Helmus et al., 2007b). Permutation tests were used to determine whether the average PSV value of all box cores was significantly different from that expected given two null hypotheses – 'Null 1' and 'Null 2' – (outlined by Helmus et al. (2007a)). 'Null 1' assumes that each box core sample consists of a random draw of taxa from the available taxa pool – i.e. no phylogenetic structure is present in either taxa prevalence (the number of box cores each taxon is present in), or assemblage composition (the co-occurrence of taxa in a box core after taking into account their prevalence) (Helmus et al., 2007b). 'Null 1' achieves this by randomising taxon presence within box core assemblages (Kembel et al., 2014). 'Null 2' assumes that each box core assemblage consists of a random draw of taxa from the available taxa pool given their prevalence among the box cores – i.e. there is no phylogenetic structure present in assemblage composition (Helmus et al., 2007b). It achieves this by randomising taxon occurrences between box cores (Kembel et al., 2014). By testing both of these hypotheses,

one can determine whether any phylogenetic structure is the result of differences in the prevalence of taxa, or differences in the probability of co-occurrence of related taxa. The box core assemblage matrix was permuted under each of these null hypotheses to give 100000 permutation datasets. For each permutation dataset, average PSV was calculated, generating a null distribution against which the average box core PSV value could be compared.

2.3.5 Testing for functional structure

Functional structure was investigated both across all box core samples, and within the subsets of samples, using the constructed functional dendrogram (Figure 2.3) and family-level assemblage matrix. Again, box cores 250 and 350 were removed from the analysis.

Since functional dendrograms and phylogenies are analogous in form (Petchey and Gaston, 2007) they can, theoretically, be analysed using identical mathematical methodology. Thus identical methodology was employed as outlined above for the testing of phylogenetic structure.

2.4 Results

2.4.1 Phylogenetic structure

In total, 20245 specimens of peracarid crustacean were identified, representing 74 families and 177 genera. Considering the distribution of these genera across all box cores and their relatedness as described by the constructed supertree (figures 2.1, 2.2 and A8.1), use of the metric PSV indicates that these benthic peracarid assemblages are composed of genera that are more closely related, on average, than would be expected by chance. Both Null 1 and Null 2 hypotheses can be rejected: mean $PSV_{observed}$ = 0.87282, mean $PSV_{Null\ 1}$ = 0.88170; probability mean $PSV_{observed}$ taken from null 1 distribution = <0.001 (Figure 2.4). Mean $PSV_{Null\ 2}$ = 0.88297; probability mean $PSV_{observed}$ taken from the null 2 distribution = <<<0.0001 (Figure 2.4). Thus, the sampled assemblages exhibit under-

dispersion, and there is no evidence for competitive interactions playing a role in structuring these assemblages. Similar results were obtained for all data subsets analysed.

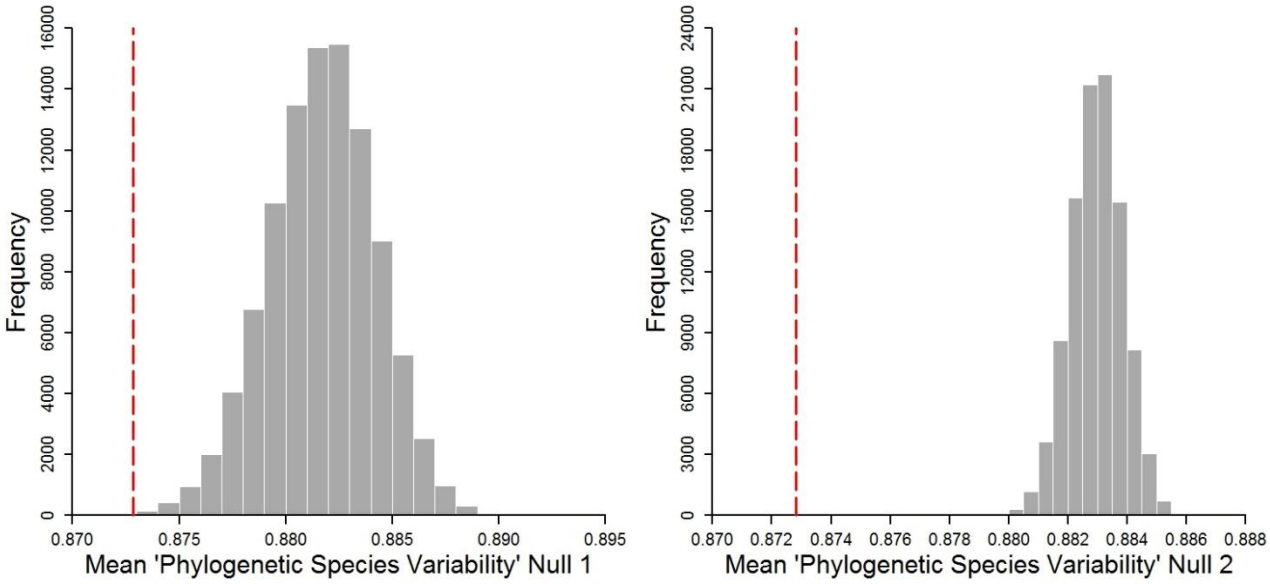


Figure 2.4: Contrast of observed (red line) and null distribution (histogram) of average 'Phylogenetic Species Variability' values for NEREIDA box core peracarid assemblages given phylogenetic relationships specified by the supertree chronogram of Peracarida (figures 2.1, 2.2 and A8.1).

2.4.2 Functional structure

Based on the distribution of peracarid families amongst the box cores and their functional similarity as described by the constructed functional dendrogram (Figure 2.3), use of the metric PSV (or 'Functional Species Variability' (FSV) as in this case) indicates that benthic peracarid assemblages in the sampling region are composed of families that are, on average, more functionally similar to one another than would be expected by chance. Both Null 1 and Null 2 hypotheses can be rejected: mean $FSV_{observed}$ = 0.82198, mean $FSV_{Null\ 1}$ = 0.83543; probability mean $FSV_{observed}$ taken from null 1 distribution = <<<0.0001 (Figure 2.5). Mean $FSV_{Null\ 2}$ = 0.82586; probability mean $FSV_{observed}$ taken from the null 2 distribution = <<<0.0001 (Figure 2.5). Thus, assemblages appear to be functionally under-dispersed, and provide no evidence that competition is a significant factor determining assemblage structure. Similar results were obtained for all data subsets analysed.

Additionally, that mean $FSV_{Null\ 2}$ is closer to the mean $FSV_{observed}$ than mean $FSV_{Null\ 1}$ is (Figure 2.5) suggests that some of the observed under-dispersion is the result of differences in the prevalence of taxa, with those taxa that are more prevalent being more functionally similar to each other than average. Since the opposite pattern is found in the supertree analysis (Figure 2.4), it suggests that some convergence of functional traits between relatively distantly related taxa is occurring.

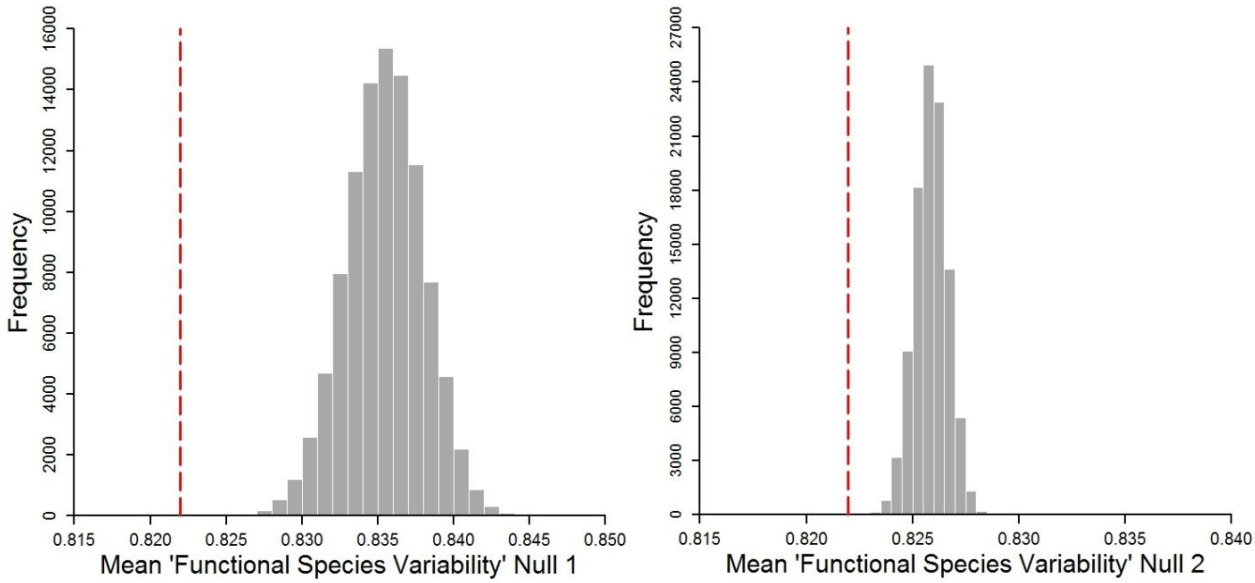


Figure 2.5: Contrast of observed (red line) and null distribution (histogram) average 'Functional Species Variability' values for NEREIDA box core peracarid assemblages given functional similarity specified by the functional dendrogram of Peracarida (Figure 2.3).

2.5 Discussion

This study aimed to test the hypothesis that competition is not a significant structuring agent in deep-sea benthic macrofaunal assemblages. It achieved this via the application of community phylogenetic methodology, and in doing so, represents the first example of such an approach for deep-sea macrofaunal assemblages. The results of these analyses strongly support this hypothesis at the spatial scales investigated. Indeed, they unambiguously point towards an under-dispersion of these assemblages at the taxonomic resolution analysed. Thus it can be concluded that peracarid crustaceans on the continental slopes of the Northwest Atlantic form assemblages that are more similar to one another (in phylogenetic

and functional senses) than would be expected if competition were a significant structuring agent. Further, that two independently collected datasets describing different facets of taxa similarity (phylogenetic vs. functional) produce similar results (figures 2.4 and 2.5) affords great confidence in this conclusion.

Comparison of these results with other studies also employing the PSV metric of Helmus et al. (2007a) suggests that the observed phylogenetic signal is comparably strong or stronger than that reported for non-marine communities, including underdispersed (Helmus et al., 2007a)/neutral (Helmus et al., 2007b) temperate lake fish assemblages, underdispersed/neutral (depending on disturbance regime) temperate plant assemblages (Dinnage, 2009), underdispersed/neutral (depending on water availability) tropical plants assemblages (Umaña et al., 2012), underdispersed/overdispersed (depending on habitat) archaea assemblages (Auguet et al., 2009) and underdispersed/neutral (depending on spatial scale) tropical bird assemblages (Gómez et al., 2010).

Under-dispersed assemblages are characterised by a greater similarity of constituent taxa than would be expected by chance. This is a product of the selection of particular phenotypic traits that are shared by relatively closely related assemblage members (Webb et al., 2002). The selecting agent in this case is the abiotic environment, with taxa persistence being determined by their physiological tolerances (Webb et al., 2002, Cavender-Bares et al., 2004, Vamosi et al., 2009). This process is known as 'environmental' or 'habitat' filtering.

Thus, the results of this study emphasise the importance of the abiotic environment in structuring deep-sea assemblages, and hint that deep-sea organisms may be highly sensitive to their environment. The identity of these environmental drivers is analysed in detail in chapters 3 and 4 (also see sections 6.1 and 6.2).

That competition is of limited importance in structuring deep-sea benthic assemblages is in agreement with the opinions of Wilson (1990) and Grant (2000), and the investigations of Rex and Waren (1981), Levin et al. (2013) and Quattrini et al. (2017). It is particularly notable that similar conclusions were drawn, for the depths studied (582 m to 2294 m) by Rex and Waren (1981); based on species:genus ratios, Rex and Waren (1981) also found evidence of environmental filtering in gastropod assemblages at continental slope depths.

Conversely, the results of this study challenge the views of Rex (1976, 1981), who argues that biological interactions are of upmost importance in structuring deep-sea communities, and are at odds with the investigations of McClain (2005) and Laakmann et al. (2009). However, it is important to note that the results of McClain are confounded by a concomitant positive correlation between species richness and apparent over-dispersion of gastropod shell morphology, the author failing to unlink this from the relationship between competition and the level of morphological dispersion in the gastropod assemblages. It is also not insignificant that the study of Laakmann et al. was conducted in a pelagic environment; it may be the case that the drivers of community structure differ between pelagic and benthic habitats.

Significantly, this study shows broad agreement with the fundamental prediction of the Stability-Time Hypothesis (Hessler and Sanders, 1967, Sanders, 1968), that is, that competitive interactions in current deep-sea communities are weak. There are, however, subtle differences between the STH and this study in the proposed mechanisms behind this observed situation. The STH predicts limited competition in deep-sea communities to be a by-product of lavish niche differentiation over geological time in a stable environment. Species have evolved to fill very narrow niches, limiting the extent of ecological overlap between taxa. Hence the hypothesis places greatest emphasis on evolutionary processes in explaining modern-day attributes of deep-sea communities. In contrast, here I suggest that the observed limited role of competition can be explained by consideration of ecological factors; an apparent limited importance of competition in structuring assemblages may

reflect a relatively enhanced role of environmental filtering, with the prevailing abiotic conditions being the dominant consideration in community assembly. In other words, it is not solely fine-scale niche differentiation, but rather a greater relative importance of the abiotic environment, compared to the biotic, that leads to the observed signal of the under-dispersion of deep-sea benthic assemblages at the spatial scales investigated. This, in turn, may hint at particularly high beta diversity amongst deep-sea environments, potentially promoting high gamma diversity globally in the deep sea.

That this analysis provides some evidence for the functional convergence of relatively unrelated taxa is also of interest. This is apparent in the topology of the functional dendrogram (Figure 2.3), and is also reflected in the analyses conducted (see Section 2.4.2 and figures 2.4 and 2.5). Some of these convergences are already well recognised amongst taxonomists – for instance, the general functional similarity of caprellid amphipods and arcturid isopods, and between Cirolanidae (Isopoda) and Lysianassidae (Amphipoda). However, other apparent convergences of functional traits are more unexpected. Examples include the apparent similarity of Nannastacidae (Cumacea) and Leptanthuridae (Isopoda), Desmosomatidae (Isopoda) and tanidacean families including Agathotanaidae and Anarthruridae, Stenothoidae (Amphipoda) and generally physically small isopod families like Haploniscidae and Munnidae, Janiridae (Isopoda) and Stegocephalidae (Amphipoda), and Janirellidae (Isopoda) and Pardaliscidae (Amphipoda).

It is not currently possible to demonstrate that the same conclusions would be made were this analysis to be repeated at species level (also see Section 6.3.1). At present, the taxonomic, phylogenetic and functional data available are prohibitive of a species-level analysis. However, that this analysis is based on higher-level taxonomic data produces interest in itself. There is some evidence to suggest that environmental filtering is of greatest strength when higher taxonomic levels are considered, with competitive forces only becoming evident at species level (Cavender-Bares et al., 2004, Cavender-Bares et al., 2006, Swenson et al., 2006). Here, environmental filtering selects for evolutionary

conserved traits that occur at higher taxonomic levels, whilst competitive sorting of taxa only becomes relevant at lower taxonomic levels. The results of this study produce no evidence to contradict this theory.

Finally, it should be noted that there are natural circumstances where not only environmental filtering, but also competitive interactions can produce patterns of under-dispersion in assemblages. Vamosi et al. (2009) and Mayfield and Levine (2010) note that if traits that confer high competitive ability are conserved within a lineage, then members of that lineage may be overrepresented within assemblages, with under-dispersion of the communities resulting. This leads to the preposition that in some circumstances competition may be more intense between ecologically dissimilar taxa (Mayfield and Levine, 2010). The key point here is that those traits that confer relatively high competitive ability must be phylogenetically conserved for under-dispersion to result. As the traits that are most important in determining competitive ability in the assemblages analysed here are not known, the strength of their phylogenetic signal cannot be determined. However, that there is some evidence for the convergence of functional traits between relatively distantly related members of these assemblages suggests that not all traits are phylogenetically conserved amongst peracarid taxa. Thus, if the competitive scenario proposed by Vamosi et al. and Mayfield and Levine is occurring in the assemblages analysed here, it seems that it is, at least, not the sole driver of the observed under-dispersion.

2.6 Concluding statement

The results of this analysis strongly suggest that, at the taxonomic and spatial scales investigated, competitive forces are of limited importance in structuring deep-sea assemblages relative to the influence of the abiotic environment. Such a conclusion supports the fundamental prediction of the Stability-Time Hypothesis; that competitive interactions in present-day deep-sea communities are weak.

However, whilst Hessler and Sanders (1967) propose an evolutionary explanation for this, assuming that environmental conditions in the deep sea are stable over geological time,

here, I suggest that the observed limited role of competition in structuring deep-sea assemblages is instead a reflection of ecological factors, with a dominant role of variation in the abiotic environment relative to the biotic resulting in the observed signal of assemblage under-dispersion. An implication of this conclusion is that the organisms that constitute deep-sea communities may be highly sensitive to environmental variation. The identity of the key physical environmental drivers shaping deep-sea peracarid assemblages is investigated in Chapter 3.

2.7 Literature cited

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Chapter 3

'Influence of the physical environment on deep-sea peracarid communities: refining prevailing paradigms'

3.1 Abstract

Oceans represent Earth's largest biome, and deep-sea benthic environments cover more than 90 % of seafloor area. Such a huge area hosts a great diversity of species, and the actions of these taxa contribute to the provision of ecosystem services of global importance. It is concluded in Chapter 2 that deep-sea peracarid assemblages are underdispersed, suggesting that the physical environment is more important than biological interactions in shaping these communities over large spatial scales. However, knowledge of how deep-sea macrofaunal communities relate to their physical environment is poor. This study refines and extends the work of Levin et al. (2001) by considering an expanded suite of faunal metrics, and an increased number of environmental factors. Physical habitat characteristics and heterogeneity, sediment characteristics, food availability, near-seabed current speed, physical disturbance, temperature and seasonality are all found to significantly influence benthic continental slope peracarid communities in the Northwest Atlantic, but often in a complex manner. Of particular interest, topographic elevation relative to surrounding areas is found to influence assemblage attributes, whilst a negative relationship between habitat heterogeneity and a number of faunal metrics is revealed, this perhaps reflecting the generally poor dispersal ability of peracarid taxa. Broad-scale sediment characteristics are found to relate significantly with assemblage attributes, but particle size diversity is found to be less influential. Relationships between food availability and faunal metrics are complex and variable depending on the proxy for food availability considered. Relationships between current speed and assemblage characteristics reflect accepted paradigms, and the results of this study restate past findings of seasonality and inter-year variability in deep-sea benthic macrofauna. With relevance to the management

of deep-sea benthic habitats, high trawling intensity is found to be associated with reduced assemblage evenness, diversity and functional variability, but slightly elevated abundance values. This may reflect direct disturbance impacts, alterations to sediment carbon cycles, signatures of prey release, or a combination of these three. Variation in temperature is also found to influence macrofaunal assemblages, with reduced faunal biomass, phylogenetic richness and phylogenetic variability, and altered assemblage structure under elevated temperature values. Future increases in deep-sea temperature, as a result of climate change, may supress the carbon storage potential of this vast environment.

3.2 Introduction

With a volume of more than 1.34 billion km^3, and an area of over 440 million km^2 (Costello et al., 2010, Danovaro et al., 2014), oceans represent Earth's largest biome. Of this, the deep sea represents 99 % of total water volume and covers more than 90 % of seafloor area (Costello et al., 2010). This huge area houses significant reservoirs of biodiversity, and the deep sea is thought to contribute greatly to a total marine richness of 0.5 – 1.5 million species (Mora et al., 2011, Appeltans et al., 2012, Costello et al., 2012) (see Section 1.2.1).

Biodiversity has been demonstrated to be positively linked to ecosystem functioning and the provision of ecosystem services (Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006) (see Section 1.5.1). In the deep sea, key ecosystem services include climate regulation, nutrient cycling, detoxification, food provision, habitat provision, bioprospecting options for potential pharmaceuticals, and cultural services (see Snelgrove (1999), Armstrong et al. (2012), Thurber et al. (2014), Levin et al. (2016), and references therein). Deep-sea peracarid communities are likely shaped predominantly by variation in their physical environment (see Chapter 2), and so knowledge of the relationships between faunal assemblages and aspects of their physical environment is highly relevant to the understanding of the provision of ecosystem services by deep-sea communities.

Levin et al. (2001) presented a conceptual model (Figure 3.1) summarising the then current knowledge of the relationship between deep-sea taxonomic richness and a selection of environmental variables (outlined below). At the time, evidence for the detailed form of this model was generally limited to small-scale observational and theoretical studies considering a limited number of environmental variables. Indeed, more than 15 years on, there is still a notable lack of published studies considering a large number of biological and environmental variables sampled over an extended geographic range and employing rigorous statistical techniques (see Section 6.2). Here, the study of Levin et al. (2001) is utilised as an anchor upon which to tether an updated discussion, based on novel analyses and considering a broader range of biological and environmental variables.

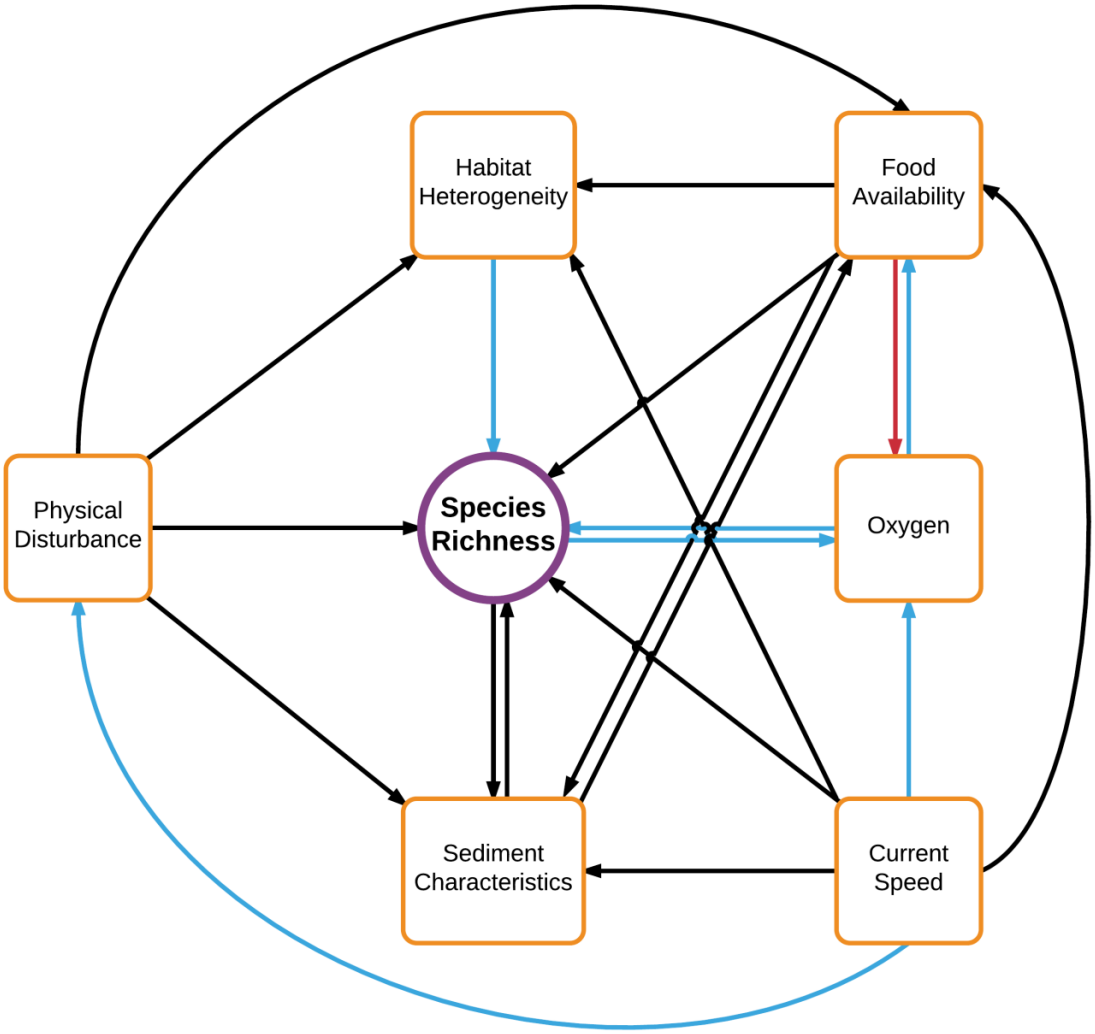


Figure 3.1: Conceptual model, specified by Levin et al. (2001), indicating the direct and indirect links between various environmental parameters (orange) and the taxonomic richness of deep-sea communities (purple). Colour of arrow represents form of relationship: blue = positive, red = negative, black = complex (e.g. 'U' shaped or uni/multi-modal).

3.2.1 Habitat heterogeneity

The importance of habitat heterogeneity over multiple spatial scales in promoting high diversity in deep-sea benthic communities is generally recognised, this stemming from work in shallow water and terrestrial realms (e.g. Heck Jr and Wetstone (1977), Tews et al. (2004)). Reflecting this, Levin et al. (2001) specified a direct positive relationship between the two variables in their conceptual model (Figure 3.1). However, efforts to quantify the details of this association in the deep sea have been limited (Levin et al., 2010), with only a handful of studies considering it in detail (Cordes et al., 2010, Vanreusel et al., 2010).

Broad-scale benthic habitat heterogeneity in the deep sea (over hundreds to thousands of metres) is believed to peak at mid-slope depths along continental margins. Here, canyons, cliffs, banks, ridges, mounds, gullies and broad slopes can all be found within a relatively limited spatial area, leading Levin et al. (2010) to describe continental margins as "*some of the most heterogeneous and dynamic real-estate on the planet*".

As well as physical heterogeneity, variability in habitat represents a proxy for differences in a number of additional environmental factors, with, for example, sediment characteristics, food availability, current speeds, oceanographic variables, and natural and anthropogenic disturbance differing between distinct bathymetric features. Thus, different geological environments (e.g. canyons vs banks) have been proposed to support contrasting faunal communities (Buhl-Mortensen et al., 2010, Levin et al., 2010, Duffy et al., 2014).

Studies to date considering the relationship between broad-scale habitat variation and benthic faunal attributes have generally focussed on canyon systems. For example, Vetter and Dayton (1998) reported raised macrofaunal density and biomass, and altered diversity patterns and community structure in Scripps and La Jolla canyons off California, relative to surrounding slope habitats. De Leo et al. (2010) documented elevated biomass of benthic infauna, epifauna, and fishes in Kaikoura Canyon off New Zealand, compared to surrounding

slopes. Both of these studies link these biological signatures of canyon habitats to their tendency to entrain organic detritus.

At a much smaller scale (centimetres to metres), heterogeneity in sediment particle size has been demonstrated to correlate positively with macrofaunal and meiofaunal diversity metrics (Etter and Grassle, 1992, Leduc et al., 2012b, Pape et al., 2013). This relationship may reflect interspecific differences in particle size preferences between sediment dwelling taxa (Etter and Grassle, 1992, Flach and Thomsen, 1998, Leduc et al., 2012b).

This study considers broad-scale habitat heterogeneity based on measures of seafloor rugosity and elevation relative to surrounding regions and geological categorisation of the study area, whilst sediment particle size diversity (PSD) is represented by the metric proposed by Etter and Grassle (1992) (see sections 3.3.2.1 – 3.3.2.3).

3.2.2 Sediment characteristics

In addition to the heterogeneity of sediment particle size classes, differences in the relative contribution of particle size classes to the sediment as a whole are also thought to influence deep-sea benthic assemblages. The characteristics of sediments can determine a suite of secondary factors relevant to benthic assemblages, including oxygen concentration, ease of burrow/tube construction, level of physical support provided, and identity of effective feeding strategies. Average sediment grain size also gives an indication of typical current speeds. As such, many morphological, physiological and behavioural adaptations of benthic taxa can be related to sediment properties (Johnson, 1971). For example, deposit feeding is common amongst benthic macrofauna (Whitlatch, 1981, Etter and Grassle, 1992), and 84 % of peracarid taxa sampled in this investigation utilise this feeding strategy at least occasionally (Appendix 4). In shallow water, there is evidence for a high selectivity by deposit feeders for particular sediment particle sizes (Fenchel, 1975, Fenchel et al., 1975, Taghon, 1982, Self and Jumars, 1988), and variability in sediment characteristics may drive turnover in benthic diversity, functional attributes, and community structure (Biernbaum,

1979, Cooper et al., 2011). In the deep sea, passing reference has been made to the influence of different particle size classes on benthic communities (e.g. Barrio Froján et al. (2012)), but there has been no detailed discussion of this environmental facet to date, to the best of my knowledge, beyond the sediment PSD work cited above.

In this study, sediment characteristics are represented by the percent sand/silt/clay fractions of sub-core samples (see Section 3.3.2.3).

3.2.3 Food availability

Investigation of the quantity (rate and regularity) and quality of organic material being delivered to the seabed has been the subject of much research effort, and is considered as one of the most fundamental factors shaping deep-sea benthic communities. For instance, it has been demonstrated to have a controlling influence over faunal abundance, biomass, diversity, body size, oxygen consumption and community composition (Gooday et al., 1990, Flach and Thomsen, 1998, Ruhl and Smith, 2004, Rex et al., 2006, Johnson et al., 2007, Smith et al., 2008, Corliss et al., 2009, Leduc et al., 2012a, Smith et al., 2013, Pilditch et al., 2015, Woolley et al., 2016). Indeed, temporal changes in surface phytoplanktonic communities can have considerable influence over ecological processes in the deep sea, often with surprisingly little time-lag (Graf, 1989, Ruhl and Smith, 2004, Smith et al., 2006, Johnson et al., 2007, Corliss et al., 2009, Billett et al., 2010, Smith et al., 2013).

Levin et al. (2001) specified a unimodal relationship between food availability and taxonomic richness; if food availability is low, diversity is depressed as a result of insufficient resources to support viable populations of species, and, when food availability is high, diversity is depressed because of a combination of reduced habitat heterogeneity and increased species dominance. Hence, diversity is proposed to be maximal at intermediate levels of food availability, this conforming with the terrestrially-developed 'Intermediate Productivity Theory' of Grime (1973). Cosson-Sarradin et al. (1998) invoked this theory in explaining a parabolic diversity/depth relationship for polychaetes in the East

Atlantic, and Leduc et al. (2012a) found evidence for a unimodal relationship between nematode biomass (used as a proxy for food availability) and species richness off New Zealand.

In this study, food availability is represented by a selection of complementary proxies, including sediment carbon content, surface chlorophyll *a* and particulate organic carbon (POC) concentrations, and modelled delivery of POC to the seafloor (see sections 3.3.2.4 – 3.3.2.5).

3.2.4 Current speed

The relationship between near-bottom current regimes and benthic faunal attributes is complex, since currents can directly influence fauna, as well as indirectly shape multiple other aspects of the environment.

At the lowest magnitudes of current speed, rates of food delivery, as well as oxygen concentrations, may be limiting, potentially depressing faunal abundance and diversity (Levin et al., 2001). At moderate current speed, however, macrofaunal abundance and diversity may be enhanced because of increased delivery of organic material to a site (Levin et al., 2001), assuming that food concentrations are not excessive. For example, Thistle et al. (1985) and Reidenauer and Thistle (1985) reported an anomalously high abundance of peracarid crustaceans on the Nova Scotian Rise, and attributed this to elevated food delivery associated with relatively strong currents. Moderate currents may also promote the dispersal of fauna via the entrainment of larval and sub-adult individuals, potentially augmenting alpha diversity, whilst varied flow conditions can increase sediment heterogeneity via the creation of numerous flow structures (Aller, 1989). Under excessive current flow, such as can occur during benthic storms, faunal abundance and diversity may be depressed as a result of the erosion of surface sediments (sometimes including their fauna), homogenisation of sediment structures, and suppression of succession (Levin et al., 2001). For instance, Gage et al. (1995) and Gage (1997) reported polychaete diversity to be

highest at tranquil sites on the Tagus Abyssal Plain and in the central North Pacific, lower in the Rockall Trough and in the hydrodynamically active Sebutal Canyon, and much reduced at the HEBBLE site off Nova Scotia, which experiences the highest flow regimes. Considering this, Levin et al. (2001) promoted a unimodal relationship between current speed and faunal diversity.

In this study, current speed is estimated both over short (annual) and long (decade) time frames (see Section 3.3.2.6).

3.2.5 Physical disturbance

The 'Intermediate Disturbance Hypothesis' of Connell (1978) claims that the relationship between disturbance frequency/magnitude and faunal diversity is unimodal in form. At low levels of disturbance, it is proposed that diversity is reduced as a result of low habitat heterogeneity and high faunal dominance (Connell, 1978, Hobbs and Huenneke, 1992). Periodic physical disturbance of intermediate intensity (for instance, as a result of the activity of mobile megafauna, or episodically raised current speeds) can, however, create a mosaic of habitats at varying stages of community recovery (Huston, 1979, Kukert and Smith, 1992, Gage, 1996), enhancing diversity (Connell, 1978). However, as disturbance frequency and magnitude increase further, environmental conditions may exceed the tolerances of the majority of species, resulting in a depauperate community (Connell, 1978, Hobbs and Huenneke, 1992, Levin et al., 2001). For instance, polychaete diversity in North Atlantic deep-sea sites has been shown to peak at intermediate disturbance levels (Paterson and Lambshead, 1995, Cosson-Sarradin et al., 1998).

Commercial bottom trawling represents a substantial form of disturbance to continental slope benthic communities, and has been associated with considerable incidental damage and/or removal as by-catch of benthic fauna (see Section 1.3.2). Thus, deep-sea bottom trawling is claimed to result in habitat modification (e.g. damage to VMEs) and related changes to benthic community structure, and reductions in the biomass and diversity of

associated benthic communities (Koslow and Gowlet-Holmes, 1998, Koslow et al., 2001, Hall–Spencer et al., 2002, Anderson and Clark, 2003, Clark and Rowden, 2009, Barrio Froján et al., 2012, Pusceddu et al., 2014). Further the physical action of bottom trawling can lead to smoothing of the seafloor over large spatial scales (Clark and Rowden, 2009, Puig et al., 2012). The net result of these impacts is an overall reduction of habitat heterogeneity with increasing trawling pressure (Rogers et al., 2008, Clark and Rowden, 2009).

In this study, the intensity of bottom trawling is employed as a metric of the frequency of high-magnitude disturbance events (see Section 3.3.2.7). High trawling intensity is hypothesised to alter community structure and negatively impact the abundance, biomass and diversity of benthic macrofauna.

3.2.6 Temperature

Temperature represents a fundamental factor shaping biological communities because of its powerful control on the metabolic rate of organisms (Brown et al., 2004, Widdicombe and Somerfield, 2012). It has direct importance in determining faunal diversity, distributions, recruitment, growth rate and species interactions in the marine realm (Danovaro et al., 2004, Perez-Rodriguez et al., 2012, Widdicombe and Somerfield, 2012, Poloczanska et al., 2013, Ashford et al., 2014, Yasuhara and Danovaro, 2014, Woolley et al., 2016), and has been shown to have a significant influence on deep-sea macrobenthic communities in multiple systems (Yasuhara et al., 2008, Barrio Froján et al., 2012, Yasuhara and Danovaro, 2014, Yasuhara et al., 2014).

Consideration of the influence of temperature on deep-sea communities has relevance to discussion of the impacts of climate change (see Section 1.3.4). Increasing deep-sea temperatures may increase metabolic rate and potentially reduce food availability, so reducing faunal biomass (Jones et al., 2014). Importantly, the relative thermal stability of the deep oceans may mean that many deep-sea species are less tolerant of changing temperatures than shallow-water species are (Tewksbury et al., 2008, Howes et al., 2015,

McCauley et al., 2015). However, the potential impacts of rising seafloor temperature on deep-sea macrofauna have yet to be investigated on a large scale (Yasuhara and Danovaro, 2014, Sweetman et al., 2017), and the association between temperature and faunal diversity was not considered by Levin et al. (2001). Based on the investigation of both contemporary and ancient seafloor communities, Yasuhara and Danovaro (2014) propose a unimodal relationship between temperature and diversity, and this forms the hypothesis for the current investigation. In this study, temperature is determined both over short (year) and long (decade) time frames.

This chapter aims to update and extend our knowledge of the relationships between the physical environmental factors listed above and deep-sea macrobenthic communities. Twelve aspects of benthic continental slope peracarid assemblages are investigated, including taxonomic measures of diversity and community structure, assemblage abundance and biomass, and both phylogenetic and functional facets of biodiversity (see Table 3.1).

3.3 Methods

3.3.1 Peracarid community metrics

Details of NEREIDA box core collection methods and peracarid identification are given in Section 2.3.1. Additionally, total wet biomass of Peracarida for each box core was recorded to an accuracy of 0.0001 g by the Institute of Estuarine and Coastal Studies (IECS), University of Hull, UK, with spirit-preserved individuals being blotted dry prior to weighing. Metrics of biomass were refined after formal specimen identification by taking the wet biomass of any non-peracarid material erroneously retained in the samples; these values were removed from the original biomass metrics to obtain total peracarid wet biomass per sample (g).

A series of faunal metrics describing various facets of peracarid assemblages were calculated for each box core (see Table 3.1) using values of peracarid abundance and biomass coupled with genus- and family-level composition data (see Section 2.3.1).

3.3.1.1 Taxonomic community metrics

Taxonomic richness, the most commonly employed metric of taxonomic diversity (Magurran, 2013), was calculated as the number of peracarid genera per box core sample using Microsoft Excel 14.0. Further, Rao's Quadratic Entropy (which simplifies to Simpson's diversity (1-D) for the case of taxonomic diversity) and Shannon's diversity per box core were calculated, based on the genus-level assemblage composition matrix (Appendix 2), in R 3.0.2 (R-CoreTeam, 2013) using the packages 'SYNCSA 1.3.2' (Debastiani, 2015) and 'vegan 2.0-9' (Oksanen et al., 2013), respectively. These provided two alternative metrics of taxonomic diversity that take into account the relative abundances of sampled taxa.

3.3.1.2 Phylogenetic community metrics

Metrics of phylogenetic diversity were calculated for each box core based on the computed supertree of Peracarida (see Section 2.3.2 and figures 2.1, 2.2 and A8.1) and genus-level assemblage composition matrix. The amphipod genus *Argissa* (one individual in box cores 76, 200 and 248, respectively) was removed from the assemblage composition matrix as it was not represented in the supertree. The metrics 'Phylogenetic Species Variability' (PSV) (see Chapter 2), 'Phylogenetic Species Richness' (PSR) and 'Phylogenetic Species Evenness' (PSE), developed by Helmus et al. (2007), were calculated in R 3.0.2 (R-CoreTeam, 2013) using the package 'picante 1.6-2' (Kembel et al., 2014). These metrics facilitate the calculation of phylogenetic variability within communities, and the incorporation of phylogenetic information into measures of taxonomic richness and taxonomic evenness (which additionally takes into account the relative abundances of taxa in assemblages) under a single theoretical framework.

3.3.1.3 Functional community metrics

Inspired by the work of Petchy and Gaston (2002, 2006, 2007), metrics of functional diversity were calculated for each box core based on the computed functional dendrogram of sampled Peracarida (see Section 2.3.3 and Figure 2.3) and family-level assemblage composition matrix. To promote consistency in methodology, and, since functional dendrograms and phylogenies are analogous in form (Petchey and Gaston, 2007), the metrics 'Phylogenetic Species Variability', 'Phylogenetic Species Richness' and 'Phylogenetic Species Evenness' (Helmus et al., 2007) were calculated in R 3.0.2 (R-CoreTeam, 2013) using the package 'picante 1.6-2' (Kembel et al., 2014). In this case, these metrics facilitate the incorporation of functional information into measures of taxonomic richness and taxonomic evenness (which additionally takes into account the relative abundances of taxa in the assemblage) under a single theoretical framework. To avoid confusion with the measures 'PSV', 'PSR' and 'PSE' calculated from the supertree, I shall refer to the diversity measures calculated from the functional dendrogram as 'Functional Species Variability' (FSV), 'Functional Species Richness' (FSR) and 'Functional Species Evenness' (FSE) henceforth.

Table 3.1: Details of peracarid assemblage metrics analysed in this chapter.

Peracarid assemblage metric	Details
Abundance	Total number of peracarid individuals per box core
Biomass	Total biomass of peracarids per box core
Richness	Total number of peracarid genera per box core
Rao Quadratic Entropy	Taxonomic diversity measure taking into account both the number of peracarid genera per box core and their relative abundances. Simplifies to Simpson's diversity (1-D) for the case of taxonomic diversity. Here represents the probability that two individuals taken from a box core sample will belong to different genera
Shannon Diversity	Taxonomic diversity measure taking into account both the number of peracarid genera per box core and their relative abundances. Here represents a quantification of the uncertainty associated with predicting the taxonomic identity of an individual taken at random from a box core
Phylogenetic Species Variability (PSV)	Measure of the distribution of peracarid genera present in a box core across a dendrogram describing their phylogenetic relatedness. See Helmus et al. (2007)

Peracarid assemblage metric	Details
Functional Species Variability (FSV)	Measure of the distribution of peracarid families present in a box core across a dendrogram describing their functional similarity
Phylogenetic Species Richness (PSR)	PSV multiplied by the richness of peracarid genera per box core. See Helmus et al. (2007)
Functional Species Richness (FSR)	FSV multiplied by the richness of peracarid families per box core
Phylogenetic Species Evenness (PSE)	PSV modified to incorporate the relative abundances of peracarid taxa per box core. See Helmus et al. (2007)
Functional Species Evenness (FSE)	FSV modified to incorporate the relative abundances of peracarid taxa per box core
Community Structure	Taxonomic identity of peracarid taxa present in a box core and their relative abundances

3.3.2 Metrics of the physical environment

3.3.2.1 Bathymetry

The location (latitude and longitude) of each box core sample was recorded to a high degree of accuracy (six decimal places) as collected using the Global Positioning System of the research vessel *Miguel Oliver*. Depth (to the nearest metre) was extracted for each box core location following multibeam bathymetric surveys using a Kongsberg EM 302 30 kHz system. Multibeam bathymetry was gridded to a 75x75 m cell size using ESRI ArcGIS 10.1, and a five-cell neighbourhood mean filter was applied to remove artefacts introduced by the gridding process.

Multibeam bathymetric data was not made directly available for analysis, and instead further bathymetric variables were derived from this grid and provided by Anna Downie (Cefas, Lowestoft) using the Spatial Analyst extension of ESRI ArcGIS 10.1. These included slope, eastness and northness, roughness (3x3 cell window) and standard deviation of bathymetry values (3x3 cell window). Benthic Terrain Modeller (Wright et al., 2012) was used to calculate Bathymetric Position Index (BPI) over a range of radii (outer radii of 25, 50, 75, 100, 125 and 150 cells, inner radius of 1 cell in all cases) as well as seafloor rugosity (5x5 and 25x25 cell windows), this data also being provided by Anna Downie.

3.3.2.2 Geological environment

The sediments of the slopes of the Flemish Cap, Flemish Pass and Grand Banks were classified into the following geological categories based on their acoustic characteristics, depth and slope (determined using Kongsberg EM 302 30 kHz multibeam bathymetric survey and TOPAS PS018 parametric sub-bottom profiler data): shelf-indenting canyon, deep-water canyon (canyon head >400 m water depth), inter-canyon or inter-channel ridge, flat area with abundant iceberg scours and pits, gully, steep flank (>6.4 º slope), thick sediment draped over irregular seafloor, sediment wave, sediment drift, smooth area without evidence of erosion, failed seabed, and rough topography of mass transport debrite (MTD) (see Anon (2011)). The category relating to the location of each box core was recorded, using ESRI ArcGIS 10.1 to aid in data visualisation.

3.3.2.3 Sediment Particle Size Analysis

Sediment particle size analysis was undertaken on box core subsamples (2 cm depth) at the Bedford Institute of Oceanography, Halifax, Canada, in the Geological Survey of Canada (Atlantic) Core Processing Laboratory by Owen Brown and colleagues using a Beckman Coulter LS 230 Laser Diffraction Particle Size Analyser (capable of measuring particles of size 0.04-2000 µm) (Weitzman et al., 2014). Percent clay/silt/sand was calculated for each core subsample based the following particle size categories consistent with the 'Phi' (Φ) scale of Krumbein (1936) – clay: 0.375 µm to <4.241 µm, silt: 4.241 µm to <63.41 µm, sand: 63.41 µm to <2000 µm. Particle size diversity was calculated from the percent dry weight of each Φ size class (12 size classes between -1 and >10 Φ) using the Shannon-Wiener diversity index (calculated in R 3.0.2 (R-CoreTeam, 2013) using the package 'vegan 2.0-9' (Oksanen et al., 2013)) and following Etter and Grassle (1992) and Leduc et al. (2012b).

3.3.2.4 Sediment carbon content

Analysis of the carbon content of box core sub-samples was undertaken at the Bedford Institute of Oceanography, Halifax, Canada, in the Geological Survey of Canada (Atlantic) Core Processing Laboratory by William Leblanc and colleagues. Total carbon and organic

carbon content were determined using a Leco TruSpec CHN analyser, model number 630-100-400. Samples were dried at 60 ^{o}C and ground to a fine homogenous powder prior to analysis. Total carbon measurements were compared with analytical standards intermittently to ensure consistency of analysis (Weitzman et al., 2014). To measure organic carbon, carbonate carbon was first removed from the dried ground samples with dilute acid: approximately 2-3 grams of sediment was placed in a 50 mL Falcon tube with 15 mL of 10 % HCl. This was shaken vigorously using a Vortex-Genie mixer and the sample was left overnight to ensure completion of reaction. The solution was decanted and replaced with 15 mL of distilled water before being shaken again in the vortex mixer. More distilled water was added to bring the total volume in the tube to 50 mL. After settling, the distilled water was decanted and the previous step repeated twice more. Following this, samples were dried completely at 60 ^{o}C before being ground once more. Once the carbonate carbon had been removed, 100 mg of each sample was weighed into a tin foil boat for analysis in the CHN analyser. Inorganic carbon was determined by the difference between the total carbon and organic carbon measurements for each sample (Weitzman et al., 2014).

3.3.2.5 Chlorophyll *a* and Particulate Organic Carbon concentrations

Observed surface chlorophyll *a* and particulate organic carbon (POC) concentrations (mg/m^3) for the NEREIDA study area were obtained from the Giovanni ocean colour radiometry online data system (accessible at http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=ocean_month). Latitude - longitude time averaged MODIS AQUA 4 km resolution data was downloaded for the years 2008, 2009 and 2010, and this was converted into a raster file in QGIS 2.2. All values smaller than zero were masked and the data were interpolated to 2500x2500 pixels (equivalent to a resolution of 525 metres) using the Inverse Distance Weighting method. Values at box core locations for the year prior to sample collection (to account for time lag between production and delivery to the seafloor) and the sample collection year were extracted by Dr Jesse van der Grient using the Point Sampling Tool in QGIS 2.2 and averaged. POC delivery to the seafloor was calculated from

surface POC concentrations following region-specific equations developed by Lutz et al. (2002) (see below). Equations calibrated using observed POC and radiochemically corrected POC values (which aim to correct for under-sampling of POC flux within the mesopelagic zone) were utilised to calculate POC transport to the depth of each box core. Since no equation specific to the Northwest Atlantic region was available, equations calibrated to the Northeast Atlantic and Sargasso Sea were used:

NE Atlantic uncorrected: $POC_{Depth} = POC_{Surface}\, e^{(-(0.008 \times Depth))} + 0.00485$

NE Atlantic Radiochemically corrected: $POC_{Depth} = POC_{Surface}\, e^{(-(0.0044843 \times Depth))} + 0.00481$

Sargasso Sea uncorrected: $POC_{Depth} = POC_{Surface}\, e^{(-(0.0045249 \times Depth))} + 0.0298$

Sargasso Sea Radiochemically corrected: $POC_{Depth} = POC_{Surface}\, e^{(-(0.0098039 \times Depth))} + 0.00617$

3.3.2.6 Oceanographic variables

Seafloor temperature and salinity values were measured at each box core location using a Sea-Bird Electronics 25 Sealogger CTD. This information was incorporated into a modelled monthly average seafloor temperature and salinity data layer (1/12 degree resolution, data between 1990 and 2012) for the whole Flemish Cap, Flemish Pass and Grand Banks area (produced by Wang and Greenan (2014), Bedford Institute of Oceanography, Halifax, Canada). Such a layer was also available for seafloor meridional and zonal current speeds (Wang and Greenan, 2014).

For temperature, salinity and meridional/zonal current speeds, seafloor monthly values were extracted for the study area and averaged across the year prior to box core collection, and across the year of box core collection. These layers were converted to raster files in QGIS 2.2 by Dr Jesse van der Grient before interpolation to 3000x3000 pixels (equivalent to a resolution of 578 metres) using the Inverse Distance Weighting method. Values were extracted at box core locations using the Point Sampling Tool of QGIS 2.2. Absolute current speed was calculated from the extracted meridional and zonal current velocity values using Pythagoras' theorem. These data were then summarised as values for the box core collection year, and an average value for the box core collection year and the

previous year (since the typical lifespan of a peracarid crustacean is one to two years (MarLIN, 2006)). Further, 10 year minimum/maximum values for temperature and current speed, respectively, and 10 year average values for both variables were calculated across the study area by Anna Downie (Cefas, Lowestoft) based on the oceanographic model of Wang and Greenan (2014) to capture longer-term variability. These layers were interpolated to a 75x75 m grid using the Empirical Bayesian Kriging tool in the Geostatistical Analyst extension of ESRI ArcGIS 10.1, and extracted at box core locations using the Extract Values to Points tool in the Spatial Analyst extension of ArcGIS 10.1.

3.3.2.7 Fishing intensity

Two metrics of fishing intensity were produced. The first was based on Vessel Monitoring System (VMS see Section 1.4.4) signal density, using data collected from 2003 to 2012 and provided by NAFO. This dataset was plotted in ArcGIS 10.1 and the Point Density Tool (Spatial Analyst extension) was used to calculate the density of VMS records per km^2 within a set radius (1, 3, or 5 km) from each box core. These values were extracted using the Extract Values to Points tool in the Spatial Analyst extension, with local interpolation option selected.

The second metric of fishing intensity was based on the conversion of time-referenced VMS signal locations (collected from 2008 to 2012 and provided by NAFO) into trawl paths. Only VMS records indicating boat speeds of between 0.5 and 5 knots (inclusive) were utilised as these are typical of active deep-sea bottom trawling operations (Lambert et al., 2011, Campbell and Federizon, 2013, Mangano et al., 2014). Individual trawl paths were identified based on boat identity, speed, location, date and time. The Points to Line Tool in ArcGIS 10.1 (Data Management) was then used to convert the point dataset into a series of trawl paths, and the Line Density Tool (Spatial Analyst extension) was used to measure the total length of trawls per km^2 within a set radius (1, 3, or 5 km) from each box core (Mangano et al., 2014). These values were extracted using the Extract Values to Points tool in the Spatial Analyst extension, with local interpolation option selected.

3.3.3 Statistical analyses

Prior to analyses, box cores 250 and 350 were removed from the dataset since they were erroneously combined during initial sample processing. Missing values in environmental data (0.42 % of values) were replaced with the arithmetic mean of that column as this was deemed preferable to sample deletion.

3.3.3.1 Initial variable selection

The environmental dataset described above was refined to remove all highly correlated variables, since high multicollinearity can have severe effects on the estimation of model parameters (Gunst and Webster, 1975). This was achieved by a two-step process. First, where a number of variables were available for a single facet of environmental variation (e.g. the case of fishing intensity), the variable in that group with the highest Variance Inflation Factor (VIF) was selected to represent that particular environmental facet (since the variable with the highest VIF value will best capture the information present in the alternative variables). Secondly, a round of VIF calculations was undertaken amongst all selected variables from the first step. Variables were removed from the analysis in a stepwise manner (those with highest VIF first) until all variables had a VIF value less than 5 - an accepted cut-off (Stine, 1995). The resulting dataset contained 19 variables describing the physical environment (see Table 3.2). All VIF calculations were undertaken in R 3.0.2 (R-CoreTeam, 2013) using the package 'HH 3.1-32' (Heiberger, 2016).

Table 3.2: Details of the environmental variables retained for analysis following Variance Inflation Factor variable selection.

Environmental facet	Representing variable
Short-term temperature	Modelled seafloor temperature – average for year box core collected (°C)
Long-term temperature	Modelled seafloor temperature – average for 10 years prior to box core collection (°C)
Short-term current speed	Modelled seafloor absolute current speed – average for year box core collected (m/s)
Long-term current speed	Modelled seafloor maximum current speed – maximum value for 10 years prior to box core collection (m/s)
Surface productivity	Surface chlorophyll *a* - MODIS average for year box core collected plus previous year (mg/m^3)
	Surface particulate organic carbon – MODIS average for year box core collected plus previous year (mg/m^3)

Environmental facet	Representing variable
Energy availability at seafloor	Particulate organic carbon at seafloor - Sargasso sea equation (not radionuclide corrected) of Lutz et al. (2002) applied to MODIS surface particulate organic carbon average for year box core collected plus previous year (mg/m^3)
	Percent total carbon content in top 2 cm of box core
	Percent organic carbon content in top 2 cm of box core
Sediment grain size	Percent sand content in top 2 cm of box core
	Shannon sediment particle size diversity in top 2 cm of box core
Geological environment	Geological environment category
Fishing intensity	Trawl density – Total trawl length per km^2 of seafloor between 2008 and 2012 within a 3 km radius of the box core location (Log_{10})
Seafloor topography	Bathymetric position index – value for 125 cell (9375 m) radius window around box core location
	Seafloor rugosity – value for a 25x25 cell (1875x1875 m) window around box core location
	Seafloor roughness – value for a 3x3 cell (225x225 m) window around box core location
Annual and seasonal variation	Collection year – year box core collected (categorical)
	Collection month – month box core collected (categorical)
Variation in collection procedure	Crew identity at time of box core collection (categorical)

3.3.3.2 Construction of Generalised Additive Models (GAMs)

Because initial data exploration revealed a high number of relationships between dependent and independent variables that appeared to be non-linear, individual GAMs were constructed in R 3.0.2 (R-CoreTeam, 2013) using the package 'mgcv 1.7-26' (Wood, 2013a) for each of the 11 univariate metrics of peracarid assemblage composition (i.e. excluding 'Community Structure', see Table 3.1) to determine which combination of the 19 physical environmental variables most effectively explained variance in each biological metric between box cores. Prior to analysis, trawling intensity (3 km radius) was transformed (Log_{10} (x + 1)) to reduce extreme skew in the data. Original measurement scales were retained for all other variables because data distributions were deemed acceptable and in order to simplify the interpretation of model outputs. Further, all box cores with zero abundance of peracarids, and box core 341 (with only one peracarid genus present), were removed.

Full GAMs consisted of all variables contained within Table 3.2, with smoothers added to all continuous variables. The most appropriate error distributions and link functions were selected via consideration of the Akaike Information Criterion (AIC) (Akaike, 1974) (see Table 3.3), and acceptable satisfaction of model assumptions (e.g. normal distribution of residuals and homogeneity of variance of residuals) was investigated using the *gam.check* function of the package 'mgcv 1.7-26' (Wood, 2013a). Where the biological metric was categorical in form ('Abundance' and 'Richness'), over-dispersion was checked for via calculation of the dispersion parameter 'theta' (where theta = residual deviance / residual degrees of freedom), and corrected as appropriate (see Table 3.3). A penalised thin-plate regression spline was used as the smoothing function, and smoothing parameters were optimised automatically on the basis of the Generalised Cross Validation criterion (Wood, 2013a).

Spatial autocorrelation is an important consideration in a correlative study such as this where samples are distributed over a large spatial extent. Model residuals were examined for the signature of spatial autocorrelation via the calculation of Moran's I (Moran, 1950) in R 3.0.2 (R-CoreTeam, 2013) using the package 'ape 3.2' (Paradis et al., 2004). In no cases could the null hypothesis (that no spatial autocorrelation is present within model residuals) be rejected and hence no further action was taken.

The explanatory terms included in each GAM were refined from the full model via backwards stepwise selection by consideration of variable *P*-values and model AIC until a minimum AIC value was reached. At this point, the model was considered optimal (Appendix 9).

Table 3.3: Details of error distribution and link functions used for each Generalised Additive Model constructed.

Peracarid community metric	Error distribution and link function	Comments
Abundance	Negative binomial, log	Negative binomial model structure used as original Poisson model exhibited unacceptable levels of overdispersion (theta >30)
Biomass	Gamma, inverse	
Richness	Quasi-Poisson, identity	Quasi-Poisson model structure used as original Poisson model exhibited an overdispersion parameter value of 2.84
Rao Quadratic Entropy	Gaussian, identity	
Shannon Diversity	Gaussian, identity	
Phylogenetic Species Variability (PSV)	Gaussian, identity	
Functional Species Variability (FSV)	Gamma, identity	
Phylogenetic Species Richness (PSR)	Gamma, identity	
Functional Species Richness (FSR)	Gamma, identity	
Phylogenetic Species Evenness (PSE)	Gaussian identity	
Functional Species Evenness (FSE)	Gaussian, identity	

3.3.3.3 Relation of community structure to physical variables

Relation of peracarid community structure to the physical environment and selection of the most relevant explanatory variables was achieved via Constrained Analysis of Principal coordinates (CAP) (Anderson and Willis, 2003) (based on Bray-Curtis dissimilarity (Bray and Curtis, 1957)) followed by backwards model refinement based on *P*-values using the function *ordistep* in the R package 'vegan 2.0-9' (Oksanen et al., 2013) (10000 permutations, *P*-in = 0.05, *P*-out = 0.1).

Constrained ordination methods explicitly relate a matrix of response variables to a selection of predictor variables. Such an approach facilitates the direct relation of community structure to the physical environment within a single analysis framework

(Anderson and Willis, 2003). CAP has the advantage over other canonical analysis techniques that any distance or dissimilarity measure can be used (Anderson and Willis, 2003).

3.4 Results

Before reporting results, it should be noted that for smoothed terms, *P*-values derived from GAMs are approximate in nature. This is because of complications with the use of smoothing parameters (Wood, 2013b). In recognition of this, some results are presented below for smoothed terms where the *P*-value is above the traditional 5 % cut-off (but below 10 %). Non-significant relationships are not reported unless otherwise stated. Please refer to tables 3.1 and 3.2 for explanations of the biological and environmental metrics analysed, and to Table 3.4 for a summary of results reported.

3.4.1 Habitat heterogeneity

Variation in the geological environment from which a box core was collected was shown to significantly influence peracarid abundance ($P = 0.014$), although this effect couldn't be attributed to a considerable influence of any single geological environment in particular. Geological environment was also found to significantly influence peracarid phylogenetic richness (PSR) ($P = 0.030$), with PSR being significantly elevated ($P = 0.019$) in the rough topography of mass transport debrites relative to the global mean. CAP ordination demonstrates that peracarid assemblage structure is significantly influenced by the prevailing geological environment ($P < 0.001$).

Bathymetric position index (BPI), a measure of the elevation of a point relative to the surrounding region (here defined by a 125 cell (9375 m) outer radius window and a 1 cell (75 m) inner radius window), was found to significantly influence peracarid biomass ($P < 0.001$). Biomass was found to be relatively elevated in cores situated topographically higher than surrounding areas (i.e. on 'ridges'), and relatively reduced in cores

topographically lower than the surrounding region (i.e. in 'valleys'). Further, the model results suggest a possible unimodal relationship between BPI and functional evenness (FSE) (P = 0.081), with FSE peaking at locations that are moderately elevated relative to the surrounding region, whilst a positive relationship was found between BPI and functional variability (FSV) (P = 0.004) (see Figure 3.2). Ordination results demonstrate that BPI influences peracarid assemblage structure (P <0.001), with valleys and ridges being characterised by different peracarid assemblages.

At a smaller spatial scale (25x25 cell window corresponding to dimensions of 1875x1875 m), a negative relationship was revealed between bathymetric heterogeneity (rugosity) and phylogenetic evenness (PSE) (P = 0.038), with PSE declining as rugosity increases. Possible relationships were found between rugosity and functional richness (FSR) (P = 0.082) and PSR (P = 0.077), these being slightly negative in form, and a significant, negative relationship was revealed between rugosity and Rao's Quadratic Entropy (P = 0.031), and possibly between rugosity and Shannon diversity (P = 0.053). Based on the results of the constrained ordination, rugosity was found to significantly influence peracarid assemblage structure (P = 0.002).

At the smallest scale of bathymetric heterogeneity considered (3x3 cell window corresponding to dimensions of 225x225 m), a possible, weakly negative relationship was revealed between roughness and FSE (P = 0.067), and the relationship between roughness and taxonomic richness was also found to be negative (P = 0.032). However, a significant unimodal relationship was found between roughness and FSV (P = 0.047), with FSV values peaking at low to moderate roughness values and steadily declining thereafter (see Figure 3.2).

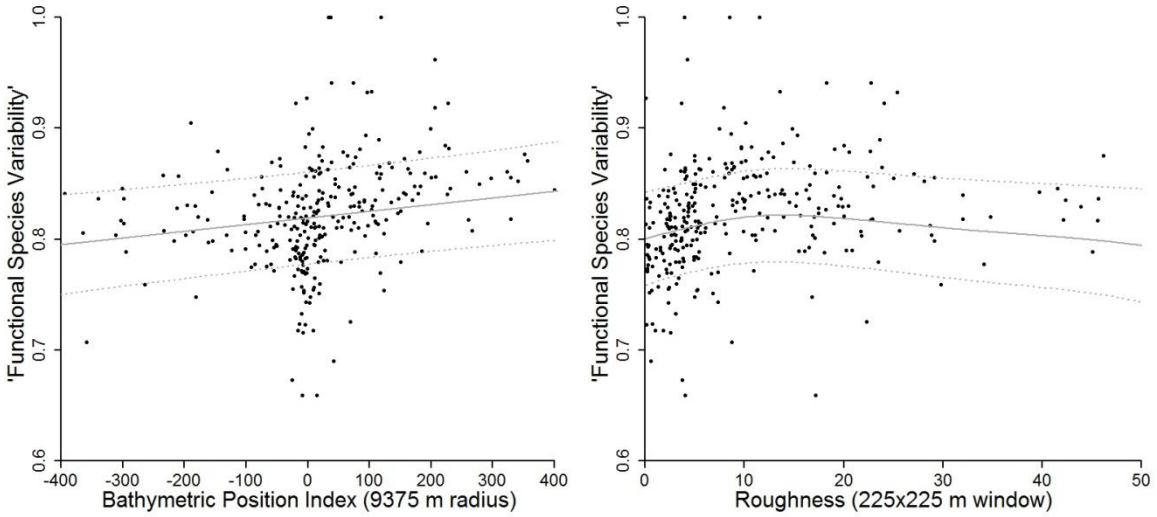


Figure 3.2: Relationship between the 'Bathymetric Position Index' of a box core location (9375 m radius) and the 'Functional Species Variability' of peracarid assemblages contained within (left) and the 'Roughness' of a box core location (225x225 m window) and 'Functional Species Variability' of peracarid assemblages contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

Sediment particle size diversity was found to significantly influence peracarid biomass (P = 0.015). The form of this relationship was found to be complex but positive overall. Further, a possible positive relationship (P = 0.098) between sediment PSD and phylogenetic variability (PSV) was recovered.

3.4.2 Sediment characteristics

Sediment characteristics (percent sand) were found to significantly influence peracarid abundance (P <0.001), with values peaking at both low (~0-15 %), and high (~60-75 %) proportions of sand. Sediment percent sand content was also found to be correlated with a linear increase in FSE (P <0.001) (see Figure 3.3) and possibly PSE (P = 0.073), whilst a possible unimodal relationship between percent sand and Rao's Quadratic Entropy (P = 0.093) was revealed, with diversity peaking at ~60 % sand content. Sediment characteristics were further found to influence taxonomic, phylogenetic and functional metrics of richness. The relationship between percent sand and FSR (P <0.001) is complex (see Figure 3.3), but appears to be double peaked, with maximal FSR at both lower (~8-13 %) and higher (~65-75 %) proportions of sand. The recovered relationship between

percent sand and taxonomic richness (*P* = 0.003) is also double-peaked, with maximal richness at both lower (~8-13 %) and higher (~68-78 %) sand content. With some similarity to this, the relationship between percent sand and PSR (*P* <0.001) is weakly 'U'-shaped, with PSR being at a minimum between ~15 % and ~45 % sand content. The possible relationship between percent sand and PSV (*P* = 0.083) is also 'U'-shaped in form, with PSV being at a minimum between ~18 % and 68 % sand. Using constrained ordination, sediment characteristics were shown to influence peracarid assemblage structure (*P* <0.001).

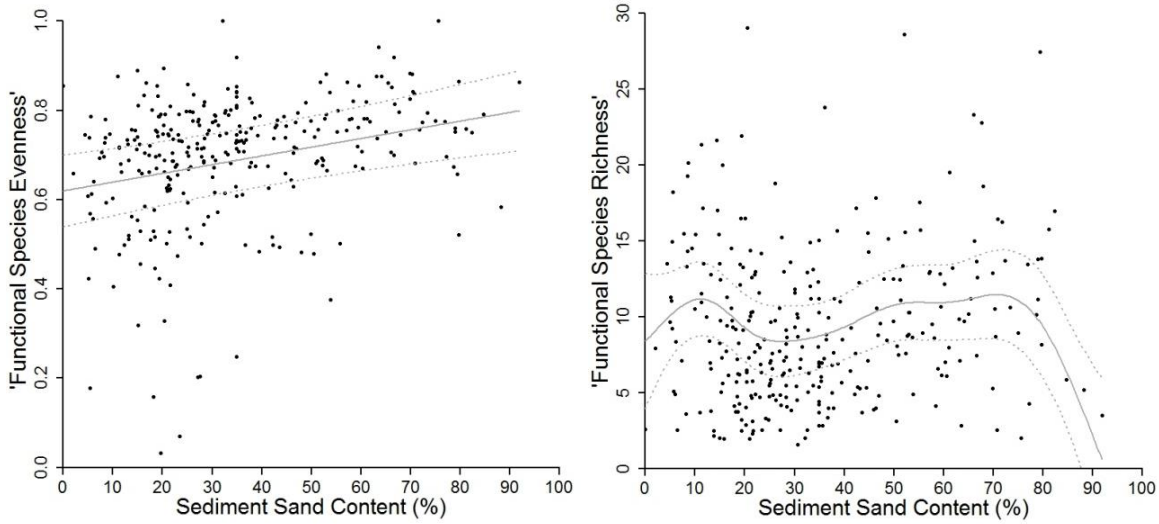


Figure 3.3: Relationship between the sediment percent sand content of a box core and the 'Functional Species Evenness' of peracarid assemblages contained within (left) and the sediment percent sand content of a box core and the 'Functional Species Richness' of peracarid assemblages contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

3.4.3 Food availability

A number of complementary metrics of food availability were assessed. Average sea surface chlorophyll *a* concentration values were found to be positively correlated with peracarid abundance (*P* = 0.018) and biomass (*P* <0.001), but negatively correlated with FSE (*P* = 0.025) and Rao's Quadratic Entropy (*P* = 0.020). A significant relationship was also found between surface chlorophyll *a* concentrations and PSE (*P* = 0.049), with PSE values peaking between ~0.6 mg/m^3 and 0.85 mg/m^3 of chlorophyll *a*, and declining thereafter. A similar pattern is seen with PSV (*P* = 0.007), with phylogenetic variability peaking between

~0.75 mg/m^3 and ~0.85 mg/m^3 chlorophyll *a* and dropping as concentrations increase further (see Figure 3.4). Based on the ordination results, average surface chlorophyll *a* concentrations were found to significantly influence peracarid assemblage structure (*P* <0.001).

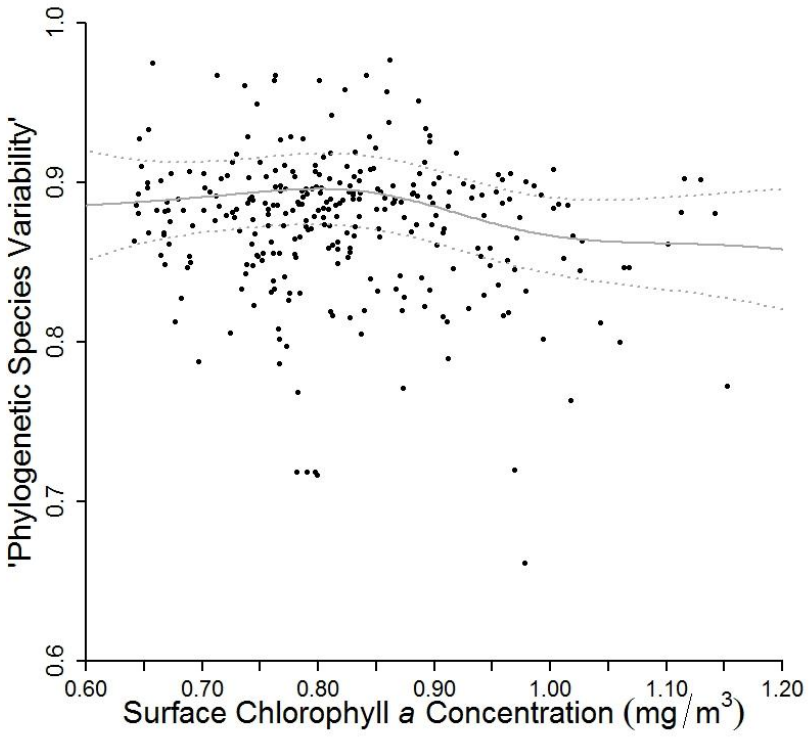


Figure 3.4: Relationship between the average surface Chlorophyll *a* concentration directly above box core locations for the collection year and the 'Phylogenetic Species variability' of peracarid assemblages contained within. Grey line is a line of best fit as determined by Generalised Additive Modelling. Red dotted lines are 95 % confidence intervals.

In contrast to the surface chlorophyll concentration results, average POC concentrations at the sea surface were found to be negatively correlated with peracarid abundance (*P* <0.001) and biomass (*P* = 0.012). Similarly, richness of genera (*P* <0.001) and FSR (*P* <0.001) (see Figure 3.5) appear to decrease as surface POC concentrations increase. Based on the ordination results, average surface POC concentrations were also found to significantly influence peracarid assemblage structure (*P* <0.001).

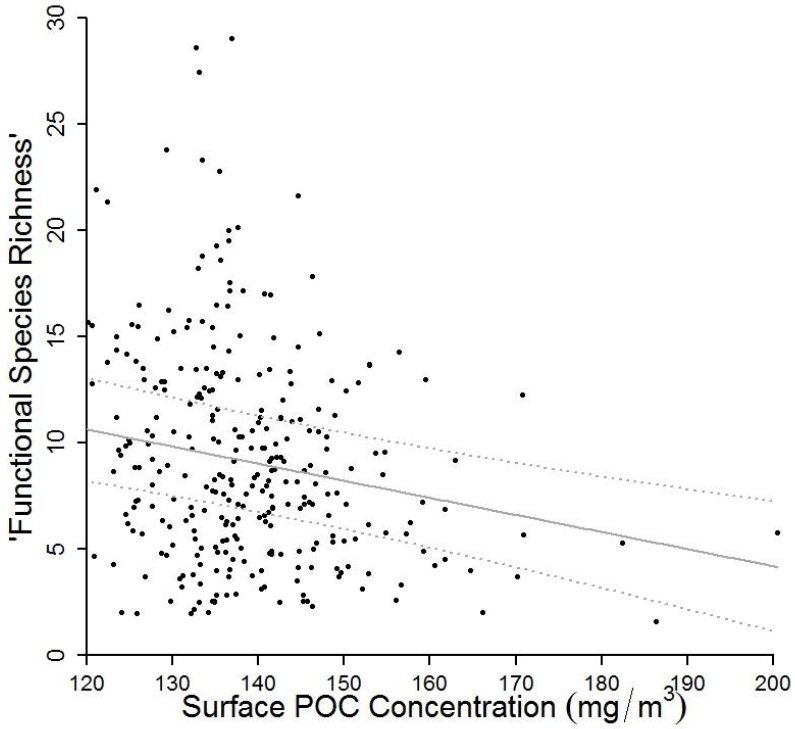


Figure 3.5: Relationship between the average surface particulate organic carbon concentration directly above box core locations for the collection year and the 'Functional Species Richness' of peracarid assemblages contained within. Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

Considering POC values corrected for box core sampling depth (see Section 3.3.2.5 and Table 3.2), peracarid biomass was found to show a complex, but overall negative relationship with average seafloor POC concentrations (P <0.001). In contrast, positive relationships between seafloor POC and FSR (P = 0.018), PSE (P = 0.005), Rao's Quadratic Entropy (P = 0.030) (see Figure 3.6), and possibly Shannon diversity (P = 0.057) and FSE (P = 0.095) were uncovered. Using constrained ordination, seafloor POC concentrations were found to significantly influence peracarid assemblage structure (P <0.001).

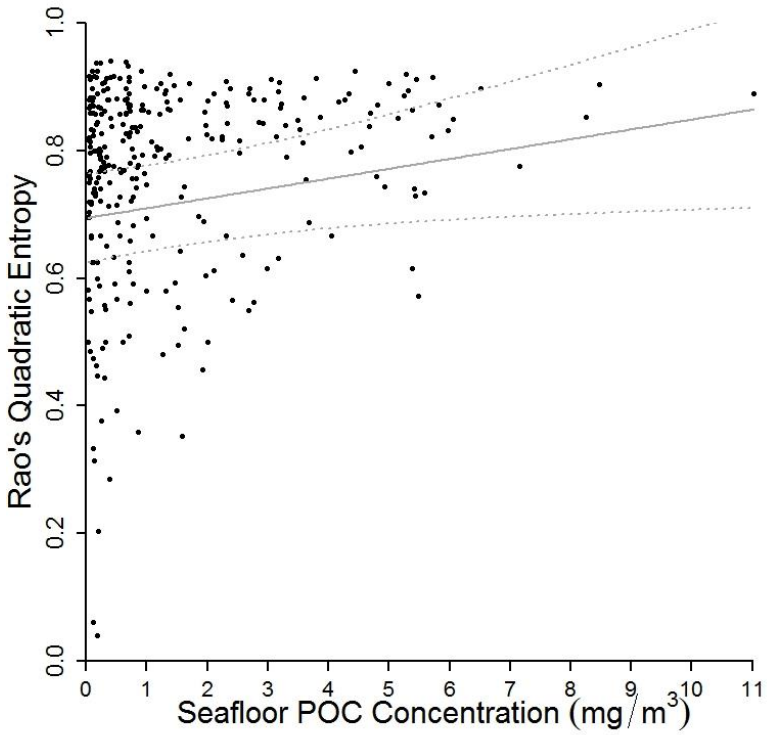


Figure 3.6: Relationship between the modelled seafloor particulate organic carbon concentration at box core locations for the collection year and Rao's Quadratic Entropy of peracarid assemblages contained within. Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

Measures of total carbon content from box core sub-samples highlighted a negative relationship with peracarid abundance (P <0.001) (see Figure 3.7), biomass (P <0.001), PSR (P <0.001), FSR (P <0.001) and taxonomic richness (P <0.001). However, a positive relationship was found between sediment total carbon content and PSE (P = 0.042). The relationship between sediment total carbon content and FSV (P = 0.019) was found to be complex, but positive overall in nature. Based on the ordination results, sediment total carbon content was found to significantly influence peracarid assemblage structure (P <0.001).

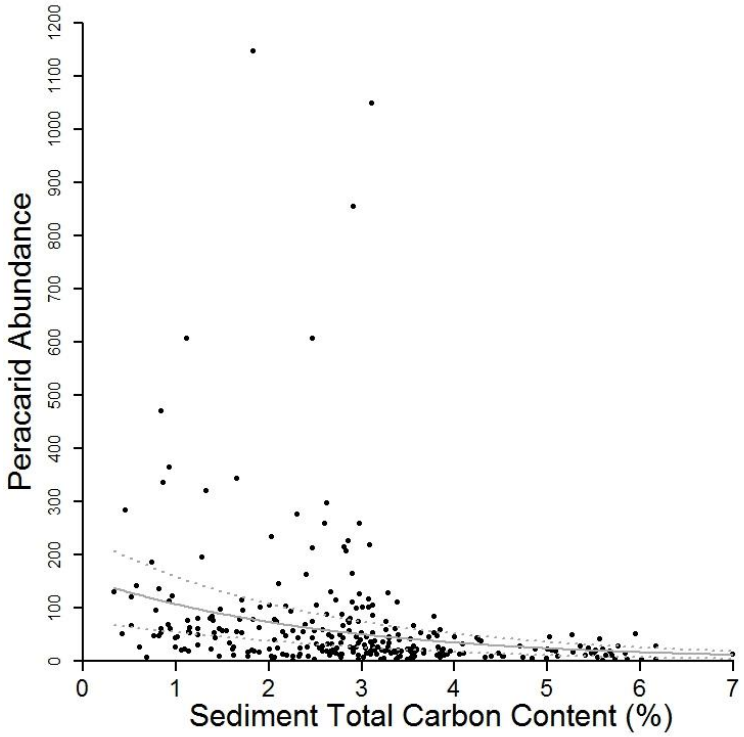


Figure 3.7: Relationship between the sediment total carbon content of box core sub-samples and the abundance of peracarids contained within. Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

A significant relationship was revealed between sediment organic carbon content and peracarid biomass (P <0.001), this being weakly unimodal in form, with biomass peaking slightly between ~1.4 % and 2.2 % organic carbon content. A unimodal relationship between sediment organic carbon content and FSR was also uncovered (P = 0.038), with FSR peaking between ~1.7 % and 2.3 % organic carbon content, and a unimodal relationship was found between organic carbon content and FSE (P = 0.018) (see Figure3.8) and possibly between organic carbon and PSE (P = 0.060), with both peaking at around ~1.0 % to 1.2 % sediment organic carbon. Rao's Quadratic Entropy was found to display a more typically negative relationship with organic carbon content (P = 0.009), whilst a complex but overall positive association between PSV and organic carbon (P <0.001) was revealed.

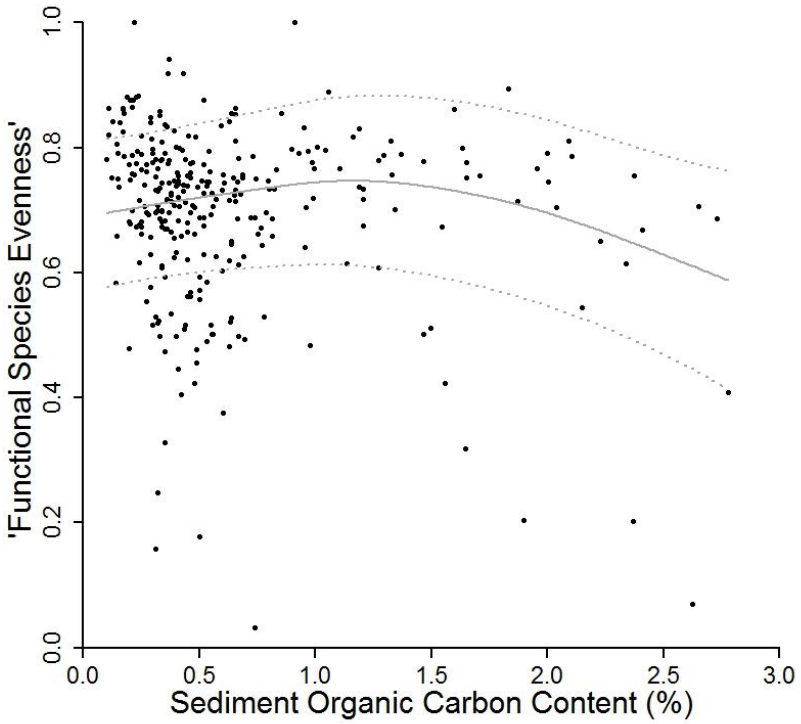


Figure 3.8: Relationship between the sediment organic carbon content of box core sub-samples and the 'Functional Species Evenness' of peracarid assemblages contained within. Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

3.4.4 Current speed

Peracarid abundance was found to vary significantly with the average seafloor current speed for the year of box core collection (P <0.001), with abundance rising sharply with increasing current speed to a maximal at ~0.18 m/s, then dropping and plateauing as current speed increases further. Average current speed was found to significantly influence PSR (P <0.001), with the relationship showing undulation, but being positive overall in form. FSR was also found to be positively associated with average current speed (P = 0.017), with FSR rising rapidly as current speed increases to ~0.25 m/s, then increasing at a much reduced rate thereafter. A significant relationship was also revealed between average current speed and taxonomic richness (P = 0.004) with richness increasing rapidly with increasing current speed to a maximal of ~0.20 m/s, then dropping before increasing again at a much reduced rate.

Maximal current speeds over a 10-year period were found to significantly influence peracarid abundance (*P* <0.001), this relationship being unimodal in form, with abundance increasing to greatest values in areas where maximal current speed was between ~0.10 m/s and 0.18 m/s. Rao's Quadratic Entropy (*P* = 0.082) and Shannon diversity (*P* = 0.012) may too be influenced by maximal current speed, these relationships displaying a unimodal shape, with diversity peaking at around 0.22 m/s. A broadly similar form of relationship was uncovered between maximal current speed and PSR (*P* <0.001) (see Figure 3.9), FSR (*P* = 0.086), and taxonomic richness (*P* = 0.008). Values of the three variables peaked at current speeds between ~0.18 m/s and 0.25 m/s, and then declined rapidly as current speed increased further. PSV, in contrast, showed a direct decline with increasing maximal current speed (*P* = 0.025). Based on the ordination results, 10-year maximal current speeds were demonstrated to significantly influence peracarid assemblage structure (*P* <0.001).

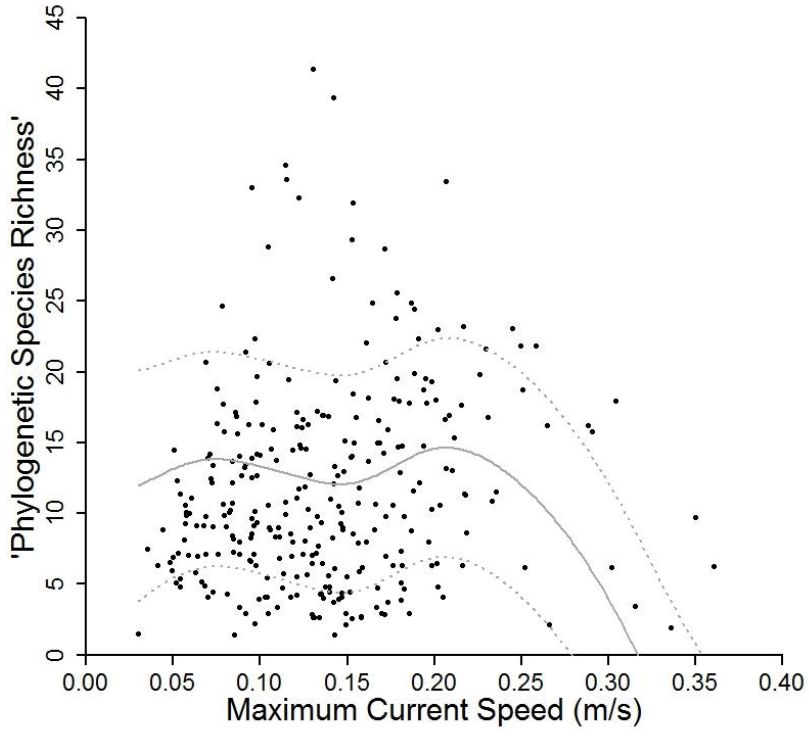


Figure 3.9: Relationship between the 10-year maximum current speed at box core locations and the 'Phylogenetic Species Richness' of peracarid assemblages contained within. Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

3.4.5 Physical disturbance

Trawling intensity was used here as a proxy for physical disturbance frequency. Trawling intensity was found to relate positively with peracarid abundance (P <0.001) (see Figure 3.10), but was linked with reductions in FSE (P <0.001), PSE (P = 0.002) and Rao's Quadratic Entropy (P = 0.027), these metrics showing a rapid initial decline with increasing trawling intensity, followed by undulation with an overall negative trend. Further, increased trawling intensity was found to be negatively associated with FSV (P = 0.045) (see Figure 3.10). Based on the CAP ordination analysis, peracarid assemblage structure was found to be significantly influenced by trawling intensity (P <0.001), with the cumacean genera *Diastylis*, *Diastyloides* and *Eudorella* seemingly less impacted by trawling disturbance than other peracarid genera, and the tanaidacean genera *Leptognathioides, Typhlotanais* and *Pseudosphyrapus* also showing relative resistance, albeit to a smaller extent.

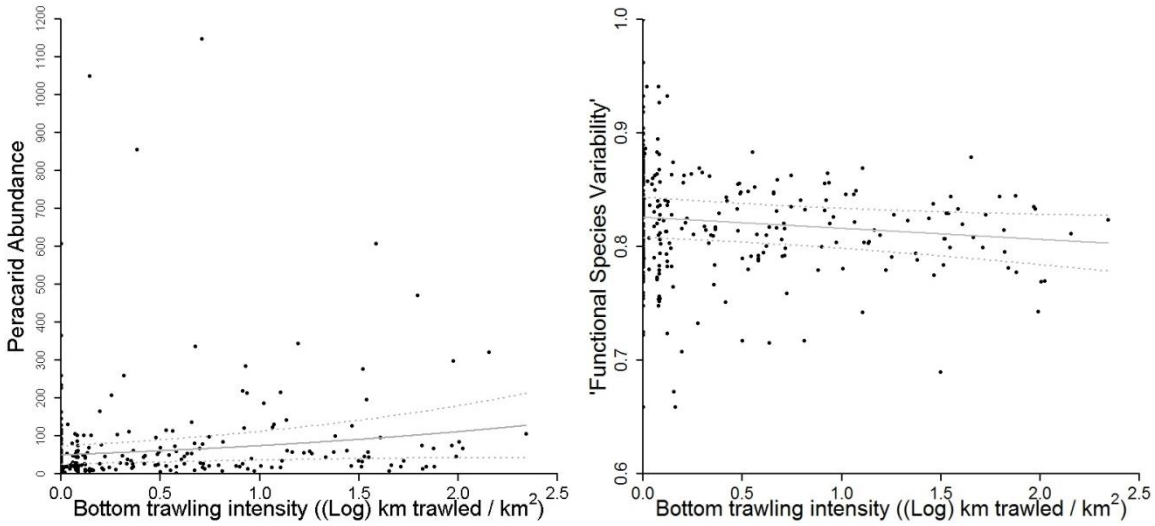


Figure 3.10: Relationship between the (Log) trawling intensity within a 3 km radius of a box core location and the abundance of peracarids contained within (left) and the (Log) trawling intensity within a 3 km radius of a box core location and the 'Functional Species Variability' of peracarid assemblages contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

3.4.6 Temperature

Peracarid biomass was found to vary significantly with the average seafloor temperature for the year of box core collection (*P* = 0.003), the relationship being negative overall in form. PSV was also negatively affected by annual average temperature (*P* = 0.029) (Figure 3.11). Increasing long-term (10-year) average seafloor temperature was possibly found to be positively associated with peracarid biomass (*P* = 0.090). In contrast, PSR was found to decline overall as long-term average temperature increased (*P* = 0.010) (see Figure 3.11). Long-term average seafloor temperature was potentially associated with PSV (*P* = 0.076), this relationship taking a shallow 'U'-shaped form, with PSV declining with increasing temperature up until ~4.0 °C, then increasing slightly thereafter. Ordination results showed long-term average seafloor temperature to be significantly associated with peracarid assemblage structure (*P* <0.001).

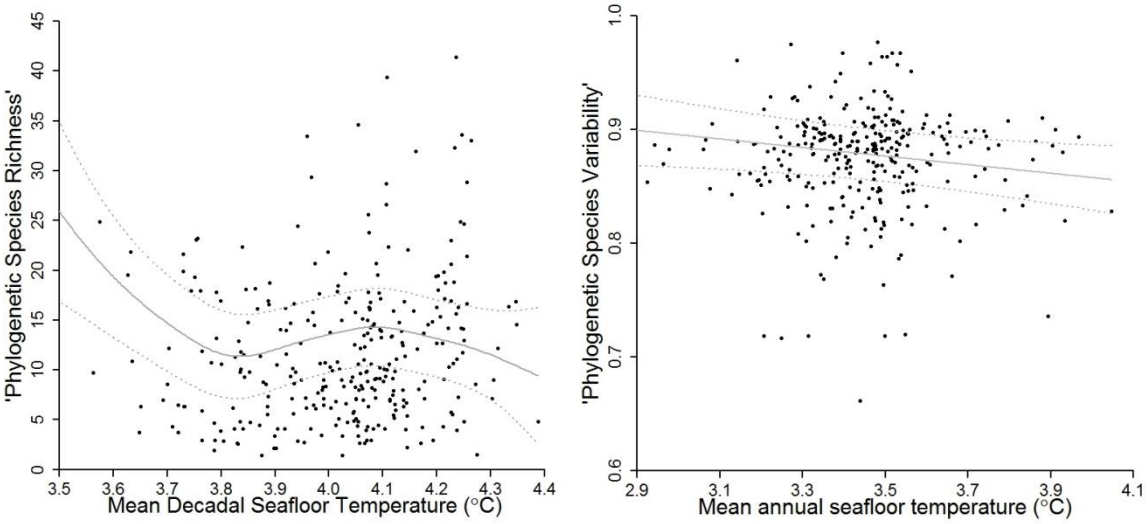


Figure 3.11: Relationship between the mean decadal seafloor temperature at a box core location and the 'Phylogenetic Species Richness' of peracarid assemblages contained within (left) and the mean annual temperature (for collection year) at a box core location and the 'Phylogenetic Species Variability' of peracarid assemblages contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

3.4.7 Inter- and intra-annual variability

Many of the biological metrics investigated varied by collection year (2009/2010) and month (May/June/July/August), this being, perhaps, suggestive of annual and seasonal turnover of peracarid communities. For example, peracarid abundance (*P* = 0.020), PSR

(*P* <0.001) and taxonomic richness (*P* = 0.044) were all significantly reduced in 2010 relative to 2009, yet peracarid biomass (*P* <0.001), PSE (*P* = 0.020), FSE (*P* <0.001), PSV (*P* <0.001) and Rao's Quadratic Entropy (*P* = 0.002) were all significantly elevated in 2010 relative to 2009.

In terms of collection month, FSE (*P* <0.001), PSE (*P* <0.001), PSV (*P* <0.001), Rao's Quadratic Entropy (*P* <0.001) and Shannon diversity (*P* <0.001) were consistently elevated in May, June and July, relative to August, generally taking the form of a decline in values towards the summer. FSV was found to peak in June (*P* = 0.027). However, peracarid biomass was found to reach a minimal value in July, relative to the other months that collections were made (*P* = 0.001).

Table 3.4: Summary of results of statistical analyses conducted. Blue colouration denotes a positive relationship between dependent and independent variables. Red colouration denotes a negative relationship between dependent and independent variables. Black colouration denotes a complex (e.g. 'U' shaped or uni/multi-modal) relationship between dependent and independent variables. Dark colour blocks represent significant relationships (*P* <0.05). Light colour blocks (light blue / light red / grey) represent marginal relationships (*P* <0.1). NS stands for 'not significant'.

	Abundance	Biomass	Richness	Rao Quadratic Entropy	Shannon Diversity	PSV	FSV	PSR	FSR	PSE	FSE	Community Structure
Annual temperature	NS		NS	NS	NS		NS	NS	NS	NS	NS	NS
Decadal temperature	NS		NS	NS	NS		NS		NS	NS	NS	
Annual current speed		NS		NS	NS	NS	NS			NS	NS	NS
Max decadal current speed		NS					NS			NS	NS	
Surface chlorophyll *a*			NS		NS	NS	NS	NS	NS			
Surface POC				NS	NS	NS	NS	NS		NS	NS	
Seafloor POC	NS		NS			NS	NS	NS				
Sediment total carbon				NS	NS	NS					NS	
Sediment organic carbon		NS	NS		NS		NS	NS				NS
Sediment sand content		NS			NS		NS					
Sediment PSD	NS		NS	NS	NS		NS	NS	NS	NS	NS	NS

	Abundance	Biomass	Richness	Rao Quadratic Entropy	Shannon Diversity	PSV	FSV	PSR	FSR	PSE	FSE	Community Structure
Geological environment		NS	NS	NS	NS	NS	NS		NS	NS	NS	
Trawling density		NS	NS		NS	NS		NS	NS			
BPI (9375 m radius)	NS		NS	NS	NS	NS		NS	NS	NS		
Rugosity (1875 x 1875 m)	NS	NS	NS			NS	NS				NS	
Roughness (225 x 225 m)	NS	NS		NS	NS	NS		NS	NS	NS		NS
Collection year					NS	NS			NS			NS
Collection month	NS		NS			NS			NS			NS

3.5 Discussion

3.5.1 Habitat heterogeneity

Prior observations concerning the importance of habitat characteristics in determining community attributes and structure (Vetter and Dayton, 1998, De Leo et al., 2010, Levin et al., 2010) are reiterated here by the finding of a significant relationship between geological environment and the structure, abundance and phylogenetic richness of peracarid communities. However, whilst significantly elevated PSR in the rough topography of mass transport debrites is suggestive of a role of elevated habitat heterogeneity in promoting increased faunal richness (Levin et al., 2001, Tews et al., 2004), these results could otherwise not be directly attributed to a considerable influence of any single geological environment in particular.

That peracarid biomass, functional evenness and functional variability are all influenced by the relative bathymetric position of a sample builds upon a number of recent studies demonstrating increased taxonomic richness and faunal biomass on abyssal hills relative to plains for both meiofauna and megafauna (Durden et al., 2015, Morris et al., 2016, Stefanoudis et al., 2016). All three of these studies link increased faunal biomass to

elevated food availability on hills relative to plains as a result of topographically enhanced current speeds. However, neither current speed nor food availability was found to positively influence peracarid biomass in this study.

The negative effect of elevated seafloor rugosity on the taxonomic richness (and possibly phylogenetic and functional richness), phylogenetic evenness (and possibly functional evenness) and Rao's Quadratic Entropy (and possibly Shannon diversity) of peracarid communities is in direct contradiction with the accepted influence of habitat heterogeneity on deep-sea communities (Levin et al., 2001, Cordes et al., 2010, Vanreusel et al., 2010). Indeed, the only evidence that increased bathymetric heterogeneity promotes macrofaunal diversity comes from the recovered unimodal relationship between roughness (225x225 m window) and functional variability (see Figure 3.2). These relationships may be linked to the fact that peracarids are brooders with only limited dispersal potential (see Appendix 1). As such, elevated large-scale bathymetric heterogeneity may act as a dispersal barrier to peracarids. If dispersal is reduced, smaller meta-population sizes will result, and this could leave populations prone to local extinction because of the Allee effect (Lamont et al., 1993, Stephens and Sutherland, 1999). That the metric of functional variability employed here does not include information on taxa richness or evenness (just their spread over the functional dendrogram – Figure 2.3) may help explain why this biological metric describes a slightly different pattern than the others investigated, with some positive influence of increased heterogeneity before local non-random extinctions reduce functional spread. Alternatively, areas of increased bathymetric heterogeneity are also characterised by increased disturbance frequency resulting from reduced sediment stability. Following the intermediate disturbance hypothesis (Connell, 1978) the frequency and magnitude of these disturbances may limit communities to relatively early successional states characterised by reduced richness, and diversity.

3.5.2 Sediment characteristics

The importance of sediment characteristics in determining the structure, abundance, taxonomic richness, functional richness, phylogenetic richness, functional evenness, and possibly Rao's Quadratic Entropy, phylogenetic evenness and phylogenetic variability of benthic communities is in agreement with shallow-water studies (Johnson, 1971, Biernbaum, 1979, Cooper et al., 2011). Here, both moderately low and high proportions (~5-15 % and ~60-80 %, respectively) of sand-sized particles appear optimal in promoting maximal abundance, functional, taxonomic and phylogenetic richness, and phylogenetic variability, with higher proportions of sand-sized particles being more beneficial overall when taxonomic diversity and functional and phylogenetic evenness measures are additionally considered. These results are suggestive of two general assemblage composition states, possibly characterised by particle size preferences for feeding (Fenchel et al., 1975, Taghon, 1982, Self and Jumars, 1988) or perhaps burrow/tube construction. The first (slightly more restricted) assemblage is characterised by those taxa that utilise relatively small particles (low sand percent), whilst the second (slightly more taxonomically and functionally diverse (Figure 3.3)) is characterised by those taxa preferring relatively large particles (high sand percent). That maximal values of biotic metrics do not occur at extreme values of sand content is suggestive that there is some cross-over of these communities.

Considering particle size diversity, the results of this study contradict those of Etter and Grassle (1992), Leduc et al. (2012b), and Pape et al. (2013) in that no influence of PSD on the richness or diversity of assemblages was found. However, that PSD was found to positively influence peracarid biomass, but not abundance, suggests that increased PSD may promote larger individual body size, perhaps reflecting greater feeding opportunities.

These results suggest that communities are more greatly structured by average overall particle size than they are by the specifics of particle size diversity. Sediment

characteristics clearly deserve thought when considering patterns of deep-sea macrobenthic diversity.

3.5.3 Food availability

The relatively large number of complementary metrics of food availability assessed provides a complex picture of the influence of food availability on deep-sea peracarid communities. However, these food availability metrics can be defined into two broad groupings based on the similarity of results obtained; grouping 1 being composed of surface POC, seafloor POC and sediment total carbon metrics, and grouping 2 including surface chlorophyll *a* and sediment organic carbon metrics. For example, increasing surface POC, seafloor POC and total carbon all negatively influence peracarid biomass, and increasing surface POC and total carbon both negatively affect peracarid abundance and richness metrics, whilst increasing surface chlorophyll *a* and organic carbon concentrations both show unimodal relationships with phylogenetic evenness and a negative relationship with Rao's Quadratic Entropy, this being in contrast with the relationships obtained between these biological metrics and those of the first food availability grouping.

These two broad groupings, which I will refer to henceforth as 'total carbon' proxies and 'organic carbon' proxies, respectively, demonstrate a notable similarity of results obtained from modelled surface food concentrations, modelled seafloor food concentrations, and actual measurements of carbon content from core sub-samples. This was unexpected, to some degree, since the modelled food availability metrics do not account for lateral movement of water between surface layers and seabed, and disregard the potential importance of down-slope transport of coastal primary production and riverine inputs, which, in some cases, may be of such importance that they represent the primary shaping factors of the underlying trophic regime (Johnson et al., 2007).

Considering the 'total carbon' proxies, increasing food availability was found to reduce the abundance (Figure 3.7), biomass, taxonomic richness, functional richness (Figure 3.5) and

phylogenetic richness of communities, whilst promoting increased functional evenness, phylogenetic evenness, taxonomic diversity (Figure 3.6) and functional variability. These results are broadly the opposite of those expected, since deep-sea environments are traditionally considered food-limited (Gooday et al., 1990, Rex et al., 2006, Johnson et al., 2007, Smith et al., 2008, Corliss et al., 2009). Such findings are not unique, however. Rohal et al. (2014) reported a negative relationship between food availability and copepod abundance. The authors attributed this to the possibility of confounding effects of sediment chemistry, with sediment oxygen concentrations being depressed in areas with increased food availability as a result of enhanced bacterial respiration, and the potential for increased predation pressure with increased food availability. Whilst it is true that low oxygen concentrations typically support a reduced abundance of crustacean macrofauna, it also typically leads to depressed faunal evenness and diversity (Levin, 2003, Woulds et al., 2007, Moffitt et al., 2015), a pattern that is not observed in this study. Increased strength of predation seems a more parsimonious explanation. Elevated density-dependent predation pressure in regions of higher food availability has been suggested to promote high levels of evenness and diversity, whilst supressing overall faunal abundance and biomass (Dayton and Hessler, 1972, Rex, 1976, Rex, 1981).

'Organic carbon' proxies were found generally not to correlate as strongly as the 'total carbon' proxies with the biological metrics investigated. However, the relationships that were recovered contrast, to some extent, with those suggested by the 'total carbon' metrics. Increases in the 'organic carbon' metrics were found to correlate with increased peracarid abundance, whilst a unimodal relationship was recovered between organic carbon and biomass, functional evenness (Figure 3.8), phylogenetic evenness and phylogenetic variability (Figure 3.4), and a negative relationship was revealed with taxonomic diversity. These results fit most neatly with the 'Intermediate Productivity Theory' (Grime, 1973), with food availability in the study region being at levels towards the peak of the theoretical curve. This is most clear in the form of the relations between organic carbon and peracarid biomass, functional (Figure 3.8) and phylogenetic evenness and phylogenetic variability

(Figure 3.4). This theory has been invoked before in the deep sea in an attempt to explain parabolic depth/diversity, and richness/productivity relationships (Cosson-Sarradin et al., 1998, Leduc et al., 2012a).

Why the 'total carbon' and 'organic carbon' proxies provide differing conclusions is unclear. Certainly each proxy is indicating a different facet of food availability for peracarids. Several studies have found a relatively low importance of labile detritus in deep benthic food webs (Smith et al., 1998, Iken et al., 2005, van Oevelen et al., 2012). For example, van Oevelen et al. (2012) reconstructed benthic carbon flows in the Porcupine Abyssal Plain using linear inverse modelling, and concluded that labile detritus contributes <5 % of the total carbon requirements for bacterial, meiofaunal and macrofaunal components of the food web. Considering this, and the results obtained in the present study (Table 3.4 and Figure 3.12), it is possible that the 'organic carbon' and 'total carbon' groupings identified here reflect proxies for labile and more refractory carbon components, respectively. Clearly, details of the utilisation of food by deep-sea benthic macrofauna requires further investigation (van Oevelen et al., 2012).

3.5.4 Current speed

The relationships between seafloor current speed and the faunal metrics examined here sit relatively comfortably with the unimodal form proposed by Levin et al. (2001). For instance, peracarid abundance, taxonomic diversity, and functional, phylogenetic and taxonomic richness (Figure 3.9) were found, generally, to describe a unimodal shape with increasing current speed, with values of these variables peaking in currents of around 0.15-0.25 m/s. This result is in agreement with the hypotheses set out in Section 3.2.4, whereby faunas are depauperate at excessively low and high current speeds. At low current speeds, faunas may be depauperate because of limiting food and oxygen concentrations. However, at moderate current speeds, macrofaunal communities show high levels of diversity and abundance, perhaps reflecting non-limitation of food, assisted dispersal, and complexity of sediment flow structures (Levin et al., 2001). At high current speeds, faunal abundance and diversity is again depressed, perhaps as a result of the erosion of surface

sediments, homogenisation of sediment structures, and suppression of succession (Levin et al., 2001).

3.5.5 Physical disturbance

That trawling intensity was found to positively correlate with peracarid abundance (Figure 3.10), negatively affect functional and phylogenetic evenness, taxonomic diversity, and functional variability (Figure 3.10), and alter assemblage structure is generally concordant with the few studies that have investigated trawling impacts on deep-sea macro- and meiofauna (Koslow and Gowlet-Holmes, 1998, Koslow et al., 2001, Clark and Rowden, 2009, Pusceddu et al., 2014, Román et al., 2016, van der Grient, 2016). Common to the form of response of evenness and diversity metrics investigated was a rapid initial decline, followed by undulation with an overall negative gradient. It is possible that this undulation reflects turnover in assemblage structure with increasing trawl intensity.

If trawling pressure is considered simply to represent a physical disturbance of the seabed, then these results are readily explained by the intermediate disturbance hypothesis (Connell, 1978), repeated trawl passage representing a high magnitude disturbance resulting in a reduction in faunal diversity. Interestingly, since no influence of trawl intensity on any measure of richness was uncovered, the observed declines in evenness and diversity likely reflect relative increases in the abundance of particular taxa that are less sensitive to disturbance. This is supported by slightly elevated peracarid abundance and depressed functional variability (Figure 3.10) as trawl intensity increases, and hints that trawling has a filtering effect on the benthic community, promoting the occurrence and abundance of particular functional sub-sets over others.

However, trawling has more far-reaching impacts on the seafloor than simply physical disturbance. Increased trawling, and associated sediment re-suspension, has been shown to reduce the bio-availability of carbon (Pusceddu et al., 2005, Pusceddu et al., 2014), reducing the diversity of benthic meiofauna (Pusceddu et al., 2014). There may be some

signal of this in the present dataset, with reductions in functional and phylogenetic evenness, taxonomic diversity, and functional variability, but elevated faunal abundance mirroring the community responses recovered for reductions in the 'total carbon' proxies discussed above.

Fishing, as discussed for variation in food availability, can also influence predator/prey relationships (Shepherd and Myers, 2005, Frank et al., 2011, Perez-Rodriguez et al., 2012), this resulting from the direct removal of large mobile predators. Peracarid crustaceans represent a significant dietary component of many fish species, including ones of commercial value (Modica et al., 2014). In the NEREIDA study area, peracarids are one of the major prey of small (<20 cm) Greenland Halibut (Bowering and Lilly, 1992). Considering this, and in contrast to the suggested role of predation in influencing levels of evenness and diversity with variation in food availability (Section 3.5.3), the observed changes in peracarid assemblages with increasing fishing intensity (increased abundance, reduced evenness and diversity, reduced functional variability) could represent a signature of the release, and subsequent proliferation, of particular prey taxa. Here, ordination results suggest the identity of these groups to be the cumacean genera *Diastylis, Diastyloides* and *Eudorella,* and the tanaidacean genera *Leptognathioides, Typhlotanais* and *Pseudosphyrapus*.

Finally, however, it should be remembered that as this is a correlational study, and correlation does not necessarily imply causation, the potential impacts of fishing reported here may in fact be attributable to another variable that is closely correlated with fishing effort but has not been incorporated into the models analysed in this study. Experimental work is required if the potential impacts of fishing reported here are to be proven beyond doubt.

3.5.6 Temperature

That high temperature values were found to have a significant negative impact on the biomass, phylogenetic richness and phylogenetic variability of peracarid communities is in agreement with the recognition of temperature as a fundamental controlling environmental factor (Brown et al., 2004, Danovaro et al., 2004, Perry et al., 2005, Poloczanska et al., 2013, Ashford et al., 2014), and with the potentially high sensitivity of deep-sea organisms to temperature change (Tewksbury et al., 2008, Howes et al., 2015, McCauley et al., 2015). These findings have clear relevance to the discussion of potential climate change impacts in the deep sea. As predicted, under higher temperature regimes, increased metabolic rates (respiration rates increase exponentially with temperature) (Brown et al., 2004) coupled with potentially reduced food availability (Moran et al., 2010, Jones et al., 2014, Howes et al., 2015) appears to result in reduced peracarid biomass. A concerning implication of this is that an increase in ocean temperature (particularly at continental slope depths (Ramirez-Llodra et al., 2011, Balmaseda et al., 2013, Llovel et al., 2014, Howes et al., 2015)) will result in depressed ecosystem functioning and a weakened provision of ecosystem services by the deep sea. For example, a reduction in the biomass of the carbonate-rich shells of peracarids may supress carbon storage, this being of particular significance considering the supposed importance of continental slopes for carbon storage (Muller-Karger et al., 2005, Rogers et al., 2015, Sweetman et al., 2017).

In agreement with the proposition of Yasuhara and Danovaro (2014) that temperature may only significantly influence faunal diversity when at relatively high and low levels, no influence of temperature on the diversity or evenness measures investigated was found. However, temperature was found to influence both phylogenetic richness and phylogenetic variability in a negative manner. That no effect on taxonomic richness was found suggests that the phylogenetic component of phylogenetic richness is the key driver here. In other words, phylogenetic relatedness appears to be a good predictor of the sensitivity of peracarid taxa to temperature, with filtering for a relatively select phylogenetic group of thermally tolerant taxa with increasing temperature (Figure 3.11).

3.5.7 Inter- and intra-annual variability

Findings of variability in peracarid communities both between collection months and between collection years builds on the findings of previous studies that record seasonality in deep-sea fauna (Smith and Baldwin, 1984, Gooday, 1988, Graf, 1989, Corliss et al., 2009). Considering inter-annual variability first, findings of reduced peracarid abundance and phylogenetic and taxonomic richness, but elevated biomass, functional and phylogenetic evenness, taxonomic diversity and phylogenetic variability in 2010 relative to 2009 may be related to the extreme northern-hemisphere winter that occurred between the two years as a result of a negative North Atlantic Oscillation (Seager et al., 2010, Fereday et al., 2012). According to the analysed datasets, whilst temperature and salinity do not differ greatly between 2009 and 2010 at the sampled locations (2009 mean temperature = 3.46 ^{o}C, 2010 mean temperature = 3.44 ^{o}C; 2009 mean salinity = 34.77 ‰, 2010 mean salinity = 34.65 ‰), current speeds differ dramatically (2009 mean speed = 0.060 m/s, 2010 mean speed = 0.421 m/s). Other environmental factors will clearly have differed between the sampling years, but this difference in mean current speed may help in part to explain the faunal differences.

Observed trends of declines in functional and phylogenetic evenness, taxonomic diversity, and phylogenetic variability moving from May to August may reflect a signature of the seasonal pulsing of labile organic matter to depth that occurs in temperate regions (Billett et al., 1983, Ittekkot et al., 1984, Rice et al., 1986). This phenomenon has been called upon in past studies to explain similar patterns (Gooday, 1988, Corliss et al., 2009). The observed changes in the above biological variables are suggestive of an increase in the relative dominance of particular functional and phylogenetic groups as food becomes more plentiful between spring and summer.

Considering these results, benthic communities do not appear to be greatly buffered from surface and atmospheric processes.

3.5.8 Functional convergence

That the functional and phylogenetic metrics examined here do not always provide similar results deserves discussion. For example, BPI was found to significantly influence functional evenness and possibly functional variability, but not the phylogenetic equivalents of these terms. Sediment characteristics were found to alter functional evenness but not phylogenetic evenness. Increasing trawling intensity was found to reduce functional variability, but not phylogenetic variability, and seafloor temperature significantly influenced phylogenetic variability and richness, but not the functional equivalents of these terms. These observations further demonstrate, as remarked upon in Chapter 2, that for Peracarida, phylogeny is not a perfect proxy for functional similarity, with functional convergences occurring sometimes between distantly related taxa (see Section 2.5).

3.5.9 Conceptual model

Synthesising the results presented here, an updated and expanded interpretation of Levin et al.'s (2001) conceptual model (Figure 3.1) is presented:

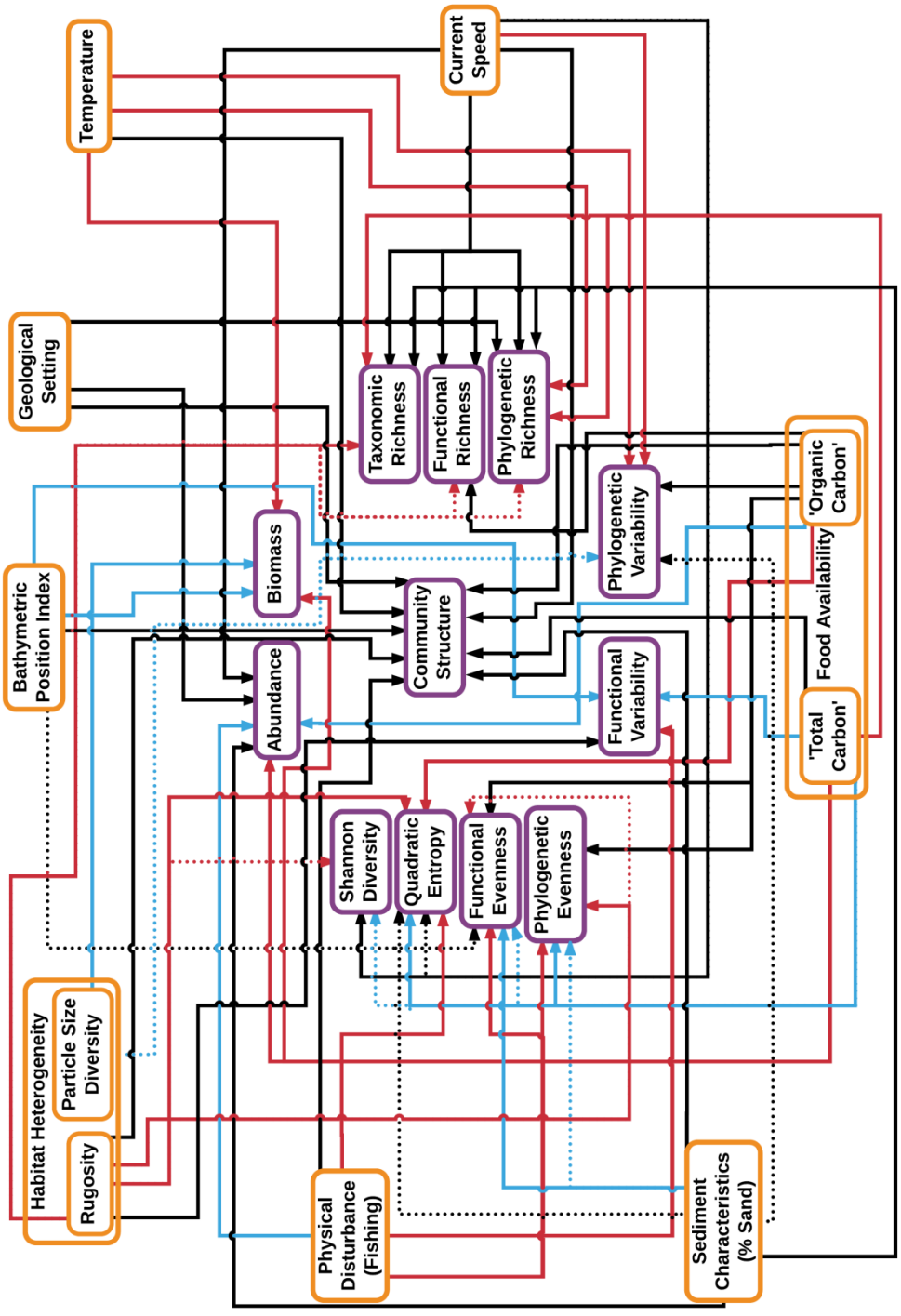


Figure 3.12: Revision of Levin et al.'s (2001) conceptual model based on analyses conducted in this chapter. Links between environmental parameters (orange) and biological parameters (purple) are specified. The colour of arrow represents form of relationship: blue = positive, red = negative, black = complex (e.g. 'U' shaped or uni/multi-modal). Solid arrows represent significant relationships (P <0.05). Dotted arrows represent marginal relationships (P <0.1).

3.6 Concluding statement

Despite the fact that deep-sea benthic communities cover more than 90 % of seafloor area (Costello et al., 2010), host hundreds of thousands of species (Mora et al., 2011, Appeltans et al., 2012, Costello et al., 2012) and contribute significantly to ecosystem services of global relevance (Thurber et al., 2014), knowledge of the ecology of deep-sea soft-sediment communities is still wanting. This chapter aimed to significantly progress our understanding of the intricate relationships between deep-sea benthic macrofauna and their environment via the consideration of a broad selection of biological metrics (including phylogenetic and functional information) and a large number of environmental variables.

Contrary to hypotheses, high habitat heterogeneity was found to be associated with reduced values of a number of faunal metrics. It is proposed here that highly heterogeneous environments may present dispersal barriers to peracarid taxa. Different results may be obtained if alternative taxonomic groups are investigated. Broad-scale sediment characteristics were found to have a greater influence on peracarid community attributes than particle size diversity (Etter and Grassle, 1992), perhaps suggesting that macrofaunal communities respond predominantly to general changes in sediment characteristics, rather than details of PSD. Particularly striking was the complexity of relationships obtained with proxies for food availability, with conclusions drawn being highly dependent on the particular metric of food availability considered. In contrast, relationships between fauna and seafloor current speed and seasonality are in general agreement with the accepted paradigms. Evidence is presented here that climate change may significantly influence deep-sea benthic communities, with potentially reduced faunal biomass, phylogenetic richness and phylogenetic variability, and altered community structure under elevated temperature values. With relevance to the management of deep-sea benthic habitats, the intensity of bottom-trawling was found to negatively affect assemblage evenness, diversity and functional variability, but promote slightly elevated abundance values. These faunal changes may reflect direct disturbance impacts, alterations to sediment carbon cycles, prey release, or a combination of the three.

Finally, the results of this study emphasise that deep-sea benthic ecosystems are not highly buffered from surface and atmospheric processes. Indeed, it appears likely that predicted changes to surface and atmospheric environments over the coming decades will rapidly propagate through the water column and alter deep-sea benthic communities, this having concomitant effects on ecosystem functioning and the provision of ecosystem services.

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Chapter 4

'On the importance of Vulnerable Marine Ecosystem habitats for deep-sea macrofaunal communities'

4.1 Abstract

Vulnerable marine ecosystems (VMEs) are considered hotspots of faunal diversity in the deep sea; boosting habitat area and complexity, providing appropriate spawning locations for fish and offering protection from predation and enhanced feeding opportunities to macrofauna. However, they are also characterised by a high vulnerability to disturbance and a low recovery potential. Because of this, a series of United Nations General Assembly resolutions have been developed since 2006 in an attempt to ensure the protection of VMEs in international waters. In the Northwest Atlantic Fisheries Organisation (NAFO) Regulatory Area, some effort has been made to delineate the distribution of VME-indicator taxa, and large areas of seabed have been closed to bottom-contact fishing as a result. However, knowledge of the importance of VMEs and the appropriateness of current spatial closures for macrofauna in the NAFO Regulatory Area is limited. This chapter aims to determine the relationship between the biomass of VME-indicator taxa (specifically poriferans [sponges], gorgonian corals and pennatulaceans [sea pens]) in the NAFO Regulatory Area and an extensive suite of peracarid biodiversity metrics. The optimality of current spatial closures for the protection of peracarid diversity is also analysed. Of the three VME-indicator taxa analysed, poriferans were found to have the greatest influence over peracarid communities in the study area, with altered assemblage structure and elevated abundance, biomass, taxonomic, functional and phylogenetic richness, taxonomic diversity, and functional variability with increasing poriferan biomass, reaffirming the perception of poriferans as crucial structural components of VMEs. Gorgonian corals were found to have little influence over peracarid assemblages, and this may reflect their low prevalence in the study area. Similarly, pennatulacean biomass was found to influence peracarid assemblages only weakly, with the relationships uncovered being either negative, or complex in form. This

may also reflect a moderately low prevalence of Pennatulacea in the study area, but could also be linked to increased predation of peracarids by demersal fish in the vicinity of pennatulaceans. The results of this study further suggest that the application of evidence from taxon distribution models to ecological investigations and management decisions in data-limited environments (such as the deep sea) may not be fully appropriate. Finally, the results of this study indicate that the current spatial closures enforced by NAFO may not be fully optimal in terms of maximising protection for all components of diverse benthic communities against the impacts of bottom trawling. A review of the current system of spatial closures is proposed in light of these results.

4.2 Introduction

The concept of a 'Vulnerable Marine Ecosystem' centres upon the presence of distinct, diverse benthic assemblages that are limited and fragmented in their spatial extent, and dominated, in terms of biomass, by rare, endangered or endemic component species that are physically fragile, and so vulnerable to damage (or structural/biological alteration) by human activities, especially those that contact the seabed (Fuller et al., 2008, Rogers et al., 2008, FAO, 2009, Parker et al., 2009, Rogers and Gianni, 2009, Auster et al., 2011, Hansen et al., 2013).

VMEs are recognised as hotspots of ecosystem functioning, but they are also easily disrupted or degraded, and, since their component species typically exhibit traits of slow growth, late maturity, low fecundity, unpredictable recruitment and high longevity, VMEs are characterised by extremely slow recovery from damage (Fuller et al., 2008, Rogers et al., 2008, FAO, 2009, Parker et al., 2009, Hogg et al., 2010, Auster et al., 2011, Hansen et al., 2013). Specifically, the following list of characteristics is provided by the FAO (2009) in order to define VMEs:

i) Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include: habitats that contain endemic species; habitats of rare,

threatened or endangered species that occur only in discrete areas; or nurseries or discrete feeding, breeding, or spawning areas.

ii) Functional significance of the habitat - discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.

iii) Fragility - an ecosystem that is highly susceptible to degradation by anthropogenic activities.

iv) Life-history traits of component species that make recovery difficult - ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics: slow growth rates; late age of maturity; low or unpredictable recruitment; or long-lived.

v) Structural complexity - an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

Taxa which when in sufficient density are considered to be indicative of the presence of a VME include a myriad of deep-sea corals, hydrozoans, cerianthids, sponges, ophiuroids, stalked crinoids, ascidians, bryozoans, brachiopods, xenophyophores, and deep-water serpulid and oyster reefs, and chemosynthetic species (Fuller et al., 2008, Parker et al., 2009, Rogers and Gianni, 2009, Gianni et al., 2011, Murillo et al., 2012).

Whilst the overarching concept of a VME, and directed efforts to protect deep-sea VME-indicator taxa (e.g. via spatial closures (Koslow and Gowlet-Holmes, 1998)) have been important aspects of deep-sea ecology and fishery management for at least 20 years, formalisation of the term only occurred in the mid-2000s following international efforts to reduce the loss of VMEs attributable to bottom-trawling activities (see Section 1.4.2).

Starting in 2004, a series of United Nations General Assembly (UNGA) resolutions of increasing strength and urgency were adopted – UNGA 59/25 (2004), UNGA 61/105 (2006), UNGA 64/72 (2009) and UNGA 66/68 (2011). These resolutions, complemented by guidelines published by the Food and Agriculture Organisation of the United Nations (FAO, 2009), called for states and Regional Fisheries Management Organisations (RFMOs) to formally recognise the immense importance and value of deep-sea ecosystems and the biodiversity that they contain by adhering to the precautionary principle and ecosystem approach when harvesting biological products from the deep sea. Specifically, these resolutions called for immediate action to reduce the frequency of Significant Adverse Impacts (SAIs) on VMEs. A SAI is defined as any disturbance to a VME that impairs the ability of affected VME constituent populations to replace themselves, degrades the long-term productivity of the habitat, and causes a significant loss of species richness, habitat diversity and structure whilst occurring at an interval that is, on average, shorter than the recovery time for the habitat in question (Hogg et al., 2010) (see Section 1.4.3).

In order to achieve this goal, a number of management tasks have been proposed (FAO, 2009), including the production of thorough impact assessments prior to the commencement of bottom fishing, the development of 'move-on' rules, the spatial closure of known VME locations to all fishing activities which may involve contact with the sea bed, and directed efforts to map VME locations (including the continued monitoring of distributions pending potential change associated with oceanographic variables), this all being bound by appropriate control and surveillance mechanisms (see sections 1.4.2 to 1.4.4).

Application of these resolutions in the high seas has been variable. For instance, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has banned all commercial bottom-trawling and the use of gillnets in their convention area, whilst benthic long-lining is only permitted in water depths greater than 550 m (Gianni et al., 2016). Further, impact assessments are mandatory prior to the commencement of fishing

activities, and a well-developed and functional 'move-on' rule is in place (Gianni et al., 2016). In contrast, large areas of the high seas, such as the South West Atlantic, remain essentially unmanaged, with no RFMO, or only a 'regional fisheries arrangement' in place (see Section 1.4.5).

NAFO has responded to the UNGA resolutions primarily via the mapping of VME locations, the establishment of 21 spatial closures covering a total sea-surface area of over 390000 km^2, and the development of a move-on protocol (Gianni et al., 2016, NAFO, 2017) (see Section 1.6.1). However, questions remain as to whether the NAFO move-on protocol and spatial closures are optimal solutions to minimising SAIs to VMEs, or whether they represent a compromise in order to limit conflict with present fishing activities in the Regulatory Area (Wright et al., 2015, Gianni et al., 2016). Overall, it appears that total progress towards fulfilment of the UNGA resolutions in the high seas is only moderate.

4.2.1 The value of vulnerable marine ecosystems

The general importance and value of VMEs can be divided into two major categories: 1) the inherent value of the key structure-forming taxa of VMEs, and, 2) the value of these structure-forming taxa to other faunal components of the ecosystem.

4.2.1.1 The inherent value of structure-forming VME-indicator taxa

Both poriferans and cold-water corals (key VME-indicator taxa) have been shown to provide a particularly strong link between pelagic and benthic foodwebs, with benthic-pelagic coupling, nutrient cycling, respiration rates and energy exchange all being intensified in sponge grounds and cold-water coral reefs (Hentschel et al., 2002, Pile and Young, 2006, van Oevelen et al., 2009, Cathalot et al., 2015). For example, Cathalot et al. (2015), using aquatic Eddy Correlation techniques, found *in-situ* community aerobic respiration rates (a proxy for ecosystem functioning) for cold-water coral and sponge ecosystems to be enhanced by 20 times and 9 times, respectively, over reef structures relative to surrounding soft sediments.

Of more applied interest, numerous VME-indicator taxa (particularly Porifera), have been associated with the provision of novel biomolecules, gaining them attention from pharmaceutical and biotechnology industries (Skropeta, 2008, Jobstvogt et al., 2014). For example, the anti-tumour drug 'discodermolide' was extracted from the deep-sea sponge *Discodermia dissoluta* in 1990 by the Harbour Branch Oceanographic Institution, and the same institution has also isolated lasonolides A, C, D, E, F and G from the sponge Forcepia sp. (Wright et al., 2004), with lasonolides A appearing particularly effective as an anti-tumour drug (Jossé et al., 2015). Biomolecules of pharmaceutical interest have also been isolated from deep-sea corals (Skropeta, 2008). For instance, the compounds 'linderazulene (25-27)', with potential application to the treatment of leukaemia that deserves further investigation, have been isolated form the gorgonian coral genus *Paramuricea* (Reddy et al., 2005). Recently, the wider biotechnological potential of sponges in providing new designs for fibre optics, glass, civil engineering and even semiconductors is starting to be recognised (Hogg et al., 2010).

4.2.1.2 The value of structure-forming taxa to other faunal components of VMEs

The presence of benthic structure-forming taxa, such as sponges and corals, greatly elevates the physical heterogeneity of these environments relative to surrounding soft sediments. This provides an enhanced number and diversity of microhabitats available to associated metazoans and microbes (Thrush et al., 1998, Tissot et al., 2006, Fuller et al., 2008, Rogers et al., 2008, Buhl-Mortensen et al., 2010). Thus, these environments can be viewed as oases of complex habitat on the seabed, this being of special importance in the deep sea, where background physical substratum heterogeneity can be low (Buhl-Mortensen et al., 2010). Considering both theoretical and demonstrated relationships between habitat heterogeneity and species diversity (Connell and Orias, 1964, Abele, 1974, Heck Jr and Wetstone, 1977, Tews et al., 2004), and the concept of ecosystem engineering (Jones et al., 1994), it follows that VMEs represent important biological hotspots in the deep sea, with faunal abundance, biomass, richness and diversity all being elevated in these regions compared to surrounding habitats (Bett and Rice, 1992, Edinger et al., 2007, van Oevelen

et al., 2009, Hogg et al., 2010, Barrio Froján et al., 2012, Beazley et al., 2013, Beazley et al., 2015).

A remarkably large number of associated species can be found living on, in, and around sponges, leading Pearse (1932) to describe them as "*veritable living hotels*". For instance, upon the examination of 11 species of outer-shelf and upper-slope sponges off the Faroe Islands, Klitgaard (1995) documented over 240 epi- and infaunal associated species, the majority of these occurring epifaunally on the sponges. The structure of these associated communities is often specific to particular sponge taxa (Gerovasileiou et al., 2016), and sponge morphology (such as the size and shape of canals in sponge tissue) and biochemistry are thought to play an important role in determining the abundance and species composition of associated fauna (Klitgaard, 1995, Wulff, 2006). Larger canal volume has been shown to promote a higher taxonomic richness and abundance of associated taxa (Rützler, 1976, Cinar et al., 2002), whilst the external morphology of sponges can influence the number of taxa able to utilise them as settlement substrate (Klitgaard, 1995, Beazley et al., 2013). Porifera can elevate substratum heterogeneity even after death; the skeletal remains of hexactinellid sponges forming dense spicule mats. These mats act to stabilise the surrounding sediment, and can inhibit colonisation by certain infaunal taxa, so providing a unique substratum for colonisation by benthic fauna. Indeed, spicule mats have been shown to be characterised by a prominence of epifaunal organisms (Bett and Rice, 1992, Beazley et al., 2013), and the abundance and biomass of macrofaunal taxa has been shown to be elevated in their vicinity (Bett and Rice, 1992).

Gorgonian corals also house a rich associated fauna. Echinoderms (particularly ophiuroids) appear to take advantage of the structural form of large gorgonian corals to gain access to the higher current flows found elevated from the seabed (Buhl-Mortensen and Mortensen, 2005, Buhl-Mortensen et al., 2010). Crustaceans, too, are often found in association with gorgonian corals, and whilst many of these seem to utilise the structure provided by corals

as protection against predation, some (e.g. poecilostomatid copepods) are obligate parasites (Buhl-Mortensen and Mortensen, 2004).

Scleractinian corals may also host a high diversity of associated fauna, but these associations appear to be mainly facultative in nature (Rogers, 1999, Buhl-Mortensen et al., 2010). Like sponge spicule mats, scleractinian coral rubble and dead coral skeletons host a fauna that is relatively distinct from surrounding sediments, and taxa that utilise this habitat exhibit adaptations to withstand elevated current speed (Raes and Vanreusel, 2005, Gheerardyn et al., 2009).

The heterogeneous and complex habitat afforded by VMEs further provides shelter from adverse hydrological conditions and predation for a multitude of taxa, including commercially important fish and crustacean species (Barthel, 1992, Husebø et al., 2002, Krieger and Wing, 2002, Henkel and Pawlik, 2005, Tissot et al., 2006, Amsler et al., 2009). As a result, VMEs often represent aggregation and spawning sites for fish and other taxa (Freese and Wing, 2003, Etnoyer and Warrenchuk, 2007, Baillon et al., 2012, Pham et al., 2015). For example, Auster (2005) noted that sponge grounds are used as nursery areas by fish, with juvenile *Sebastes* spp. being particularly prevalent both inside and between sponges. *Sebastes* spp. larvae have also been found associated with pennatulaceans in the Laurentian Channel and Southern Grand Banks (Baillon et al., 2012), whilst Etnoyer and Warrenchuk (2007) documented the use of gorgonian coral aggregations by catshark species as egg-laying grounds.

Additionally, structure-forming VME-indicator taxa can provide both a direct food source to some taxa, and offer increased access to alternative food sources for others. For example, many species of fish, mollusc, echinoderm and crustacean (including peracarids) graze sponges (Wulff, 2006, Buhl-Mortensen et al., 2010), echinoderms and molluscs may consume octocorals (Krieger and Wing, 2002), and nudibranchs and amphipods may graze pennatulaceans (Buhl-Mortensen et al., 2010), all often non-fatally.

As for alternative food sources, the high abundance and biomass of associated fauna in VMEs means that they represent important forage areas for fish and other predators (Husebø et al., 2002, Hogg et al., 2010). Observations from seamounts suggest that the base of sponges and corals can trap vertically migrating macrozooplankton, so providing enhanced feeding opportunities for predators (Auster et al., 2011). The increased turbulence created by VME frameworks also affords a raised supply of suspended particles (van Oevelen et al., 2009), and the elevated platform created by structural VME taxa provides suspension feeders with access to food transported in the faster flowing parts of the benthic boundary layer (Krieger and Wing, 2002, Buhl-Mortensen and Mortensen, 2005, Wulff, 2006, van Oevelen et al., 2009, Buhl-Mortensen et al., 2010). In a more intimate relationship, species living within sponges often directly utilise the suspended particles pumped into the sponge by the action of the choanoderm tissue (Buhl-Mortensen et al., 2010).

4.2.2 VMEs of the Flemish Cap, Flemish Pass and slopes of the Grand Banks

A large number of VME-indicator taxa have been identified around the Flemish Cap, Flemish Pass and slopes of the Grand Banks. Porifera appear to dominate in terms of abundance and biomass, particularly at upper slope depths of 200-1500 m in regions of high maximal current flow and irregular topography (Knudby et al., 2013a) where they can account for up to 90 % of invertebrate biomass (Fuller et al., 2008, Murillo et al., 2012). At least 30 poriferan species, representing 10 families and all three classes (Calcarea, Desmospongiae and Hexactinellidae), have been identified. Additionally, a number of coral taxa (such as zoanthids, antipatharians, gorgonians, pennatulaceans and scleractinians), hydrozoans, cerianthids, brachiopods, cirripedians, ascidians, stalked crinoids, various ophiuroids, holothurians, cidaroids, upright bryozoans such as phidoloporids, and xenophyophores are also found (Fuller et al., 2008, Barrio Froján et al., 2012, Kenchington et al., 2014).

Studies investigating the influence of significant aggregations of VME-indicator taxa on surrounding benthic communities in the study area are relatively limited, but tend to

suggest a positive influence. Barrio Froján et al. (2012) documented a higher biomass and distinct macrofaunal community in the presence of VME-indicator taxa on the Sackville Spur region of the NAFO Regulatory Area, whilst Beazley et al. (2015) found the abundance of structure-forming sponge species to be the most important variable for predicting the structure of other components of the megafaunal community in this region. Also investigating megafauna, Beazley et al. (2013) found the presence of structure-forming sponges around the Flemish Cap and Flemish Pass to promote a higher abundance and diversity of other megafaunal taxa, and an altered community composition relative to non-sponge-dominated habitat.

In this chapter, three VME-forming taxa are investigated: Porifera, Pennatulacea and gorgonian corals. All three of these taxa can occur as isolated individuals, but, under discrete geological, oceanographic and biological conditions, they can also each form aggregations, dominating the benthos in terms of body size, biomass and abundance (Fuller et al., 2008, Buhl-Mortensen et al., 2010, Hogg et al., 2010). In these circumstances, the aggregations are referred to as sponge grounds, sea pen fields and gorgonian coral forests, respectively.

Both mapping and modelling approaches have been employed in efforts to determine the distribution of these taxa in the NAFO Regulatory Area. Fuller et al. (2008) presented the first map of sponge distributions, as determined from Spanish and EU groundfish surveys, with this being updated in 2012 by Murillo et al. Using data from the same surveys, Murillo et al. (2011) mapped the distribution of deep-water corals around the Flemish Cap, Flemish Pass and tail of the Grand Banks. There have been two published attempts to predict sponge and coral distributions in the NEREIDA sampling area utilising random forest modelling (Knudby et al., 2013a, Knudby et al., 2013b), and in both cases, modelled distributions of these VME-indicator taxa are shown to be more extensive than that reported by Murillo et al. (2011, 2012). The kernel density surface modelling approach of Kenchington et al. (2014) lies between previous mapping and modelling efforts, applying a

smoothing function to the observed data, but not using this to predict VME biomass across relatively distant un-sampled areas. This chapter will utilise both the approach of Kenchington et al. (2014) and *de novo* random forest models to estimate the distribution of poriferan, pennatulacean and gorgonian biomass at box core locations.

This study aims to investigate the influence of sponge grounds, sea pen fields and gorgonian coral forests on peracarid crustacean assemblages, as well as to determine whether or not current spatial closures enforced by NAFO are located in optimal regions for the protection of peracarid biodiversity hotspots. Several facets of the peracarid community will be considered (see Table 4.1), including taxonomic, phylogenetic and functional diversity metrics, and it is hypothesised that these metrics will respond positively to increases in biomass of the investigated VME-indicator taxa.

4.3 Methods

4.3.1 Peracarid community metrics

A series of metrics describing various facets of the peracarid fauna at box core locations were investigated. These included peracarid abundance, biomass, taxonomic richness and diversity, phylogenetic richness, evenness and variability, functional richness, evenness and variability, and community structure (see Table 4.1). Details of NEREIDA box core collection methods and peracarid identification are given in Section 2.3.1, and details of the calculation of peracarid biomass and taxonomic, phylogenetic and functional community metrics are given in Section 3.3.1.

Table 4.1: Details of peracarid assemblage metrics analysed in this chapter.

Peracarid community metric	Details
Abundance	Total number of peracarid individuals per box core
Biomass	Total biomass of peracarids per box core
Richness	Total number of peracarid genera per box core
Rao Quadratic Entropy	Taxonomic diversity measure taking into account both the number of peracarid genera per box core and their relative abundances. Simplifies to Simpson's diversity (1-D) for the case of taxonomic diversity. Here represents the probability that two individuals taken from a box core sample will belong to different genera
Shannon Diversity	Taxonomic diversity measure taking into account both the number of peracarid genera per box core and their relative abundances. Here represents a quantification of the uncertainty associated with predicting the taxonomic identity of an individual taken at random from a box core
Phylogenetic Species Variability (PSV)	Measure of the distribution of peracarid genera present in a box core across a dendrogram describing their phylogenetic relatedness. See Helmus et al. (2007)
Functional Species Variability (FSV)	Measure of the distribution of peracarid families present in a box core across a dendrogram describing their functional similarity
Phylogenetic Species Richness (PSR)	PSV multiplied by the richness of peracarid genera per box core. See Helmus et al. (2007)
Functional Species Richness (FSR)	FSV multiplied by the richness of peracarid families per box core
Phylogenetic Species Evenness (PSE)	PSV modified to incorporate the relative abundances of peracarid taxa per box core. See Helmus et al. (2007)
Functional Species Evenness (FSE)	FSV modified to incorporate the relative abundances of peracarid taxa per box core
Community Structure	Taxonomic identity of peracarid taxa present in a box core and their relative abundances

4.3.2 Metrics relating to the presence of VMEs

4.3.2.1 Location of NAFO VME closures

Box core samples were categorised into being collected from within an area currently closed to bottom fishing (see Section 1.6.1) or not, based on the published locations of closures by NAFO (https://www.nafo.int/Data/GIS) (accessed 28/11/2016). Visualisation was aided using ESRI ArcGIS 10.1 (see Figure 4.1).

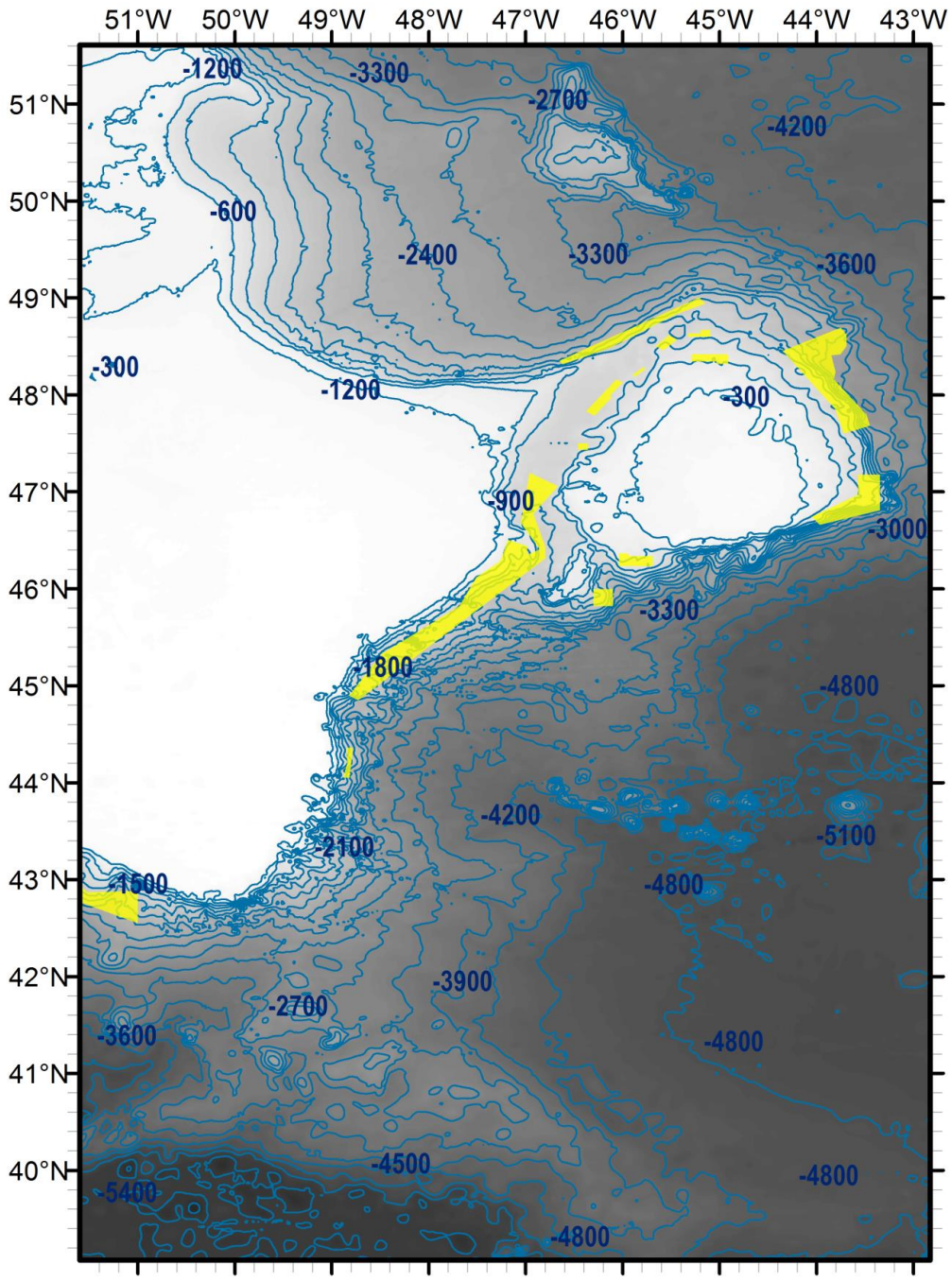


Figure 4.1: Positions of Northwest Atlantic Fisheries Organisation Vulnerable Marine Ecosystem closures around the Flemish Cap, Flemish Pass and slopes of the Grand Banks (yellow polygons). Locations correct as of December 2016. Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

4.3.2.2 Sponge spicule presence

During the process of the taxonomic identification of peracarids, the presence/absence, of siliceous sponge spicules in each box core sample was recorded (see Figure 4.2).

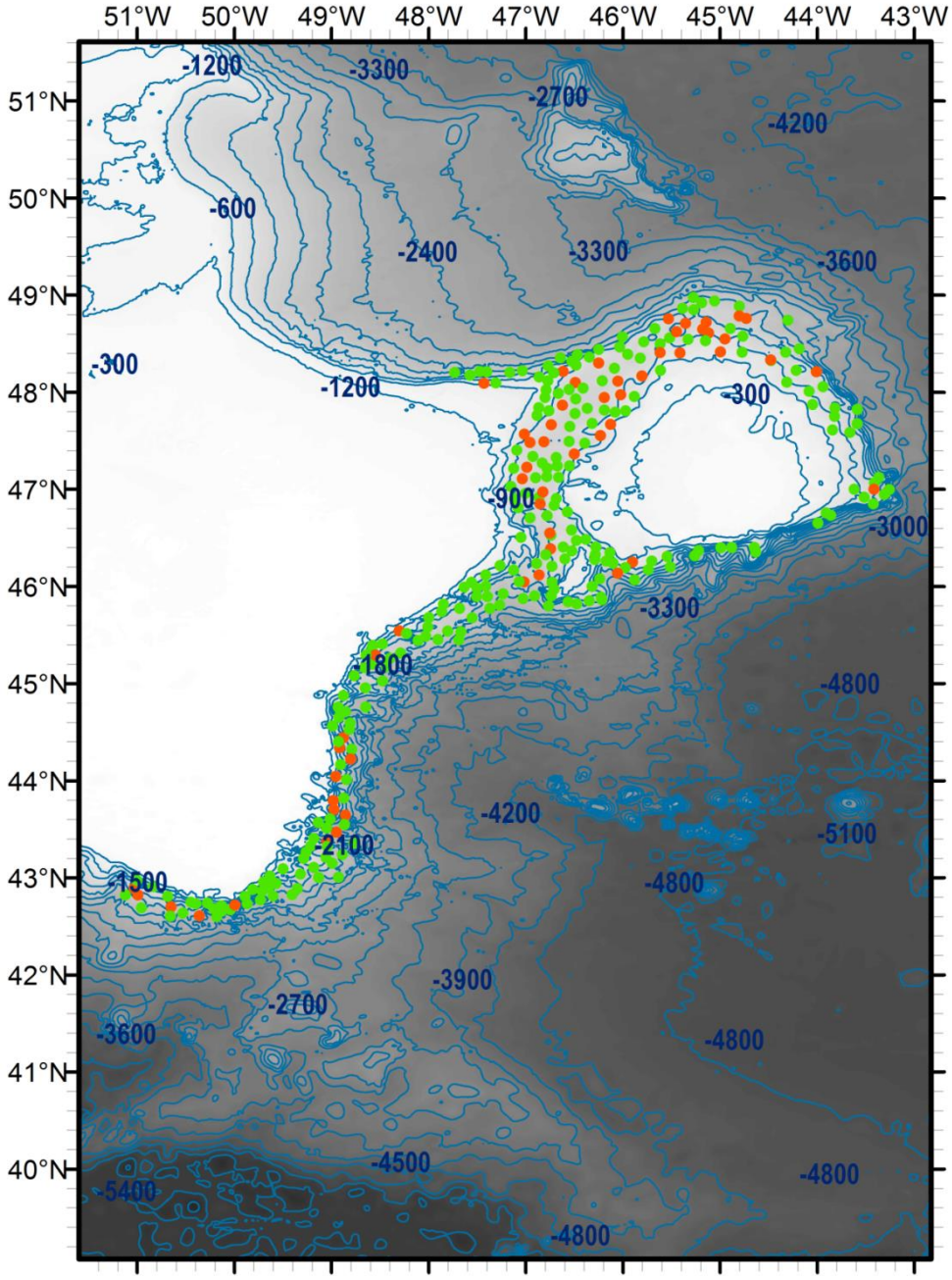


Figure 4.2: Presence (green)/absence (red) of siliceous sponge spicules in box cores over the NEREIDA study area. Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

4.3.2.3 Kernel density approach to estimation of VME biomass

Poriferan, gorgonian coral and pennatulacean biomass was estimated across the study area via kernel density surface estimation of bycatch data obtained from Spanish and Canadian research trawls (raw data acquired directly from Dr Ellen Kenchington (Bedford Institute of Oceanography); poriferan biomass estimated from data collected between 1995 – 2013,

gorgonian and pennatulacean biomass estimated from data collected between 2005 - 2013) following the methodology published in Kenchington et al. (2014) (see figures 4.3, 4.4 and 4.5). Kernel density estimation, a non-parametric smoothing technique commonly used in ecology, particularly in relation to the estimation of animal home range sizes (Worton, 1989), was undertaken using the Kernel Density tool in the Spatial Analyst extension of ESRI ArcGIS 10.1. Poriferan, gorgonian coral and pennatulacean biomass at box core locations was extracted using the Extract Values to Points tool in the Spatial Analyst extension, with local interpolation option selected.

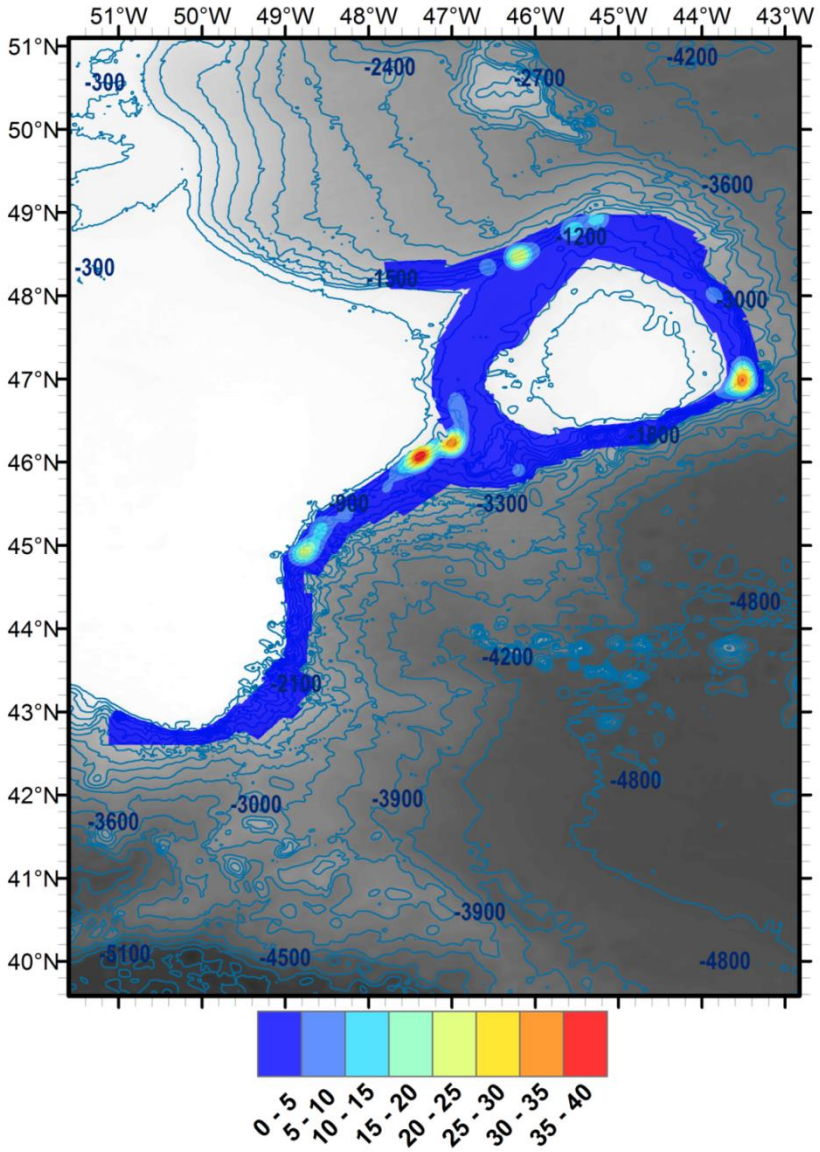


Figure 4.3: Relative biomass of Porifera over the NEREIDA study area (high = red, low = blue), as determined by kernel density surface estimation (see Section 4.3.2.3), following Kenchington et al. (2014). Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

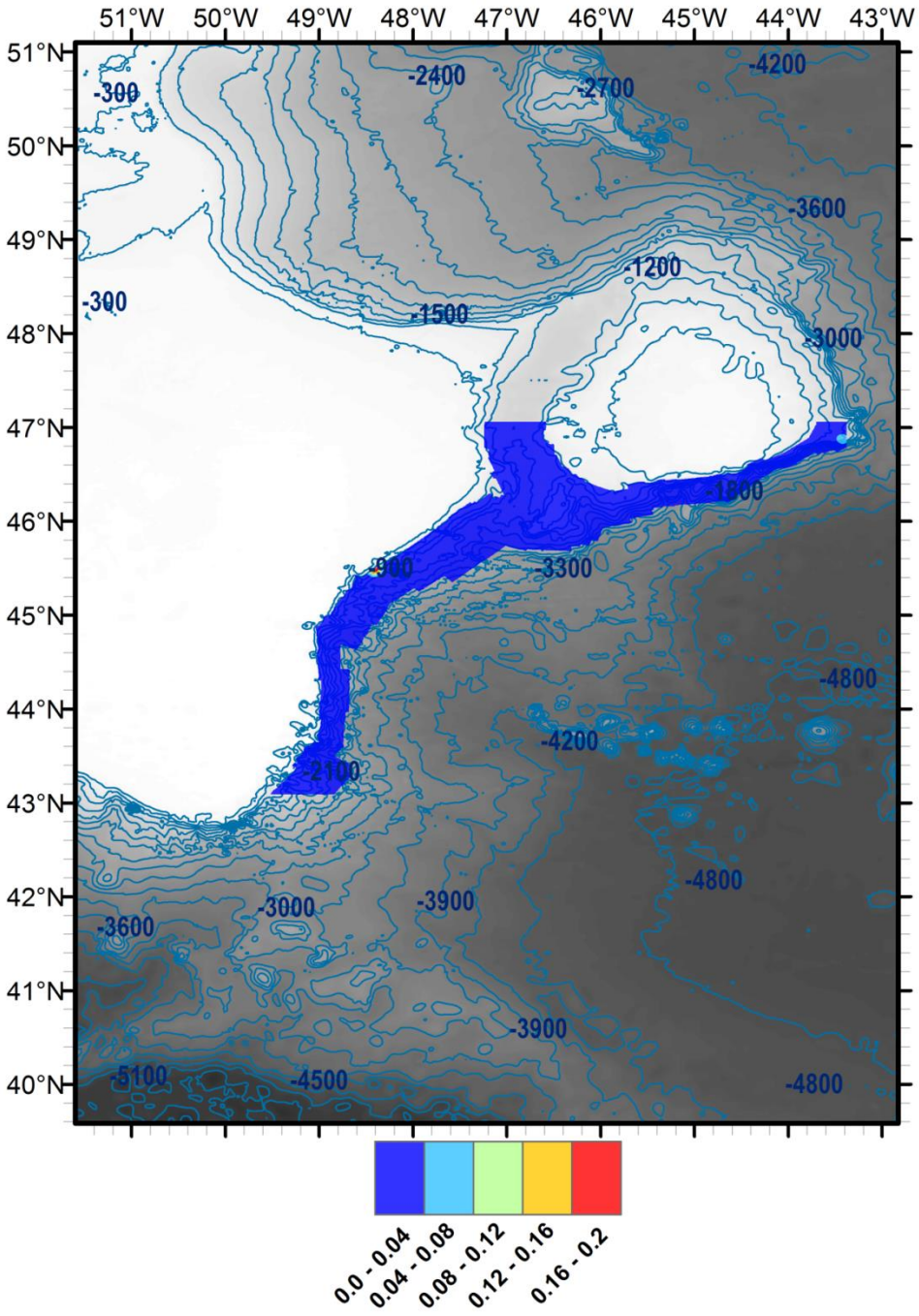


Figure 4.4: Relative biomass of gorgonian corals over the NEREIDA study area (high = red, low = blue), as determined by kernel density surface estimation (see Section 4.3.2.3), following Kenchington et al. (2014). Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

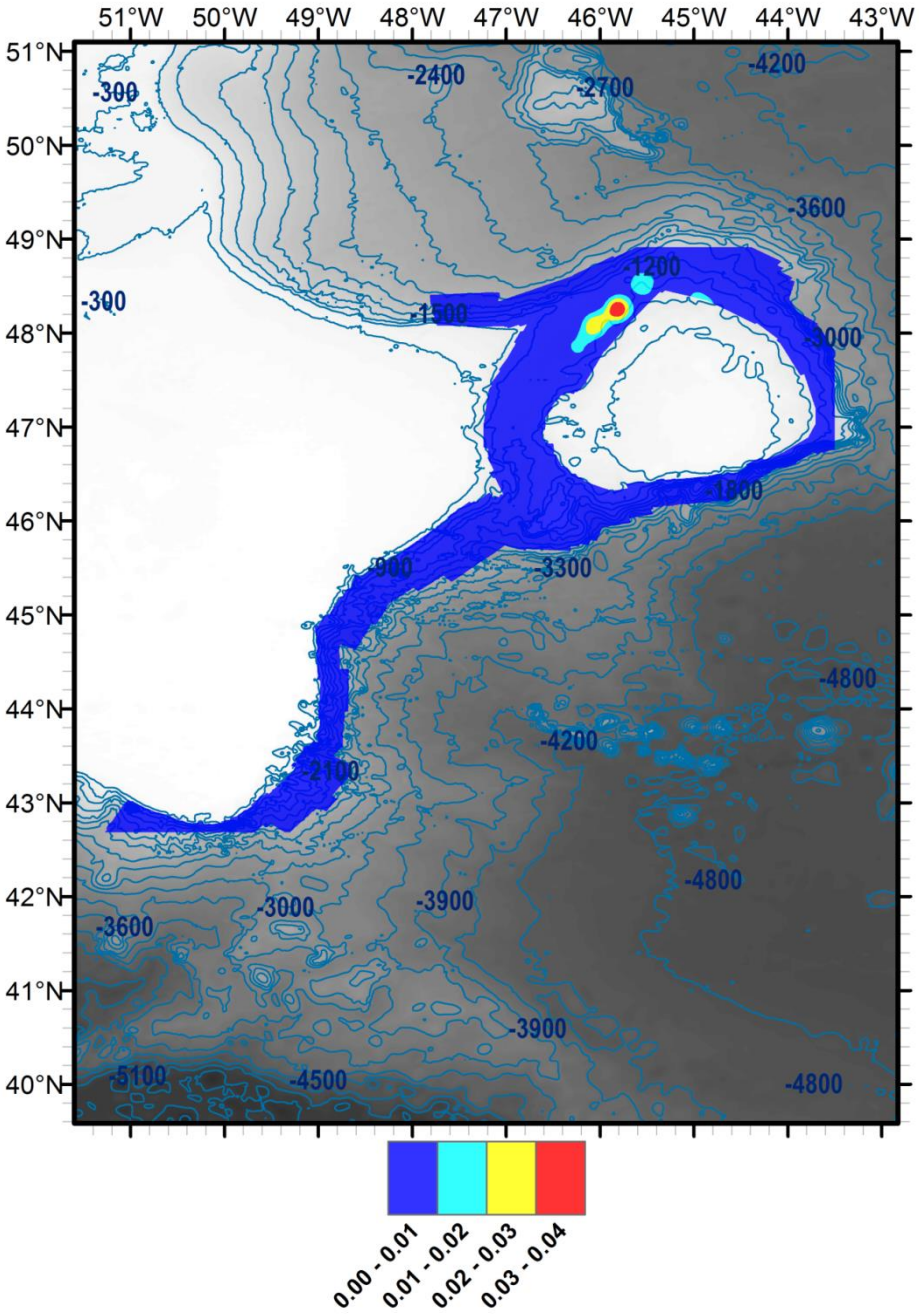


Figure 4.5: Relative biomass of Pennatulacea over the NEREIDA study area (high = red, low = blue), as determined by kernel density surface estimation (see Section 4.3.2.3), following Kenchington et al. (2014). Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

4.3.2.4 Random forest approach to estimation of VME biomass

Further biomass estimates for Porifera, gorgonian corals and Pennatulacea were provided by Anna Downie (Cefas, Lowestoft), produced by the following procedures: point biomass estimates (at trawl start positions) for the three VME-indicator taxa were obtained from annual fishery survey trawls conducted by Canada and Spain between 2011 and 2013.

Random forest regression models (which have been shown to perform well in species distribution modelling contexts (Cutler et al., 2007)) were built for each of the VME-indicator taxa investigated, using square root-transformed biomass as the response variable, and a selection of physical environmental factors as explanatory variables. The random forest method fits many decision trees (typically 500-1000 bootstrap samples) to a data set and combines predictions from all trees (Cutler et al., 2007). All models were produced in R 3.0.2 (R-CoreTeam, 2013) using the package 'randomForest 4.6-12' (Liaw et al., 2015) under default settings and 1000 trees. Predictor variables were first reduced in number by removing all those that had a higher than 0.5 correlation with another predictor. Predictor variables were then selected by applying an iterative permutation procedure using the boruta function in the R package 'Boruta 5.1.0' (Kursa and Rudnicki, 2010).

The following variables were retained in each model - for Porifera: percent clay and silt, mean seafloor current speed, seafloor temperature variability, rugosity, and fishing intensity; for gorgonian corals: depth, eastness, northness, percent organic carbon, rugosity and fishing intensity; for Pennatulacea: benthic position index (150 cell [11250 m] radius), percent clay, eastness, minimum seafloor temperature, percent organic carbon and fishing intensity (see Section 3.3.2 for explanation of these variables, as required).

Models were validated based on a training/test routine, whereby 80 % of data for the response variable was used to 'train' the model, and the remaining 20 % to 'test' the model. R^2 and Normalised Root Mean Squared Error (NRMSE) values were used as validation statistics, calculated using the package 'caret 6.0-71' (Kuhn, 2016) in R 3.0.2 (R-CoreTeam, 2013). The models for Porifera and Pennatulacea both performed well, with R^2 scores of 0.53 and 0.38, respectively, and both achieving mean NRMSE values of 0.10. The model for gorgonian corals performed less well, with an R^2 value of 0.05, and mean NRMSE value of 0.08, this poor performance likely being the result of a high degree of zero inflation (A. Downie, personal communication).

The resulting models represent predictions of relative VME biomass in the NEREIDA sampling area taking into account the likely influence of fishing intensity, and other environmental variables, on their densities (see figures 4.6, 4.7 and 4.8).

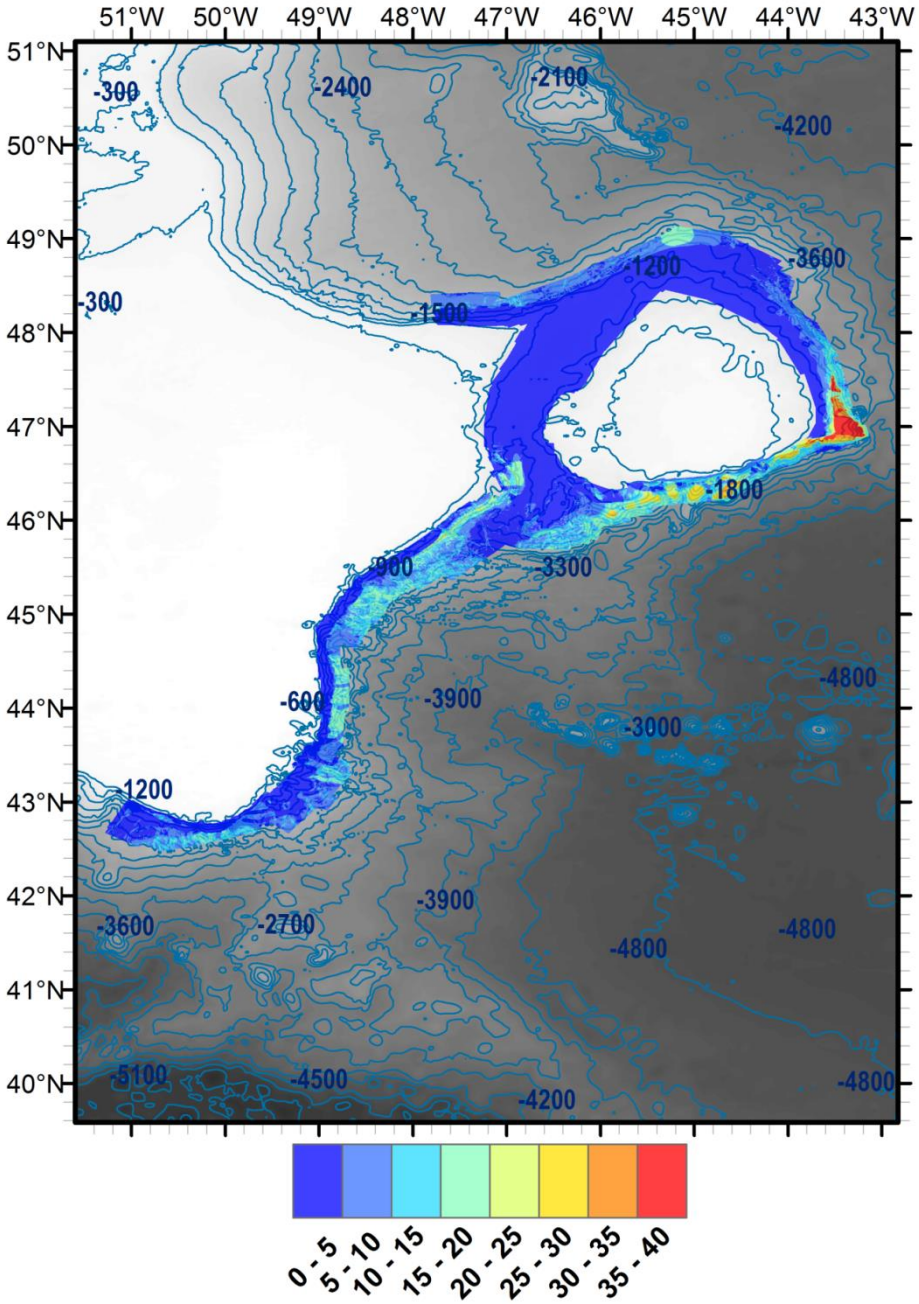


Figure 4.6: Relative biomass of Porifera over the NEREIDA study area (high = red, low = blue), as determined by random forest regression models (produced by Anna Downie, Cefas) (see Section 4.3.2.4). Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

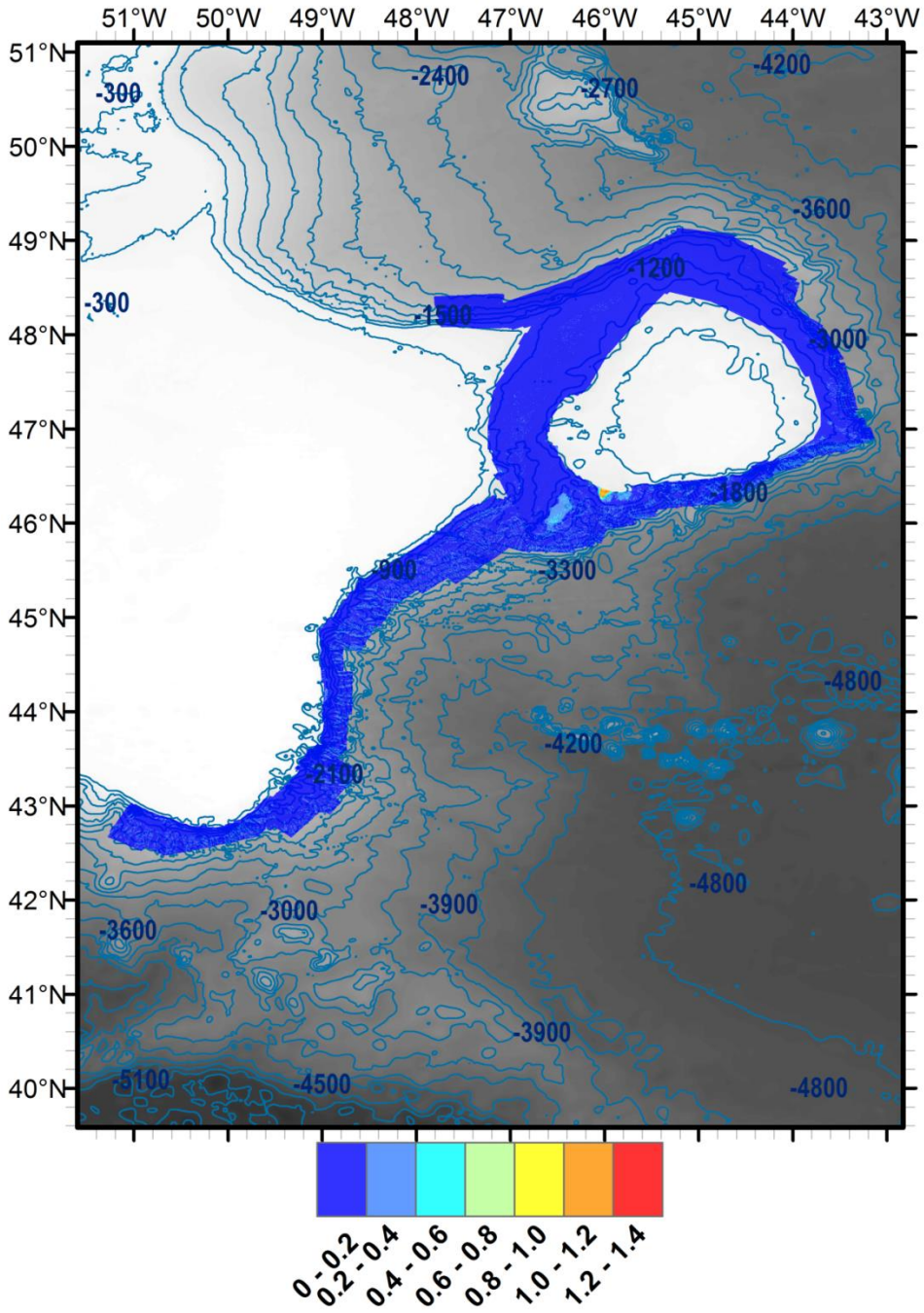


Figure 4.7: Relative biomass of gorgonian corals over the NEREIDA study area (high = red, low = blue), as determined by random forest regression models (produced by Anna Downie, Cefas) (see Section 4.3.2.4). Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

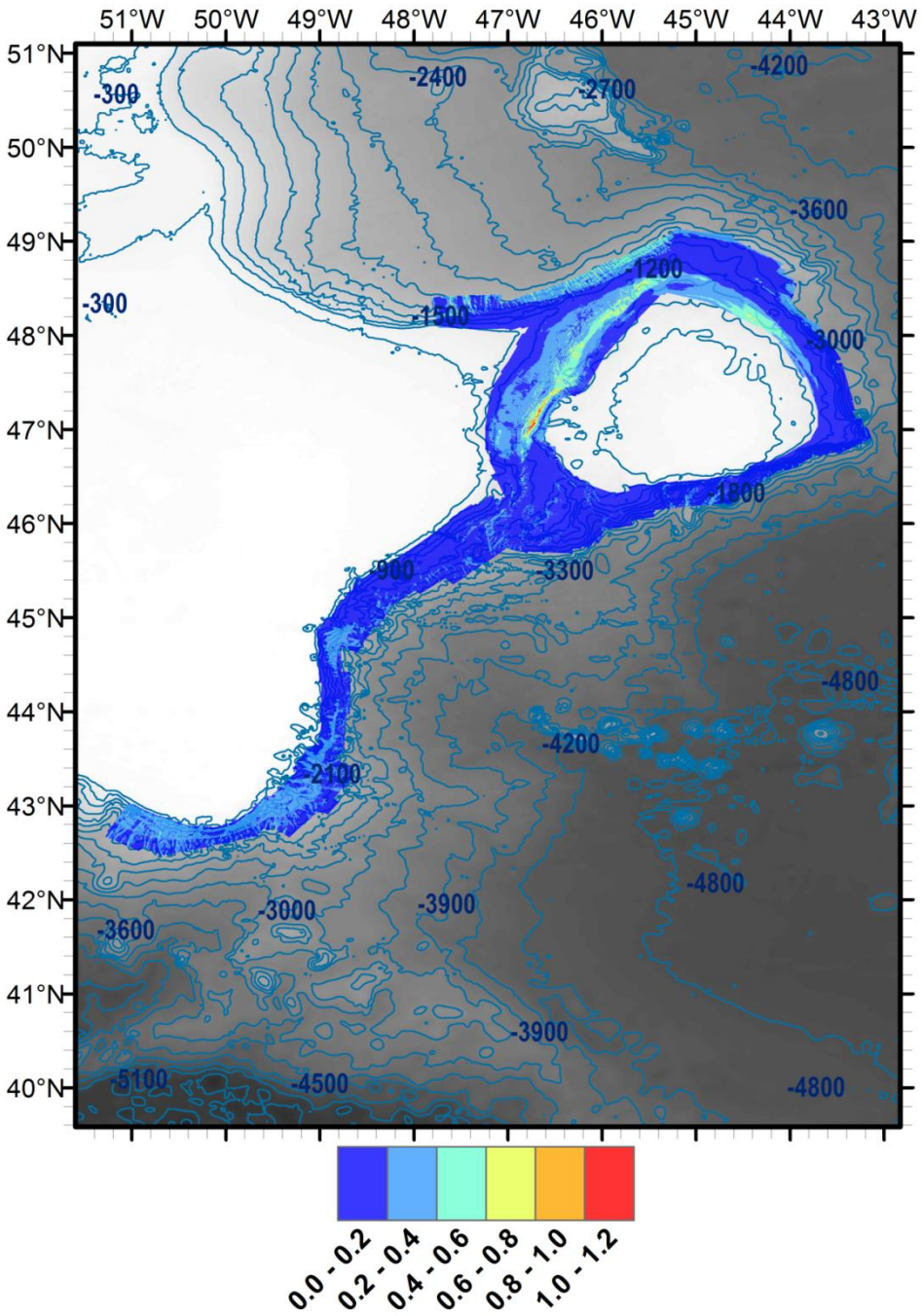


Figure 4.8: Relative biomass of Pennatulacea over the NEREIDA study area (high = red, low = blue), as determined by random forest regression models (produced by Anna Downie, Cefas) (see Section 4.3.2.4). Contours in metres. SRTM30 bathymetric data (a topographical layer produced from a combination of data from the U.S. 'Shuttle Radar Topography Mission' and the U.S. Geological Survey's 'Global 30" Elevation Data Set') used.

4.3.3 Statistical analyses

Prior to analyses, box cores 250 and 350 were removed from the dataset since they were erroneously combined during initial sample processing.

4.3.3.1 Testing for high multicollinearity

Since high multicollinearity amongst explanatory variables can have severe effects on the estimation of model parameters (Gunst and Webster, 1975), Variance Inflation Factors (VIFs) were calculated for all continuous environmental variables. No variable was found to have a VIF value greater than 5 - an accepted cut-off (Stine, 1995) (all values, in fact, were less than 1.6), and hence all variables were retained for analysis. All VIF calculations were undertaken in R 3.0.2 (R-CoreTeam, 2013) using the package 'HH 3.1-32' (Heiberger, 2016).

Table 4.2: Details of the environmental variables retained for analysis following Variance Inflation Factor variable selection.

Environmental facet	Representing variable
NAFO VME closure	Box core taken from within a NAFO closed area or not (categorical)
Porifera presence	Presence, or not, of siliceous sponge spicules in the box core sample (categorical)
	Relative poriferan biomass (√ transformed) at box core locations based on kernel-density surface estimation of bycatch data obtained from Spanish and Canadian research trawls (following the methods of Kenchington et al. (2014)) (2.7 km radius)
	Relative poriferan biomass at box core locations based on random forest regression modelling of bycatch data obtained from Spanish and Canadian research trawls, using a series of environmental factors as predictor variables. Produced by Anna Downie (Cefas) (75x75 m cell size)
Large gorgonian coral presence	Relative large gorgonian biomass at box core locations based on kernel-density surface estimation of bycatch data obtained from Spanish and Canadian research trawls (following the methods of Kenchington et al. (2014)) (2.0 km radius)
	Relative large gorgonian biomass (√ transformed) at box core locations based on random forest regression modelling of bycatch data obtained from Spanish and Canadian research trawls, using a series of environmental factors as predictor variables. Produced by Anna Downie (Cefas) (75x75 m cell size)
Pennatulacea presence	Relative pennatulacean biomass at box core locations based on kernel-density surface estimation of bycatch data obtained from Spanish and Canadian research trawls (following the methods of Kenchington et al. (2014)) (2.7 km radius)
	Relative pennatulacean biomass (√ transformed) at box core locations based on random forest regression modelling of bycatch data obtained from Spanish and Canadian research trawls, using a series of environmental factors as predictor variables. Produced by Anna Downie (Cefas) (75x75 m cell size)
Location	Latitude of box core sampling location
Variation in collection procedure	Crew identity at time of box core collection (categorical)

4.3.3.2 Construction of Generalised Additive Models (GAMs)

Because initial data exploration revealed a high number of relationships between dependent and independent variables that appeared to be non-linear, individual GAMs were constructed in R 3.0.2 (R-CoreTeam, 2013) using the package 'mgcv 1.7-26' (Wood, 2013a) for each of the 11 univariate metrics of peracarid community composition (i.e. excluding 'Community Structure', see Table 4.1) to determine which combination of the 10 environmental variables examined (see Table 4.2) most effectively explained variance in each faunal metric between box cores.

Prior to analysis, all VME biomass estimates obtained based on the methodology of Kenchington et al. (2014) were transformed (square root) to reduce skew in the data and increase consistency with the VME biomass estimates obtained via random forest methodology. Original measurement scales were retained for all other variables because data distributions were deemed acceptable and in order to simplify the interpretation of model outputs. Further, all box cores with zero abundance of peracarids, and box core 341 (with only one peracarid genus present) were removed.

Full GAMs consisted of all variables contained within Table 4.2, with smoothers added to all continuous variables. Appropriate error distributions and link functions were selected via consideration of the Akaike Information Criterion (AIC) (Akaike, 1974) (see Table 4.3), and acceptable satisfaction of model assumptions (e.g. normal distribution of residuals and homogeneity of variance of residuals) was investigated using the *gam.check* function of the package 'mgcv 1.7-26' (Wood, 2013a). Where the biological metric was categorical in form (abundance and taxonomic richness), over-dispersion was checked for via calculation of the dispersion parameter, theta (where theta = residual deviance / residual degrees of freedom) and corrected as appropriate (see Table 4.3). A penalised thin-plate regression spline was used as the smoothing function, and smoothing parameters were optimised automatically on the basis of the Generalised Cross Validation criterion (Wood, 2013a).

Model residuals were examined for the signature of spatial autocorrelation by the calculation of Moran's I (Moran, 1950) in R 3.0.2 (R-CoreTeam, 2013) using the package 'ape 3.2' (Paradis et al., 2004). In no cases could the null hypothesis (that no spatial autocorrelation is present within model residuals) be rejected and hence no further action was taken.

The explanatory terms included in the GAMs were refined from the full model via backwards stepwise selection by consideration of variable *P*-values and model AIC until a minimum AIC value was reached. At this point, the model was considered optimal (Appendix 9).

Table 4.3: Details of error distribution and link functions used for each Generalised Additive Model constructed.

Peracarid community metric	Error distribution and link function	Comments
Abundance	Negative binomial, log	Negative binomial model structure used as original Poisson model exhibited unacceptable levels of overdispersion (theta >30)
Biomass	Gamma, inverse	
Richness	Quasi-Poisson, identity	Quasi-Poisson model structure used as original Poisson model exhibited an overdispersion parameter value of 3.02
Rao Quadratic Entropy	Gaussian, identity	
Shannon Diversity	Gaussian, identity	
Phylogenetic Species Variability (PSV)	Gaussian, identity	
Functional Species Variability (FSV)	Gamma, identity	
Phylogenetic Species Richness (PSR)	Gamma, log	
Functional Species Richness (FSR)	Gamma, log	
Phylogenetic Species Evenness (PSE)	Gaussian identity	
Functional Species Evenness (FSE)	Gaussian, identity	

4.3.3.3 Relation of community structure to VME variables

Relation of peracarid community structure to the presence of VMEs, and selection of the most relevant explanatory variables was achieved via Constrained Analysis of Principal coordinates (CAP) (see Section 3.3.3.3) (Anderson and Willis, 2003) (based on Bray-Curtis dissimilarity (Bray and Curtis, 1957)) followed by backwards model refinement based on *P*-values using the function *ordistep* in the R package 'vegan 2.0-9' (Oksanen et al., 2013) (10000 permutations, *P*-in = 0.05, *P*-out = 0.1).

4.4 Results

Before reporting results, it should be kept in mind that for smoothed terms, *P*-values derived from GAMs are approximate in nature. This is because of complications with the use of smoothing parameters (Wood, 2013b). In recognition of this, some results below are presented for smoothed terms where the *P*-value is above the traditional 5 % cut-off (but below 10 %). Non-significant relationships are not reported. Please refer to tables 4.1 and 4.2 for explanations of the biological and environmental metrics analysed, and to Table 4.4 for a summary of results reported.

4.4.1 Influence of poriferan biomass

Poriferan biomass was found to significantly influence the majority of the biological metrics considered. By the most direct measure, presence of siliceous sponge spicules in box core samples was found to positively influence peracarid abundance ($P < 0.001$), biomass ($P < 0.001$), taxonomic richness ($P < 0.001$), functional richness ($P < 0.001$) (Figure 4.9) and phylogenetic richness ($P < 0.001$), Rao's Quadratic Entropy ($P = 0.018$), Shannon diversity ($P < 0.001$) and functional variability (FSV) ($P = 0.013$) (Figure 4.9). Based on the constrained ordination results, the presence of sponge spicules was also found to significantly affect peracarid community structure compared to samples lacking spicules ($P < 0.001$).

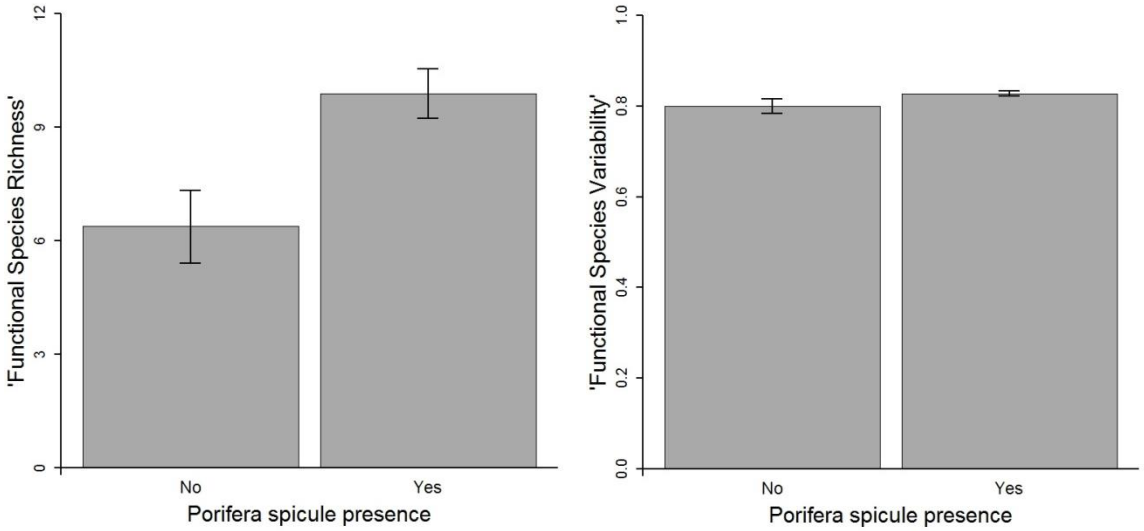


Figure 4.9: Comparison of the 'Functional Species Richness' (left) and 'Functional Species Variability' (right) of box core peracarid assemblages between box cores containing siliceous sponge spicules and those not containing siliceous sponge spicules. Black 'error bars' are 95 % confidence intervals.

At a larger spatial scale, random forest-modelled poriferan biomass (75x75 m cell size) was found to correlate negatively with peracarid abundance (P <0.001), biomass (P <0.001), taxonomic richness (P <0.001), functional richness (P <0.001) and phylogenetic richness (P <0.001). However, this metric of poriferan biomass was found to positively influence peracarid functional evenness (P = 0.033) and phylogenetic evenness (P = 0.005), and functional variability (P = 0.013) and phylogenetic variability (P = 0.009) (Figure 4.10). Further, random forest-modelled poriferan biomass was found to significantly influence peracarid assemblage structure (P <0.001).

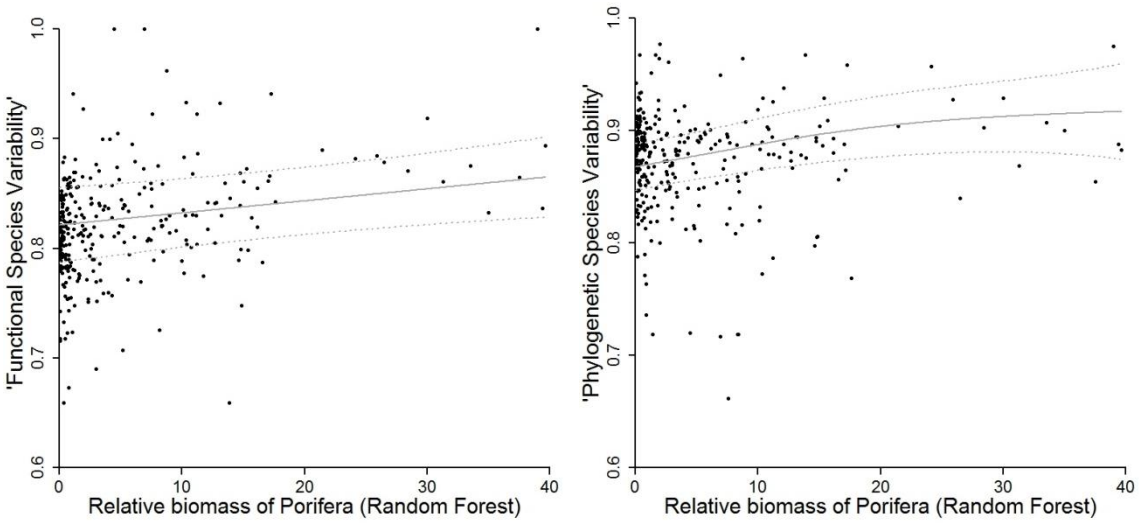


Figure 4.10: Relationship between relative biomass of Porifera at a box core location (as derived via random forest modelling) and the 'Functional Species Variability' of peracarids contained within (left), and the relative biomass of Porifera at a box core location and the 'Phylogenetic Species Variability' of peracarids contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

Based on the kernel density estimation approach of Kenchington et al. (2014) (2.7 km radius window), slightly different results were obtained. Estimated poriferan biomass at box core locations was found to correlate positively with peracarid abundance (P <0.001), biomass (P = 0.001), taxonomic richness (P <0.001), functional richness (P <0.001) and phylogenetic richness (P <0.001) (Figure 4.11), and Shannon diversity values (P <0.001) (Figure 4.11). Further, a possible relationship between this measure of poriferan biomass and the Quadratic Entropy of box core assemblages was uncovered (P = 0.093), this being complex in form but positive overall. Increasing biomass of Porifera was not found to influence phylogenetic or functional variability, or phylogenetic evenness, but functional evenness was found to vary significantly with this metric (P = 0.033). This relationship is double-peaked, with functional evenness being maximised when relative poriferan biomass is between 0.4 and 2.0, and 14.4 and 17.6. Based on the ordination results, kernel density-estimated poriferan biomass was found to significantly influence the structure of peracarid assemblages (P <0.001).

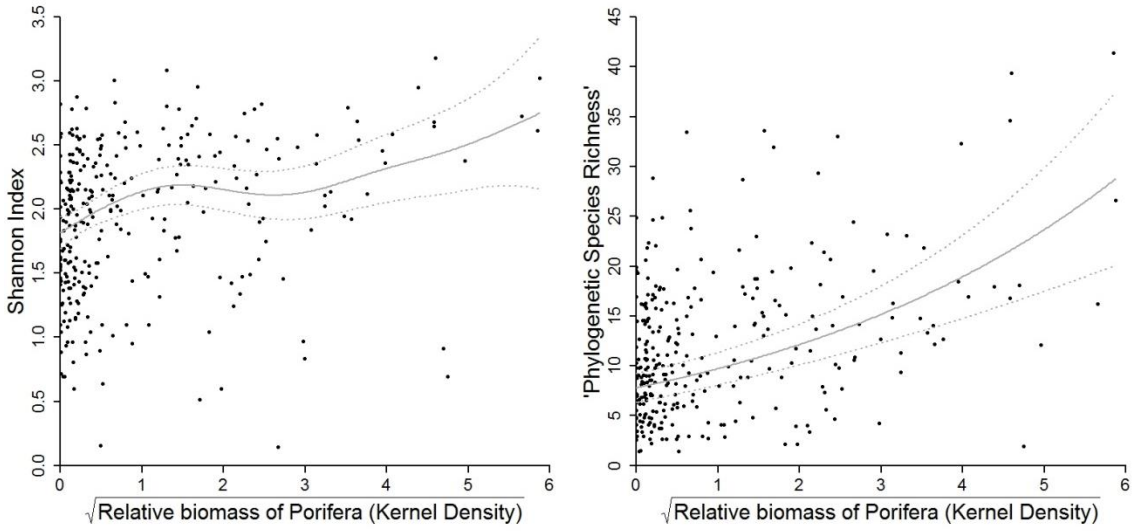


Figure 4.11: Relationship between relative poriferan biomass at a box core location (as derived via Kernel density estimation) (√ transformed) and the Shannon Index of the peracarid assemblage contained within (left) and the relative biomass of Porifera at a box core location (√ transformed) and the 'Phylogenetic Species Richness' of peracarid assemblages contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

4.4.2 Influence of gorgonian coral biomass

Considering both the random forest and kernel density approaches to biomass estimation, gorgonian coral biomass was found to have only a weak influence on peracarid communities. Kernel density-estimated gorgonian coral biomass was not found to influence any of the faunal metrics considered in this analysis, whilst random forest-modelled biomass was found to relate only to phylogenetic variability (P = 0.050), this relationship being complex and negative overall. However, based on the results of the constrained ordination, random forest-modelled gorgonian biomass was found to significantly influence peracarid community structure (P <0.001).

4.4.3 Influence of pennatulacean biomass

Pennatulacean biomass was found to relate to peracarid communities only weakly. Random forest-modelled pennatulacean biomass was found to have only a possible (P = 0.055) effect on peracarid biomass (this relationship taking a complex, undulating form, with no overall directionality; see Figure 4.12), and a significant influence on community structure (P = 0.001).

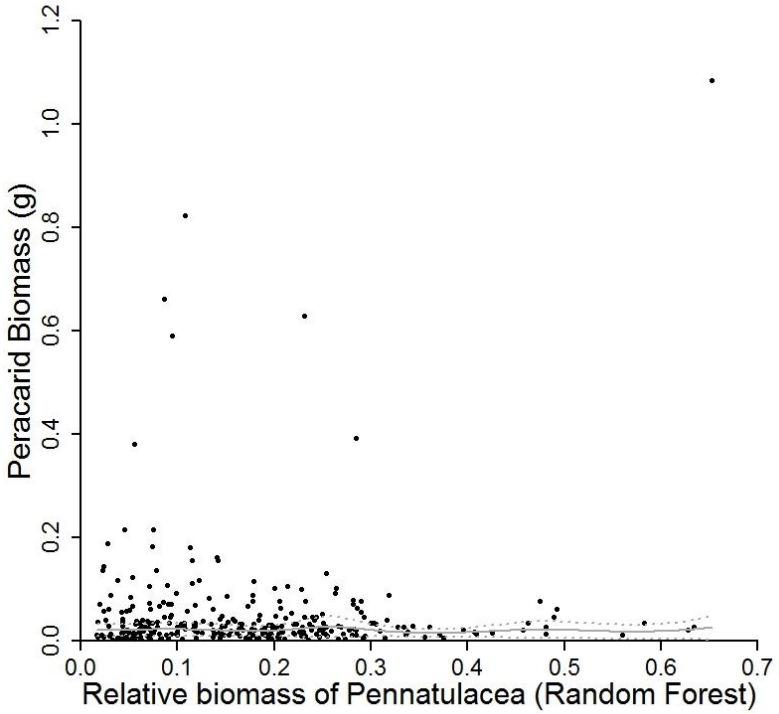


Figure 4.12: Relationship between relative biomass of Pennatulacea at a box core location (as derived via random forest modelling) and the biomass of peracarids contained within. Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

Based on kernel density-estimated pennatulacean biomass (2.7 km radius window), a greater number of significant relationships between pennatulacean biomass and peracarid assemblages were uncovered, but these were found to be generally weak and complex in form. A negative relationship between pennatulacean biomass and peracarid abundance (P <0.001) and functional evenness (P = 0.027) (Figure 4.13) was revealed, and peracarid biomass (P = 0.007), taxonomic richness (P = 0.020) (Figure 4.13), functional richness (P = 0.041) and phylogenetic richness (P = 0.025) were found to vary in a complex, but overall negative manner with increasing pennatulacean biomass. Further, the biomass of pennatulaceans at box core locations was found to significantly influence peracarid assemblage structure (P <0.001).

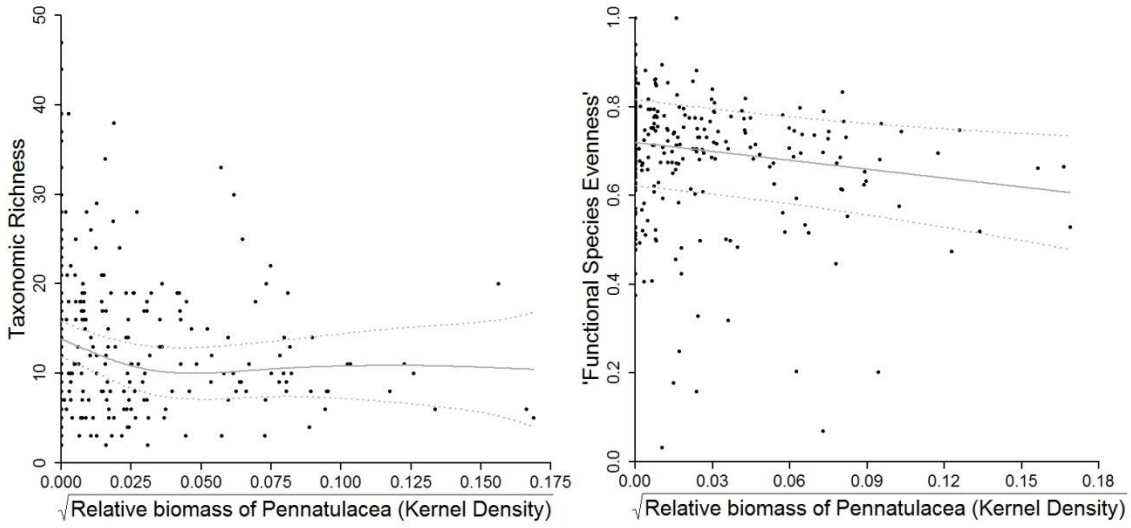


Figure 4.13: Relationship between relative pennatulacean biomass at a box core location (as derived via Kernel density estimation) (√ transformed) and the richness of peracarid genera contained within (left) and the relative biomass of Pennatulacea at a box core location (as derived via Kernel density estimation) (√ transformed) and the 'Functional Species Evenness' peracarid assemblages contained within (right). Solid line is a line of best fit as determined by Generalised Additive Modelling. Dotted lines are 95 % confidence intervals.

4.4.4 Influence of closure status

Whether box cores were collected from an area currently closed to bottom trawling by NAFO, or not, was found to have only limited influence over the faunal metrics investigated. Peracarid abundance was found to be slightly depressed in cores taken from closed regions compared to those from regions open to bottom trawling (P = 0.026), whilst functional evenness was found to be slightly elevated in box cores taken from closed areas relative to those from areas where bottom trawling is permitted (P = 0.032) (Figure 4.14). Whether or not a box core was taken from an area currently closed to bottom trawling was not found to influence any other of the faunal metrics considered.

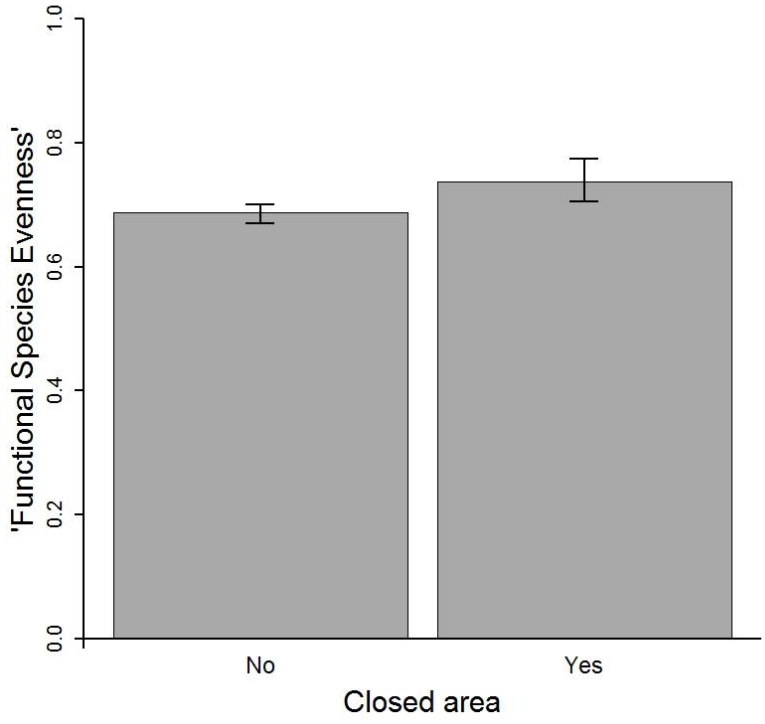


Figure 4.14: Comparison of the 'Functional Species Evenness' of box core peracarid assemblages between cores collected from regions subject to Northwest Atlantic Fisheries Organisation Vulnerable Marine Ecosystem closures and those collected from areas with no spatial restrictions. Black 'error bars' are 95 % confidence intervals.

The above reported relationships are summarised by Figure 4.15 and Table 4.4:

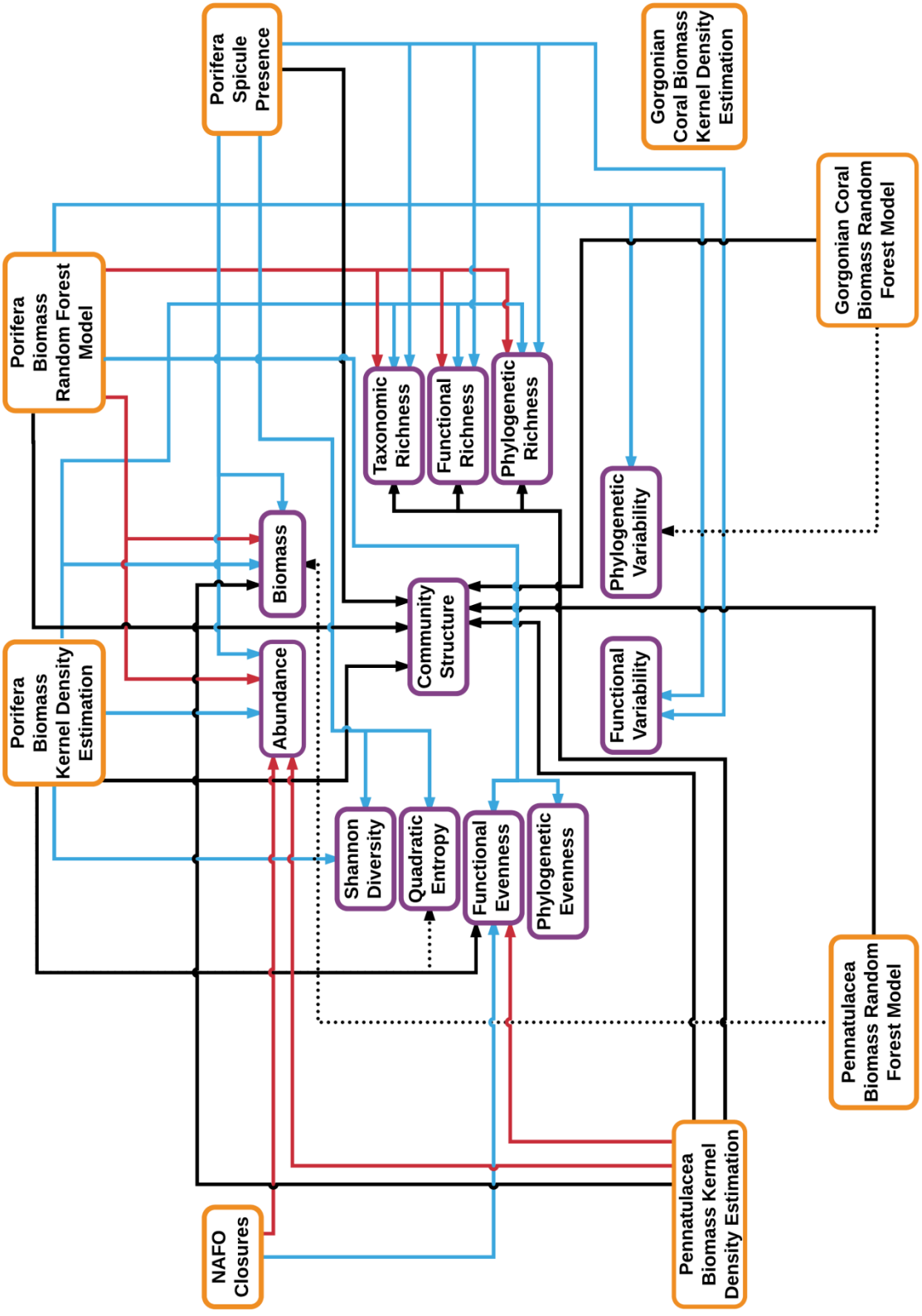


Figure 4.15: Conceptual model detailing influence of VME-indicator taxa and spatial closures on the peracarid fauna of the NEREIDA study area, based on analyses conducted in this chapter. Links between environmental parameters (orange) and biological parameters (purple) are specified. The colour of arrow represents form of relationship: blue = positive, red = negative, black = complex (e.g. 'U' shaped or uni/multi-modal). Solid arrows represent significant relationships (P <0.05). Dotted arrows represent marginal relationships (P <0.1).

Table 4.4: Summary of results of statistical analyses conducted. Blue colouration denotes a positive relationship between dependent and independent variables. Red colouration denotes a negative relationship between dependent and independent variables. Black colouration denotes a complex (e.g. 'U' shaped or uni/multi-modal) relationship between dependent and independent variables. Dark colour blocks represent significant relationships (P <0.05). Light colour blocks (light blue / light red / grey) represent marginal relationships (P <0.1). NS stands for 'not significant'.

	Abundance	Biomass	Richness	Rao Quadratic Entropy	Shannon Diversity	PSV	FSV	PSR	FSR	PSE	FSE	Community Structure
VME closure		NS	NS	NS	NS	NS	NS	NS	NS	NS		NS
Porifera spicule presence						NS				NS	NS	
Porifera biomass kernel density						NS	NS			NS		
Porifera biomass random forest				NS	NS							
Gorgonian coral biomass kernel density	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gorgonian coral biomass random forest	NS	NS	NS	NS	NS		NS	NS	NS	NS	NS	
Pennatulacea biomass kernel density				NS	NS	NS	NS			NS		
Pennatulacea biomass random forest	NS		NS	NS	NS	NS	NS	NS	NS	NS	NS	

4.5 Discussion

4.5.1 Porifera-dominated VMEs

The results of this study strongly suggest that, of the three VME-indicator taxa investigated, Porifera has the greatest influence on peracarid assemblages in the study area (see Table 4.4 and Figure 4.15). High poriferan biomass, as determined both by the presence of hexactinellid sponge spicules (Figure 4.2), and by the biomass estimates of Kenchington et al. (2014) (Figure 4.3) was found to promote an elevated abundance, biomass, taxonomic richness, functional richness (Figure 4.9), phylogenetic richness (Figure 4.11), Quadratic Entropy, Shannon diversity (Figure 4.11), and functional variability (Figure 4.9) of peracarids within assemblages (see Figure 4.15). In contrast, however, high poriferan density, as determined by random forest modelling, was found to correlate with a

depressed abundance, biomass, taxonomic richness, functional richness and phylogenetic richness, but an enhanced phylogenetic variability (Figure 4.10), functional variability (Figure 4.10), phylogenetic evenness and functional evenness of peracarid assemblages. The results of this study highlight a role of poriferans in shaping peracarid assemblage structure for all metrics of poriferan presence investigated.

These findings of positive relationships between hexactinellid sponge spicule presence and peracarid assemblage biodiversity metrics are consistent with the hypothesis of this chapter, as well as with the conclusions of past studies. For example, Bett and Rice (1992) found macrofaunal abundance and biomass to be elevated in areas of dense spicule mats relative to surrounding sediments. They attributed this to the local enhancement of organic matter availability (for instance, by the trapping of phytodetrital matter by the spicule matrix, and by the provision of elevated feeding positions in the water column), and to a reduction in predation pressure (stemming from the inhibition of predatory feeding activities by the spicule matrix) for associated macrofauna. Barrio Froján et al. (2012) also found evidence for enhanced benthic macrofaunal abundance, biomass and taxonomic richness, as well as altered assemblage structure, in samples taken from areas characterised by dense siliceous spicule mats. Further to these investigations, this study documents a positive influence of spicule presence on taxonomic metrics of diversity, phylogenetic and functional metrics of richness, and functional variability (Figure 4.9), further extending knowledge of the influence sponge spicule mats have on deep-sea macrofaunal assemblages. This is a habitat arguably deserving of additional research attention.

Based on poriferan biomass as determined by Kenchington et al. (2014), the findings of this study are consistent with those of previous investigations highlighting an increased abundance, richness and diversity, and an altered community structure of benthic fauna in proximity to poriferan aggregations (Pearse, 1932, Klitgaard, 1995, Beazley et al., 2013, Beazley et al., 2015). Such results are most frequently attributed to the beneficial

influence of sponge biomass on three-dimensional habitat space and complexity, reduced predation pressure, and increased feeding opportunities (Cinar et al., 2002, Wulff, 2006, Buhl-Mortensen et al., 2010, Hogg et al., 2010, Beazley et al., 2013).

Overall, if only poriferan presence as determined by the presence of hexactinellid sponge spicules and the kernel density biomass estimates of Kenchington et al. (2014) are considered, the results of this study reaffirm the perception of poriferans as important ecosystem engineers in the deep sea.

4.5.2 Reliability of SDMs for ecological investigation and management applications

The contrast in results obtained between sponge spicule data and the poriferan biomass data of Kenchington et al. (2014) (both firmly linked to ground-truthed data), and those obtained from the random forest modelling approach (which involves a much larger degree of extrapolation), however, is conspicuous (see Table 4.4 and Figure 4.15). These findings bring into doubt the dependability of distribution modelling approaches for management and ecological investigation purposes in the NAFO Regulatory Area and further afield.

Commonly, poor performance in Species Distribution Models (SDMs) leads to the overfitting of model parameters, with resulting predictions being overly sensitive to environmental differences between cells. Poor model performance may be caused by insufficiency and/or bias in the number and spatial spread of biological records, inappropriate weighting of particular biological records, and an inadequacy of available environmental data to fully reflect a taxon's fundamental niche (Feeley and Silman, 2011).

For the random forest model of Porifera utilised here, the following environmental variables were incorporated: sediment percent clay and silt content, average seafloor current speed, variability in annual seafloor temperature, seafloor rugosity and bottom trawling intensity. However, a number of environmental variables typically recognised as being important in determining poriferan biomass across space were not considered,

including seafloor oxygen concentration (Buhl-Mortensen et al., 2010) and concentration of suspended organic matter (Knudby et al., 2013a). Further, it should be noted that the random forest model utilised did not account for any form of relevant biological information, such as details of population connectivity or any biogeographic constraints that may apply. Incorporation of this information may help to improve model performance.

Whilst SDM methods appear to perform consistently well in cases of discrete, geographically limited focal areas that are well sampled, they often struggle where data is limited and/or spatially or temporally biased (Anderson and Gonzalez Jr, 2011, Feeley and Silman, 2011), as well as when extrapolation to new regions with different prevailing environmental conditions is required (Randin et al., 2006, Anderson and Gonzalez Jr, 2011, Knudby et al., 2013a). In these circumstances, which may indeed apply to the random forest models produced in this study, poor model performance and over-prediction can occur, resulting in a high rate of false positive and false negative results (Anderson and Gonzalez Jr, 2011, Ashford et al., 2014). Considering this and the results of the present study, I argue that, even considering that the NAFO Regulatory Area is one of the most data-rich deep-sea areas globally, VME distribution modelling in this region is not yet sufficiently developed to be relied upon in isolation for scientific and management applications, with the use of firmly ground-truthed data being preferable. More biological sampling and the collection of additional high-quality environmental information is first required.

4.5.3 Gorgonian coral-dominated VMEs

The results of this investigation suggest that gorgonian corals have very little influence over peracarid communities in the study region. Indeed, based on gorgonian coral biomass estimates as reported by Kenchington et al. (2014), no significant relationships with any of the facets of peracarid biodiversity analysed were obtained. With regards to gorgonian coral biomass estimates produced by random forest modelling, only a possible (P = 0.050), complex relationship with phylogenetic variability, and an influence on assemblage

structure were uncovered. These results should be treated with caution, however, since validation statistics suggest a poorly performing random forest model (R^2 = 0.05).

Such findings may reflect a very low prevalence of gorgonian corals in the study area (see figures 4.4 and 4.7), rather than an irrelevance of their presence to benthic macrofaunal communities in general. It appears that at no location from which box core samples were taken do gorgonian corals reach sufficient density to dominate the benthic community, form coral forests, and significantly shape peracarid communities.

4.5.4 Pennatulacea-dominated VMEs

Like gorgonian corals, pennatulaceans also appear to have little influence over peracarid communities in the study area. Furthermore, as found for Porifera, the results of the analyses presented here contrast depending on which metric of pennatulacean biomass is considered – that provided by Kenchington et al. (2014), or that given by the random forest distribution model.

Based on random forest model predictions, only a possible (*P* = 0.055), complex relationship with peracarid biomass, and an influence of pennatulacean biomass on peracarid community structure were revealed. Conversely, if estimates of pennatulacean biomass provided by Kenchington et al. (2014) are analysed, a more complex picture, generally in conflict with the hypothesis of this study, is painted. Specifically, biodiversity metrics are either negatively influenced by increasing sea pen biomass (Figure 4.13), show no clear directionality (Figure 4.13), or exhibit no significant relationship at all (Table 4.4, Figure 4.15). Conspicuously, no positive influence of pennatulacean biomass on any of the faunal metrics analysed was recovered. This is surprising since sea pen fields are traditionally thought to provide elevated habitat heterogeneity in the deep sea, and can act as a food source for some amphipod species (Buhl-Mortensen et al., 2010).

Two factors may help to explain these recovered relationships. Firstly, like gorgonian corals, it appears that sea pens do not reach particularly high densities in the study area

(see figures 4.5 and 4.8). As a result, their densities may never be great enough to strongly shape peracarid communities. Secondly, sea pen fields in relative proximity to the sampling regions are known to be utilised extensively by fish (particularly *Sebastes* spp.) as spawning and nursery grounds (Baillon et al., 2012). It is possible that the above recovered relationships reflect a signature of top-down control on peracarid communities by fish in proximity to sea pen fields.

4.5.5 Influence of closure status

That box core samples taken from within spatial closures currently enforced by NAFO in the sampling area (Figure 4.1) did not exhibit elevated peracarid abundance, biomass or diversity was unexpected since the locations of these closures were selected, at least in part, on the basis of evidence for elevated VME biomass, and this, in turn, should influence macrofaunal communities. In fact, it appears that peracarid assemblages sampled from within the spatial closures are statistically indistinguishable (save for slightly lowered abundance and marginally elevated functional evenness (Figure 4.14)) from those sampled from surrounding areas. This finding may, in part, reflect the simple shapes of the spatial closures (Figure 4.1); because of this simplicity, the area encompassed by each spatial closure may include a variety of benthic habitats. As a result, that a box core was collected from within a closure does not necessarily guarantee that the box core was collected from within a VME. Conversely, not all areas that are known/are likely to house VMEs are currently protected by spatial closures (NAFO, 2015, Barrio Froján et al., 2016, Gianni et al., 2016) (see Section 6.2). Thus, that a box core was collected from outside of a closure does not necessarily guarantee that the box core was collected from a non-VME habitat. In addition, there is evidence that some of the spatial closures currently enforced by NAFO (e.g. the 3O coral closure) describe areas where VME density is unlikely to be significantly higher than surrounding areas, and so could be re-located more appropriately (Rogers and Gianni, 2009). If this is commonly the case, one would not expect benthic communities to differ significantly between closures and surrounding areas.

Overall, the optimality of the current system of spatial closures is called into question in terms of its provision of protection to all components of diverse benthic communities across the NAFO Regulatory Area. A review of the details of current NAFO spatial closures is proposed in light of this (see Section 6.5).

4.6 Concluding statement

Whilst VMEs are considered faunal oases in the deep sea, boosting habitat area and complexity (Buhl-Mortensen et al., 2010), providing appropriate spawning locations for fish (Baillon et al., 2012) and offering protection from predation and enhanced feeding opportunities to macrofauna (Wulff, 2006), studies investigating the influence of key structure-forming taxa on macrofaunal communities are rare. As such, this chapter aimed to significantly extend knowledge of the importance of structure-forming taxa (specifically sponge grounds, gorgonian coral forests and sea pen fields) to peracarid crustacean communities, as well as examine the appropriateness of current spatial closures for the protection of benthic diversity in the NAFO Regulatory Area. This was achieved via the consideration of a broad selection of biological metrics (including phylogenetic and functional information) and various metrics of VME presence.

The results of this study re-emphasise the important influence that structure-forming taxa have over a variety of macrofaunal community attributes. Particularly striking was the clear dominance of sponge grounds over the coral habitats analysed in terms of their value to macrofaunal communities, this confirming their status as the key habitat-forming structures in the study region.

The apparent limited influence of gorgonian coral biomass on peracarid communities may be a result of their relatively low prevalence in the study area, rather than an irrelevance of their presence to benthic macrofaunal communities in general. This too may, in part, explain the complex relationships recovered between pennatulacean biomass and the peracarid assemblage attributes measured. However, that sea pen fields are known to be

aggregation spots for fish species that prey on peracarid taxa may also help explain the apparent complex negative influence of this habitat on peracarid communities.

A key conclusion of this study is that evidence derived from deep-sea taxon distribution models should be treated with caution at present. The results of this study suggest that distribution models are not yet dependable enough to be applied as the sole form of information for ecological investigations or management decisions in the NAFO Regulatory Area (and, perhaps, in the deep sea in general), with firmly ground-truthed data being more suitable. At present, SDMs generally appear to be too data-limited to provide dependable insights into the distributions of focal taxa. Further biological sampling, and the collection of additional high-quality environmental data, should be promoted.

Lastly, the results of this study suggest that the current spatial closures enforced by NAFO in the study area may not be fully optimal with regards to the protection of macrofaunal diversity hotspots against the impacts of bottom-contact activities. A review of the specifications of the current system of spatial closures is proposed (see Section 6.5) in light of the information presented in this chapter.

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Chapter 5

'What is the form of deep-sea biodiversity – ecosystem functioning relationships?'

5.1 Abstract

Biodiversity – ecosystem functioning (BEF) research aims to determine the directionality and form of link between biodiversity and ecosystem functioning in biological systems. Investigation of this relationship is important as humans are impacting global biodiversity. BEF research in terrestrial and shallow water environments is relatively well developed, with studies typically demonstrating a positive BEF relationship taking one of three major forms: saturating, linear or accelerating. In contrast, BEF research in the deep sea is in its infancy, with just five publications reporting deep-sea BEF relationships to date. All of these studies examine BEF relationships only in nematodes (meiofauna) and focus on bathyal depths, yet report contrasting conclusions of accelerating, linear or saturating relationships. This study advances and clarifies knowledge of deep-sea BEF relationships via an analysis, using Structural Equation Modelling, of the largest deep-sea BEF dataset yet produced. Macrofauna (Peracarida) are investigated, and a wide range of biodiversity metrics (including taxonomic, functional and phylogenetic measures) are studied. BEF relationships are found to be generally positive, but variable in form depending on the biodiversity and ecosystem functioning metrics in question. It is argued that deep-sea BEF relationships should not be forced into one of three basic forms, and instead, a new theory is proposed whereby all positive BEF relationships take a single sinusoidal form consisting of accelerating, linear and saturating portions being expressed in that order with increasing biodiversity. It is hypothesised that the comparative dominance of each of these portions is dependent on the average 'interaction frequency' of organisms (relative to body size) contributing to the ecosystem function in question. With a lower average 'interaction frequency' of organisms, expansion of the accelerating portion of the curve is promoted, whilst with a higher average 'interaction frequency' of organisms, magnification of the

saturating portion of the BEF relationship results. The average 'interaction frequency' of organisms is, in turn, most greatly influenced by the energy availability of the system and the generality of the ecosystem function in question. Such a theory can be employed to explain apparent differences between deep-sea and shallow-water or terrestrial BEF relationships, and between different BEF studies within the same system that analyse different ecosystem functions or taxonomic groups. Further, this theory can be used to predict the likely vulnerability of an ecosystem function to biodiversity loss.

5.2 Introduction

Biodiversity – ecosystem functioning research aims to interrogate the fundamental form of the relationship between the level of diversity in a biological system and the rate at which various ecosystem functions occur in that system (Naeem, 2012). Here, the term 'biodiversity' is defined, following DeLong (1996), as '*a concept that specifically refers to the magnitude of biological variety within and among communities of organisms at any spatial scale – from microsites to the entire biosphere'*. In turn, ecosystem functioning is defined as '*the aggregate effect of physical, chemical and biological processes associated with the flow of energy and matter within and between trophic levels, communities and ecosystems'*, after Danovaro et al. (2008), Loreau (2008) and Paterson et al. (2012).

Following Darwin's observation that plant communities containing a greater variety of species are likely to be more productive than monocultures (Darwin, 1859), there is now strong evidence of a consistent link between biodiversity and ecosystem functioning (and so the provision of ecosystem services). This link is typically positive and appears to hold true over multiple trophic levels and ecosystem types, including terrestrial and marine, with reductions in ecosystem resilience, stability and multifunctionality as biodiversity declines (Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006, Danovaro et al., 2008, Naeem et al., 2012, Strong et al., 2015, Soliveres et al., 2016). In a world where biodiversity is under increasing threat (Jackson, 2008, Cardinale et al., 2012, Naeem et al., 2012, Ceballos et al., 2015, McCauley et al., 2015), it is now more important

than ever that BEF relationships are understood in detail. As such, BEF research has been termed *"the utilitarian rationale for biodiversity conservation"* (Magurran, 2012).

Directed BEF research first emerged in the 1970s in the form of studies investigating the relationship between the diversity of systems and their stability (e.g. Gardner and Ashby (1970), De Angelis (1975)), but it was not until the mid-1990s that BEF relationships were considered in detail and significant advances were made (Lawton, 1994, Naeem et al., 1994, Naeem et al., 1995). These initial studies were generally small in scale (both spatially and temporally), highly controlled, and experimental in type, and investigated communities of limited complexity (see Section 1.5.2). Only relatively recently has the quest for external validation and generalisability led to an increase in the number of taxa, trophic levels, functions and ecosystems considered (Naeem et al., 2012, Wu et al., 2015).

5.2.1 Alternative forms of the BEF relationship

The form of the relationship between biodiversity and ecosystem functioning could, in theory, take a number of shapes: positive/negative/idiosyncratic, linear/exponential/logarithmic, etc. However, based on ecological theory and research, three generalised forms can be distinguished as the most common shape for natural BEF relationships: 1) an asymptotic curve of increasing ecosystem functioning with increasing biodiversity, 2) a linear relationship between biodiversity and ecosystem functioning, and 3) an accelerating relationship between biodiversity and ecosystem functioning (Naeem et al., 1994, Naeem et al., 1995, Hector et al., 1999, Tilman et al., 2001, Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006, Danovaro et al., 2008, Mora et al., 2011, Naeem, 2012, Strong et al., 2015) (see Figure 5.1).

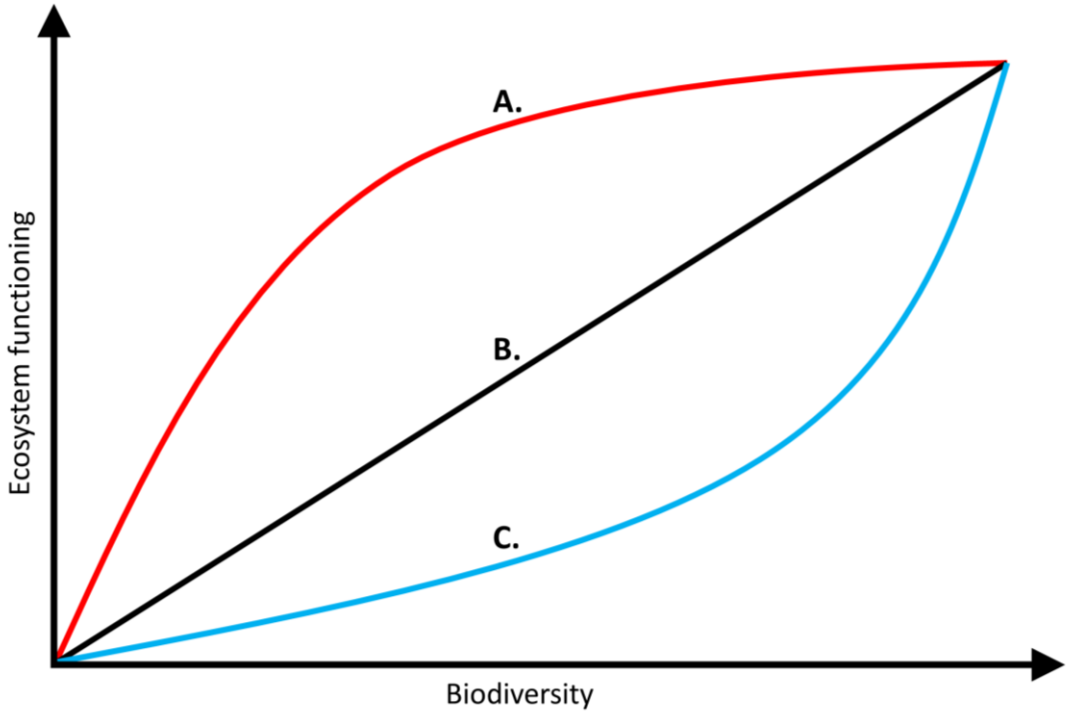


Figure 5.1: Three most likely forms that biodiversity - ecosystem functioning relationships may take in nature. A: saturating form (red). B: direct linear form (black). C: accelerating form (blue).

A positive but saturating relationship is the form most frequently reported in BEF studies, having been demonstrated with remarkable consistency across multiple trophic levels and ecosystems (Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006). For example, in a meta-analysis of marine BEF experiments and observational studies, Worm et al. (2006) concluded that as diversity declines in marine systems, rates of resource collapse increase, and ecosystem resilience, stability and water quality decrease exponentially. A saturating relationship has thus come to represent the standard hypothesis for the form of BEF relationships.

Such a relationship can be explained by a combination of functional redundancy in natural ecological systems (many species may contribute relatively little to ecosystem properties (Lawton, 1994, Snelgrove, 1997, Hooper et al., 2005, Leduc et al., 2013)), and increased interspecific competition within highly diverse systems, reducing the efficiency of species processes (Lawton, 1994, Leduc et al., 2013).

Whilst rarer, linear relationships between biodiversity and ecosystem functioning have been reported in a number of studies across multiple ecosystems. For example, Naeem et al. (1994, 1995) found evidence for a positive linear relationship between biodiversity and a range of ecosystem processes in their closely controlled 'Ecotron' experiment, whilst similar positive linear relationships have been reported in experimental (Hector et al., 1999, Spehn et al., 2000) and observational (Tilman et al., 1996, Troumbis and Memtsas, 2000, Pape et al., 2013, Pusceddu et al., 2014) studies in the field.

Linear BEF relationships are suggestive of low levels of functional redundancy and/or a limited or balanced influence of negative and positive species interactions. Thus, linear BEF relationships represent a form of the 'rivet hypothesis' of Lawton (1994) whereby species appear to make a distinct and approximately equal absolute contribution to ecosystem performance.

An accelerating relationship between biodiversity and ecosystem functioning suggests that increasing biodiversity promotes ever greater ecosystem functioning. Such a relationship has been dismissed as unlikely (Naeem, 2012), yet has been reported by a small number of studies, these generally being observational rather than experimental in type (Mora et al., 2014), and focussed on marine environments (Duarte, 2000, Danovaro et al., 2008, Mora et al., 2011, Pape et al., 2013). Of particular note is the global-scale study of Danovaro et al. (2008), which reported evidence for an exponential BEF relationship on the deep ocean floor. Given the huge area of the deep-sea benthos (Costello et al., 2010), accelerating BEF relationships may be more common than presently given credit for.

Accelerating BEF relationships are indicative of a high level of complementarity between species (promoting increased efficiency of ecosystem processes with increasing diversity (Loreau and Hector, 2001)), a low level of functional redundancy, and very limited influence of competitive interactions. Complementarity can be brought about either via positive species interactions such as facilitation, or by effective resource partitioning

(Loreau and Hector, 2001). Facilitation, whereby positive interactions between species in a mixed community enhance ecosystem processes (Connell and Slatyer, 1977, Bruno et al., 2003, Danovaro et al., 2008, Loreau, 2008, Duffy et al., 2012), was first proposed in the ecological literature by Connell and Slatyer (1977), and is the most popular explanation for accelerating BEF relationships (Gross and Cardinale, 2005, Danovaro et al., 2008, Loreau, 2008). Examples of facilitation have been known in shallow marine communities for some time (Gallagher et al., 1983, Jones et al., 1994, Bruno et al., 2003), and Danovaro et al. (2008) promote the importance of facilitation in explaining the apparent accelerating BEF relationships of deep-sea benthic communities.

5.2.2 Implications of the BEF relationship

Any of the three common BEF relationships outlined above has serious implications when viewed in a framework of the continuing erosion of biodiversity globally, since all predict that reductions in the biodiversity of environments will be linked to reductions in ecosystem functioning (and so the provision of ecosystem services), this having potentially severe consequences for human wellbeing (Naeem et al., 1994, Naeem et al., 1995, Doak et al., 1998, Solan et al., 2004, Hooper et al., 2005, Worm et al., 2006, Danovaro et al., 2008, Frank et al., 2011, Duffy et al., 2012, Emmerson, 2012, Holt et al., 2012, Naeem, 2012, Thrush and Lohrer, 2012, Thurber et al., 2014, Strong et al., 2015). However, determination of the detailed form of BEF relationships in ecosystems is of importance since each of the alternative forms has different implications for the vulnerability of ecosystem functioning to biodiversity loss. For example, for a saturating BEF relationship, as recovered for some shallow water systems (Worm et al., 2006), reductions in levels of ecosystem functioning will accelerate as biodiversity loss progresses (Figure 5.2). In other words, such a relationship suggests that biodiversity acts as a biogeochemical catalyst with Michaelis-Menton-like kinetics (Naeem, 2012, Fung et al., 2015); as diversity is reduced, the effectiveness of this natural catalyst declines at an ever increasing rate. An important characteristic of this relationship is that it is suggestive of a BEF tipping point in certain environments. At levels of diversity above this point, ecosystem functioning will be

relatively robust to changes in diversity (Figure 5.2), being buffered by functional redundancy (Hooper et al., 2005, Raffaelli and Friedlander, 2012, Leduc et al., 2013). However, as biodiversity loss passes this tipping point, ecosystem functioning will spiral downwards. Given the current imprint of humanity on shallow-water environments (Jackson et al., 2001, Myers and Worm, 2003, McCauley et al., 2015) (see Section 1.3), current levels of diversity loss may be approaching this hypothesised tipping point in some ecosystems (Naeem, 2012).

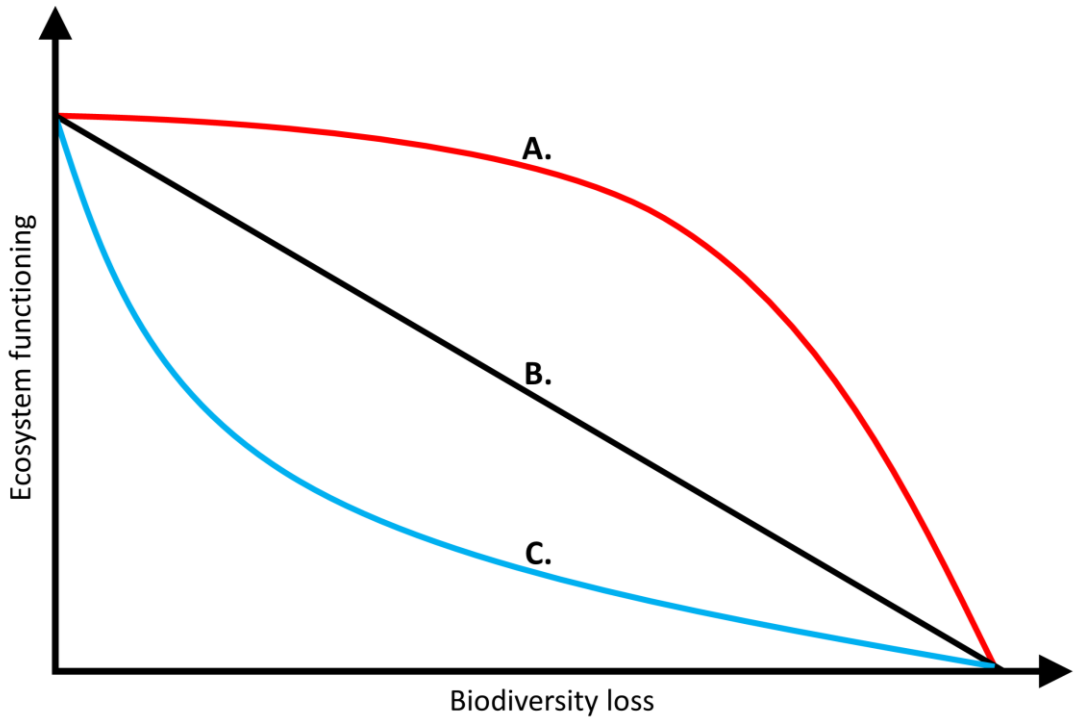


Figure 5.2: Relationships between biodiversity loss and ecosystem functioning for the three most likely forms that the biodiversity - ecosystem functioning relationship may take in nature. A: saturating form (red). B: direct linear form (black). C: accelerating form (blue).

Consequences of a linear BEF relationship for the vulnerability of ecosystem functioning are simpler, suggesting that any reduction in the diversity of communities will be accompanied by a proportional decline in ecosystem functioning (Tilman et al., 1996, Troumbis and Memtsas, 2000) (Figure 5.2). In cases of this relationship, the relative vulnerability of ecosystem functioning to declines in biodiversity will remain independent of current diversity levels.

The final alternative hypothesis of an accelerating BEF relationship in some environments, including the deep sea, has even more serious consequences, suggesting that any reduction in the diversity of such ecosystems will be associated with a rapid decline in ecosystem functioning (Danovaro et al., 2008, Loreau, 2008) (Figure 5.2). In other words, even seemingly modest reductions in biodiversity may result in severe declines in ecosystem functioning, and so the provision of ecosystem services, perhaps because functional redundancy is low and positive species interactions are delicate. Such systems can be defined as highly vulnerable to loss of ecosystem functioning (Danovaro et al., 2008, Loreau, 2008, Danovaro, 2012).

5.2.3 Deep-sea BEF research

BEF research in the deep sea has lagged behind that in terrestrial and shallow water environments, with only five published studies documenting deep-sea BEF relationships (Danovaro et al., 2008, Leduc et al., 2013, Narayanaswamy et al., 2013, Pape et al., 2013, Zeppilli et al., 2016), and only three of these (those of Danovaro et al. (2008), Leduc et al. (2013) and Pape et al. (2013)) discussing these relationships in detail. All these studies focus on nematode assemblages at bathyal depths, yet provide somewhat contrasting conclusions.

Danovaro et al. (2008) reported an exponential increase in a suite of ecosystem functioning and efficiency metrics with increasing functional and taxonomic diversity, finding this relationship to hold true for samples from the Atlantic, Pacific, and Southern Oceans, and the Mediterranean sea. In agreement with this, Narayanaswamy et al. (2013) and Zepilli et al. (2016) documented a positive and exponential form to the deep-sea BEF relationship. This possibility of an exponential BEF relationship is intriguing since it suggests that positive species interactions (particularly facilitation) prevail in the largest biome of our biosphere (Danovaro et al., 2008, Loreau, 2008, Danovaro, 2012, Leduc et al., 2013, Thurber et al., 2014).

In contradiction to this, Leduc et al. (2013) found no relationship between biodiversity and ecosystem functioning on the continental slopes of New Zealand after accounting for confounding variables. This was interpreted as evidence for a saturating style BEF relationship, with the data scattered around the asymptotic (high diversity) portion of the BEF relationship. Such a conclusion sits more comfortably with the generally accepted BEF patterns of terrestrial and shallow water environments (Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006), being suggestive of the occurrence of functional redundancy and competitive interactions at high levels of diversity (Leduc et al., 2013).

To muddy the waters further, Pape et al. (2013) reported a positive accelerating relationship between nematode diversity and estimated nematode community respiration rates when disregarding the possible confounding relationship between diversity and nematode biomass, but found a linear BEF relationship when the influence of biomass was accounted for. Clearly, the form of deep-sea biodiversity – ecosystem functioning relationships requires further clarification.

This study aims to advance and clarify knowledge of the form of deep-sea BEF relationships via an analysis of the largest deep-sea BEF dataset yet produced. In contrast to previous published studies, this analysis will investigate BEF relationships in macrofauna (peracarid crustaceans) rather than meiofauna, and will consider a wider range of biodiversity metrics than ever before (including phylogenetic, functional and taxonomic measures), along with a suite of ecosystem functioning proxies. Further, Structural Equation Modelling, a statistical method particularly suited to the analysis of ecological relationships (Grace, 2006, Hodapp et al., 2015), will be employed. Based on the conclusions of Chapter 2 (that competitive interactions do not play a central role in structuring deep-sea peracarid assemblages), and the studies of Danovaro et al. (2008), Narayanaswamy et al. (2013), Zepilli et al. (2016) and, to some extent, Pape et al. (2013), it is predicted that the BEF relationships investigated will be positive and accelerating in form.

5.3 Methods

5.3.1 Biodiversity metrics

As in chapters 3 and 4, a series of metrics describing various facets of the peracarid fauna at box core locations was investigated. Specifically, these were peracarid abundance, taxonomic richness, Rao Quadratic Entropy, Shannon Diversity, phylogenetic richness, phylogenetic evenness, phylogenetic variability, functional richness, functional evenness and functional variability. Details of box core collection methods and peracarid identification are given in Section 2.3.1. Details of the calculation of peracarid taxonomic, phylogenetic and functional biodiversity metrics are given in Section 3.3.1.

5.3.2 Environmental metrics

Only continuous physical and biogenic environmental metrics that were determined in chapters 3 and 4 to significantly relate to the above biodiversity metrics were investigated. Specifically, these environmental metrics were short- and long-term average seafloor temperature, average and maximum seafloor current speed, surface chlorophyll *a* and particulate organic carbon concentrations, modelled seafloor particulate organic carbon concentration, sediment percent total/organic carbon, sediment percent sand content, sediment particle size diversity, bottom trawling intensity (Log_{10} transformed), bathymetric position index (BPI), seafloor rugosity and roughness, kernel density-estimated Porifera and Pennatulacea biomass, and latitude of box core collection. Random forest-modelled estimations of biogenic habitat density were excluded because of their questionable performance in Chapter 4 (see Section 4.5.2). Details pertaining to the calculation of physical environmental variables are given in Section 3.3.2. Details of the calculation of kernel density-estimated biogenic habitat density are given in Section 4.3.2.3.

5.3.3 Ecosystem functioning metrics

Proxies for ecosystem functioning investigated included peracarid ‘standing stock’, ‘ecosystem efficiency’ and ‘carbon cycling efficiency’. Standing stock was represented by

the total wet biomass of Peracarida for each box core (see Section 3.3.1). Ecosystem efficiency is defined here as the efficiency of the conversion of available carbon to peracarid biomass. Two related metrics were calculated as proxies for this: the ratio of peracarid biomass per box core to the percent total carbon content in the top 2 cm of that box core, and the ratio of peracarid biomass per box core to the percent organic carbon content in the top 2 cm of that box core (see Section 3.3.2.4 for details of the calculation of box core carbon content).

Carbon cycling efficiency is defined here as the implied rate of use of benthic carbon relative to the magnitude of its delivery to the seabed. This was calculated as the ratio of modelled particulate organic carbon transport to a box core location from surface waters relative to the percent total carbon content in the top 2 cm of that box core (see Section 3.3.2.5 for details of the calculation of seafloor POC concentrations).

5.3.4 Statistical analyses

5.3.4.1 Overview of structural equation modelling

Originating in the social sciences, Structural Equation Modelling (SEM) is a multivariate modelling technique that facilitates (whilst accounting for measurement error) the simultaneous investigation of all direct and indirect relationships between a selection of conceptual variables that are linked in the form of a network (see Figure 5.3) (Grace, 2006, Hair et al., 2011, Hodapp et al., 2015). Such an approach is highly relevant to ecological investigations where relationships between variables may take the form of a network (see Figures 3.12 and 4.15), and where overarching concepts, such as 'biodiversity' or 'ecosystem functioning' are not directly measureable, but can be represented by a selection of indices (Grace, 2006, Hodapp et al., 2015).

Two approaches to structural equation modelling are currently in use: covariance-based SEM (CB-SEM), and Partial Least Squares SEM (PLS-SEM) (Hair et al., 2011). CB-SEM represents a confirmatory analysis method that aims to reproduce the covariance matrix of a dataset as closely as possible via the fitting of a selection of structural equations (Grace,

2006). In doing so, CB-SEM requires a number of assumptions regarding sample size and data distributions to be met that are often unrealistic in ecological investigations (Hair et al., 2011). In contrast, PLS-SEM represents an exploratory analysis method that aims to maximise the explained variance of specified latent constructs. PLS-SEM is robust to non-normal data, and can give accurate results even in cases of relatively low sample size (Hair et al., 2011). Thus, PLS-SEM is the method selected here.

In SEM, theoretical concepts of interest are referred to as 'latent variables', and these latent variables are specified by a selection of complementary proxies known as 'indicator variables'. For example, in this analysis, the latent variable 'richness' is specified by three indicator variables: taxonomic richness, phylogenetic richness and functional richness (see Table 5.1). Latent variables are further defined as being 'reflective' or 'formative' based on the selection of indicator variables employed. A latent variable is defined as reflective when all its indicator variables are highly correlated with one another and with the total latent variable score (Kock, 2015). Conversely, a latent variable is defined as formative when its indicator variables all measure particular aspects of the latent variable, but are not necessarily highly correlated with one another or with the total latent variable score (Kock, 2015).

5.3.4.2 Specification of structural equation model

A structural equation model was constructed in order to interrogate relationships between calculated biodiversity and ecosystem functioning metrics whilst accounting for environmental influences on these metrics (Figure 5.3).

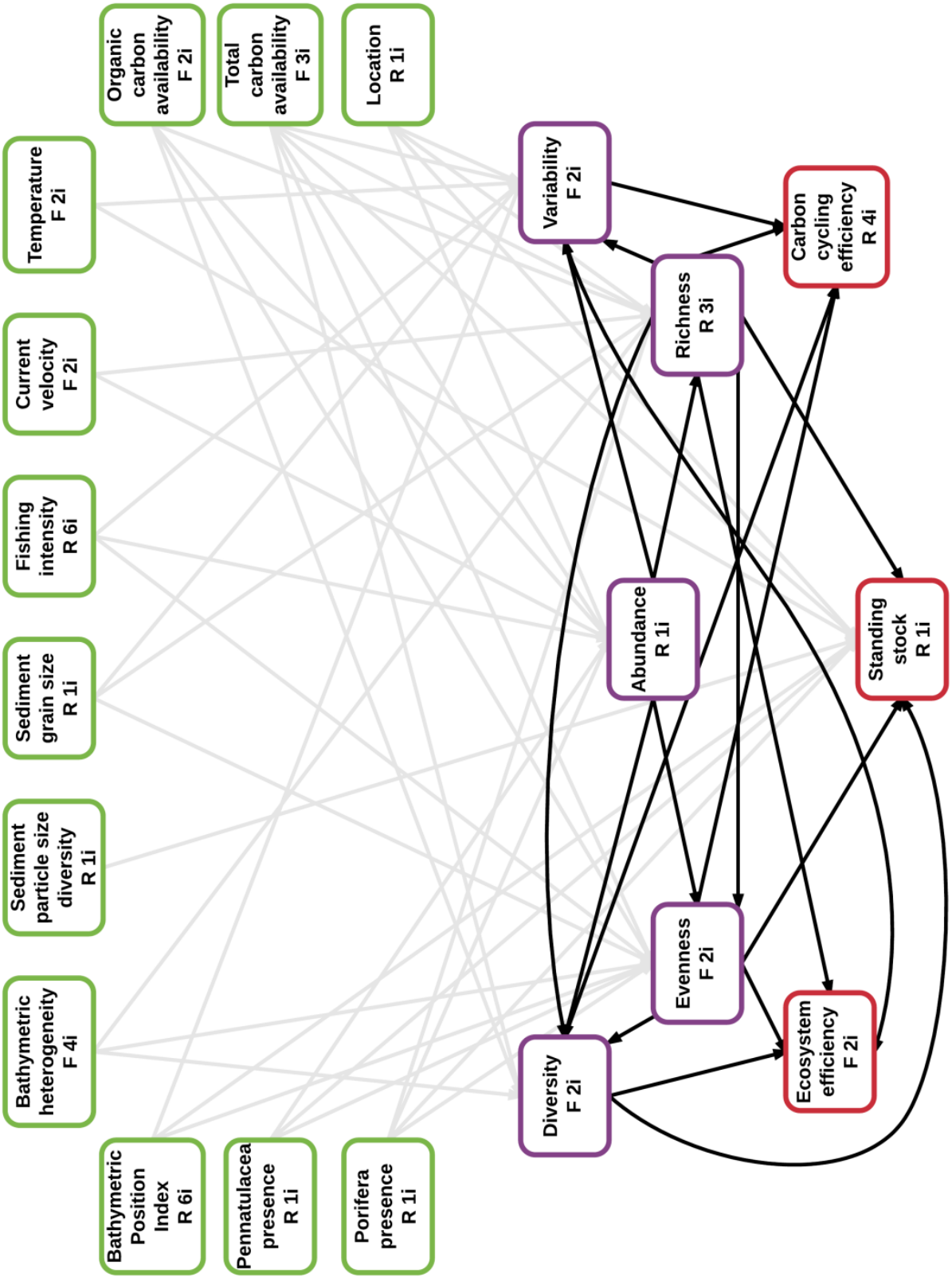


Figure 5.3: Form of structural equation model analysed. Green boxes = environmental latent variables, purple boxes = biodiversity latent variables and red boxes = ecosystem functioning latent variables (see Table 5.1). Arrows between latent variables denote direct links. 'R' or 'F' (following the name of each latent variable) specifies whether the latent variable is defined as reflective or formative, respectively. The number followed by 'i' specifies the number of indicator variables associated with each latent variable.

For the environmental component of the structural equation model (green variables in Figure 5.3), the following latent variables were specified (with their indicator variables following in brackets): 'temperature' (average for year of box core collection and average for 10 years prior to box core collection), 'current speed' (average for year of box core collection and maximum value for 10 years prior to box core collection), 'organic carbon availability' (sea surface chlorophyll *a* concentration and percent organic carbon content of box core sediment), 'total carbon availability' (sea surface particulate organic carbon concentration, seafloor particulate organic carbon concentration, and percent total carbon content of box core sediment), 'sediment grain size' (percent sand content of box core), 'sediment particle size diversity' (Shannon sediment particle size diversity of box core), 'fishing intensity' (VMS signal density and trawl density within 1 km, 3 km and 5 km radius of box core location), 'bathymetric position index' (BPI for a 1875 m, 3750 m, 5625 m, 7500 m, 9375 m and 11250 m radius window around box core location), 'bathymetric heterogeneity' (seafloor rugosity for 375x375 m and 1875x1875 m windows around box core location, seafloor roughness for a 225x225 m window around box core location, and standard deviation of bathymetry values for a 225x225 m window around box core location), 'Porifera presence' (poriferan biomass according to Kenchington et al. (2014)), 'Pennatulacea presence' (pennatulacean biomass according to Kenchington et al. (2014)), and 'location' (latitude of box core sampling location).

For the biodiversity component of the structural equation model (purple variables in Figure 5.3), the following latent variables were specified: 'abundance' (total number of peracarids per box core), 'richness' (taxonomic richness, phylogenetic richness, and functional richness per box core), 'variability' (phylogenetic and functional variability per box core), 'evenness' (phylogenetic and functional evenness per box core), and 'diversity' (Shannon diversity and Rao's Quadratic Entropy per box core).

For the functioning component of the structural equation model (red variables in Figure 5.3), the following latent variables were specified: 'standing stock' (total biomass of

peracarids per box core), 'ecosystem efficiency' (ratio of standing stock to percent total/organic carbon content of box core), and 'carbon cycling efficiency' (ratio of modelled seafloor particulate organic carbon to percent total carbon content of box core). Details of the latent variables specified in this analysis are summarised in Table 5.1.

Table 5.1: Details of indicator variables for the latent variables specified in the structural equation model.

Latent variable	Type	Indicator variable(s)
Environmental metrics		
Temperature	Formative	Modelled seafloor temperature – average for year box core collected (°C)
		Modelled seafloor temperature – average for 10 years prior to box core collection (°C)
Current speed	Formative	Modelled seafloor absolute current speed – average for year box core collected (m/s)
		Modelled seafloor maximum current speed – maximum value for 10 years prior to box core collection (m/s)
Organic carbon availability	Formative	Surface chlorophyll *a* - MODIS average for year box core collected plus previous year (mg/m^3)
		Percent organic carbon content in top 2 cm of box core
Total carbon availability	Formative	Surface particulate organic carbon – MODIS average for year box core collected plus previous year (mg/m^3)
		Particulate organic carbon at seafloor - Sargasso sea equation (not radionuclide corrected) of Lutz et al. (2002) applied to MODIS surface particulate organic carbon average for year box core collected plus previous year (mg/m^3)
		Percent total carbon content in top 2 cm of box core
Sediment grain size	Reflective	Percent sand content in top 2 cm of box core
Sediment particle size diversity	Reflective	Shannon sediment particle size diversity in top 2 cm of box core
Fishing intensity	Reflective	VMS signal density – Total number of VMS signals per km^2 of seafloor between 2003 and 2012 within a 5 km radius of the box core location (Log_{10})
		VMS signal density – Total number of VMS signals per km^2 of seafloor between 2003 and 2012 within a 3 km radius of the box core location (Log_{10})
		VMS signal density – Total number of VMS signals per km^2 of seafloor between 2003 and 2012 within a 1 km radius of the box core location (Log_{10})
		Trawl density – Total trawl length per km^2 of seafloor between 2008 and 2012 within a 5 km radius of the box core location (Log_{10})
		Trawl density – Total trawl length per km^2 of seafloor between 2008 and 2012 within a 3 km radius of the box core location (Log_{10})
		Trawl density – Total trawl length per km^2 of seafloor between 2008 and 2012 within a 1 km radius of the box core location (Log_{10})
Bathymetric position index	Reflective	Bathymetric position index – value for 1875 m radius window around box core location

Latent variable	Type	Indicator variable(s)
		Bathymetric position index – value for 3750 m radius window around box core location
		Bathymetric position index – value for 5625 m radius window around box core location
		Bathymetric position index – value for 7500 m radius window around box core location
		Bathymetric position index – value for 9375 m radius window around box core location
		Bathymetric position index – value for 11250 m radius window around box core location
Bathymetric heterogeneity	Formative	Seafloor rugosity – value for a 375x375 m window around box core location
		Seafloor rugosity – value for a 1875x1875 m window around box core location
		Seafloor roughness – value for a 225x225 m window around box core location
		Standard deviation of bathymetry values for a 225x225 m window around box core location
Porifera presence	Reflective	Relative poriferan biomass at box core locations based on kernel density surface estimation of bycatch data obtained from Spanish and Canadian research trawls (following the methods of Kenchington et al. (2014)) (2.7 km radius window)
Pennatulacea presence	Reflective	Relative pennatulacean biomass at box core locations based on kernel density surface estimation of bycatch data obtained from Spanish and Canadian research trawls (following the methods of Kenchington et al. (2014)) (2.7 km radius window)
Location	Reflective	Latitude of box core sampling location
Biodiversity metrics		
Abundance	Reflective	Total number of peracarid individuals per box core
Richness	Reflective	Total number of peracarid genera per box core
		Total number of peracarid genera per box core scaled by their phylogenetic variability. See Helmus et al. (2007)
		Total number of peracarid families per box core scaled by their functional variability. See Helmus et al. (2007)
Variability	Formative	PSV - Measure of the distribution of peracarid genera present in a box core across a dendrogram describing their phylogenetic relatedness. See Helmus et al. (2007)
		FSV - Measure of the distribution of peracarid families present in a box core across a dendrogram describing their functional similarity
Evenness	Formative	PSV modified to incorporate the relative abundances of peracarid taxa per box core. See Helmus et al. (2007)
		FSV modified to incorporate the relative abundances of peracarid taxa per box core. See Helmus et al. (2007)
Diversity	Formative	Rao Quadratic Entropy - Taxonomic diversity measure taking into account both the number of peracarid genera per box core and their relative abundances. Simplifies to Simpson's diversity (1-D) for the case of taxonomic diversity. Here represents the probability that two individuals taken from a box core sample will belong to different genera
		Shannon Diversity - Taxonomic diversity measure taking into account both the number of peracarid genera per box core and their relative abundances. Here represents a quantification of the uncertainty associated with predicting the taxonomic identity of an individual taken at random from a box core

Latent variable	Type	Indicator variable(s)
Ecosystem Functioning metrics		
Standing stock	Reflective	Total biomass of peracarids per box core
Ecosystem efficiency	Formative	Ratio of the standing stock of peracarids per box core relative to the percent organic carbon content in top 2 cm of box core
		Ratio of the standing stock of peracarids per box core relative to the percent total carbon content in top 2 cm of box core
Carbon cycling efficiency	Reflective	Ratio of the seafloor particulate organic carbon concentration at a box core location (Sargasso sea equation [not radionuclide corrected] of Lutz et al. (2002) applied to MODIS surface particulate organic carbon average for year box core collected plus previous year (mg/m^3)) to the percent total carbon content in top 2 cm of the box core
		Ratio of the seafloor particulate organic carbon concentration at a box core location (Sargasso sea equation [radionuclide corrected] of Lutz et al. (2002) applied to MODIS surface particulate organic carbon average for year box core collected plus previous year (mg/m^3)) to the percent total carbon content in top 2 cm of the box core
		Ratio of the seafloor particulate organic carbon concentration at a box core location (Northeast Atlantic equation [not radionuclide corrected] of Lutz et al. (2002) applied to MODIS surface particulate organic carbon average for year box core collected plus previous year (mg/m^3)) to the percent total carbon content in top 2 cm of the box core
		Ratio of the seafloor particulate organic carbon concentration at a box core location (Northeast Atlantic equation [radionuclide corrected] of Lutz et al. (2002) applied to MODIS surface particulate organic carbon average for year box core collected plus previous year (mg/m^3)) to the percent total carbon content in top 2 cm of the box core

All links between latent variables were established based on general concepts of deep-sea benthic ecology (e.g. Levin et al. (2001)), the conclusions of chapters 3 and 4 of this thesis (see tables 3.4 and 4.4, and figures 3.12 and 4.15), previous studies of biodiversity – ecosystem functioning relationships (Cardinale et al., 2006, Worm et al., 2006, Danovaro et al., 2008, Flynn et al., 2011, Mora et al., 2011, Bremner, 2012, Naeem, 2012, Leduc et al., 2013, Pape et al., 2013, Fung et al., 2015, Hodapp et al., 2015) and data availability. Latent variables were defined as being reflective or formative in type based on the values of Variance Inflation Factors (VIFs) calculated in R 3.0.2 (R-CoreTeam, 2013) using the package 'HH 3.1-32' (Heiberger, 2016). Where VIF values were high (all greater than 5 (Stine, 1995, Hair et al., 2011)), latent variables were defined as reflective. Where VIF values were low (all less than 5 (Stine, 1995, Hair et al., 2011)), but all indicator variables shared a conceptual connection to the latent variable, latent variables were defined as

formative in nature. Links between latent variables were further refined following preliminary analyses, with any links producing negative R^2 contributions being removed. The resulting form of the structural equation model is shown in Figure 5.3.

5.3.4.3 Analysis of structural equation model

The structural equation model was analysed using WarPLS 5.0 (Kock, 2015); the only program currently available to identify and appropriately model non-linear relationships between pairs of latent variables. Prior to analysis, box cores 250 and 350 were removed from the dataset since they were erroneously combined during initial sample processing. Missing values in environmental data (0.42 % of values) were replaced with the arithmetic mean of that column as this was deemed preferable to sample deletion and has been shown to be an appropriate method for SEM analysis (Kock, 2014). Further, all box cores with zero abundance of peracarids, and box core 341 (with only one peracarid genus present), were removed, and indicator variables were standardised. The following options were specified in WarpPLS 5.0: "outer model analysis algorithm = PLS mode M, inner model analysis algorithm = Warp3, resampling method = Stable3".

5.4 Results

Consideration of model validation statistics revealed that model performance was excellent (Table 5.2), giving high confidence in the associated results (Figure 5.4). However, the ability of the model to explain observed variation in ecosystem functioning differed greatly depending on the proxy considered. Variation in peracarid 'standing stock', and 'ecosystem efficiency' were both well explained (R^2 = 0.69 and 0.48, respectively), but a high level of unexplained variation in 'carbon cycling efficiency' remains (R^2 = 0.073).

Table 5.2: Validation statistics for constructed structural equation model. For full explanation, see Kock (2015).

Model fit/quality index	Observed value	Acceptable cut-off
Average Block VIF	1.64	< 5
Average Full Collinearity VIF	2.59	< 5
Tenenhaus Goodness of Fit	0.62	Large = > 0.36
Simpson's Paradox Ratio	1.0	> 0.7
R^2 Contribution Ratio	1.0	> 0.9
Statistical Suppression Ratio	0.84	> 0.7
Non-linear Bivariate Causality Direction Ratio	0.76	> 0.7

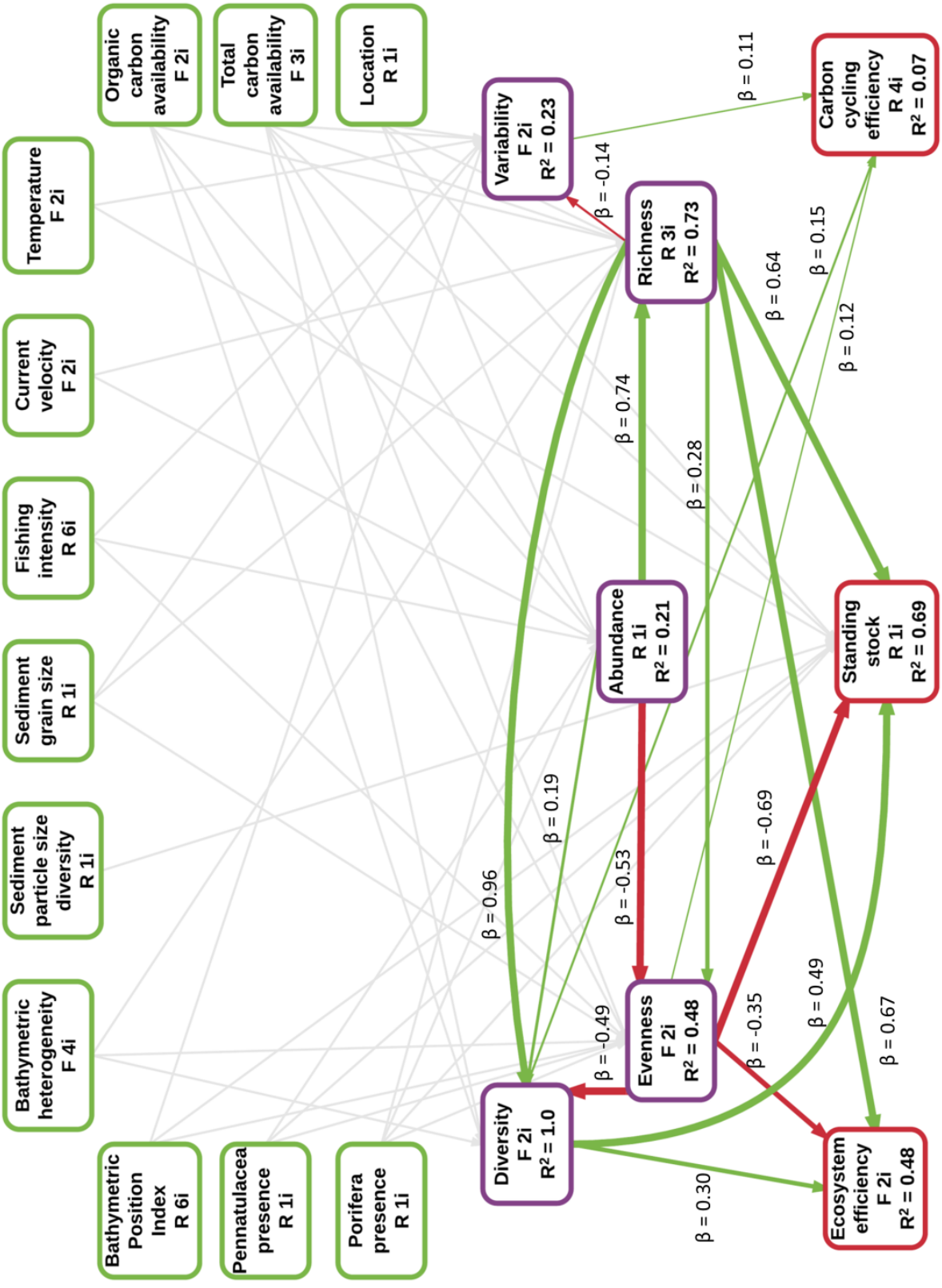


Figure 5.4: Structural equation model results. Only significant links between biodiversity and ecosystem functioning latent variables are detailed for simplicity, with their associated β coefficients displayed. Of these, positive relationships are highlighted in green and negative relationships in red. The width of each significant link is directly proportional to its β coefficient. R^2 values are displayed for endogenous variables.

5.4.1 'Richness' and ecosystem functioning

The 'richness' of peracarid assemblages within each box core was found to strongly influence observed levels of ecosystem functioning, with 'ecosystem efficiency' (β = 0.665, *P* <0.001) and 'standing stock' (β = 0.638, *P* <0.001) both displaying a significant positive relationship with this biodiversity metric (Figure 5.5). However, the detailed form of each relationship was found to be subtly different; increasing 'richness' was associated with a rapid increase in 'ecosystem efficiency', followed by a slight saturation at high magnitudes of the variable (Figure 5.5). In contrast, no evidence was found for a saturation of the relationship between 'richness' and 'standing stock', indeed, the relationship is weakly accelerating in form (Figure 5.5).

The 'richness' of peracarid assemblages was not found to significantly influence 'carbon cycling efficiency' (β = 0.07, *P* = 0.11).

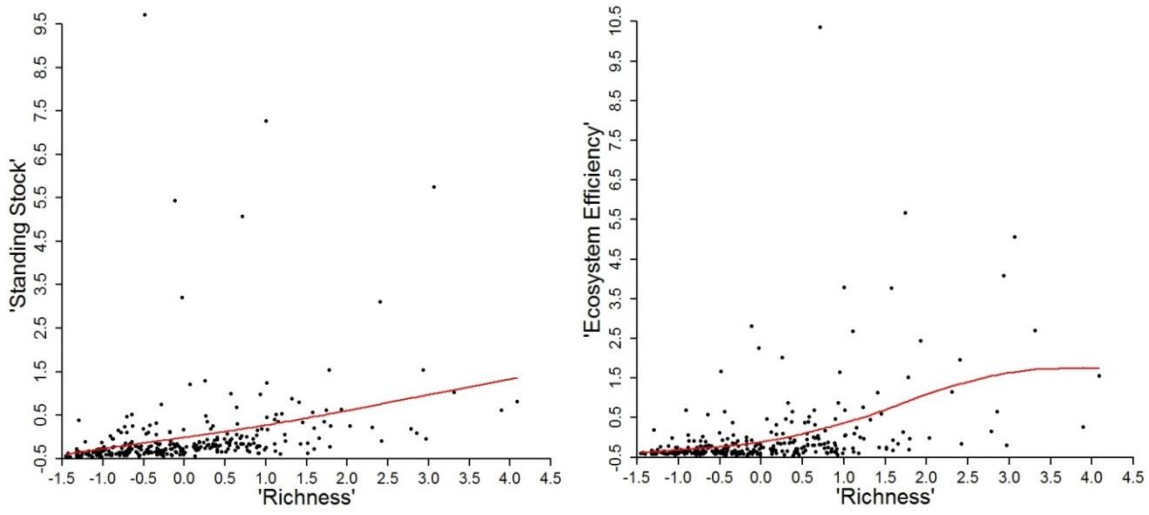


Figure 5.5: Standardised relationships between the latent variables 'richness' and 'standing stock' (left), and 'richness' and 'ecosystem efficiency' (right). The latent variable scores plotted here are a weighted composite of standardised indicator variable values, as determined by the SEM analysis. See Table 5.1 for details of the indicator variables ascribed to each latent variable.

5.4.2 'Diversity' and ecosystem functioning

The 'diversity' of peracarid assemblages was also found to significantly influence ecosystem functioning, with a strong positive effect on 'ecosystem efficiency' (β = 0.303, *P* <0.001) and 'standing stock' (β = 0.488, *P* <0.001), and a weaker, but significant, effect on 'carbon cycling efficiency' (β = 0.151, *P* = 0.004) (figures 5.6 and 5.7).

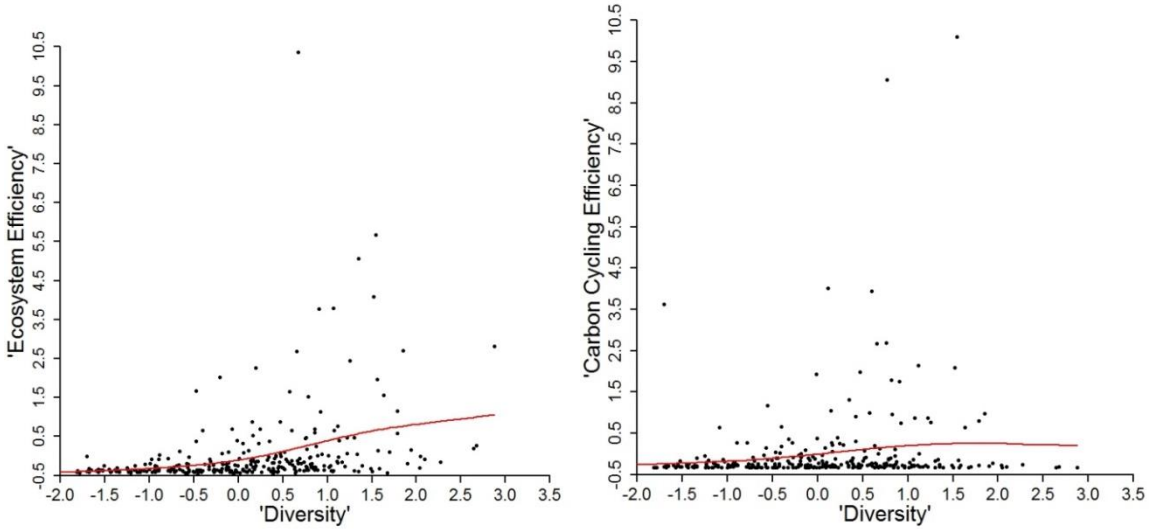


Figure 5.6: Standardised relationships between the latent variables 'diversity' and 'ecosystem efficiency' (left), and 'diversity' and 'carbon cycling efficiency' (right). The latent variable scores plotted here are a weighted composite of standardised indicator variable values, as determined by the SEM analysis. See Table 5.1 for details of the indicator variables ascribed to each latent variable.

As was found for 'richness', the form of each of these relationships differed depending on the ecosystem functioning variable in question. 'Ecosystem efficiency' was found to increase with increasing 'diversity' in essentially a linear manner (Figure 5.6). 'Carbon cycling efficiency' was found to increase with increasing 'diversity', but this relationship quickly reached saturation (Figure 5.6). In contrast, no such evidence for saturation was found between 'standing stock' and 'diversity', with the positive nature of the relationship increasing in strength at the highest measured levels of 'diversity' (Figure 5.7).

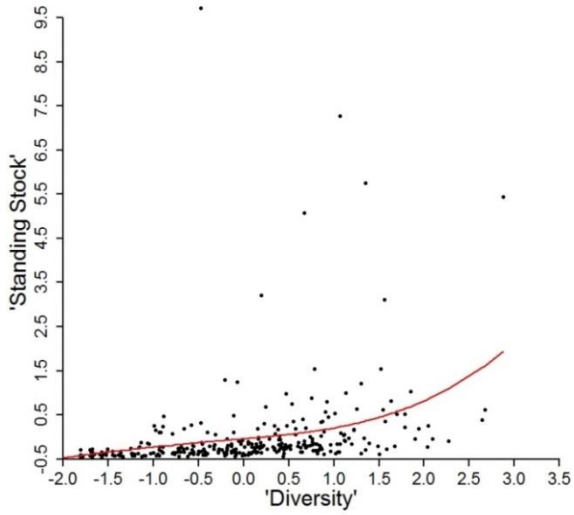


Figure 5.7: Standardised relationship between the latent variables 'diversity' and 'standing stock'. The latent variable scores plotted here are a weighted composite of standardised indicator variable values, as determined by the SEM analysis. See Table 5.1 for details of the indicator variables ascribed to each latent variable.

5.4.3 'Evenness' and ecosystem functioning

In contrast to the other biodiversity metrics analysed, the 'evenness' of peracarid communities was found to be strongly negatively related to both 'ecosystem efficiency' (β = -0.348, *P* <0.001) and 'standing stock' (β = -0.690, *P* <0.001), with the form of these relationships being similar (Figure 5.8).

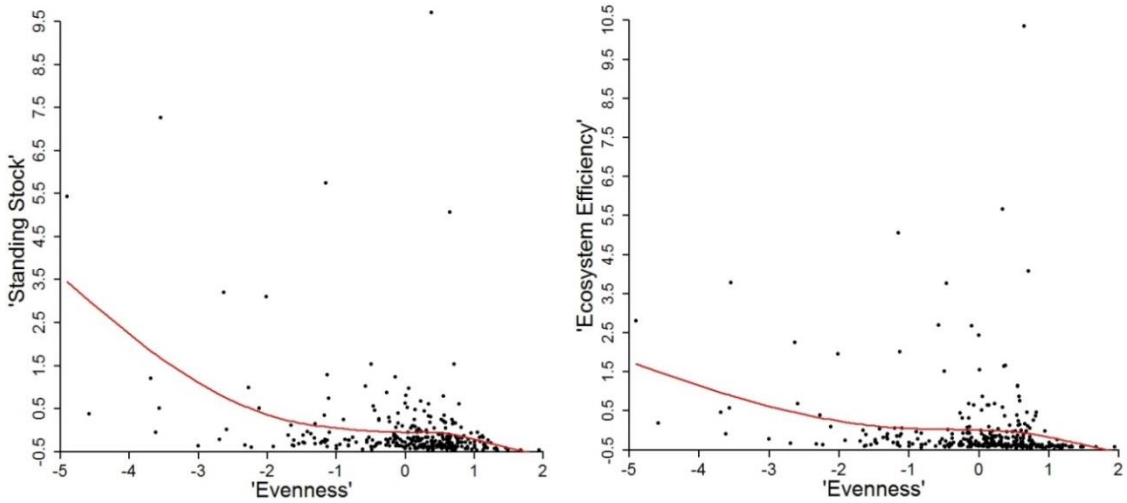


Figure 5.8: Standardised relationships between the latent variables 'evenness' and 'standing stock' (left), and 'evenness' and 'ecosystem efficiency' (right). The latent variable scores plotted here are a weighted composite of standardised indicator variable values, as determined by the SEM analysis. See Table 5.1 for details of the indicator variables ascribed to each latent variable.

However, 'evenness' was found to be positively (albeit relatively weakly) related to 'carbon cycling efficiency' (β = 0.122, *P* = 0.016), with the values of this functioning metric increasing with increasing 'evenness', before reaching saturation (Figure 5.9).

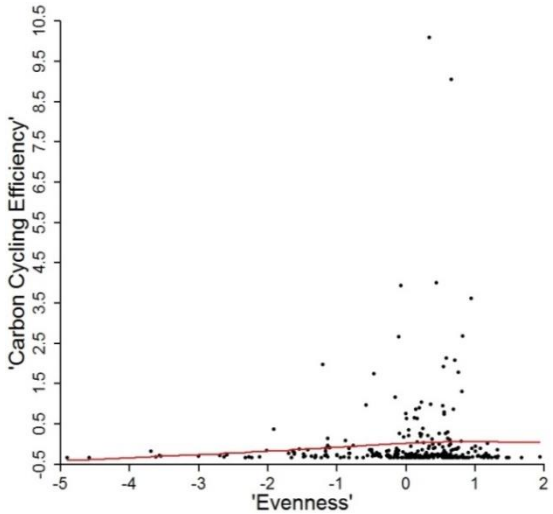


Figure 5.9: Standardised relationship between the latent variables 'evenness' and 'carbon cycling efficiency'. The latent variable scores plotted here are a weighted composite of standardised indicator variable values, as determined by the SEM analysis. See Table 5.1 for details of the indicator variables ascribed to each latent variable.

5.4.4 'Variability' and ecosystem functioning

Of the three ecosystem functioning metrics analysed, the biodiversity latent variable 'variability' was found to have a significant influence only on 'carbon cycling efficiency' (β = 0.108, *P* = 0.029) (Figure 5.10), the form of this relationship being positive and saturating.

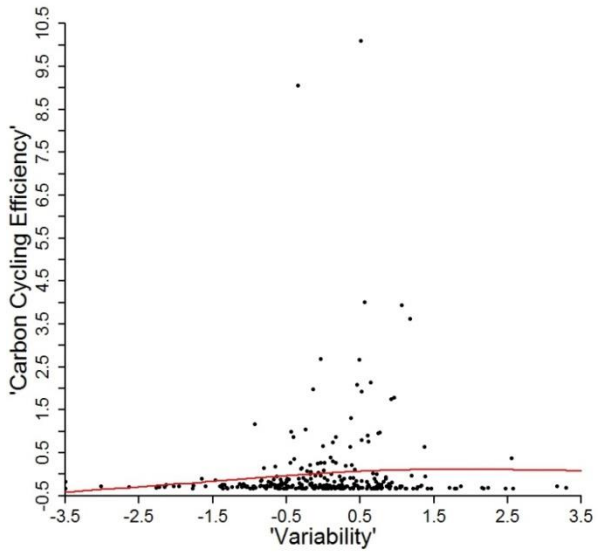


Figure 5.10: Standardised relationship between the latent variables 'variability' and 'carbon cycling efficiency'. The latent variable scores plotted here are a weighted composite of standardised indicator variable values, as determined by the SEM analysis. See Table 5.1 for details of the indicator variables ascribed to each latent variable.

5.5 Discussion

In agreement with generally accepted BEF relationships in terrestrial and shallow water environments (Hooper et al., 2005, Balvanera et al., 2006, Cardinale et al., 2006, Worm et al., 2006), the biodiversity of continental slope macrobenthic peracarids was found to significantly influence the magnitude of a selection of ecosystem functioning metrics (Figure 5.4). However, the extent of variation explained for each ecosystem functioning metric by biodiversity metrics was found to be highly variable. For example, variation in the functions 'standing stock' and 'ecosystem efficiency' was found to be relatively well explained by the structural equation model (R^2 = 0.69 and 0.48, respectively), but a high level of unexplained variance in the more broad-scale functioning metric 'carbon cycling efficiency' remained following model fitting (R^2 = 0.073). Such differences can be

explained, in part, by consideration of the generality of each functioning metric. For example, 'standing stock' represents a latent variable that is highly related to the peracarid community present, and as a result, variation in 'standing stock' is relatively well explained by peracarid biodiversity metrics. In contrast, the latent variable 'ecosystem efficiency' incorporates some information that is not as closely related to the peracarid community present - sediment percent carbon content, as well as peracarid biomass data. Hence, this latent variable is less well explained by variation in peracarid biodiversity metrics than 'standing stock' is. Continuing this progression, the functioning metric 'carbon cycling efficiency' incorporates only information that is relatively removed from peracarid assemblages (Table 5.1). Thus, variation in the values of this metric will be dependent on a number of variables not measured in this analysis, as well as on peracarid biodiversity metrics. Not only will actions of the peracarid community influence 'carbon cycling efficiency', but so will the actions of other biological fractions, such as microbes, meiofauna, other macrofauna and megafauna.

Variation is also apparent in the directionality and absolute form of the recovered BEF relationships. For example, all significant relationships between biodiversity metrics and 'carbon cycling efficiency' were found to be positive and saturating in form (Figures 5.6, 5.9 and 5.10). However, evidence for saturation in the BEF relationship was otherwise only found between 'richness' and 'ecosystem efficiency', with saturation occurring only at the highest recorded richness levels (Figure 5.5). 'Evenness' was the only biodiversity metric found to relate negatively to ecosystem functioning, with the relationships between 'evenness' and 'standing stock', and 'evenness' and 'ecosystem efficiency' both following an exponential decay form (Figure 5.8). In contrast, 'diversity' was found to relate to 'ecosystem efficiency' in, essentially, a linear manner (Figure 5.6), whilst only the relationships between 'diversity' and 'standing stock', and 'richness' and 'standing stock' were found to have an accelerating form across the spectrum of biodiversity values encountered in this study.

Considering these results, it seems unwise to attempt to classify all deep-sea BEF relationships as aligning with one particular form over another – e.g. accelerating (Danovaro et al., 2008, Narayanaswamy et al., 2013, Zeppilli et al., 2016), saturating (Leduc et al., 2013), or linear (Pape et al., 2013). Instead, I argue here that the form of deep-sea BEF relationships is dependent on the type and scale of biodiversity and ecosystem functioning metrics analysed, and also likely the taxon and environment in question. For example, a saturating BEF relationship was recovered most overtly and consistently for the most broad-scale of the ecosystem functioning metrics analysed – 'carbon cycling efficiency'. The saturating form of these BEF relationships could reflect a negative influence of strong interspecific competition within peracarid assemblages, and/or between peracarids and other components of the community. However, considering the conclusions of Chapter 2, this seems unlikely. Instead, this saturating form is more suggestive of a high level of redundancy within peracarid assemblages with respect to their contribution to overall continental slope community carbon cycling efficiency (Lawton, 1994, Snelgrove, 1997, Leduc et al., 2013). As 'carbon cycling efficiency' was found to saturate at relatively low magnitudes of 'diversity', 'evenness' and 'variability' (figures 5.6, 5.9 and 5.10), it appears that this function can be optimised by a relatively small selection of the total peracarid assemblage, with additional taxa, or more even representation of taxa, doing little to enhance overall functioning. Instead, further enhancement of this broad-scale function may require the addition of greater functional variability than can be contributed solely by peracarids – such as that that can be offered by microbial, meiofaunal, other macrofaunal, and megafaunal portions of the community (Snelgrove, 1997). Indeed, this result hints at a level of redundancy within Peracarida in terms of its contribution to all broad-scale ecosystem functions, and it may be the case that the magnitude of these ecosystem functions is not highly vulnerable to a loss of peracarid biodiversity.

If ecosystem functions that are more tightly linked to the peracarid assemblages in question are analysed, resulting BEF relationships appear slower to reach saturation. For example, 'ecosystem efficiency' begins to saturate only at very high 'richness' values (Figure 5.5),

whilst the relationship between 'diversity' and 'ecosystem efficiency' shows no sign of saturation across the range of diversity values investigated (Figure 5.6). This approximately linear BEF relationship is suggestive of low functional redundancy within Peracarida for this more specific ecosystem functioning metric, and also suggests that both positive and negative species interactions are of limited significance, or balanced in strength. Here, peracarid taxa appear to contribute relatively equally and independently to ecosystem efficiency, in agreement with the 'rivet hypothesis' of Lawton (1994).

The recovered relationship between 'richness' and 'ecosystem efficiency' (Figure 5.5) is of particular interest since it appears to provide evidence for a progression from an importance of positive species interactions (such as facilitation) at low 'richness' values (as highlighted by Danovaro et al. (2008)) towards a dominance of functional redundancy (and possibly negative species interactions) at greater community richness values, resulting in a saturation of the BEF relationship. Such a progression is consistent with the study of Leduc et al. (2013), these authors arguing that the lack of BEF relationship uncovered in their investigation reflects a breakdown of the exponential form and a saturation of BEF relationships at high magnitudes of diversity.

'Standing stock' is the ecosystem functioning proxy most overtly related to peracarid assemblages, and it is this metric that is both best explained by the structural equation model produced, and that which provides greatest evidence for an absence of functional redundancy and an importance of positive interactions between taxa in the deep sea. For example, the modelled relationship between 'richness' and 'standing stock' exhibits a mildly accelerating form (Figure 5.5), with this form being more apparent for the relationship between 'diversity' and 'standing stock' (Figure 5.7). As only positive species interactions are known to produce accelerating BEF relationships (Loreau and Hector, 2001, Gross and Cardinale, 2005, Loreau, 2008), this suggests that facilitative interactions between peracarid taxa act to promote elevated biomass at high 'richness' and 'diversity' levels. Thus, it seems that for ecosystem functioning metrics that are closely related to

peracarid communities, facilitative interactions may be important. Such a conclusion implies that these functions will also be those that are most vulnerable to any loss of peracarid biodiversity.

Negative BEF relationships were recovered only between 'evenness' and 'standing stock', and 'evenness' and 'ecosystem efficiency' (Figure 5.8), with highest magnitudes of these functioning metrics occurring in peracarid assemblages with low evenness. Such relationships suggest that, under particular circumstances, a high magnitude of functioning can be promoted by the dominance of a small subset of taxa exhibiting particular characteristics. Hence, this appears to represent an example of a positive 'selection effect' in the deep sea, whereby communities are dominated by taxa with high values for particular traits or ecosystem processes (Loreau, 2000, Loreau and Hector, 2001). Examination of community composition data reveals that all six box core samples with particularly low evenness values (Figures 5.8) were dominated by one of two genera: *Haploops* (Ampeliscidae: Amphipoda) for box cores 71, 79, 84 and 319, and *Harpinia* (Phoxocephalidae: Amphipoda) for box cores 280 and 281. Both of these amphipod genera are typically benthic/demersal, and can form large aggregations under particular circumstances. *Haploops* is a tube-dwelling suspension and deposit feeder (see Appendix 4) and may form large populations in areas that are particularly suitable for suspension feeding, these populations further favouring the sedimentation of particles from the water column (Dauvin and Bellan-Santini, 1990). *Harpinia* may form large demersal mating swarms, achieving a high density in these situations (Oakden, 1984) (see Appendix 4). It is possible that those box cores with very low evenness values, but high values for 'standing stock' and 'ecosystem efficiency' represent instances of sampling these aggregations.

Considering the negative influence of 'evenness' on 'standing stock' and 'ecosystem efficiency', it is notable that the latent variable 'diversity' (which incorporates some measure of evenness) still relates positively with these ecosystem functioning proxies. This suggests that the richness component of 'diversity' is of greater relevance than the

'evenness' component in promoting high magnitudes of ecosystem functioning. Coupling this with the only weak relations found between variability and the functioning metrics examined (Figure 5.4), it seems that the absolute number of taxa/functional groups in an assemblage is of greatest significance in promoting high rates of ecosystem functioning.

This study suggests a more complex picture of deep-sea BEF relationships than previously reported (Danovaro et al., 2008, Leduc et al., 2013, Narayanaswamy et al., 2013, Pape et al., 2013, Zeppilli et al., 2016) or hypothesised, with the form of recovered relationships being dependent on the type and scale of ecosystem functioning and biodiversity metrics in question, and also likely the ecological characteristics of the taxa under analysis (e.g. their body size and natural density of populations).

Combining the evidence above, I believe that a more general truth becomes apparent; that BEF relationships cannot be classified into discreet categories of saturating/linear/accelerating (Figure 5.1), but rather, that all positive BEF relationships will contain portions of all three of these categories. Further, these categories will always be exhibited in the same sequence with increasing magnitudes of biodiversity: an accelerating portion at relatively low biodiversity values, progressing to a linear portion at moderate biodiversity values, ending in saturation at relatively high biodiversity values, together forming a sinusoidal pattern (Figures 5.11 and 5.5).

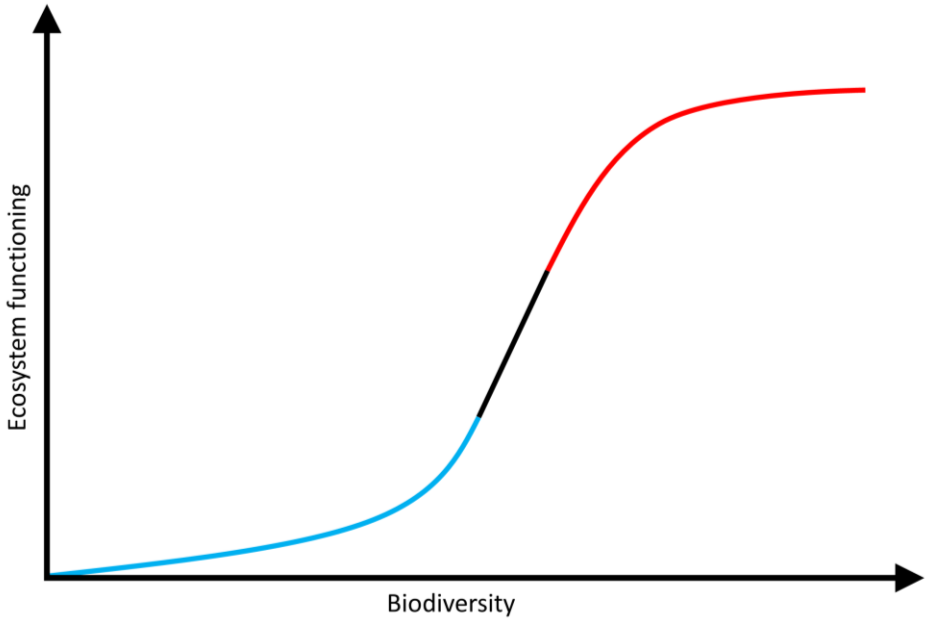


Figure 5.11: Hypothesised form of biodiversity ecosystem functioning relationships. All relationships are composed of three portions: accelerating portion (blue), linear portion (black), and saturating portion (red). The relative dominance of each of these three components of the relationship (accelerating/linear/saturating) in natural communities is dependent on the average 'interaction frequency' of organisms contributing towards the ecosystem function in question.

Such a progression has been briefly discussed by Leduc et al. (2013), however, here I develop this further by hypothesising that the relative dominance of each of these three components of the BEF relationship (accelerating → linear → saturating) in natural communities is dependent on the average 'interaction frequency' of organisms contributing towards the ecosystem function in question, 'interaction frequency' being defined here as *the number of individuals per unit area contributing towards a particular ecosystem function, divided by the reciprocal of the average body size of the individuals in question* (i.e. density / (1 / average body size)). At a low average 'interaction frequency' of organisms, the accelerating portion of the relationship will be relatively magnified, with facilitation and low levels of redundancy and competition promoting accelerating ecosystem functioning with increasing biodiversity levels (Figure 5.12 'B'). In contrast, at a high average 'interaction frequency' of organisms, the saturating portion of the BEF relationship will be relatively expanded, with high functional redundancy and competitive interactions setting a limit to potential ecosystem functioning levels (Figure 5.12 'A').

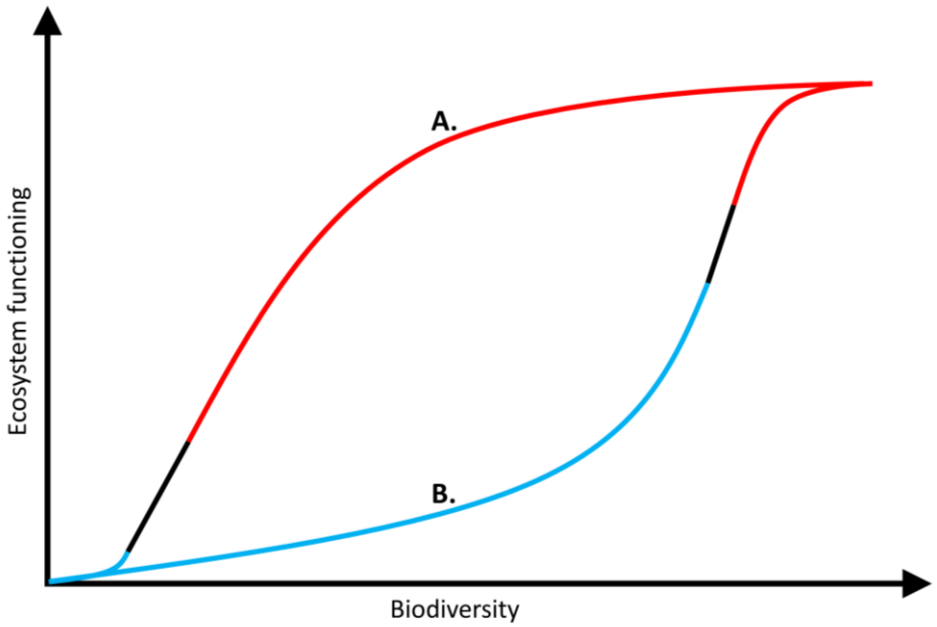


Figure 5.12: Hypothesised form of biodiversity ecosystem functioning relationships in regions of higher (A) and lower (B) average 'interaction frequency' of organisms. Both relationships are composed of three portions: accelerating portion (blue), linear portion (black), and saturating portion (red), but the relative dominance of each of these portions differs between the relationships. In cases of high average 'interaction frequency', the accelerating portion of the BEF relationship (blue area) is relatively reduced, whilst the saturating portion (red area) is much enhanced. In cases of low average 'interaction frequency', the opposite is true, with the accelerating portion of the relationship (blue area) being enhanced, and the saturating region (red area) being limited to the high diversity part of the BEF curve.

It is further postulated that the average 'interaction frequency' of organisms contributing towards a particular ecosystem function will depend most greatly (and positively) on the generality of the ecosystem function in question (e.g. 'standing stock' versus 'carbon cycling efficiency') and on the level of energy availability in the system (e.g. shallow vs deep water). In other words, for a set taxonomic group and ecosystem functioning metric, how rapidly saturation in ecosystem functioning is reached with increasing biodiversity will depend on the magnitude of biologically available energy (and so the average 'interaction frequency' of organisms contributing towards functioning). For example, this theory predicts that, for a set taxonomic group and functioning metric, saturation in an examined BEF relationship will be reached at much lower biodiversity values in shallow water than in the deep sea because of typically elevated biologically available energy in shallow water relative to the deep sea. Conversely, for a given taxonomic group and set energy availability, how rapidly saturation in ecosystem functioning is reached will depend on the

generality of the functioning metric analysed (and so the average 'interaction frequency' of organisms contributing to functioning). For instance, in the present study, it was found that the most general ecosystem functioning metric ('carbon cycling efficiency') also showed greatest evidence for saturation with increasing biodiversity, whilst the most specific ecosystem functioning metric (with a much smaller subset of the total faunal community contributing to it) – 'standing stock' produced greatest evidence for accelerating BEF relationships.

5.6 Concluding statement

This investigation represents the first deep-sea biodiversity – ecosystem functioning study to consider taxonomic, phylogenetic and functional metrics of diversity. In agreement with stated hypotheses, recovered BEF relationships were found to be generally positive in type. However, these relationships were not found to be exclusively accelerating in form. Instead, a variety of forms were recovered (saturating, linear and accelerating) depending on the biodiversity and ecosystem functioning metric combination analysed.

Whilst this study aimed to clarify the particular form of deep-sea BEF relationships, instead a range of forms were recovered. However, rather than causing further confusion, I argue that the results of this study point towards a more general truth; BEF relationships should not be forced into one of three basic forms, but instead all positive BEF relationships follow a set shape, with accelerating, linear and saturating portions being expressed in turn with increasing biodiversity. The relative dominance of each of these portions is further dependent on the average 'interaction frequency' of organisms (relative to body size) contributing to the ecosystem function in question, this average 'interaction frequency' being set predominantly by the energy availability of the study system, characteristics of the taxonomic group analysed, and the generality of the ecosystem function investigated. Further testing of this theory is required, for example by the comparison of set BEF relationships between cold seeps (with relatively high energy availability) and surrounding background sediments (with relatively low energy availability). Under such circumstances,

one would expect BEF relationships to saturate more rapidly at cold seeps compared to background sediments.

5.7 Literature cited

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Chapter 6

'Summary, conclusions, limitations and future research directions'

6.1 Summary of chapters

Scientific understanding of deep-sea ecosystems has progressed greatly over the past two centuries, from argument over the existence of life in the deep sea (De La Beche, 1834, Forbes, 1844) (see Section 1.1.1), to recognition of high species and habitat diversity (Hessler and Sanders, 1967, Grassle and Maciolek, 1992, Levin et al., 2010), the discovery of bizarre and highly productive chemosynthetic habitats (Corliss et al., 1979, Paull et al., 1984), and the recognition of broad macroecological trends in the deep (Rex, 1973, Rex et al., 1993, Culver and Buzas, 2000) (see Section 1.2). However, this permanently dark portion of our planet, which represents about 99 % of the volume of our oceans (Costello et al., 2010), remains chronically under sampled (Rogers et al., 2015a). As a result, knowledge of the fundamental ecology of deep-sea ecosystems is still immature relative to more familiar shallow-water and terrestrial habitats (McClain and Schlacher, 2015). This ignorance is of concern given that the deep sea is being subjected to increasing stress from anthropogenic pressures, both direct (fishery activities, oil and gas extraction, cable laying, and the dumping of litter, biological, chemical and radioactive waste and munitions) and indirect (increasing temperatures, deoxygenation and acidification) (Ramirez-Llodra et al., 2011) (see Section 1.3).

The investigations presented in this thesis aim to extend knowledge of the ecology of deep-water ecosystems via the analysis of one of the largest deep-sea benthic datasets yet produced. This dataset is regional in extent, comprising 20245 peracarid crustaceans representing 177 genera in 74 families collected by over 300 box core samples covering a greater latitudinal and longitudinal range than England (Figure 1.2). To complement this

biological information, an extensive suite of environmental data is associated with each box core sample, describing numerous aspects of the benthos, including temperature, salinity, current speed, food availability, sedimentary variables, geology, benthic terrain variables, biomass of habitat-forming megafauna, and fishing effort (see Appendix 3). To further enhance the power of this dataset, phylogenetic (via the construction of a fossil-calibrated supertree of Peracarida (figures 2.1, 2.2 and A8.1)) and functional (via the collation of peracarid trait data from 93 sources (Appendix 4)) metrics of diversity have been calculated.

By using these datasets strategically, this thesis brings much needed statistical power, replication and state-of-the-art analysis techniques to the realm of deep-sea ecology, and, as a result, I believe that the conclusions of the analyses conducted within significantly progress understanding of the ecology of deep-sea benthic ecosystems. For example, it is demonstrated that the macrofaunal assemblages studied are more strongly structured by variation in environmental parameters than they are by competitive interactions. It is suggested that the intensity of bottom trawling, seafloor temperature, current speed, food availability, sediment characteristics and physical habitat heterogeneity are candidates for these environmental parameters; these variables all being found to significantly influence deep-sea peracarid assemblage biodiversity metrics. Further, the importance of high poriferan biomass for the promotion of peracarid assemblages of high density, biomass, richness and diversity is highlighted. Of relevance to the management of deep-sea ecosystems, the results of this thesis suggest that caution should still be exercised when applying species distribution models to data-deficient environments, whilst it is found that the location of spatial closures in the NAFO Regulatory Area may not be fully optimal for the protection of all components of benthic assemblages against the impacts of bottom trawling. The importance of high deep-sea diversity is demonstrated by the finding of positive biodiversity – ecosystem functioning relationships. However, the form of these relationships is found to be dependent on the biodiversity and ecosystem functioning metrics employed, and a hypothesis for a generalised form of biodiversity – ecosystem

functioning relationships is proposed. Before taking a holistic view of these findings, it is first helpful to review chapters 2 to 5 of this thesis in greater detail.

Chapter 2 investigates the importance of abiotic variables relative to competition in shaping deep-sea assemblages, a question described as of "*fundamental importance and excitement*" by McClain and Schlacher (2015), and with relevance to the 'Stability Time Hypothesis' (Hessler and Sanders, 1967, Sanders, 1968). This is achieved via the application of community phylogenetics methodology to community structure data and an associated supertree and functional dendrogram. The results of these analyses suggest that, in the region investigated, the abiotic environment is of greater importance than competition in structuring benthic peracarid assemblages. This, in turn, implies a strong filtering of these deep-sea benthic assemblages by prevailing environmental conditions, further suggesting that deep-sea organisms are stenotypic and sensitive to their environment. This high environmental sensitivity may reflect adaptation to typically predictable oceanographic conditions. For example, at the box core locations analysed in this study, mean temperature in 2010 varied only between 2.89 °C and 4.11 °C amongst box cores, whilst mean salinity varied only between 34.29 ‰ and 34.93 ‰. These conclusions are explored in chapters 3 and 4, where relationships between various environmental variables (including temperature, fishing intensity, and the density of biogenic habitat) and numerous facets of peracarid biodiversity are investigated.

Chapter 3 aims specifically to extend knowledge of the relationships between various aspects of the deep-sea physical environment and continental slope macrofaunal communities. In contrast to more traditional deep-sea biodiversity studies, a broad suite of biodiversity metrics are investigated, including peracarid abundance, biomass, community structure, taxonomic richness and diversity, and functional and phylogenetic measures of diversity. As a result, the work of Levin et al. (2001) is expanded upon, and paradigms of deep-sea ecology are discussed.

Key findings of Chapter 3 include the relevance of 'bathymetric position index' in determining peracarid biomass and functional measures of diversity (mirroring recent findings in abyssal environments (Durden et al., 2015, Morris et al., 2016, Stefanoudis et al., 2016), an unexpected negative influence of increasing bathymetric heterogeneity on the richness, evenness and diversity of assemblages (which may be related to the particular life-history characteristics of peracarids), a greater importance of absolute sediment characteristics relative to particle size diversity in shaping macrofaunal assemblages, and a complex influence of food availability on assemblages (highlighting continued uncertainty regarding the identity of food sources for deep-sea macrofauna).

With relevance to the understanding of the impacts of human activities on deep-sea ecosystems, variation in trawling intensity and temperature across the study area was found to relate significantly to a selection of the biodiversity facets analysed. Increasing trawling intensity was found to be associated with altered community structure and reduced assemblage evenness, diversity and functional variability, but slightly elevated peracarid densities. This, perhaps, reflects responses to the direct impacts of physical disturbance (Connell, 1978), alterations to natural carbon cycling (Pusceddu et al., 2014) and/or a signature of prey-release (Shepherd and Myers, 2005, Frank et al., 2011, Perez-Rodriguez et al., 2012). Higher temperature values were found to be associated with reduced peracarid biomass, altered community structure, and depressed phylogenetic richness and variability, in agreement with the recognition of temperature as a fundamental controlling environmental factor (e.g. Brown et al. (2004)) and the potential for deep-sea organisms to be highly sensitive to temperature change (Tewksbury et al., 2008, McCauley et al., 2015).

The strength of the recovered influence of trawling intensity and temperature on peracarid assemblages is of concern in an environment traditionally considered the last great wilderness of our planet. Indeed, whilst Danovaro et al. (2017) suggest that cumulative human impacts in the deep sea have the potential to cause regime shifts, just as they have

in some shallow-water environments (e.g. Frank et al. (2011)), the changes to peracarid assemblages observed here as a result of fishing pressure hint that such regime shifts may already have occurred in some areas.

With respect to prediction of the future impacts of climate change on deep-sea communities, the results of Chapter 3 suggest that increasing temperatures may lead to supressed ecosystem functioning and a weakened provision of ecosystem services, such as carbon storage; this being of particular significance considering the supposed importance of continental slopes for global carbon storage (Muller-Karger et al., 2005, Rogers et al., 2015b).

Chapter 4 uses GAMs to extend and refine knowledge of the relationships between various aspects of the deep-sea environment and taxonomic, functional and phylogenetic metrics of continental slope peracarid biodiversity. Here, the focus is placed upon biogenic habitat provision by 'Vulnerable Marine Ecosystem' (VME) indicator taxa and the spatial closures enforced by the Northwest Atlantic Fisheries Organisation (NAFO). This chapter builds upon the few studies that attempt to quantify the influence of VMEs and spatial closures on benthic communities in the NAFO Regulatory Area. Investigations to date have been focused on the analysis of megafaunal communities (Beazley et al., 2013, Beazley et al., 2015), with only the analysis of Barrio Froján et al. (2012) studying macrofauna.

Results of particular note in Chapter 4 include that Porifera was found to be the VME indicator taxon analysed with greatest apparent influence over peracarid assemblage attributes, reaffirming the perception of poriferans as crucial structural components of VMEs in the NAFO Regulatory Area. The presence of poriferan aggregations was found to result in the alteration of community structure and elevation of peracarid abundance, biomass, taxonomic, functional and phylogenetic richness, taxonomic diversity and functional variability. In contrast, gorgonian corals were found to have only very limited influence over peracarid assemblages, and this likely reflects a relatively low density of this

VME indicator taxon in the study area (figures 4.4 and 4.7). The density of Pennatulacea was found to influence peracarid assemblages only subtly, with the few significant relationships uncovered being either weakly negative, or complex in form. Pennatulaceans too fail to reach particularly high densities in the study area, but the recovered relationships may also reflect predation pressure upon peracarids in the vicinity of sea pens by demersal fish such as *Sebastes* spp.

The results of Chapter 4 additionally suggest that caution should be exercised when applying evidence from species distribution models to management decisions in data-poor environments, which includes much of the deep sea.

With direct relevance to the management of bottom trawling within the NAFO Regulatory Area, peracarid assemblages collected from within and outside current spatial closures were found to be highly similar to one another. This result was unexpected given that the location of these closures was selected to provide protection from bottom trawling to dense aggregations of VME indicator taxa (which should, in turn, influence the peracarid assemblages found there). This finding may reflect too generalised boundaries of these closures, the presence of VMEs outside of current closures, or the inappropriate location of some of the closures (Rogers and Gianni, 2009).

The results of Chapter 4 emphasise the importance of continued efforts to map the true extent of sponge grounds in the NAFO Regulatory Area in order that they can be effectively protected by spatial measures. However, at present it appears that species distribution modelling may not be reliable enough for this purpose. The optimality of current spatial closures, in terms of maximising protection for all components of diverse benthic assemblages against the impacts of bottom trawling, is questioned, to an extent, by this analysis, and the boundaries of current spatial closures ought to be revised. Based on the datasets analysed in this thesis, I plan to implement a MARXAN analysis in order to achieve this (see Section 6.5).

Having determined the suite of environmental variables analysed that significantly influence peracarid biodiversity in the study area, Chapter 5 focusses on the relationship between biodiversity and ecosystem functioning in the deep sea. Controversially, this relationship has been suggested to take an exponential form (Danovaro et al., 2008, Narayanaswamy et al., 2013, Zeppilli et al., 2016), with the implication that positive species interactions are the norm for deep-sea benthic habitats, and that any loss of biodiversity will be associated with a rapid decline in ecosystem functioning. Chapter 5 investigates this claim, using data on peracarid assemblages, by analysing a greater range of biodiversity metrics than previous deep-sea BEF studies, a selection of functioning metrics that vary in specificity to the peracarid community, and powerful statistical methodology – namely 'Structural Equation Modelling' (see Section 5.3.4.1). The results of this analysis reinforce the generally accepted positive nature of deep-sea biodiversity – ecosystem functioning relationships. However, no consistent form of the relationship was recovered, it instead being dependent on the biodiversity and ecosystem functioning metrics in question. As such, it is argued that positive BEF relationships do not distil into alternative basic forms, but instead all take the same generalised sinusoidal form, with accelerating, linear and saturating portions being expressed in that order with increasing biodiversity (see Figure 5.11). It is further hypothesised that the relative dominance of each of these three portions is dependent on the potential relative density of organisms contributing to the metric of ecosystem functioning in question, with a lower average 'interaction frequency' of organisms promoting expansion of the accelerating portion of the curve, and a higher average 'interaction frequency' of organisms leading to magnification of the saturating portion of the BEF relationship.

Applying this hypothesis to the deep sea, it is suggested in Chapter 5 that the generally negative relationship between water depth and organismal density (Rex et al., 2006) should promote an increasing dominance of the accelerating portion of the BEF curve with increasing water depth. This would suggest that levels of ecosystem functioning in the deep

sea are typically more vulnerable to biodiversity loss than in shallow water, and that this vulnerability increases with increasing water depth. It is further predicted that this relationship will be most apparent when ecosystem functioning metrics that are specifically linked to a particular component of the community are analysed. In contrast, it is predicted that broad-scale ecosystem functions, such as community nutrient cycling, will not be as overtly vulnerable to a loss of diversity in a particular taxonomic group (see Section 5.5).

There is room to develop the conclusions of Chapter 5 to more practical ends; analysis of standard BEF relationships could produce a measure of the relative vulnerability of ecosystem functioning to biodiversity loss at different locations (Strong et al., 2015). Such analyses would have relevance to impact assessments and any decisions regarding the authorisation of resource extraction from deep-sea environments.

6.2 Broader implications of conclusions

Taking a more holistic view of this thesis, its focus, conclusions, and the implications of these conclusions emphasise the immaturity of scientific knowledge of deep-sea ecosystems relative to their shallow-water and terrestrial counterparts. It can be argued that the deep-sea ecological research community has been sometimes slow to embrace trends in terrestrial ecological research and analysis techniques. For example, the first analysis of BEF relationships in the deep sea was published only in 2008, and there are still no published studies investigating microbial, macrofaunal or megafaunal BEF relationships, whilst the analysis techniques employed in this thesis are rare amongst deep-sea studies. Further, deep-sea research and sample collection still frequently lacks well defined collective objectives and direction.

Often, the limited scope of some deep-sea ecological research is attributed to difficulties in obtaining sufficiently replicated datasets because of logistical difficulties, safety considerations, and the high costs involved. Although this study demonstrates that it is

indeed feasible to collect and analyse large deep-sea datasets, this opinion of the difficulties of deep-sea sampling remains relatively common amongst the deep-sea ecological community. As a result, expectations may be set low by default with respect to the quantity of samples collected, and so questions investigated and analyses methods employed. For example, in the study of De Leo et al. (2017), which investigated the synergistic impacts of oxygen minimum zones and trawling activity on benthic continental slope fauna, only two ROV transects were analysed, whereas similar studies in shallower water typically analyse ten times this number of transects (e.g. Orejas et al. (2009)). To give another example, the deep-sea gastropod population genetics study of Chen et al. (2016) analysed only 93 specimens collected from three sites, whilst the terrestrial gastropod population genetics study of Hayes et al. (2008) analysed 783 individuals from 221 sites. Further, this common problem of small datasets is frequently exaggerated by a propensity to claim stronger conclusions than are justifiable given the data used to reach them.

The results of the analyses presented in this thesis emphasise deep-sea benthic communities to be highly diverse not only in taxonomic terms, but also by phylogenetic and functional measures, whilst the concept of a high sensitivity of deep-sea benthic communities to environmental change is corroborated by the analyses of chapters 2, 3 and 4, with relevance to our understanding of the potential for anthropogenic disturbances to alter deep-sea communities. Indeed, the evidence presented here suggests that direct anthropogenic pressures, like bottom trawling, are already significantly impacting peracarid community structure, diversity and abundance, whilst indirect pressures such as elevated temperatures as a result of climate change may potentially result in supressed deep-sea diversity and biomass in coming decades. Further, the results of Chapter 5 suggest that levels of ecosystem functioning in the deep sea are likely to be more vulnerable to biodiversity loss than is typical for shallow water and terrestrial realms. To summarise, this thesis demonstrates that deep-sea benthic peracarid communities are highly diverse, fragile and sensitive to environmental change.

As put succinctly by Duffy et al. (2012) "*the certainty of future uncertainty argues for a precautionary approach to managing our interaction with the biosphere*". Based on the conclusions of this thesis, it is strongly advocated that deep-sea environments are to be treated with caution and respect. Indeed, the deep sea is perhaps the environment most suited to the application of the precautionary principle, and I believe the results of this thesis have relevance to future policy decisions concerning interactions between humans and the deep sea.

Bottom trawling represents arguably the greatest human disturbance of deep-sea ecosystems at present (Palanques et al., 2006, Bailey et al., 2009, Benn et al., 2010, Ramirez-Llodra et al., 2011, Puig et al., 2012). Reflecting this, the United Nations General Assembly (UNGA) Resolutions 59/25, 61/105, 64/72 and 66/68 directly call for states and Regional Fisheries Management Organisations to formally recognise the immense importance and value of deep-sea ecosystems and the biodiversity that they contain by adhering to the precautionary principle and ecosystem approach when harvesting biotic resources from the deep sea, taking special actions to manage bottom fisheries in order to protect VMEs from Significant Adverse Impacts (SAIs) (Gianni et al., 2016).

In the region investigated in this thesis, NAFO has put in place a series of measures in order to reduce the chances of SAIs to VMEs, and so make progress towards fully achieving the aims of the above-mentioned UNGA Resolutions. These measures include the use of Vessel Monitoring Systems (VMS) to track the location of fishing vessels, closure of some areas to bottom-contact fishing that are known to house large aggregations of VME indicator taxa, initiation of a 'move-on' rule, enforcement of 100 % impartial observer coverage on all fishing vessels, and research to assess the magnitude of fishery impacts on the wider ecosystem (see Section 1.6.1) (Gianni et al., 2016, NAFO, 2017).

However, while NAFO has made good progress towards implementing the UNGA Resolutions, further effort is still required to ensure that they are fully realised. For example, not all areas that are known to, or are likely to house VMEs are protected by spatial closures (Barrio Froján et al., 2016), with 45 % of sponge grounds, 63 % of sea pen fields and 31 % of gorgonian corals, by area (for which significant aggregations are known) remaining at risk of disturbance from fishery activities (NAFO, 2015, Gianni et al., 2016). Full impact assessments of fishery activities on VMEs are yet to be completed, bottom-trawl research surveys continue to cause damage to VMEs even within spatial closures (Gianni et al., 2016), and the current 'move-on' protocol appears ineffective, having yet to be triggered, perhaps of a failure of observers and/or vessel masters to collect or report data on encounters, and/or a setting of threshold catch weights that are too high (see Section 1.6.1) (Gianni et al., 2016).

The results of the analyses conducted in this thesis provide NAFO with important additional information pertaining to the impact of fisheries on macrofaunal size-classes, and the effectiveness of current spatial closures for the protection of macrofaunal communities. These results provide evidence that bottom trawling is having a significant impact on benthic peracarid assemblages, on top of the accepted overt impact on megafauna (Koslow et al., 2001), and that biogenic habitat provided by sponge aggregations is important for peracarid communities, promoting assemblages of higher abundances, biomass and diversity.

However, the results of Chapter 4 emphasise that current NAFO spatial closures require revision if all components of VMEs are to be protected from the possibility of SAIs. Future proposals for spatial closures, impact assessments, and attempts to manage the NAFO Regulatory Area under an ecosystem approach need to pay additional attention to the importance of sponge-dominated biogenic habitat and the impacts of trawling activity on macrofauna, as well as megafauna.

6.3 Limitations

Whilst the results of the analyses presented here significantly progress scientific knowledge of the ecology of deep-sea benthic macrofaunal communities, there are a number of potential limitations to the study that require discussion.

6.3.1 Limitations of the biological dataset

Firstly, and perhaps most overtly, the analyses conducted here are based on data only from peracarid crustacean assemblages. Peracarids are a highly suitable study taxon that can afford high resolution to ecological studies as a result of their low dispersal potential (peracarids are brooders with no obligate pelagic dispersive phase) (Martin and Davis, 2001, Gage, 2004, Poore, 2005, Blazewicz-Paszkowycz et al., 2012, Larsen et al., 2014), high taxonomic diversity (peracarids are amongst the most speciose animal groups in the deep sea) (Gage, 2004), their superabundance in marine environments (Poore, 2005, Drumm, 2010), and their ecological importance (for example as prey, predators and ecosystem engineers) (Snelgrove, 1997, Drumm, 2010, Larsen et al., 2014, Modica et al., 2014) (see Appendix 1). However, peracarids are but one component of the deep-sea benthic macrofauna in the region analysed, with polychaetes also being particularly abundant in the box core samples (mean polychaete abundance per box core = 169.7 individuals (van der Grient, 2016)), along with molluscs. Macrofauna, in turn, represent only one portion of the total benthic community.

Whilst greatest ecological insight would likely be gained from studying the benthic community as a whole, to identify all taxa present in even perhaps 5 % of the box cores collected would be far too time consuming to attempt during the course of a PhD, the resulting low replicate number would drastically reduce statistical power, and any use of phylogenetic or functional diversity measures would necessarily have to be simplified. As such, analysis of only peracarid assemblages was considered to represent the optimal balance between detail of data, time required, replication achieved, and so insight gained.

A similar argument can be applied as to why peracarids were identified to genus rather than species level, and why functional trait data were collected at family level. Clearly, identifying peracarids to their species would permit a higher resolution analysis, and species represent a natural biological unit, whilst genera and families do not. However, with a high proportion of new species in most deep-sea samples (e.g. in a recent exploration of infaunal macrofauna at lower bathyal depths off the western margin of Australia, 94.6 % of crustacean species collected were undescribed (Poore et al., 2015)), and a paucity of appropriate taxonomic keys and natural history information, identifying species and collecting trait data at species-level would have been far too time consuming and would have resulted in a high proportion of missing functional data, with replication and data quality suffering as a result. Since there is ample evidence that higher-level taxonomy (especially at genus-level) represents a good surrogate for species-level diversity and community structure measures (Balmford et al., 1996a, Balmford et al., 1996b, Roy et al., 1996, Báldi, 2003, Doerries and Van Dover, 2003, Olsgard et al., 2003, Heino and Soininen, 2007, Terlizzi et al., 2009), there is little reason to believe that, were this analysis to be conducted at species-level, the conclusions would have been greatly different.

Also relevant to discussion of the portion of the benthic community studied, although a 500 µm mesh sieve was used on-board the *Miguel Oliver* during box core collection, this investigation utilised a 1 mm mesh sieve during sample processing post collection, despite the fact that 500 µm or 350 µm aperture sieves are most commonly used in deep-sea studies. This sieve size was selected, prior to the commencement of this study, in agreement with NE Atlantic Marine Biological Analytical Quality Control Scheme (NMBAQC) protocols, which are biased towards shallow-water samples. Undeniably, observed total macrofaunal abundance will have been depressed to an extent as a result of this, with some of the smaller macrofaunal organisms being lost through the larger sieve mesh compared to if a 500 µm one were used. Because of this, the ability to measure the total richness and

abundance of macrofauna collected in the box cores will have been compromised, and so it is not possible to compare these values directly with those of other deep-sea studies. However, it can be argued that, as sieve mesh sizes are relatively arbitrary (Bett, 2013), the exact choice of sieve utilised is not overly important as long as it is applied consistently throughout a dataset. As this thesis is primarily concerned with large-scale ecological patterns, not absolute abundance or richness values, and these large-scale patterns will likely apply consistently regardless of whether a 1 mm or 500 µm mesh sieve is used, this choice of sieve mesh size is not viewed here as a major limitation.

This study utilised a box corer in order to retrieve samples of the benthos. Box corers were developed in the 1960s and 1970s (Reineck, 1963, Hessler and Jumars, 1974) in order to promote quantitative sampling of soft seabed sediments (Blomqvist, 1991), enabling the collection of a large, standardised area of the seafloor (typically 0.25 m^2) with little loss of faunal content. However, use of box corers is not without associated issues. Chief amongst these is the bow-wave effect, whereby the motion of the box corer through the water column during deployment creates a bow wave that causes disturbance and dispersal of flocculent and soft surficial sediments (which can contain organisms) as the box corer approaches the sea bed (Blomqvist, 1991, Bett et al., 1994, Shirayama and Fukushima, 1995). Current box core designs aim to reduce the bow-wave effect by promoting an unimpeded water flow through the corer prior to contact with the sediment surface, yet bow waves cannot be eliminated entirely (Blomqvist, 1991, Shirayama and Fukushima, 1995).

A further limitation of box corers is that the degree and rate of penetration of the sample box into the sediment is highly dependent on the physical characteristics of the sediment, and, if not deployed appropriately, variation in the volume of sediment collected may occur (Blomqvist, 1991) (e.g. see Figure 6.1). The speed of approach and penetration depth of box corers is a variable that can be influenced by the behaviour of the winch operator on ship, and so use of different operators can introduce variation in the quality of box core

samples collected. In order to obtain as consistent as possible samples of the benthos, it has been recommended that the sample box of the box corer should contact and penetrate the sediment surface slowly, perhaps aided by the use of a stand for the box corer (which would come to rest on the seafloor before penetration of the sample box) and the use of a live video relay (Blomqvist, 1991). The box core samples analysed in this study were collected over six research cruises, and so it is likely that there were several operators of the box corer. In an attempt to account for this, as well as variation in sieving behaviour between cruises, cruise identity was incorporated as a covariate in the GAMs constructed.

Alternative benthic sampling devices to box corers are available, and there is some evidence that they may be more efficient, particularly for the sampling of meiofauna. For example, mega corers and multi corers have been shown to produce a much smaller bow wave than box corers (Barnett et al., 1984, Blomqvist, 1991, Bett et al., 1994, Shirayama and Fukushima, 1995). However, these alternative devices do not collect as large a volume of sediment as box corers, and as box corers appear reliable for sampling macrofauna if operated suitably (Blomqvist, 1991), they remain the sampling device of choice for most modern deep-sea investigations of benthic macrofauna.

6.3.2 Limitations of the environmental dataset

A key strength of this investigation is the wealth of environmental data associated with each box core location (see Appendix 3). Nevertheless, a small number of environmental variables, which it would have been beneficial to study, were not available. In particular, it would have been of interest to analyse peracarid community patterns with respect to natural variation in pH and oxygen concentration at the seafloor, and access to such information would have facilitated a more holistic investigation of the potential impacts of climate change on deep-sea environments – a topic that is reviewed briefly below.

The oceans have absorbed about a third of anthropogenic carbon dioxide emissions to date (Orr et al., 2005), and the rate of formation of carbonic acid is greater than the ability of

the oceans to buffer against it. As a result, the pH of seawater has dropped by 0.1 units since the beginning of the Industrial Revolution (Sabine et al., 2004, Cao and Caldeira, 2008), this representing an approximately 26 % increase in hydrogen ion concentrations (Cao and Caldeira, 2008, Howes et al., 2015). Most of this increase has occurred over recent decades, and a further reduction of 0.3 - 0.5 units in the average pH of surface waters is expected by 2100 (Caldeira and Wickett, 2005, Feely et al., 2009). Such a drop in pH is predicted to result in a shoaling of the carbonate compensation depth (CCD), and this will lead to increased metabolic costs of skeleton production in deep waters by taxa such as molluscs, cnidarians, echinoderms and crustaceans (Fabry et al., 2008, Jackson et al., 2014). This could lead to a reduction in the abundance of key habitat-forming taxa, including cold-water corals, with potential knock-on effects for commercial fish stocks (Ramirez-Llodra et al., 2011, Jackson et al., 2014, Thresher et al., 2015) (see Section 4.2.1.2). Further potential physiological effects of ocean acidification include developmental abnormalities (Kurihara, 2008), and metabolic suppression (Fabry et al., 2008). There is also evidence that ocean acidification may make it more difficult for some taxa to detect prey items (Cripps et al., 2011, Dixson et al., 2015, Howes et al., 2015).

In terms of primary production in the oceans, increased carbon dioxide availability will result in increased photosynthetic rates for some species (Beardall and Raven, 2004, Doney et al., 2012). However, the structure of phytoplankton communities will also likely change as a result of ocean acidification, with picoplankton representation set to increase relative to larger calcifying taxa such as coccolithophores. Picoplankton export to deeper waters is less efficient than for larger phytoplankton groups, and so trophic impacts are expected for deep-sea ecosystems (Smith et al., 2008, Howes et al., 2015). Changes to nitrogen cycling in sediments is also likely as a result of ocean acidification, with Laverock et al. (2013) predicting a drop in pH to cause a substantial reduction in benthic ammonia oxidation rates in bioturbated sediments.

The expansion of oxygen minimum zones (OMZs – areas where oxygen concentrations are chronically below 1.3 mL L^{-1}) in the oceans is another facet of the impact of climate change

(Howes et al., 2015). Oxygen concentrations have been declining in the oceans since the mid-20th century, with a further decline of between 1 % and 7 % expected by 2100 (Shaffer et al., 2009, Keeling et al., 2010). Associated with this will be an expansion of OMZs, particularly at depths between 200 m and 700 m in the tropics and sub-tropics (Stramma et al., 2008, Stramma et al., 2010) as a result of reduced oxygen solubility in warm surface waters (the entry point for all oxygen in the oceans), elevated organismal respiration rates under warmer temperatures and physiological stress (Hofmann and Schellnhuber, 2009), increased ocean stratification (Polovina et al., 2008), and reduced oxygen production by phytoplankton (Behrenfeld et al., 2006). It is further predicted that ocean circulation patterns, such as deep thermohaline circulation will be altered as a result of climate change (Broecker, 1997, Schmittner et al., 2008), with a likelihood that the formation of cold, oxygenated polar water (a significant source of oxygen to the deep sea) will slow over coming decades (Schmittner et al., 2008), depressing oxygen concentrations in the deep sea globally.

Such a reduction in oxygen concentration is predicted to impact organismal communities throughout the oceans at multiple levels. At the individual level, metabolic and behavioural changes may occur (Wu, 2002), potentially leading to reduced growth, reproduction and survival, although responses amongst species are expected to be variable (Doney et al., 2012). At the ecosystem level, expansion of OMZs will result in habitat compression for many taxa. For instance, billfishes have been shown to be depth-limited by OMZs (Prince et al., 2010), whilst in the case of diel vertical migrating taxa, increasing temperature and decreasing oxygen concentrations in surface waters, coupled with a shoaling of low-oxygen water layers may put a double squeeze on habitat space, resulting in reduced transport of nutrients between deep and surface waters (Seibel, 2011). However, those taxa able to function in hypoxic waters, such as Humboldt squid and the gelatinous zooplankton, may benefit from a lower-oxygen ocean, expanding in their distributions (Rosa and Seibel, 2010, Howes et al., 2015). As for the benthos, nematodes, annelids and some mollusc species appear to be relatively common in areas of low oxygen concentrations, whilst crustaceans

and echinoderms are under-represented (Levin, 2003, Moffitt et al., 2015), and sponges largely absent (Buhl-Mortensen et al., 2010). As a result, changes to deep-sea community structure and diversity are to be expected following the expansion of low oxygen waters.

In addition to a lack of pH and oxygen data, it should be briefly noted that raw multibeam bathymetric data was not made available for analysis by Cefas. As such, the bathymetric variables analysed in this thesis were constrained to those provided by Anna Downie (Cefas, Lowestoft). Were raw multibeam bathymetric data to be made available to me, it would be interesting to analyse an expanded range of spatial scales in order to attempt to determine which scale has greatest relevance to the structuring of benthic peracarid assemblages.

Finally, whilst a number of proxies for food availability at the seafloor were utilised in this study (see tables 3.2, 4.2 and 5.1), arguably none of these metrics optimally captured true food availability to peracarids. Alternative measures of food availability are available, including sediment biopolymeric carbon content (Danovaro et al., 2008) and chloroplastic pigment concentration (combined chlorophyll *a* and phaeopigment concentrations) (Grove et al., 2006, Leduc et al., 2013, Zeppilli et al., 2016), and the use of such measures may have removed some confusion and uncertainty over the relationship between food availability and peracarid community attributes.

6.3.3 Limitations of ecosystem functioning metrics

Whilst peracarid biodiversity is well characterised in the structural equation model of Chapter 5, ecosystem functioning is described less thoroughly. This is an area where the post hoc nature of the analysis of samples is more evident – as these box core samples were not collected with the investigation of deep-sea BEF relationships specifically in mind. Analysis of additional functioning metrics would strengthen the chapter, and these could include measures of organic matter decomposition rates (e.g. as determined from extracellular enzymatic activities on surface sediments) (Danovaro et al., 2008, Leduc et al., 2013), sediment community oxygen consumption (Leduc et al., 2013), rates of carbon

and nitrogen cycling (based on food-web models calibrated with isotope data) (van Oevelen et al., 2009, van Oevelen et al., 2010), and ecosystem efficiency based on sediment biopolymeric carbon content and chloroplastic pigment concentrations as measures of food availability (Danovaro et al., 2008, Leduc et al., 2013). Quantification of the degree of evidence for bioturbation, based on photographs of the surface of each box core prior to sieving, was initially considered as an ecosystem functioning proxy. However, this was abandoned because the available photographs were neither of high enough resolution, nor taken in a standardised enough manner (variable distance and angle from the box core surface, inconsistent lighting and exposure) for valid comparisons to be made between cores (Figure 6.1).



Figure 6.1: Photographs of NEREIDA box core numbers 39, 136, 243, 256, 291 and 315 (clockwise from top left) demonstrating lack of standardisation of the photography method employed. Note variation in the distance and angle of camera from the box core surface, and inconsistent lighting and exposure.

6.4 Generalisability of conclusions

A question that requires careful consideration is whether the conclusions of this thesis can be generalised to greater depths and alternative locations. For example, this study was regional in extent, but the range of depths sampled was limited to continental slope

depths, with a minimum and maximum sampling depth of 582 m and 2294 m, respectively (mean = 1221 m, standard error = 20.9 m), and a particularly high sampling density between 1000 m and 1200 m (Figure 6.2). Thus, this study focusses firmly on bathyal depths, and so there are questions as to whether its results are relevant to even greater depths (Gage, 2004).

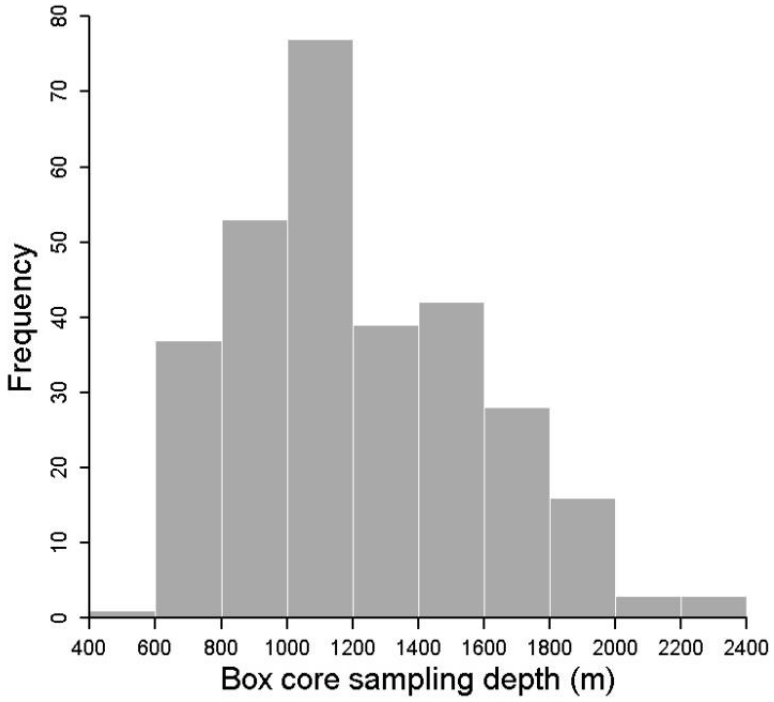


Figure 6.2: Histogram of NEREIDA box core sampling depths.

Abyssal environments, for example, tend to have lower individual and species density values than bathyal (Rex et al., 2005, Rex et al., 2006), and, further, afford more limited ecological and evolutionary opportunities because of the exponential decline in organic carbon flux with increasing depth and distance from the coast (McClain et al., 2004, Rex et al., 2005, Rex et al., 2006). However, as abyssal environments are arguably even more environmentally stable and food limited than bathyal ones, it is possible that the results of this study will be further amplified in abyssal habitats relative to the bathyal zone. For example, the lower organismal densities, increased environmental stability and reduced overall substratum heterogeneity of abyssal zones relative to bathyal should promote an even lower likelihood of competitive interactions, even greater sensitivity to environmental

change, and a relatively enhanced importance of biogenic habitat for macrofaunal communities. Additionally, according to the BEF hypothesis developed in Chapter 5, it is predicted that the accelerating portion of the BEF relationship will be further enhanced in abyssal environments relative to bathyal. Hence, the overall conclusions drawn from this thesis, where relevant, may be even more apparent in greater depths than the bathyal environment investigated.

Considering location, the samples analysed here cover a very large geographical extent, but this does represent only one region of the North Atlantic Ocean. It has been questioned whether conclusions based on samples taken from one area/region can be safely applied to alternative basins/oceans (Gage, 2004), and in answering these concerns, consideration of the geological history of the sampling area in question is very important (Allen and Sanders, 1996, Wilson, 1998, Gage, 2004, Gage et al., 2004). The North Atlantic is still relatively young, in geological terms, with formation commencing in the mid-Mesozoic Era during the break-up of Pangea (Le Pichon and Fox, 1971, Müller et al., 2008), with full spreading rates currently at a reasonably high ~2 - 3 cm per year (Müller et al., 2008).
The North Atlantic can also be considered a relatively isolated water mass, as continuity with adjacent oceans is limited (Wilson, 1998). Indeed, it has been likened to a peninsula compared to Pacific and Indian Ocean deep-sea areas (Wilson, 1998, Gage, 2004). As a result of this young age and relative isolation, opportunities for radiation and immigration into the North Atlantic have been limited compared to, for example, Pacific and Indian Oceans.

Further, it should be noted that the North Atlantic (particularly the northwest) has been greatly disturbed by the release of large quantities of icebergs and changes in physical oceanography as a result of recent Quaternary glaciations (Heinrich, 1988, Bond and Lotti, 1995, Cronin and Raymo, 1997, Yasuhara et al., 2014). Evidence of iceberg scours, pits and ice-rafted debris and till is still discernible to the present around the Flemish Cap (Dr David Piper, Geological Survey of Canada, personal communication).

This young geological age, relative isolation and physical and oceanographic disturbance associated with Quaternary glaciation means that North Atlantic deep-sea benthic communities may be relatively immature and depauperate, ecologically speaking, compared to those of other oceans (Poore and Wilson, 1993, Rex et al., 1993, Wilson, 1998, Gage et al., 2004). As such, the generalisability of the results of this study to alternative deep-sea areas is not well understood. Analysis of samples from additional localities may help to determine this.

6.5 Future research directions

The findings and implications of this thesis hold great promise for further study, and additional investigations have been conceived.

For example, there are plans for the analyses of chapters 2 and 3 to be repeated using additional samples that were collected from the continental slopes off the west coast of Africa and east coast of South America during exploratory oil and gas drilling surveys, these being made available via collaboration with a PhD student at the National Oceanography Centre, Southampton. Such analyses will help to determine how well the conclusions of this thesis can be applied to alternative locations with different geological histories, and across a slightly extended depth range.

To expand upon the work of Chapter 4, where a review of the specifications of the current system of spatial closures in the NEREIDA sampling area was proposed in light of the information presented in the chapter, a MARXAN analysis is planned. MARXAN is a conservation planning software package that attempts to select spatial units for protection that are cohesive and meet pre-defined biodiversity targets whilst minimising total costs (Ball et al., 2009). Using simulated annealing algorithms that are fast, simple and robust, MARXAN identifies multiple alternative solutions to the proposed problem, and produces a consensus spatial network based on these (Ball et al., 2009). The software is flexible, open

source, can handle large datasets, and can provide repeatable solutions. Such an analysis would represent the first example (to the best of my knowledge) of the application of MARXAN software to the design of protected areas in the deep sea. Here, fishing effort per unit area will be used as a cost parameter, whilst information on all environmental variables found in this thesis to significantly shape communities will be incorporated, along with details of current spatial closures, and a target of peracarid biodiversity representation.

Plans to further my proposed theory of the form of biodiversity – ecosystem functioning relationships are also well developed. In the short term, I hope to collaborate with Dr Jesse van der Grient, using her data on polychaete diversity and biomass in the NAFO Regulatory Area to test the hypothesis that for taxa with a higher average 'interaction frequency' of individuals in a given environment (mean polychaete abundance per NEREIDA box core = 169.7 individuals, relative to 67.5 individuals for peracarids), the saturating portion of the sinusoidal BEF curve (Figure 5.11) will be reached at lower biodiversity values than for taxa with a lower average 'interaction frequency' of organisms. Preliminary observations lend some support to this hypothesis (van der Grient, 2016). Further, hypotheses regarding the influence of increasing energy availability on the form of BEF relationships will be tested as part of my planned postdoctoral studies by the comparison of chemosynthetic (cold seep – high energy) and non-chemosynthetic (background sediments – low energy) environments in the Pacific Ocean. Based on the theory set out in Chapter 5, it is hypothesised that BEF relationships will be faster to saturate at cold seep sites relative to background sediments because of the typically higher density of organisms at chemosynthetic sites owing to their greater energy availability.

6.6 Concluding remarks

Here, the creation of regional-scale biological and environmental datasets has facilitated an analysis of deep-sea benthic community ecology with a scope beyond that which is typical for deep-sea ecological investigations. The study of patterns of peracarid phylogenetic and functional diversity along the continental slopes of the Northwest Atlantic has been made possible via the construction of a supertree and collation of an extensive functional trait database. State-of-the-art analysis techniques, such as community phylogenetic methodology, multivariate statistics and structural equation modelling have been applied to exciting and valuable questions in order to maximise the ecological insight gained from this unique dataset.

To summarise, the results of these analyses demonstrate that deep-sea benthic peracarid communities are highly diverse, fragile and extremely sensitive to their environment. The detailed results contained within this thesis extend, refine and revise current paradigms of deep-sea community ecology. Additionally, they have importance to deep-sea management and policy decisions, especially within the NAFO Regulatory Area.

Crucially, this thesis illustrates that it is possible to undertake cutting-edge ecological research in the deep sea, and thus calls for more ambitious ecological investigations in deep-sea benthic environments in years to come. However, it is recognised that there are some limitations to the dataset investigated, for example in its taxonomic, bathymetric and geographic scope, specifics of the sampling methodology employed, and details of the environmental and ecosystem functioning metrics considered.

As a result, an exciting programme of future work is proposed, ranging from a MARXAN analysis of spatial closures in the NAFO Regulatory Area to investigation of biodiversity - ecosystem functioning relationships in cold-seep environments. It is hoped that the results of this research will continue to extend the boundaries of knowledge in deep-sea ecology, further illuminating the truths of this enigmatic and fascinating environment.

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Appendix 1

The superorder Peracarida

Peracarida Calman, 1904 is a superorder within Eumalacostraca consisting of 11 accepted extant orders: Amphipoda, Bochusacea, Cumacea, Isopoda, Lophogastrida, Mictacea, Mysida, Spelaeogriphacea, Stygiomysida, Tanaidacea and Thermosbaenacea (Mees et al., 2015). These orders are united by the brooding of direct-developing young in a marsupium formed by branches of the thoracic limbs, the presence of the lacinia mobilis in adults, the presence of an epipodite on the maxiliped, paired endoderm plates generating the midgut gland, elongate non-flagellate sperm bodies with extended striated acrosomal processes, and a backwards shift of the anterior border of the heart (Richter and Scholtz, 2001, Poore, 2005, Spears et al., 2005, Wilson, 2009, Wirkner and Richter, 2010). In the box cores analysed in this thesis, amphipods, isopods, cumaceans and tanaidaceans were by far the most abundant and diverse of the above orders, with 14110, 2373, 1774 and 1985 individuals collected, respectively.

Amphipods (see Figure A1.1) are characterised by the fusion of the coxae of the first thoracopods (maxillipeds), extensive differentiation of the thoracopods, and the presence of three pairs of pleopods and three pairs of uropods (Richter and Scholtz, 2001, Horton et al., 2013). Four suborders are accepted at present: Gammaridea, Hyperiidea, Ingolfiellidea and Senticaudata, these containing over 170 families and more than 9500 described species (Horton et al., 2013). Amphipods range in length from under 1 mm to over 340 mm and are found in all marine habitats, as well as freshwater and some terrestrial habitats, where they act as important herbivores, detritivores, scavengers and predators (see Appendix 4). Ectoparasitic taxa have also been described (Horton et al., 2013).

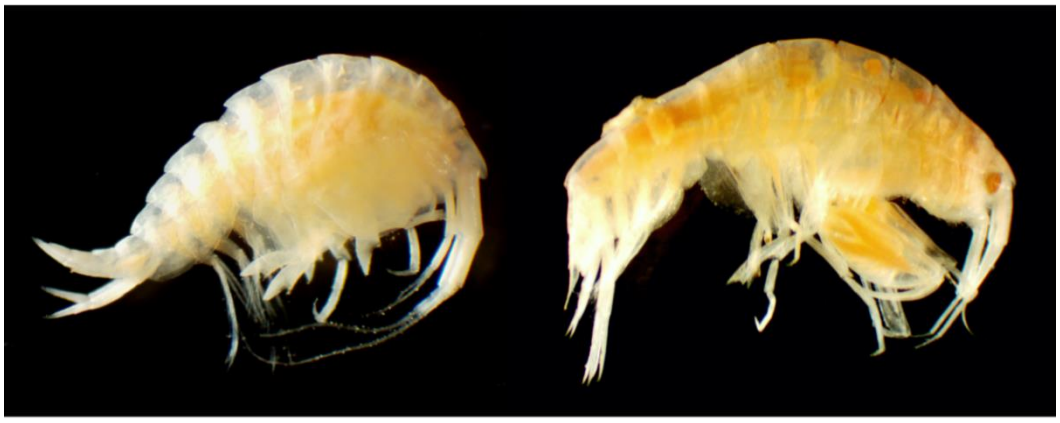


Figure A1.1: Examples of Amphipoda. Left: *Cressa*. Right: *Leucothoe*. © Oliver S. Ashford.

Isopods (see Figure A1.2) show a high level of morphological variation, but are united by the common characters of biphasic moulting, striated muscles with a unique myofibril ultrastructure, uropodal rami that are always uniarticulate, the absence of gills and instead use of the pleopods for gas exchange, and the positioning of the heart in the posterior section of the thorax as a result (Nylund et al., 1987, Richter and Scholtz, 2001, Schotte et al., 2008, Wilson, 2009). 11 suborders are accepted at present (Assellota, Calabozoidea, Cymothoida, Limnoriidea, Microcerberidea, Oniscidea, Phoratopidea, Phreatoicidea, Sphaeromatidea, Tainisopidea and Valvifera, these containing over 120 families and more than 10000 described species (Schotte et al., 2008, Mees et al., 2015). These species range in size from less than 1 mm to nearly 500 mm and occur globally in terrestrial, freshwater and marine (tidal to abyssal) habitats (Soto and Mincarone, 2001, Schotte et al., 2008). In the marine realm, isopods act as important herbivores, detritivores, scavengers, predators and parasites (see Appendix 4).

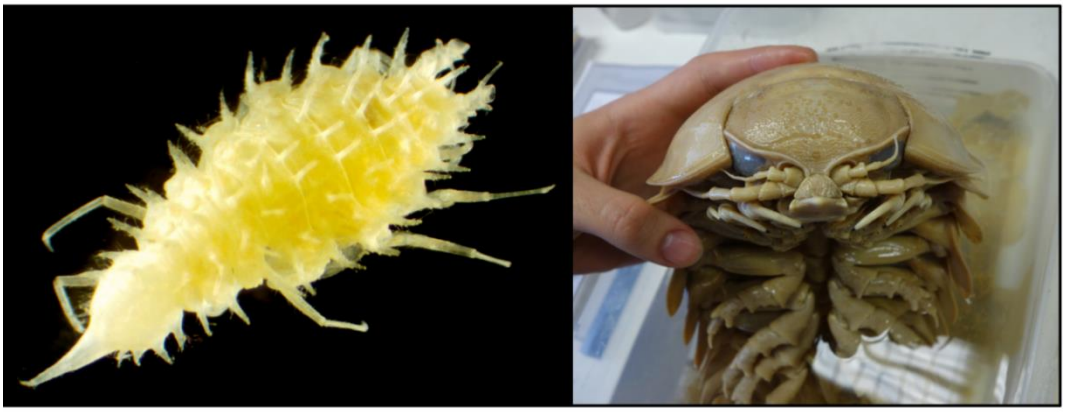


Figure A1.2: Examples of Isopoda. Left: *Janirella*. Right: *Bathynomus giganteus*. © Oliver S. Ashford.

Cumaceans are characterised by a large carapace covering at least the first three thoracic somites and bearing paired pseudorostral lobes that extend beyond a unique mid-dorsal ocular lobe, the modification of the first three thoracopods into maxillipeds (with the first maxilliped functioning as a respiratory organ), and a long slender abdomen consisting of six segments that terminates in a forked tail (Richter and Scholtz, 2001, Haye et al., 2004, Watling, 2005). Nine cumacean families are recognised at present: Bodotriidae, Ceratocumatidae, Diastylidae, Gynodiastylidae, Lampropidae, Leuconidae, Nannastacidae, Platyaspidae and Pseudocumatidae, and over 1400 species have been described (Haye et al., 2004, Watling, 2005, Appeltans et al., 2012). These species range in size from 1 mm up to around 20 mm and occur in surface sediments in brackish and marine waters from tidal to abyssal depths globally (Johnson et al., 2001, Haye et al., 2004, Watling, 2005). Here they act as detritivores, suspension feeders and predators (Jones, 1976, Haye et al., 2004, Watling, 2005) (see Appendix 4).

Tanaidaceans (see Figure A1.3) are characterised by a carapace that covers the first two thoracic segments (which are fused with the head), the modification of the second thoracopod into a large claw, the presence of a small distal palp on the hypopharynx, and a short ring-shaped ischium of the pereopods (Sieg, 1984, Drumm, 2010). The order is currently divided into two extant suborders – Apseudomorpha and Tanaidomorpha, these containing 35 families and over 1100 species (Drumm, 2010, Kakui et al., 2011, Appeltans et al., 2012, Blazewicz-Paszkowycz et al., 2012, Larsen et al., 2014). Typically these species range in size from 1-10 mm (although the largest reported species, *Gigantapseudes maximus* Gamo 1984 reaches lengths of over 70 mm) and can be found in surface sediments in freshwater, brackish water and oceans globally from tidal to abyssal depths, locally reaching densities of up to 140000 individuals per m^2 (Delille et al., 1985, Drumm, 2010, Blazewicz-Paszkowycz et al., 2012). Here they act as suspension feeders, deposit feeders and predators (Blazewicz-Paszkowycz, 2014) (see Appendix 4).



Figure A1.3: Example of Tanaidacea: *Pseudosphyrapus*. © Oliver S. Ashford.

Why study peracarids?

A number of characteristics make peracarids an excellent model taxon for the study of deep-sea benthic ecology. Peracarids exhibit low dispersal potential, having no obligate pelagic dispersive phase, direct-developing young, and generally limited swimming ability (Martin and Davies, 2001, Gage, 2004, Poore, 2005, Blazewicz-Paszkowycz et al., 2012, Larsen et al., 2014). In the case of tanaidaceans, mancae typically settle and construct tubes in close proximity to the maternal tube (Blazewicz-Paszkowycz et al., 2012). The result of this is that the geographic distributions of peracarid populations are generally narrow, and so high beta and gamma diversity results (Grassle and Maciolek, 1992, Smith et al., 2008, Blazewicz-Paszkowycz et al., 2012), increasing the potential geographic resolution of ecological studies. This low dispersal ability also ensures a strong link between an organism's geographic location and the recent and current ambient environmental conditions (Gage, 2004).

As highlighted in the above section, peracarids are taxonomically very diverse, being amongst the most speciose groups in the deep sea (Gage, 2004), and accounting for about a third of all described crustacean species (Spears et al., 2005). Further, the total number of peracarid species in the world's oceans may be as much as an order of magnitude greater than currently recognised (Appeltans et al., 2012). Coupled with this high diversity is a high

abundance, with amphipods, isopods, cumaceans and tanaidaceans being described as 'superabundant' in marine environments (Poore, 2005, Drumm, 2010), and locally reaching very high abundances (Delille et al., 1985). This great diversity and abundance provides the taxonomic resolution required to probe the ecological questions that are the subject of this thesis.

Further, as a result of their superabundance, peracarids represent ecologically important components of deep-sea ecosystems (Drumm, 2010, Larsen et al., 2014). For example, the tubes of some peracarid taxa, like ampeliscid amphipods, act to bind and stabilise sediments, influencing sediment transport (Snelgrove, 1997), whilst the movement of peracarids in surface sediments (burrowing, forming tubes etc.) is important in sediment irrigation – so regulating oxygen penetration (Aller, 1983, Giblin et al., 1995). This in turn is important in regulating the cycling of carbon, nitrogen and sulphur (Snelgrove, 1997). Peracarids also represent significant dietary components of many fish species, including ones of commercial value (Modica et al., 2014). For instance, in the NEREIDA study area (see Section 1.6.2), peracarids are one of the major prey objects of small (<20 cm) Greenland Halibut (Bowering and Lilly, 1992). The importance of the ecological roles and functions of peracarids, and their activeness at the sediment/water interface make them an excellent study taxon for exploring questions relating to deep-sea BEF relationships and other themes in benthic ecology.

Peracarid phylogeny

The major phylogenetical questions relating to peracarids are those concerning the monophyly of Peracarida and its constituent orders, the interrelationships of these orders, and the position of Peracarida within Crustacea.

The monophyly, or not, of Peracarida has been a topic of controversy for over 100 years. Calman (1904), following the well elucidated ideas of Hansen (1893), was the first to propose uniting Amphipoda, Cumacea, Isopoda, Tanaidacea and Mysida as a natural

grouping based on morphological features. He named this group Peracarida, and reaffirmed these views in 1909 (Calman, 1909). However, as new peracarid orders were discovered in the 20th Century (e.g. Bochusacea, Mictacea and Thermosbaenacea), the monophyly of Peracarida began to be questioned. This progressed to such an extent that in 1986, Frederick Schram proposed the complete elimination of the grouping, arguing that it united taxa of only superficial similarity (Schram, 1986). Such a view has been supported by a small number of studies. For example, Mayrat and de Saint Laurent (1996) concluded Peracarida to be polyphyletic, with Amphipoda resolved as the sister taxon to all other malacostracans and Cumacea and Mysida being more closely associated with taxa such as Decapoda than with other peracarids. Jarman et al. (2000), produced a phylogeny based on 28S rDNA data, and too found Peracarida to be polyphyletic, with Amphipoda resolved as more closely related to Decapoda, and Mysida more closely related to Euphausiacea and Anaspidacea, than to other peracarids. However, the majority of studies maintain a monophyletic Peracarida, either in its traditional sense, or with the removal of Mysida. Those studies preserving the monophyly of Peracarida in original sense are generally based on the analysis of morphological data via maximum parsimony methodology (e.g. Richter and Scholtz (2001), Poore (2005) and Wirkner and Richter (2010)). Those finding a monophyletic Peracarida only with the exclusion of Mysida do include parsimony studies based on morphological data (Watling, 1999), but are generally based on molecular data (Babbit and Patel, 2005, Spears et al., 2005, Meland and Willassen, 2007). At present, Mysida is retained within Peracarida, and the supertree produced in this thesis (figures 2.2 and A8.1) supports a monophyletic Peracarida even with the inclusion of Mysida.

In contrast, the "*monophyly of most peracarid orders has not been disputed*" (Poore, 2005). In particular, the monophyletic status of amphipods, isopods, cumaceans and tanaidaceans is well supported by both morphological and molecular datasets (Richter and Scholtz, 2001, Poore, 2005, Spears et al., 2005, Meland and Willassen, 2007, Wilson, 2009, Drumm, 2010), as well as the supertree produced in this thesis (figures 2.2 and A8.1), and these taxa are particularly well defined by synapomorphies (see above). Evidence for the

monophyly of the remaining orders is also strong (Richter and Scholtz, 2001, Poore, 2005, Spears et al., 2005, Meland and Willassen, 2007). Similarly, the taxonomic position of Peracarida within Crustacea is not under dispute. Calman (1904) was the first to propose a Peracarida residing within Malacostraca, and subsequent phylogenetic analyses utilising both morphological and molecular data do not challenge this view (Richter and Scholtz, 2001, Poore, 2005, Spears et al., 2005, Meland and Willassen, 2007).

Attempts to elucidate phylogenetic relationships between malacostracan orders has been high on the agenda of systematics "*since the awakening in natural science that followed the publication of the Origin of Species*" (Brooks, 1883). However, like the topic of peracarid monophyly, the question of the interrelationships of peracarid orders remains a source of controversy. Whilst Mysida is most commonly placed basally within Peracarida (Poore, 2005, Spears et al., 2005, Jenner et al., 2009, Wilson, 2009, Wirkner and Richter, 2010) (figures 2.2 and A8.1), the relationships of cumaceans, isopods, tanaidaceans and amphipods to each other and to other peracarids, and especially the question of the sister group to isopods represent reoccurring issues in peracarid systematics (Wilson, 2009). Initial attempts at tackling this puzzle resulted in the proposal of a Cumacea + Tanaidacea + Isopoda clade, named 'Mancoida' (Siewing, 1951, Siewing, 1953, Hessler, 1983), with workers arguing that similarities between Amphipoda and Isopoda are the result of convergence. However, towards the end of the 20th Century, an Amphipoda + Isopoda sister-taxon relationship gained in popularity, being obtained in multiple phylogenetic analyses (e.g.Wills, 1998, Poore, 2005). Other workers strongly reject such a relationship, instead retaining the 'Mancoida' clade with either Cumacea (Spears et al., 2005, Meland and Willassen, 2007, Wirkner and Richter, 2010) or Tanaidacea (Wilson, 2009) as sister taxon to Isopoda, or Isopoda to be sister-taxon to a Cumacea + Tanaidacea clade (Jenner et al., 2009), and it should be noted that 'Mancoida' is recovered in the supertree produced here (figures 2.2 and A8.1), with Cumacea resolved as sister taxon to a Tanaidacea + Isopoda clade. Much of this disagreement stems from argument over character interpretation. Wilson (2009) in particular criticises the character coding of Poore (2005),

claiming that some characters are repeated, others are over-generalisations, some are mis-scored, and that some potentially informative characters are ignored. However, Jenner et al. (2009) argue that issues run deeper than this, with their analysis detecting significant conflict in signal between genes and between morphological and molecular data. Additionally, the authors detected heterogenerous substitution rates between peracarid taxa, and emphasise the possibility of long-branch attraction. It should also be noted that the short internal branches that separate many of the peracarid orders in the above phylogenetic analyses (and in the supertree produced in this thesis) are indicative of a rapid radiation within the superorder, consistent with the fossil record, but making phylogenetic reconstruction especially difficult. At present, it appears that the molecular and morphological data currently available are not yet sufficient to determine the relationships between peracarid orders with complete confidence.

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Appendix 2

Table of peracarid assemblages from NEREIDA box cores

Box core	Ampeliscidae Ampelisca	Amphilochidae Amphilochus	Amphilochidae Gitana	Amphilochidae Gitanopsis	Aoridae Lembos	Argissidae Argissa	Calliopiidae Amphithopsis	Caprellidae Aeginella	Pinnotheridae Pinnotheres	Corophiidae Protomedeia	Cressidae Cressa	Cressidae Cressina	Cyprideididae Steginoteca	Deamanidae Deamanidae	Dulichiidae Dulichopsis	Dynamenidae Dynamene	Perradoridae Perradoridae	Podoceridae Laetmatophilus	Xenoclea Xenoclea	Ephemeridae Ponamphithoe
BC4	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
BC5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC10	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC18	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC19	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC22	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	5	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
BC51	0	4	38	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	0	0
BC52	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	2	416	0	0	3	0	0	0	1	0	0	0	0	0	0	0	34	0	0
BC60	0	2	35	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC61	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	1	19	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
BC64	0	1	2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC67	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
BC68	0	68	51	0	0	13	0	0	0	0	0	0	0	0	0	0	0	7	0	0
BC70	0	41	7	14	0	80	0	0	0	0	1	0	0	0	18	0	0	73	0	0
BC71	0	1	196	857	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC72	0	6	13	0	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0
BC73	0	0	6	23	0	0	0	2	0	0	0	1	0	0	0	4	0	0	0	0
BC74	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC76	0	13	0	0	0	2	1	0	0	0	0	1	0	0	0	0	0	0	1	0
BC77	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC79	0	34	237	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC81	0	1	22	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC82	0	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC83	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC84	0	3	1029	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC85	0	0	19	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
BC86	0	1	18	0	0	2	0	0	0	0	0	0	0	0	44	0	0	2	0	0
BC87	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC89	0	0	5	0	0	2	0	0	0	0	0	1	0	0	0	0	0	2	0	0
BC90	0	1	8	105	0	0	0	0	0	0	0	1	0	0	10	0	0	0	0	0
BC91	0	3	3	71	1	0	0	0	0	0	0	1	0	0	17	0	0	0	0	0
BC92	0	0	1	25	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0
BC93	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC94	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC95	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC97	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC98	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC99	0	2	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC100	0	0	0	3	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0
BC101	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	0	0	0	152	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
BC103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC104	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC108	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC110	0	2	6	36	0	0	0	3	0	0	0	0	0	0	10	0	0	0	0	0

Box core	Eusiridae *Eusirella*	*Eusirus*	*Rhachotropis*	Hyperiidae *Themisto*	Ischyroceridae *Bemlos*	*Erichthonius*	*Jschyrocerus*	*Jassa*	Siphonoecetes	Lepechinellidae *Lepechinella*	Leucothoidae *Leucothoe*	Acidostomatidae *Acidostoma*	Aoridae *Aoridius*	Lysianassidae *Caulleriella*	*Gronella*	*Hippomedon*	*Lepidepecreum*	*Onchumene*	*Tryphosella*	Urothoidae *Anonyx*	*Tmetonyx*	Maeridae *Maera*	Melitidae *Megamoera*	*Quasimelita*
BC4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC8	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC11	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0
BC19	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC20	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC21	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC22	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC23	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
BC33	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	2	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
BC38	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0
BC41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC42	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	0	0	0	0	0	5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	0	0	0	0	0	0	5	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
BC60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC61	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC67	0	0	0	0	3	0	8	0	0	1	0	0	0	0	0	0	0	0	0	8	1	5	0	0
BC68	0	0	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	3	0	0	0	0
BC70	0	0	0	0	19	4	7	0	0	4	0	0	0	0	0	0	0	0	0	5	0	0	0	0
BC71	0	0	0	0	0	0	48	0	0	0	0	0	0	0	0	0	0	0	0	6	0	1	0	0
BC72	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC73	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC76	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC78	0	0	0	0	3	0	8	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	30
BC79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
BC81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
BC86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC88	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC90	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC91	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC92	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0
BC95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC96	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC99	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Box core	Maldanidae Maldanidae	Oedicerotidae Ameroculodes	Ampelisca	Bathymedon	Byblis	Halicoides	Monoculodes	Perioculodes	Pardaliscidae Halice	Halicoides	Nicippe	Pardalisca	Pardaliscella	Pseudolibrotus	Phoxocephalidae Gammaropsis	Photis	Harpinia	Harpiniopsis	Leptophoxus	Pontophoxus	Pleustidae Atrypholestes	Stenopleustes	Pontogeneiidae Dautzenbergia
BC4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
BC5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0
BC6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0
BC7	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
BC9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
BC11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
BC19	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0
BC22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0
BC31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0	0	0	1
BC35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0
BC51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	108	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	34	0	0	0	1	0	0
BC60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0
BC61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC63	1	0	0	0	0	0	0	0	0	0	1	0	0	0	76	0	2	0	0	0	0	0	0
BC64	1	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0
BC67	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	17	0	0	0	0	0	0
BC68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	0	16	0	0	0	0	0	0
BC70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	634	0	24	0	0	0	0	0	0
BC71	2	0	0	0	0	0	0	1	0	0	0	0	0	0	7	0	1	0	0	0	0	0	0
BC72	0	0	0	0	0	0	0	0	0	0	0	0	0	1	36	0	4	0	0	0	0	0	0
BC73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	6	0	0	0	0	0	0
BC74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	18	0	0	0	0	1	0
BC76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0
BC77	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0
BC79	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	2	0	0
BC81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC85	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0
BC86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0
BC87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	1	0	0
BC88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	10	0	0	0	0	1	0
BC91	0	0	0	0	0	0	1	0	0	0	0	0	0	0	58	0	2	0	0	0	0	0	0
BC92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	13	0	0	0	0	0	0
BC93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	10	0	0	0	0	0	0
BC94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0
BC95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC96	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	16	0	0	0	1	0	0
BC97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	2	0	0
BC98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0
BC99	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
BC100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
BC104	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC105	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
BC108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Stegocephalidae		Stenotholidae		Synoplidae			Uncidolidae		Urothoidae		Arcturidae	Cirolanidae		Dendrotionidae	Desmosomatidae					
Box core	*Andaniexis*	*Glorandaniexis*	*Stegocephalus*	*Metopa*	*Metopella*	*Probolaides*	*Bhawaliopsis*	*Syrrhoe*	*Syrrhoites*	*Tiron*	*Neohela*	*Uncicola*	*Urothoe*	*Caranogaia*	*Astacilla*	*Cirolana*	*Natatolana*	*Dendrotion*	*Chelator*	*Desmosoma*	*Eugerda*	*Eugerdella*	*Mirabilicosa*	*Prochelator*
BC4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	6	1	0	0	0	0
BC5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
BC6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
BC7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC9	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0
BC10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0
BC11	0	0	0	0	0	1	0	0	0	0	0	12	1	0	1	5	0	1	0	1	0	1	0	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	0
BC13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC19	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
BC23	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	10	0	3	0	0	0	0	0	0
BC31	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	0	0	0	3	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	0	0	0	0	0	0	0	0	0	0	0	1	10	0	0	0	0	0	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC60	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0
BC64	0	0	0	1	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
BC67	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC68	0	0	0	1	0	0	0	0	0	0	0	0	26	0	11	0	0	0	0	0	0	0	0	1
BC70	7	0	0	2	3	0	0	2	0	0	0	1	60	0	0	0	0	1	0	0	0	0	0	0
BC71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC73	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC77	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC78	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
BC79	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
BC81	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC82	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	8	0	1	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
BC87	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
BC88	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC90	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC91	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
BC92	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0
BC93	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
BC94	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC95	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
BC96	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
BC99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	0	0	0	0
BC101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0
BC103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
BC105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC110	0	0	0	0	0	0	0	0	0	0	0	2	5	0	0	0	0	1	0	2	0	0	0	0

Box core	Pseudomesus	Goeldiidae Bathyarthrite	Caecognathia	Gnathiidae	Haplomunnidae Munnella	Thylakogaster	Haploniscidae Haploniscus	Ischnomesidae Carnomesus	Gnathiidae	Haplomesus	Heteromesus	Ischnomesus	Janiridae Janiella	Janiridae Janira	Janiridae	Tole	Leptanthuridae Calathura	Macrostylidae Macrostylis	Munnidae Munna	Munnopsidae Betamorpha	Disconectes	Echinozoone	Eurycope
BC4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC5	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	0	1	0	0	1
BC6	5	0	0	0	0	0	0	0	2	0	1	0	0	2	0	0	0	1	0	0	0	0	0
BC7	2	0	0	0	0	0	0	0	4	0	5	0	0	0	0	0	0	2	0	0	0	0	5
BC9	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0
BC10	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
BC11	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC12	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC19	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0	0	0
BC21	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
BC22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	8	0	0	0
BC31	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	2	0	0	1
BC32	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	2
BC67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC68	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	6	0	0	3
BC69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC70	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0
BC71	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	21	0	0	17
BC72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	44	0	15	0	1	0
BC73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	7	0	0	3
BC74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1
BC76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	3	0	0	1
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1
BC81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC82	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	1	0	0	1
BC88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC89	0	2	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0
BC90	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	3	0	0	7
BC91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC92	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0	1
BC93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC94	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	5	0	0	1
BC95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC96	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC98	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC100	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0
BC103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC105	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC110	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	2	0	0	0

Box core	Hyperiidae	Mentis 'Group A'	Munnopsurus	Pseudomunnopsis	Sturtiyngura	Nannoniscidae Nannoniscus	Nannoniscus	Rupenisca	Thaumastosioma	Paramunnidae Pleurogonium	Paranthuridae Paranthura	Thambematidae Thambema	Agathotanaidae Agathotanais	Paranarthrura	Paragathotanais	Akanthophoreidae Tumidocheila	Stenotanais	Apseudidae Leviapseudes	Anthuridae Ithyoma	Colletteidae Collettea
BC4	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	2	0	0
BC5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0
BC7	0	0	0	0	0	0	2	0	0	0	0	0	10	0	2	0	0	0	0	2
BC9	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
BC13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC18	1	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	1	0	0
BC19	3	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	2
BC20	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC23	0	1	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
BC31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC41	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	2
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	2	0	0	0	0	0	2	0	0	0	0	0	7	2	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	2	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	1
BC60	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC61	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC67	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC68	0	0	0	0	0	0	0	0	0	0	0	0	5	2	0	0	0	0	0	2
BC70	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC71	0	0	0	0	0	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0
BC72	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1
BC73	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC74	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
BC76	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC78	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC79	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC81	0	0	0	0	0	0	0	0	0	0	0	0	1	9	0	0	0	0	0	0
BC82	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	2
BC86	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC87	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0
BC88	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0
BC89	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1	0	1
BC90	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
BC91	0	0	0	0	0	0	0	0	0	0	0	0	5	22	0	0	0	2	0	0
BC92	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
BC93	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1
BC94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1
BC99	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1
BC100	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
BC102	2	0	0	1	0	0	0	0	0	0	0	0	4	1	0	1	0	0	0	2
BC103	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0
BC104	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC105	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC108	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC110	0	0	0	0	0	0	2	0	0	0	0	0	15	0	0	0	0	1	0	0

Box core	Filhanoli	Leptognathopsis	Cryptocopidae Cryptocopa	Cryptocopoides	Insertae sedis Leptognathoides	Pertenstrum	Singula	Leptochelidae Heterotanais	Leptognathidae Leptognatha	Neotanaidae Neotanais	Pseudotanaidae Pergoseudotanais	Pseudotanais	Sphyrapodidae Pseudosphyrapus	Tiphlotanaidae Meromonokanthe	Paratiphlotanais	Torquella	Typhlotanais	Bodotriidae Atlantocuma	Bathycuma	Hypocuma
BC4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC5	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC6	0	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
BC7	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0
BC9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC10	0	0	0	0	0	13	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC11	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	4	0	0	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC14	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC18	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC19	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0
BC20	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	7	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC22	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC31	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	0	0	2	0	0	0	2	0	0	0	0	0	1	0	0	10	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	1	0	0	0	7	0	0	0	0	0	0	0	3	0	0	1	1	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	0	0	0	0	9	0	0	0	0	0	0	0	2	0	0	0	1	0	0
BC60	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC67	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	5	0	0	0
BC68	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	13	0	0	0
BC70	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	20	0	0	0
BC71	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC72	0	0	0	2	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
BC73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC74	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC76	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC81	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0
BC82	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC84	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC86	0	0	0	0	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC87	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC88	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC89	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC90	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	1	0	0	0
BC91	0	0	0	0	0	0	0	0	0	0	0	1	0	6	0	0	2	0	0	0
BC92	0	1	0	0	0	0	0	0	0	3	0	0	0	16	0	1	3	0	0	0
BC93	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC95	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC97	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC98	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC99	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC100	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
BC101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC104	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC105	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC110	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0

Box core	Diastylidae Bodotriastylis	Diastylis/Oxystylopsis	Leptostylis	Leptostylopsis	Makrokylindrus	Vivodiastylis	Lamprops/Hemilamprops	Lamprops	Mesolamprops	Platysympus	Leucon	Eudorellopsis	Nannastacidae Campylaspis	Cumellopsis	Pseudocumatidae Petalosarsia	Myrsida
BC4	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC7	0	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC11	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
BC18	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC19	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0
BC20	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC22	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC51	0	11	0	0	0	0	0	0	1	0	0	0	2	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	7	0	0	0	0	1	2	0	1	0	0	3	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC59	0	4	0	0	0	0	0	4	0	0	0	0	1	0	0	0
BC60	0	6	2	0	0	0	0	0	0	0	0	0	2	0	0	0
BC61	0	4	1	0	0	0	0	0	0	0	0	0	3	0	0	0
BC63	0	43	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC67	3	0	0	0	0	0	0	3	0	1	0	0	0	1	0	0
BC68	0	6	2	0	0	0	0	0	0	2	0	0	0	2	1	0
BC70	0	1	0	0	0	0	0	2	0	0	0	0	1	0	0	0
BC71	0	18	0	0	0	0	0	4	0	0	0	0	0	0	0	0
BC72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC73	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC74	2	6	0	0	0	0	0	0	0	0	0	0	2	4	0	0
BC76	2	4	0	0	0	0	0	3	0	0	0	1	0	1	0	0
BC77	5	13	1	0	0	2	0	0	0	0	0	2	3	3	1	0
BC78	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC79	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC81	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC82	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC83	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC85	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC86	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC87	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC89	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
BC90	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
BC91	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC92	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC93	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC95	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC96	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC97	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC98	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC101	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC102	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC103	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC104	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC105	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC106	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC107	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC108	0	4	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC110	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Bay core	Ampeliscidae Ampelisca	Amphilochidae Gitana	Amphilochidae Gitanopsis	Ampithoidae Ampithoe	Argissidae Argissa	Calliopiidae Amphilochoides	Caprellidae Aegaeella	Phoxocephalidae Pontharpinia	Corophiidae Protomedeia	Cressidae Cressa	Crassicorophiidae Crassicorophium	Cyproideidae Siagopleus	Dexaminidae Dexamine	Dulichiidae Dulichiopsis	Dyopedos	Paradulichia	Podoceridae Laetmatophilus	Jassidae	Epimeriidae Pseudepimeria
BC111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC144	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC145	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC146	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
BC147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC148	0	0	2	3	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
BC149	0	3	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC150	0	2	0	20	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC151	0	0	0	15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC152	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC153	0	6	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC154	0	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC156	0	3	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC157	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC158	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC159	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC160	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC161	0	2	15	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC162	0	0	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC163	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC164	0	1	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC165	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC166	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC167	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC168	1	0	0	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC169	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC170	0	4	0	21	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
BC171	1	10	9	30	0	0	0	1	0	0	0	1	0	0	16	0	0	2	0
BC172	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC174	0	3	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC175	0	6	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC176	0	6	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC177	0	6	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC180	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC181	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC182	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC183	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC185	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0
BC186	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC187	0	1	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
BC188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC190	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC192	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC196	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC197	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
BC199	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC200	0	4	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
BC201	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC202	0	1	0	1	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0
BC204	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC206	0	1	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC207	0	4	1	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC210	0	2	0	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

Box core	Eusiridae *Eusiella*	*Eusirus*	Rhachotropis	Hyperiidae *Themisto*	Lycaeopsidae *Bovienella*	*Erichthonius*	*Jacheyoceras*	*Jassa*	Siphonoecetes	Lepechinellidae *Lepechinella*	Leucothoidae *Leucothoe*	Acidostomatidae *Acidostoma*	Aoridae *Aoridius*	Lysianassidae *Cavimedon*	*Gronella*	*Hippomedon*	*Lepidepecreum*	*Onchumene*	*Tryphosella*	Urothoidae *Anonyx*	*Tmetonyx*	Maeridae *Maera*	Medonidae *Megamoera*	*Quasimelita*
BC111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
BC113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
BC117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC123	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC124	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC126	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC130	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC139	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC141	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC142	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC143	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
BC145	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	1	0	0	0	0
BC146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC151	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC152	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC153	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC157	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC161	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC163	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC166	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC167	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC168	0	0	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
BC169	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC170	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC171	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
BC181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC210	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Box core	Maldanidae Maldanidae	Oweniidae Owenia fusiformis	Ampharetidae Ampharete	Bathyporeiidae Bathyporeia	Oedicerotidae Oedicerotidae	Haustoriidae Haustorius	Phoxocephalidae Monoculodes	Pseudocumatidae Pseudocuma	Pseudocumatidae Pseudocuma	Pseudocumatidae Pseudocuma	Pseudocumatidae Pseudocuma	Pseudocumatidae Pseudocuma	Pseudocumatidae Pseudocuma	Phoxocephalidae Harpinia	Harpiniopsis	Leptophoxus	Perophoxus	Pisidiidae Astrophiuretes	Stenothoidae	Podoceridae Dexiodensity
BC111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
BC113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0
BC116	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0
BC117	0	0	0	0	0	0	0	0	0	0	0	1	0	0	11	0	0	0	0	0
BC118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
BC119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
BC120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
BC122	0	0	2	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0
BC123	1	0	0	0	0	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0
BC124	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8	0	0	0	0	0
BC125	0	0	0	0	0	0	1	0	0	0	0	0	0	0	16	0	0	0	0	0
BC126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	2	0	0
BC129	0	0	3	0	0	0	2	0	0	0	0	0	0	0	15	0	0	0	0	0
BC130	0	0	1	0	0	0	1	0	0	0	0	0	0	0	18	0	0	1	0	0
BC131	0	0	0	0	0	0	1	0	0	0	0	0	0	0	18	0	0	0	0	0
BC132	0	0	0	0	0	0	1	0	0	0	0	0	0	0	35	0	0	0	0	0
BC133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0
BC134	0	0	1	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0
BC135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC137	0	0	0	0	0	0	1	0	0	0	0	0	0	0	28	0	0	0	0	0
BC138	0	0	0	0	0	0	0	0	1	0	0	0	0	0	8	0	0	0	0	0
BC139	0	0	0	0	0	0	2	0	0	0	0	0	0	0	17	0	0	0	0	0
BC140	0	0	0	0	0	0	1	0	0	0	0	0	0	0	20	0	0	0	0	0
BC141	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	1	0	0
BC142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0
BC143	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
BC144	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	0	0
BC145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0
BC146	0	0	1	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	1
BC147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	47	0	0	0	0	0
BC148	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC149	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0
BC150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
BC151	0	0	0	0	0	0	1	0	0	0	0	0	0	1	27	0	0	0	0	0
BC152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0
BC153	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8	0	0	0	0	0
BC154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
BC156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0
BC157	0	0	0	0	0	0	2	0	0	3	1	0	0	0	21	0	0	0	0	0
BC158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0
BC159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0
BC160	0	0	0	0	0	0	1	0	0	0	2	0	0	0	32	0	0	0	0	0
BC161	0	0	0	0	0	0	1	0	0	0	0	0	3	0	18	0	0	0	0	0
BC162	0	0	1	0	0	0	1	0	0	0	0	0	0	0	6	0	0	0	0	0
BC163	0	0	0	0	0	0	0	0	0	0	0	0	1	0	15	0	0	0	0	0
BC164	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
BC166	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
BC167	0	0	4	0	0	0	3	0	0	0	0	0	0	0	12	0	0	0	0	0
BC168	0	0	0	0	0	0	0	0	0	0	1	0	0	0	14	0	0	0	0	0
BC169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
BC170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC171	0	0	0	0	0	0	0	0	0	1	0	0	5	0	12	0	0	0	0	0
BC172	0	0	1	0	0	0	0	0	0	0	0	0	36	0	28	0	0	0	0	0
BC173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	1	0	0
BC174	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC175	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
BC176	0	0	3	0	0	0	1	0	0	0	0	0	1	0	5	0	0	0	0	0
BC177	0	0	3	0	1	0	1	0	0	2	0	0	0	0	36	0	0	0	0	0
BC180	0	0	0	0	0	0	0	0	0	0	0	0	1	0	29	0	0	0	0	0
BC181	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC183	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC185	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC188	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
BC189	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0
BC190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC192	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0
BC196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC197	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
BC199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC201	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0
BC202	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
BC204	0	0	0	0	0	0	0	0	0	0	1	0	0	0	10	0	0	0	0	0
BC206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1
BC208	0	0	1	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0
BC210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Stegocephalidae:			Stenothoidae		Podoceridae	Synopiidae:		Unciolidae		Urothoidae		Acanthidae	Cheluridae	Dexaminidae		Dexaminoidea				
Box core	Andaniexis	Glorandaniotes	Stegocephalus	Metopa	Metopella	Podoceloides	Bruzelisipsis	Syrrhoe	Syrrhoites	Tiron	Unciola	Urothoe	Carangella	Acanthomunna	Cheluroides	Metaceloma	Dexaminidae: Dexamininae	Dexamoxene	Eogarrella	Eogarrodes	Mirabilicoxa	Prachelator
BC111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC112	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
BC113	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0
BC114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC115	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	1	0	2	0	0	0	1
BC116	0	0	0	0	0	0	0	0	0	0	5	0	1	0	0	0	0	0	2	0	0	1
BC117	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	1	0	0	0	0	0
BC118	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
BC119	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC122	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
BC123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC125	0	0	0	0	0	0	0	0	4	1	0	0	17	0	0	0	0	0	0	0	0	0
BC126	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	1	0	0	0	0	0
BC129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC131	0	0	0	4	1	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0
BC132	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
BC133	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC134	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
BC135	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC136	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
BC137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC138	0	0	0	0	0	0	0	0	1	0	4	0	4	0	0	0	0	0	0	0	0	0
BC139	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
BC140	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
BC141	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
BC142	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC143	0	0	0	1	0	0	0	0	6	0	0	0	0	0	0	0	0	0	1	0	0	0
BC144	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC145	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
BC146	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC148	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC149	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	10	0	1	0
BC150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	5	3
BC151	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	1	0	0	0
BC152	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	3	1
BC153	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
BC154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC157	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0
BC158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
BC159	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	0
BC160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC161	0	0	0	0	0	0	0	0	1	0	12	0	1	0	0	0	0	0	2	0	2	0
BC162	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
BC163	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	2
BC164	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC165	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
BC166	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC167	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0
BC168	0	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0
BC169	0	0	0	0	0	0	0	0	3	0	1	0	1	0	0	0	0	0	0	0	0	1
BC170	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1
BC171	0	0	0	1	0	0	0	0	1	0	2	0	0	0	0	0	0	0	16	0	3	5
BC172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
BC173	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC174	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	2	0
BC175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC176	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0
BC177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
BC180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1
BC181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC182	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
BC183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
BC187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC188	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

| Box core | *Pseudonereis* | Goniadidae *Bathyglycinde* | *Caecognathia* | Glyceridae *Glycinde* | Hesionidae *Microphthalmus* | Hesionidae *Nereimyra* | Hesionidae *Nereimyrella* | Hesionidae *Ophiodromus* | Hesionidae *Podarkeopsis* | Hesionidae *Pseudomicromastus* | Hesionidae *Schistomeringos* | Hesionidae *Syllidia armata* | Hesionidae *Syllides* | Hesionidae *Vigtorniella* | Lacydoniidae *Lacydonia* | Lumbrineridae *Lumbrineris* | Lumbrineridae *Scoletoma* | Magelonidae *Magelona* | Nephtyidae *Aglaophamus* | Nephtyidae *Nephtys* | Nereididae *Ceratonereis* | Nereididae *Hediste* | Nereididae *Nereis* | Nereididae *Platynereis* | Nereididae *Websterinereis* | Onuphidae *Diopatra* | Onuphidae *Hyalinoecia* | Onuphidae *Nothria* | Onuphidae *Onuphis* | Onuphidae *Paradiopatra* | Oweniidae *Owenia* | Paraonidae *Aricidea* | Paraonidae *Paradoneis* | Paraonidae *Paraonella* | Paraonidae *Paraonis* | Pectinariidae *Amphictene* | Pectinariidae *Pectinaria* | Phyllodocidae *Eteone* | Phyllodocidae *Mystides* | Phyllodocidae *Phyllodoce* | Pilargidae *Ancistrosyllis* | Pilargidae *Pilargis* | Pilargidae *Sigambra* | Pilargidae *Synelmis* | Pisionidae *Pisione* | Polynoidae *Antinoella* | Polynoidae *Eunoe* | Polynoidae *Harmothoe* | Polynoidae *Lepidonotus* | Polynoidae *Malmgreniella* | Polynoidae *Polynoe* | Sabellariidae *Sabellaria* | Sabellidae *Chone* | Sabellidae *Euchone* | Sabellidae *Jasmineira* | Sabellidae *Myxicola* | Sabellidae *Pseudopotamilla* | Scalibregmatidae *Scalibregma* | Serpulidae *Hydroides* | Spionidae *Aonides* | Spionidae *Laonice* | Spionidae *Malacoceros* | Spionidae *Polydora* | Spionidae *Prionospio* | Spionidae *Pseudopolydora* | Spionidae *Spio* | Spionidae *Spiophanes* | Spionidae *Streptosyllis* | Sternaspidae *Sternaspis* | Syllidae *Amblyosyllis* | Syllidae *Eurysyllis* | Syllidae *Exogone* | Syllidae *Parapionosyllis* | Syllidae *Pionosyllis* | Syllidae *Sphaerosyllis* | Syllidae *Streptosyllis* | Syllidae *Syllis* | Terebellidae *Amphitrite* | Terebellidae *Lanassa* | Terebellidae *Nicolea* | Terebellidae *Pista* | Terebellidae *Polycirrus* | Terebellidae *Proclea* | Terebellidae *Streblosoma* | Terebellidae *Terebellides* | Trichobranchidae *Terebellides* | Trichobranchidae *Trichobranchus* | Typosyllidae *Typosyllis* | Acrocirridae *Acrocirrus* | Ampharetidae *Amage* | Ampharetidae *Ampharete* | Ampharetidae *Anobothrus* | Ampharetidae *Melinna* | Ampharetidae *Sosanopsis* | Ampharetidae *Sosanopsis wireni* | Ampharetidae *Terebellides* | Capitellidae *Capitella* | Capitellidae *Heteromastus* | Capitellidae *Mediomastus* | Capitellidae *Notomastus* | Cirratulidae *Aphelochaeta* | Cirratulidae *Caulleriella* | Cirratulidae *Chaetozone* | Cirratulidae *Cirratulus* | Cirratulidae *Cirriformia* | Cirratulidae *Monticellina* | Cirratulidae *Tharyx* | Flabelligeridae *Diplocirrus* | Flabelligeridae *Flabelligera* | Flabelligeridae *Pherusa* | Maldanidae *Asychis* | Maldanidae *Clymenura* | Maldanidae *Euclymene* | Maldanidae *Maldane* | Maldanidae *Nicomache* | Maldanidae *Praxillella* | Maldanidae *Rhodine* | Oenonidae *Drilonereis* | Oenonidae *Oenone* | Orbiniidae *Leitoscoloplos* | Orbiniidae *Naineris* | Orbiniidae *Orbinia* | Orbiniidae *Phylo* | Orbiniidae *Protoaricia* | Orbiniidae *Scoloplos* | Paralacydoniidae *Paralacydonia* | Poecilochaetidae *Poecilochaetus* | Spionidae *Dipolydora* | Spionidae *Laonice* | Spionidae *Polydora* | Spionidae *Prionospio* | Spionidae *Pseudopolydora* | Spionidae *Spio* | Spionidae *Spiophanes* | Spionidae *Streptosyllis* | Sternaspidae *Sternaspis* | Syllidae *Amblyosyllis* | Syllidae *Eurysyllis* | Syllidae *Exogone* | Syllidae *Parapionosyllis* | Syllidae *Pionosyllis* | Syllidae *Sphaerosyllis* | Syllidae *Streptosyllis* | Syllidae *Syllis* | Terebellidae *Amphitrite* | Terebellidae *Lanassa* | Terebellidae *Nicolea* | Terebellidae *Pista* | Terebellidae *Polycirrus* | Terebellidae *Proclea* | Terebellidae *Streblosoma* | Terebellidae *Terebellides* | Trichobranchidae *Terebellides* | Trichobranchidae *Trichobranchus* | Typosyllidae *Typosyllis* | Acrocirridae *Acrocirrus* | Ampharetidae *Amage* | Ampharetidae *Ampharete* | Ampharetidae *Anobothrus* | Ampharetidae *Melinna* | Ampharetidae *Sosanopsis* | Ampharetidae *Sosanopsis wireni* | Ampharetidae *Terebellides* | Capitellidae *Capitella* | Capitellidae *Heteromastus* | Capitellidae *Mediomastus* | Capitellidae *Notomastus* | Cirratulidae *Aphelochaeta* | Cirratulidae *Caulleriella* | Cirratulidae *Chaetozone* | Cirratulidae *Cirratulus* | Cirratulidae *Cirriformia* | Cirratulidae *Monticellina* | Cirratulidae *Tharyx* | Flabelligeridae *Diplocirrus* | Flabelligeridae *Flabelligera* | Flabelligeridae *Pherusa* | Maldanidae *Asychis* | Maldanidae *Clymenura* | Maldanidae *Euclymene* | Maldanidae *Maldane* | Maldanidae *Nicomache* | Maldanidae *Praxillella* | Maldanidae *Rhodine* | Oenonidae *Drilonereis* | Oenonidae *Oenone* | Orbiniidae *Leitoscoloplos* | Orbiniidae *Naineris* | Orbiniidae *Orbinia* | Orbiniidae *Phylo* | Orbiniidae *Protoaricia* | Orbiniidae *Scoloplos* | Paralacydoniidae *Paralacydonia* | Poecilochaetidae *Poecilochaetus* | Echinocardium | Echinocyamus | Echinocyamus pusillus | Echinocyamus pusillus | Echinocyamus pusill

Box core	Jhyrachus	Marels 'Group A'	Mitonopsurus	Pseudomunnopsis	Sturtiphyganx	Nannoniscidae Nannoniscus	Nannoniscus	Rapenilscus	Thaumastosoma	Paramunnoidae Pleurogonium	Parasterhartiidae Parasterhartia	Thambematidae Thambema	Agathotanaidae Agathotanais	Paratanaitrura	Perugathotanais	Akanthophoreidae Tumidoscleila	Stenotanais	Apseudide Levipseudes	Anarthruridae Ithycerus	Colletteidae Collettea
BC111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
BC112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC113	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	1
BC114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC115	0	0	0	0	1	0	0	0	1	0	0	0	2	6	0	0	0	0	0	0
BC116	2	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0
BC117	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BC118	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC119	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0
BC120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC121	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC122	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC124	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC125	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC126	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC129	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC130	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC131	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC132	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC134	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC137	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC138	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC139	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC141	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
BC142	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC143	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC144	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC145	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC146	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC147	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC149	0	0	0	0	0	0	1	0	2	0	0	0	1	2	0	0	0	0	0	0
BC150	2	0	0	0	0	0	0	0	1	0	0	0	≥5	1	0	0	0	3	0	0
BC151	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
BC152	1	0	0	0	0	0	0	0	2	0	0	0	≥3	0	0	0	0	0	0	1
BC153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC157	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC158	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
BC159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC160	0	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0
BC161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC163	1	0	0	0	0	0	2	0	2	0	0	0	0	11	0	0	0	0	0	5
BC164	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC165	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC168	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2
BC169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC170	1	0	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	3	0	2
BC171	0	0	0	0	0	0	2	0	2	0	0	0	0	10	0	0	0	6	0	0
BC172	2	0	0	0	0	0	0	0	0	0	0	0	0	26	1	0	0	0	0	1
BC173	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
BC174	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC175	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC176	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC177	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
BC180	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC185	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BC186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC210	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0

Box core	Filtanais	Leptognathiopsis	Cryptocopidae Cryptocope	Cryptocopoides	Insertae sedis Leptognathoides	Perturotrum	Singula	Leptochiliidae Heterolanais	Leptognathiidae Leptognathia	Pseudotanaidae Nototanaidae Neotanais	Pseudotanaidae Parapseudotanais	Pseudotanais	Sphyrapodidae Pseudosphyrapus	Typhlotanaidae Micromonakantha	Paratyphlotanais	Torquella	Typhlotanais	Bodotriidae Alloniscoma	Bathysoma	Hyascoma
B111	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
B112	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
B113	0	0	0	1	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
B114	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B115	0	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B117	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
B118	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0
B119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B121	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0
B122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B123	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B124	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B125	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0
B126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B129	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B130	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
B131	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0
B132	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
B133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B136	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
B137	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B138	0	0	0	0	0	0	0	0	0	0	0	0	1	15	0	0	0	0	0	0
B139	0	0	0	0	0	1	0	0	0	0	0	0	0	23	0	0	0	0	0	0
B140	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
B141	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B142	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	1	0	0
B143	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B144	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B145	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B146	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B148	0	2	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B149	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B150	0	5	0	0	0	7	0	1	0	0	0	1	15	1	0	0	0	5	1	0
B151	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0
B152	0	0	0	0	0	3	0	2	0	0	2	2	8	0	0	0	0	0	0	0
B153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B154	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B157	0	0	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	5	0	0
B158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B159	0	0	0	0	0	1	0	1	0	0	0	0	5	0	0	0	0	0	0	0
B160	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B161	0	0	0	0	0	1	0	1	0	0	0	1	10	0	0	0	0	0	0	0
B162	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
B163	0	1	0	2	0	2	0	1	0	0	0	0	0	0	0	0	0	6	0	0
B164	0	0	0	0	0	2	0	0	0	0	0	0	35	0	0	0	0	4	0	0
B165	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B166	0	0	0	0	0	3	0	0	0	0	0	0	2	0	0	0	0	1	0	0
B167	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B168	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0
B169	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
B170	0	0	0	2	0	5	0	2	0	0	0	4	15	0	0	0	0	4	0	0
B171	0	1	0	0	0	1	0	1	0	0	2	5	6	0	0	0	0	6	0	0
B172	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B173	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B174	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
B175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B177	0	1	0	0	0	1	0	0	0	0	0	0	26	0	0	0	0	0	0	0
B180	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B185	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B189	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B200	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
B201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B202	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
B204	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B206	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0
B207	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B210	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Box core	Diastylidae Benthydiastylis	Diastylis/Oxystylis	Leptostylis	Leptostylidae Leptostylis	Makrokylindrus	Vemokylindrus	Lampropidae Hemilamprops	Lamprops	Meracleaspp	Platysyrrapus	Leuconidae Eudorella	Eudorellopsis	Leucon	Nannastacidae Cumellopsis	Pseudocumatidae Petalosarsia	Mysida
BC11	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC14	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC15	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	0	11	1	0	0	0	0	0	0	0	0	0	2	0	0	0
BC17	0	5	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC18	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC19	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC22	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC23	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC25	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC26	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
BC29	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC30	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC31	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
BC33	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC35	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC37	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	6	1	0	0	0	0	0	0	0	0	0	2	0	0	1
BC40	0	6	0	0	0	0	0	0	0	0	1	0	4	1	0	0
BC41	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC42	3	7	0	0	0	0	2	0	0	0	0	0	0	0	0	0
BC43	2	7	1	0	0	0	4	2	0	0	0	0	4	1	0	0
BC44	1	10	2	0	0	0	0	2	0	0	5	0	0	0	0	0
BC45	1	9	3	0	0	0	0	4	0	0	1	0	5	1	0	0
BC46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC48	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC49	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC50	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC52	0	1	2	0	0	0	0	1	0	0	0	0	6	0	0	0
BC53	0	17	1	0	0	0	0	0	0	0	2	0	5	2	0	0
BC54	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC56	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC57	0	13	3	0	0	0	1	0	0	0	3	0	2	0	1	0
BC58	0	6	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC59	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC60	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
BC61	0	17	0	0	0	0	0	0	0	0	2	0	0	1	1	0
BC62	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC65	0	3	0	0	0	0	0	0	0	0	1	0	0	0	1	0
BC66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC67	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC68	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC69	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
BC70	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0	0
BC71	0	6	2	0	0	0	0	0	0	0	2	0	4	0	1	0
BC72	0	1	0	0	0	0	0	0	0	0	3	0	1	0	0	0
BC73	0	3	0	0	0	0	0	0	0	0	0	0	3	0	0	0
BC74	0	3	1	0	0	0	0	0	0	0	0	0	3	0	0	0
BC75	0	1	0	0	0	1	0	0	0	0	0	0	2	0	0	1
BC76	0	4	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC77	0	0	0	0	0	0	0	0	0	0	5	0	2	0	0	0
BC80	0	0	0	0	0	0	2	0	0	0	0	0	1	11	0	0
BC81	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC82	0	3	0	0	0	0	0	0	0	0	1	0	0	1	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC86	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC87	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC91	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
BC92	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
BC96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC97	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
BC99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC00	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC01	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC02	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC04	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0
BC06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC07	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
BC08	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC10	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0

	Ampeliscidae	Aoridae	Argissidae	Calliopiidae	Caprellidae	Corophiidae	Crassicorophiidae	Cyproideidae	Dexaminidae	Dulichiidae	Dynamenidae	Gammaridae	Haustoriidae	Isaeidae	Liljeborgiidae	Lysianassidae	Melitidae	Oedicerotidae	Phoxocephalidae	Pleustidae	Stenothoidae	Urothoidae
Box core	*Ampelisca*	*Aoroides*	*Argissa*	*Amphithopsis*	*Pseudoprotella*	*Protomedeia*	*Crassicorophium*	*Cyproideis*	*Dexamine*	*Dulichiopsis*	*Dynamenella*	*Gammarus*	*Haustorius*	*Isaeidae*	*Liljeborgia*	*Lysianassidae*	*Melita*	*Monoculodes*	*Harpinia*	*Pleustes*	*Stenothoe*	*Urothoe*
BC212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC213	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC216	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC217	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC218	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC219	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC221	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC223	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC224	0	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC226	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC227	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC228	0	2	2	1	0	0	0	0	0	0	12	0	0	0	0	0	0	1	0	0	0	0
BC229	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC230	0	0	0	8	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0
BC231	0	0	1	1	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC234	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC235	0	0	0	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC236	0	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC237	0	0	5	3	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC238	0	184	19	5	1	0	2	0	0	0	14	0	0	0	0	0	0	1	0	0	0	0
BC239	0	140	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
BC240	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC241	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC242	0	0	2	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
BC243	0	0	0	2	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
BC244	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC245	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC246	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC247	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC248	0	17	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
BC249	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC250	0	1	1	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC252	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC254	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC255	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC256	0	21	4	0	0	0	1	4	0	0	0	0	0	0	0	1	0	0	0	0	0	1
BC257	0	0	0	5	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC258	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC259	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC260	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC262	0	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC263	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC264	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC265	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC266	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC268	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC271	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC272	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC274	0	40	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC275	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC276	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC277	0	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC278	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC279	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC281	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC282	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC283	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC285	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC286	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC287	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC288	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC289	0	16	3	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC291	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC292	0	2	1	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC293	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC294	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC296	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC297	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC298	0	29	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC300	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC301	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Eusiridae		Hyperiidae	Ischyrocerida				Leptochelidae	Leucothoidae	Acidostomatidae	Ampithoidae	Lysianassidae					Unciolidae	Maeridae	Melitidae	
Box core	Eusiroides	Eusirus	Rhachotropis	Themisto	Ischyrocerides	Erichthonius	Jassa	Siphonoecetes	Leptocheliidae	Leucothoe	Acidostoma	Acidulidae	Cheirimedon	Gronella	Hippomedon	Lepidepecreum	Orchomene	Tryphosella	Unciola	Tmetonyx	Maera	Megamoera	Quasimelita
BC12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC13	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC15	0	1	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC16	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC18	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC28	0	1	0	0	1	0	3	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
BC29	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC30	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC31	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC36	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
BC37	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	16
BC38	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	2	0	1
BC39	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0	22	0	0	2	0	0
BC40	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
BC41	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
BC42	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	1
BC43	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0
BC49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC54	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	5	3	0	0	0	0
BC55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC56	0	0	0	0	5	0	0	4	0	0	0	1	0	0	0	0	0	7	1	0	3	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0
BC59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
BC62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC65	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	0	2	0	5
BC66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0
BC67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC74	0	0	0	0	49	0	1	1	0	0	1	0	0	0	0	0	0	7	1	0	0	0	0
BC75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
BC77	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0
BC78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
BC80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC87	0	0	0	0	23	0	1	0	0	0	0	0	0	0	0	1	0	6	0	1	1	0	1
BC88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC89	0	0	0	0	104	0	5	0	0	0	0	0	0	0	0	0	0	6	0	0	1	0	0
BC91	0	0	0	0	3	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0
BC93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC96	0	0	0	0	10	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0
BC97	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC98	0	0	0	0	9	0	0	3	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0
BC99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC80	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
BC83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
BC84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Box core	Maldanidae Maldanidae	Oedicerotidae Ampelisca diadema	Ampelisca	Bathymedon	Diastylidae	Haploscoloplos	Monoculodes	Paradiopatra	Paradiastylidae Isaidae	Halicoides	Nicippe	Pardalisca	Pardaliscella	Pardalisoides	Phoxocephalidae Gammaropsis	Photis	Harpinia	Harpiniopsis	Leptophoxus	Pinnixa	Pisidia Actophiosites	Stenothoides	Pontogeneiidae Dactylopleopus
BQ12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BQ13	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0
BQ14	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	6	1	0	0	0	0	0
BQ15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	79	1	0	0	0	0	0
BQ16	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
BQ17	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	11	0	0	0	0	0	0
BQ18	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0
BQ19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	2
BQ20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BQ22	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ23	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ24	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ25	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ27	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0
BQ28	1	0	0	0	0	0	2	0	0	0	0	0	0	0	81	0	15	0	0	0	0	0	0
BQ29	0	0	0	0	0	0	1	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0
BQ30	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0
BQ31	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
BQ32	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BQ34	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ35	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
BQ36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
BQ37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	10	0	0	0	0	0	0
BQ38	1	0	0	0	0	0	0	0	0	1	0	0	0	0	20	0	16	0	0	0	0	0	0
BQ39	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0
BQ40	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	6	0	0	0	0	0	0
BQ41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
BQ42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0
BQ43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0
BQ44	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ45	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BQ46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	11	0	0	0	0	0	0
BQ49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	0	0	0	0	0	1
BQ50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	5	0	0	0	0	0	0
BQ51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ52	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BQ54	0	0	1	0	0	0	0	0	0	0	0	0	0	0	34	0	18	0	0	0	0	0	0
BQ55	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0	0
BQ56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	161	0	2	0	0	0	0	0	0
BQ57	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	7	0	0	0	0	0	0
BQ58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	4	0	0	0	0	0	0
BQ62	0	0	0	0	0	0	1	0	0	0	0	0	0	0	5	0	1	0	0	0	0	0	0
BQ63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0
BQ65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
BQ66	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
BQ68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	34	1	0	0	0	0	0
BQ71	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	19	4	0	0	0	0	0
BQ72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ73	2	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	18	0	0	0	0	3	0
BQ74	0	0	6	1	0	0	0	1	0	0	0	0	0	0	0	0	36	0	0	1	0	0	0
BQ75	0	0	2	1	0	0	0	0	0	0	0	1	0	0	3	0	173	0	0	0	0	0	0
BQ76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0
BQ77	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	9	0	0	0	0	0	0
BQ78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	0	0	0
BQ79	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	19	0	0	0	0	0	0
BQ80	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	49	0	0	0	0	0	0
BQ81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127	0	0	0	0	0	0
BQ82	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	73	0	0	0	0	0	0
BQ83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	76	1	0	0	0	0	0
BQ84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
BQ85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	0	4	0	0	0	0	0	0
BQ88	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
BQ89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	15	0	0	0	0	0	0
BQ91	0	0	1	0	0	0	1	0	0	0	0	0	0	0	4	0	25	0	0	0	0	0	0
BQ92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
BQ93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0
BQ94	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
BQ95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ97	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0	0
BQ98	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
BQ99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
BQ101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0
BQ102	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
BQ103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0
BQ104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0

Box core	Stegocephalidae Andaniotels	Glycerodonotes	Stegocephalus	Stenothoidae Metopa	Metopella	Podoceridae	Synopiidae Bruzelispa	Syrrhoe	Syrrhoites	Tiron	Urothoidae Nicippella	Urothoidae Urothoe	Corophiidae Corophium	Argissidae Argissa	Cirolanidae Cirolana	Nototanaidae Nototanais	Desmosomatidae Desmosoma	Desmosomatidae Chelator	Desmosomatidae Desmosoma	Eugerdella	Eugerdella	Mitrabithrus	Prochelator
BC212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC216	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1	0	0	0	0	0	0	0
BC217	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC218	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	1	0	0	0	0
BC219	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
BC220	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC221	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	1	0	0	0	0	0	0
BC222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	0	0	0	0
BC227	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC228	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	19
BC229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
BC230	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	10	0	0	0	0
BC231	0	0	1	0	0	0	0	0	2	0	0	0	0	4	0	0	0	1	5	0	0	0	2
BC232	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
BC233	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
BC234	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC235	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
BC236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC237	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC238	0	0	5	4	0	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0
BC239	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0
BC240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
BC241	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC242	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0
BC243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC244	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC246	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC247	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC248	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC249	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC250	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
BC251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC255	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
BC256	1	0	0	10	0	0	0	0	3	0	0	28	0	0	0	0	0	0	0	0	0	0	0
BC257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC258	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
BC259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC260	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
BC262	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC265	0	0	0	0	0	0	1	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
BC266	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC271	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC272	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2
BC274	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC275	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC277	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC278	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC279	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1
BC280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC282	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC285	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	1	0	0	0	0
BC286	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC287	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC288	0	0	0	2	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
BC289	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	3
BC291	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC292	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC293	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC294	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC297	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC298	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC299	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0
BC300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC301	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
BC302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	3

Box core	Pseudovesus	Goodiidae Bathyganetta	Caecogarthia	Gnathia	Haplomoomidae Monelia	Thylakogarter	Haploniscidae Haploniscus	Ischyroscelidae Carinoniscus	Gracilimesus	Hippolomesus	Heteromesus	Ischyromesus	Janiridae Janiralata	Janiridae Janiroella	Janiridae Janiru	Janiralata	Tole	Leptanthuridae Calathura	Macrochiridae Macrocyphis	Munnidae Munna	Munnopsidae Betamorpha	Disconectes	Echinosome	Eurycope
BC112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	1
BC113	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0
BC114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
BC115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC116	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
BC117	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC118	3	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0
BC119	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC120	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC121	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
BC124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
BC125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
BC126	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0
BC127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1
BC128	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
BC129	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC130	6	0	0	0	0	0	0	0	0	0	15	0	7	0	0	0	0	6	4	2	5	0	6	22
BC131	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC132	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC134	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC136	0	3	0	0	0	0	3	0	0	0	0	0	2	0	0	0	0	0	0	3	0	0	0	0
BC137	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	2	5	0	2	1	5
BC138	0	2	0	0	1	0	1	0	0	0	0	0	0	0	2	0	0	0	0	8	0	9	0	10
BC139	0	0	0	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC140	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	3	0	0
BC141	0	1	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC142	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1
BC143	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC144	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0
BC145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC146	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
BC147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC148	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0
BC149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC151	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC152	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC153	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC154	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC155	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC156	0	0	1	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	8	0	4	0	0	3
BC157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC158	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
BC159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	3
BC163	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC164	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC165	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0
BC167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
BC171	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC172	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	5	72	0	0	0	1
BC174	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC175	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC177	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC178	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC179	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10	0	1	0	0	0
BC180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
BC181	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0
BC182	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC183	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC189	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0
BC191	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
BC192	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC193	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC196	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC197	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC198	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	0	1
BC199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC301	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	0	0	0	1
BC302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC303	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3	0	0	0	3
BC304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0

Box core	Byrrhulus	Mantis 'Group A'	Munnopsurus	Pseudomunnopsis	Storthyngura	Nannoniscidae Nannoniscoides	Nannoniscus	Rapaniscus	Thaumastosoma	Paramunnidae Pleurogonium	Parastenhelidae Parastenhele	Thambematidae Thambema	Agathotanaidae Agathotanais	Peraeanthura	Perugathotanais	Akanthophoreidae Tumidochelia	Ajoneolidae Stenotenels	Ajoneolidae Levisporades	Anarthruridae Ithycnius	Colletteidae Colletteia
B212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
B213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B215	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B216	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
B217	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B218	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0
B219	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B221	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
B224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B226	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
B227	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
B228	0	0	0	0	0	0	12	0	1	4	0	0	8	1	0	0	0	0	0	1
B229	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0
B230	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	4	0	0	0	1
B231	3	0	0	0	0	0	39	1	1	0	0	0	25	0	0	0	0	0	0	1
B232	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	5	0
B234	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
B236	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B237	2	0	0	0	0	0	13	1	0	0	0	0	13	2	0	1	0	0	0	0
B238	0	3	0	0	0	0	3	0	0	5	0	0	0	26	3	0	0	0	0	0
B239	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
B240	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
B241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B242	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B243	0	0	0	0	0	0	0	0	0	0	0	0	7	5	0	0	0	0	1	0
B244	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B246	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
B247	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0
B248	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
B252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B256	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
B257	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
B258	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
B262	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
B264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B265	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
B266	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B268	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	2	0
B271	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	0	0	0	0	0
B272	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B274	14	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B276	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
B277	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0
B278	0	0	0	0	0	0	0	0	0	0	0	0	4	7	0	2	0	0	0	0
B279	1	0	0	0	0	0	2	0	0	0	0	0	2	4	1	0	0	0	0	0
B280	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
B281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B282	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
B283	0	0	0	0	0	0	0	2	0	0	0	0	11	2	4	0	0	0	0	0
B284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B285	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0
B286	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
B287	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B288	0	0	0	0	0	0	0	0	0	0	0	0	0	21	5	0	0	0	0	0
B289	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B291	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B292	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
B293	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B294	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B297	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B298	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B304	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Box core	Fiftianids	Leptognathopsis	Cryptocopidae Cryptocopa	Cryptocopoides	Insertae sedis Leptognathoides	Pertorutrum	Stigulo	Leptochelidae Heterobionis	Leptognathidae Leptognatha	Neotanaidae Neotanais	Pseudotanaidae Peropseudotanais	Pseudotanais	Sphyrapodidae Pseudosphyrapus	Tiphlotanaidae Meromonakanthe	Paratyphlotanais	Tonguella	Typhlotanais	Bodotriidae Atlantocuma	Bathycuma	Hypocuma
BC212	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC214	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC215	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC216	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC217	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC221	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC222	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC223	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC224	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC226	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC227	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC228	0	0	0	0	2	0	0	0	0	0	1	0	3	2	0	0	0	0	0	0
BC229	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC230	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC231	0	0	1	0	0	1	0	0	0	3	0	0	7	0	0	1	0	7	0	0
BC232	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC234	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC235	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
BC236	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
BC237	0	0	0	0	5	0	0	0	0	0	0	7	1	0	0	0	0	8	0	0
BC238	4	0	0	0	11	0	1	0	0	0	1	15	0	0	17	0	135	1	0	0
BC239	0	0	0	0	2	0	0	1	0	0	0	4	0	0	0	16	15	0	0	0
BC240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC243	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC244	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC245	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC246	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC247	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC248	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC249	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
BC250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC251	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
BC252	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC253	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC254	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
BC255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC256	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	4	4	0	0	0
BC257	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC258	0	0	0	0	1	0	0	0	0	0	0	0	2	1	0	0	1	0	0	0
BC259	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC262	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0
BC263	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC266	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC269	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC271	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC272	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC274	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0
BC275	0	0	0	0	8	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC276	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0
BC277	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC278	2	6	2	0	2	0	0	0	0	0	0	2	1	0	0	0	24	5	0	0
BC279	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	3	0	0
BC280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC281	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC282	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0
BC283	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC285	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC286	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC287	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC288	0	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
BC289	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC291	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
BC292	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC293	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC294	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC295	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC297	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC298	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC300	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC301	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC302	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0

Box core	Diastylidae Brachydiastylis	Diastylis/Diastyloides	Leptostylis	Leptostyloides	Makrokylindrus	Vemakylindrus	Lamprophidae Hemilamprops	Lamprops	Mesaiolamprops	Platysympus	Leuconidae Eudorella	Eudorellopsis	Leucon	Nannastacidae Campylaspis	Cumellopsis	Pseudocumatidae Petalosarsia	Mysida
BQ312	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	1
BQ313	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ314	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ315	3	0	0	0	0	0	0	0	0	0	1	0	0	5	0	0	1
BQ316	3	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
BQ317	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ318	2	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ319	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ320	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
BQ321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ322	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ323	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ324	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ326	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ328	0	1	0	0	0	0	0	0	0	0	1	0	0	7	0	0	0
BQ329	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
BQ330	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BQ331	0	7	2	0	0	0	0	0	0	0	0	0	0	7	4	0	0
BQ332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ334	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ335	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1
BQ336	0	2	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0
BQ337	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0
BQ338	0	12	2	0	0	0	4	0	0	0	4	0	0	28	11	0	0
BQ339	1	15	2	0	0	0	2	0	0	2	0	0	0	30	11	0	0
BQ340	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ341	0	14	0	0	0	0	2	0	0	0	0	0	0	1	3	0	0
BQ342	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ343	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ344	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BQ345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ347	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ348	0	11	0	0	1	5	0	0	0	0	4	0	0	9	1	0	0
BQ349	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BQ351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ352	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ353	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
BQ354	1	20	2	0	0	0	0	0	0	0	0	0	0	14	0	0	0
BQ355	0	7	2	0	0	0	0	0	0	0	6	0	0	3	2	0	0
BQ356	0	4	0	0	0	3	1	0	0	0	0	0	0	15	0	0	0
BQ357	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ358	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
BQ359	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ360	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ362	0	1	0	0	0	0	2	0	0	1	1	0	0	0	0	0	0
BQ363	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ365	0	4	0	0	0	0	0	0	0	0	2	0	0	11	0	0	1
BQ366	0	4	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0
BQ367	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
BQ368	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BQ371	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ372	0	7	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0
BQ374	0	14	0	0	0	0	2	0	0	0	2	0	0	20	3	0	0
BQ375	0	5	0	0	0	0	0	0	0	0	1	0	0	27	0	0	0
BQ376	0	7	0	0	0	0	0	0	0	0	1	0	0	8	0	0	0
BQ377	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ378	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
BQ379	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
BQ380	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
BQ381	0	4	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
BQ382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ383	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ384	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ385	0	2	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
BQ386	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ387	4	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BQ388	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ389	0	1	0	0	0	1	0	0	1	0	0	0	0	4	0	0	0
BQ391	1	24	0	0	0	17	0	0	5	0	3	0	0	13	0	0	0
BQ392	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
BQ393	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ394	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ395	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ396	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ397	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ398	4	4	0	0	0	2	0	0	2	0	0	0	0	2	1	0	0
BQ399	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
BQ300	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ302	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BQ303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BQ304	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1

	Amarthiidae	Ampeliscidae	Amphilochidae			Aoridae	Argissidae	Calliopiidae	Caprellidae	Corophiidae	Cressidae	Cyprideidae	Dexaminidae	Dulichiidae		Podoceridae		Epimeriidae
Box core	*Cleonardopsis*	*Ampelisca*	*Bybis*	*Haploops*	*Amphilochus*	*Amphilochopsis*	*Gitana*	*Gitanopsis*	*Lembos*	*Argissa*	*Amphithopsis*	*Aeginella*	*Proaeginina*	*Protomedeia*	*Cressa*	*Cressina*	*Stegoplax*	*Dexamine*	*Dulichiopsis*	*Dyopedos*	*Paradulichia*	*Laetmetophilus*	*Xenodice*	*Paramphithoe*
BC305	0	0	0	5	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC306	0	2	5	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
BC307	0	0	185	39	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
BC308	0	20	0	1	0	0	0	0	5	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
BC309	0	26	0	1	1	0	1	0	2	0	0	1	0	0	6	1	0	0	7	1	0	3	0	0
BC310	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC311	0	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC314	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC315	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC316	0	0	2	16	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0
BC317	1	6	0	18	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
BC318	0	49	6	0	0	0	0	2	3	0	0	2	0	0	0	0	0	0	11	4	2	0	2	0
BC319	0	0	5	86	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC324	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
BC327	0	17	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC328	0	15	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
BC329	0	0	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC330	0	31	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC331	0	0	0	0	0	0	0	0	0	0	0	8	0	2	0	0	0	0	0	0	0	0	0	0
BC332	0	0	1	45	0	0	0	0	0	0	0	0	0	0	0	0	2	0	11	0	0	0	0	0
BC333	0	0	3	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC334	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC339	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC340	0	5	0	4	0	0	0	0	2	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
BC341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC342	0	0	0	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC343	0	0	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC344	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
BC345	0	13	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC346	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC347	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC348	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC352	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC353	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC354	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC356	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC357	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC358	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC361	0	0	3	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC362	0	7	0	12	0	0	0	0	1	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0
BC363	0	0	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
BC364	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC365	0	0	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC366	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC367	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC369	0	1	3	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	4	0	2	0	0
BC370	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC371	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Eusiridae		Hyperiidae	Ischyroceridae					Lepechinellidae	Leucothoidae	Acidostomatidae	Aristiidae	Lysianassidae						Unidae	Maeridae	Melitidae	
Box core	*Eusirella*	*Eusirus*	*Rhachotropis*	*Themisto*	*Bonnierella*	*Erichthonius*	*Ischyrocerus*	*Jassa*	*Siphonoecetes*	*Lepechinella*	*Leucothoe*	*Acidostoma*	*Aristias*	*Coxlmedon*	*Gronella*	*Hippomedon*	*Lepidepecreum*	*Onchomene*	*Tryphosella*	*Anonyx*	*Tmetonyx*	*Maera*	*Megamoera*	*Quasimelita*
BC05	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC06	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC07	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	0
BC08	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC09	0	0	0	0	13	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC10	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC11	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
BC16	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0
BC17	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC18	0	0	0	0	24	1	2	0	1	0	0	0	0	0	0	0	0	0	4	1	1	0	1	0
BC19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC20	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
BC21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC27	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	4	0	0	0	0	0
BC28	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0
BC29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC30	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC31	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC34	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC39	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC42	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC45	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC46	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC54	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
BC63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC65	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
BC67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC69	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
BC71	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Melphidippidae	Oedicerotidae							Pardaliscidae						Photidae		Phoxocephalidae					Pleustidae		Pontogeneiidae
Box core	Melphidippa	Americhelidium	Amphilochus	Bathymedon	Deflandrea	Halicreion	Monoculodes	Paroediceros	Halice	Halicoides	Nicippe	Pardalisca	Pardaliscella	Pardalisoides	Gammaropsis	Photis	Harpinia	Harpinioides	Leptophoxus	Paraphoxus	Anisopleustes	Stenopleustes	Dautzenbergia
BC005	0	1	0	0	0	1	0	4	0	0	0	0	0	0	0	0	39	0	0	0	0	0	0	0
BC006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	18	0	0
BC007	0	0	0	0	0	0	0	0	0	0	0	0	0	1	28	0	2	0	0	0	0	0	0	0
BC008	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0
BC009	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	18	0	0	0	0	0	0	0
BC010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
BC011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	4	0	0	0	0	0	0	0
BC014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0
BC015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
BC016	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1	0	12	0	1	0	0	0	0	0
BC017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
BC018	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	25	12	0	0	0	0	0	0	0
BC019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
BC020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
BC021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC024	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	1	0	0	0	0	0
BC027	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
BC028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
BC029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
BC030	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0
BC031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	18	0	2	0	0	0	0	0
BC033	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	6	0	0	0	0	0	0	0
BC034	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	0	0	0	0	0	0	0
BC039	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
BC040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0	0	6	6
BC041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
BC042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
BC043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC044	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	9	0	0	0	0	0	0	0
BC045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0
BC047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
BC048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
BC051	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
BC056	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0
BC057	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC058	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	0	0	0	1
BC061	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
BC062	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0
BC063	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	6	0	0	0	0	0	0	0
BC064	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0
BC065	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC066	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC067	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0
BC069	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	7	0	0	0	0	0	0	0
BC070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0

	Stegocephalidae		Stenothoidae			Synopiidae			Unciolidae		Urothoidae		Acturidae	Cirolanidae		Dendrotionidae	Desmosomatidae				
Box core	*Andaniexis*	*Glorandaniotes*	*Stegocephaloides*	*Metopa*	*Metopella*	*Probolaides*	*Bruzelisopsis*	*Syrrhoe*	*Syrrhoites*	*Tiron*	*Meinhelia*	*Uncíola*	*Urothoe*	*Curangolia*	*Astacilla*	*Cirolana*	*Natatolana*	*Dendrorion*	*Cheletor*	*Desmosoma*	*Eugerda*	*Eugerdella*	*Mirabilicoxa*	*Prochelator*
BC005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC006	0	0	0	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC007	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC009	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC011	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BC014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC016	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	3	1	0	0	0	2
BC017	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	1	1	0	0	0	0	0
BC018	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
BC019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC020	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC024	0	0	0	1	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	1	0	0	0	3
BC027	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC029	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	2	0	0	0	0
BC030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC031	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC032	0	0	0	1	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	6	0	0	0	0
BC033	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	6	0	0	0	1
BC034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
BC041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC043	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC048	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0
BC051	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC053	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC054	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC056	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC057	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC058	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
BC061	0	0	0	0	0	0	0	0	0	0	0	44	0	0	3	0	0	0	0	1	0	0	1	2
BC062	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0
BC063	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC064	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC065	0	0	0	0	0	4	0	0	0	0	0	1	0	0	0	0	0	0	1	2	0	0	0	0
BC066	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC067	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
BC069	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
BC071	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0

		Gnathiidae			Haplomunnidae		Haploniscidae	Ischnomesidae				Janiretidae	Janiridae		Leptanthuridae	Macrostylidae	Munnidae	Munnopsidae			
Box core	*Pseudomesus*	*Bathygnathia*	*Caecognathia*	*Gnathia*	*Munella*	*Thylakogaster*	*Haploniscus*	*Cornuomesus*	*Gracilimesus*	*Haplomesus*	*Heteromesus*	*Ischnomesus*	*Janiretta*	*Janira*	*Jamirlaita*	*Tole*	*Calathura*	*Macrostylis*	*Munna*	*Betamorpha*	*Disconectes*	*Echinozone*	*Eurycope*
BC305	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4
BC307	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC309	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	0	0	5	0	1	0	3
BC310	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC314	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0
BC315	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
BC316	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	2
BC317	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	1
BC318	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0	0	0	0
BC319	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC324	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	1	5	0	0	0	1
BC327	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
BC328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	5	0	0	0	0
BC329	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC330	0	0	0	1	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC332	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0	1
BC333	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC334	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	26	0	1	0	0
BC339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
BC340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC342	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC343	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC347	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC352	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC353	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC354	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC356	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC357	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC361	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0	0	0	0
BC362	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC363	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BC364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
BC365	0	0	0	0	0	0	0	0	0	1	0	17	0	0	0	0	0	0	0	0	0	0	9
BC366	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC369	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0
BC370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
BC371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

					Nannoniscidae			Paramunnidae	Paranthuridae	Thambematidae	Agathotanaidae		Abanthophoreidae		Apseudide	Anarthruridae	Colletteidae
Box core	*Ilyarachna*	Merila 'Group A'	*Munnopsurus*	*Pseudomunnopsis*	*Storthyngura*	*Nannoniscus*	*Rapenicus*	*Thaumastosoma*	*Pleurogonium*	*Paranthura*	*Thambema*	*Agathotanais*	*Paragathotanais*	*Tumidochelia*	*Stenotanais*	*Levipseudes*	*Ithyomus*	*Collettina*
BC305	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC306	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC307	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC308	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC309	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC310	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC311	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC314	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC315	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC316	1	0	0	0	0	0	1	0	0	0	0	5	0	0	0	0	0	1
BC317	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC318	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC319	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC324	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
BC327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC329	1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
BC330	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC333	0	0	0	0	0	0	0	0	0	0	0	16	3	1	0	0	0	0
BC334	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC339	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC340	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC342	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC343	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC346	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
BC347	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC352	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC353	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC354	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC356	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC357	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC361	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2	0	1
BC362	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
BC363	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
BC364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC365	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0
BC366	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC367	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0
BC369	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Box core	Filitonais	Leptognathiopsis	Cryptocopidae		Incertae sedis'		Leptochelidae	Leptognathidae	Neotanaidae	Pseudotanaidae	Pseudotanaidae	Sphyrapodidae	Typhlotanaidae		Bodotriidae		
		Leptognathiopsis	*Cryptocope*	*Cryptocopoides*	*Leptognathoides*	*Parturetrum*	*Singula*	*Heterotenais*	*Leptognathia*	*Neotanais*	*Parapseudotenais*	*Pseudotanais*	*Pseudosphyrapus*	*Meromonakantha*	*Parathyhotenais*	*Torquella*	*Typhlotanais*	*Atlantocuma*	*Bathycuma*	*Hyspacuma*
BC005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC007	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
BC008	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
BC009	0	0	0	0	3	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
BC010	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0
BC011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC016	0	0	0	0	1	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
BC017	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
BC018	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
BC019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC020	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC024	0	0	0	0	0	1	0	0	0	0	0	0	4	0	0	0	1	0	0	0
BC027	0	0	0	0	4	0	0	5	0	0	0	1	0	0	0	0	3	0	0	0
BC028	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC030	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0
BC031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC033	0	0	0	0	3	0	0	0	0	0	0	0	4	0	0	0	0	0	1	0
BC034	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0
BC039	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
BC040	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
BC041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
BC048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC051	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC052	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC053	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC054	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
BC056	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC057	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC058	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC061	0	6	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
BC062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC063	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC064	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC065	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC066	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC067	0	7	0	1	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
BC069	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
BC070	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
BC071	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	Diastylidae						Lampropidae					Leuconidae			Nannastacidae		Pseudocumatidae	
Box core	Brachydiastylis	Diastylis/Diastylopsis	Leptostylis	Leptostylopsides	Makrokylindrus	Vemakylindrus	Hemilamprops	Lamprops	Meaclampops	Platycymus	Eudorella	Eudorellopsis	Leucon	Campylaspis	Cumellopsis	Petalosarsia	Mysida
BC305	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
BC306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
BC307	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC308	0	8	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0
BC309	0	15	1	0	1	0	1	0	0	0	0	3	1	5	1	2	0
BC310	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
BC311	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC314	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC315	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
BC316	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
BC317	0	11	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0
BC318	0	8	0	0	0	0	1	0	0	0	0	0	0	4	1	1	0
BC319	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
BC320	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC321	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC327	0	0	0	0	0	0	1	0	0	0	0	0	6	1	0	0	0
BC328	0	0	0	0	0	0	4	0	0	0	0	0	3	4	0	0	0
BC329	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC330	0	2	0	0	0	1	0	0	0	0	1	0	1	4	0	0	0
BC331	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC332	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1
BC333	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
BC334	0	3	0	0	1	0	0	0	0	0	0	0	0	9	8	2	0
BC339	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0
BC340	0	2	3	0	0	0	0	0	0	0	0	2	0	2	0	0	1
BC341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC342	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC343	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC344	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC345	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC346	0	1	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0
BC347	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC348	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC352	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC353	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC354	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC356	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC357	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC358	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC361	0	6	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
BC362	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BC363	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
BC364	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC366	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC367	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC369	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC370	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BC371	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3

Environmental conditions at box core locations

Box core number	Successful collection?	Latitude	Longitude	Multibeam bathymetry	Collection year	Collection month	Crew number	Seafloor temperature 2008/°C	Seafloor temperature 2009/°C	Seafloor temperature 2010/°C
1	N	48.265	-4.645	843.7	2009	may	1	3.69	3.56	3.72
2	N	48.265	-4.645	843.7	2009	may	1	3.69	3.56	3.72
3	N	48.261	-4.648	836.5	2009	may	1	3.68	3.54	3.70
4	Y	48.413	-4.324	1181.2	2009	may	1	3.54	3.46	3.59
5	Y	48.760	-4.730	1392.8	2009	may	1	3.46	3.39	3.51
6	Y	48.447	-4.183	1079.6	2009	may	1	3.42	3.35	3.46
7	Y	48.740	-4.303	1287.4	2009	may	1	3.37	3.31	3.40
8	Y	48.144	-4.024	1135.4	2009	june	1	3.69	3.60	3.74
9	Y	48.327	-4.474	900.8	2009	june	1	3.65	3.54	3.70
10	Y	48.333	-4.478	907.9	2009	june	1	3.73	3.61	3.78
11	Y	48.103	-4.312	691.8	2009	june	1	3.61	3.48	3.64
12	Y	47.752	-3.821	884.3	2009	june	1	3.61	3.50	3.65
13	Y	48.009	-4.082	834.7	2009	june	1	3.65	3.53	3.70
14	Y	48.056	-3.938	1116.1	2009	june	1	3.55	3.47	3.60
15	N	48.226	-4.216	1024.2	2009	june	1	3.61	3.51	3.66
16	Y	48.226	-4.216	1024.2	2009	june	1	3.61	3.51	3.66
17	Y	48.309	-4.008	1362.5	2009	june	1	3.47	3.39	3.51
18	Y	47.836	-3.816	994.9	2009	june	1	3.55	3.45	3.55
19	Y	47.872	-4.045	721.9	2009	june	1	3.57	3.45	3.61
20	Y	47.872	-3.396	1817.4	2009	june	1	3.45	3.38	3.48
21	Y	47.821	-3.367	1484.2	2009	june	1	3.37	3.31	3.39
22	Y	47.840	-3.843	703.3	2009	june	1	3.59	3.47	3.63
23	Y	47.986	-3.862	1016.3	2009	june	1	3.49	3.40	3.53
24	Y	47.381	-3.470	1477.0	2009	june	1	3.43	3.37	3.47
25	Y	47.321	-3.656	960.4	2009	june	1	3.57	3.48	3.62
26	Y	47.393	-3.738	732.2	2009	june	1	3.64	3.52	3.69
27	Y	47.284	-3.517	1181.9	2009	june	1	3.42	3.34	3.46
28	Y	47.365	-3.652	874.1	2009	june	1	3.50	3.40	3.54
29	Y	47.189	-3.680	732.4	2009	june	1	3.50	3.39	3.53
30	Y	47.146	-3.546	966.9	2009	june	1	3.53	3.45	3.58
31	Y	47.122	-3.365	1648.5	2009	june	1	3.40	3.35	3.43
32	Y	47.085	-3.607	813.6	2009	june	1	3.57	3.47	3.62
33	Y	47.066	-3.411	1835.9	2009	june	1	3.38	3.32	3.39
34	Y	47.121	-3.455	1169.7	2009	june	1	3.45	3.38	3.49
35	Y	47.000	-3.617	811.7	2009	june	1	3.62	3.53	3.67
36	Y	46.999	-3.414	1186.4	2009	june	1	3.33	3.27	3.37
37	Y	46.996	-3.257	1849.6	2009	june	1	3.22	3.19	3.23
38	Y	46.946	-3.306	1536.1	2009	june	1	3.10	3.06	3.12
39	Y	46.854	-3.664	938.6	2009	june	1	3.42	3.34	3.46
40	Y	46.851	-3.423	1322.7	2009	june	1	3.30	3.25	3.33
41	Y	46.919	-3.515	997.6	2009	june	1	3.63	3.56	3.69
42	Y	46.949	-3.750	831.2	2009	june	1	3.47	3.38	3.51
43	Y	46.949	-3.751	830.0	2009	june	1	3.47	3.38	3.51
44	Y	46.722	-3.660	1720.6	2009	june	1	3.59	3.51	3.64
45	N	46.758	-3.998	894.3	2009	june	1	3.42	3.33	3.46
46	Y	46.693	-3.992	1466.6	2009	june	1	3.33	3.25	3.37
47	Y	46.704	-4.070	768.8	2009	june	1	3.42	3.32	3.39
48	N	48.349	-4.001	1311.2	2009	june	1	3.32	3.23	3.45
49	Y	48.309	-4.401	1427.2	2009	june	1	3.37	3.27	3.60
50	Y	48.304	-4.163	1372.9	2009	june	1	3.49	3.38	3.46
51	Y	48.215	-4.471	1464.0	2009	june	1	3.37	3.27	3.57
52	Y	48.305	-4.729	1511.8	2009	june	1	3.32	3.21	3.46
53	Y	48.097	-4.342	725.1	2009	june	1	3.55	3.39	3.42
54	N	48.097	-4.342	725.1	2009	june	1	3.55	3.39	3.63
55	N	48.097	-4.342	725.1	2009	june	1	3.55	3.39	3.63
56	Y	48.135	-4.572	960.0	2009	june	1	3.37	3.24	3.47
57	Y	48.173	-4.570	1273.5	2009	june	1	3.36	3.24	3.45
58	Y	48.092	-4.429	664.8	2009	june	1	3.54	3.37	3.63
59	Y	48.360	-4.344	983.0	2009	june	1	3.39	3.50	3.64
60	Y	48.279	-4.480	871.8	2009	june	1	3.53	3.43	3.57
61	Y	48.211	-4.612	839.1	2009	june	1	3.39	3.47	3.65
62	N	48.220	-4.035	1446.1	2009	june	1	3.48	3.39	3.57
63	Y	48.220	-4.034	1445.6	2009	june	1	3.50	3.40	3.57
64	N	48.096	-4.308	742.9	2009	july	2	3.44	3.29	3.51
65	N	48.152	-4.237	1073.0	2009	july	2	3.46	3.33	3.54
66	N	48.095	-4.100	714.3	2009	july	2	3.75	3.57	3.82
67	Y	48.157	-4.861	760.1	2009	july	2	3.60	3.47	3.68
68	Y	48.317	-4.532	1050.3	2009	july	2	3.60	3.51	3.66
69	N	48.157	-4.862	761.3	2009	july	2	3.60	3.47	3.68
70	Y	48.173	-4.798	1337.7	2009	july	2	3.81	3.72	3.88
71	Y	48.442	-4.245	1364.1	2009	july	2	3.49	3.41	3.55
72	Y	48.385	-4.487	1439.4	2009	july	2	3.45	3.37	3.47
73	Y	48.332	-4.642	1613.3	2009	july	2	3.42	3.34	3.48
74	Y	48.116	-4.772	887.2	2009	july	2	3.62	3.47	3.68
75	N	48.158	-4.862	783.1	2009	july	2	3.60	3.47	3.68
76	Y	48.300	-4.712	819.8	2009	july	2	3.53	3.41	3.59
77	Y	48.301	-4.348	1080.5	2009	july	2	3.68	3.57	3.74
78	Y	48.488	-4.615	1029.1	2009	july	2	3.59	3.49	3.64
79	Y	48.466	-4.032	1028.5	2009	july	2	3.61	3.52	3.67
80	Y	48.557	-4.517	983.9	2009	july	2	3.64	3.54	3.70
81	Y	48.352	-4.820	1158.4	2009	july	2	3.75	3.64	3.82
82	Y	48.389	-4.950	1139.0	2009	july	2	3.57	3.47	3.63
83	Y	48.519	-4.783	1155.9	2009	july	2	3.59	3.50	3.65
84	Y	48.570	-4.001	1507.6	2009	july	2	3.50	3.43	3.55
85	Y	48.656	-4.671	1165.6	2009	july	2	3.59	3.51	3.65
86	Y	48.721	-4.329	1151.5	2009	july	2	3.63	3.56	3.69

Box core number	Seafloor temperature average for collection year/°C	Seafloor temperature average for collection and previous year/°C	Seafloor temperature 10 year minimum/°C	Seafloor temperature 10 year mean/°C	Seafloor salinity 2008/ppt	Seafloor salinity 2009/ppt
1	3.56	3.62	3.66	4.12	34.83	34.81
2	3.56	3.62	3.66	4.12	34.83	34.81
3	3.54	3.61	3.66	4.13	34.82	34.81
4	3.46	3.50	3.52	3.92	34.85	34.84
5	3.39	3.43	3.48	3.85	34.84	34.83
6	3.35	3.39	3.41	3.74	34.85	34.84
7	3.31	3.34	3.35	3.63	34.86	34.85
8	3.60	3.64	3.51	3.91	34.89	34.88
9	3.54	3.60	3.59	4.05	34.84	34.83
10	3.61	3.67	3.59	4.05	34.86	34.85
11	3.48	3.54	3.63	4.10	34.82	34.81
12	3.50	3.55	3.57	4.02	34.86	34.85
13	3.53	3.59	3.60	4.06	34.85	34.84
14	3.47	3.51	3.49	3.89	34.87	34.86
15	3.51	3.56	3.55	3.99	34.86	34.84
16	3.51	3.56	3.55	3.99	34.86	34.84
17	3.39	3.43	3.45	3.80	34.85	34.85
18	3.45	3.50	3.54	3.96	34.86	34.85
19	3.45	3.51	3.63	4.10	34.82	34.81
20	3.38	3.41	3.44	3.79	34.87	34.86
21	3.31	3.34	3.36	3.65	34.87	34.87
22	3.47	3.53	3.61	4.07	34.84	34.83
23	3.40	3.45	3.52	3.94	34.85	34.84
24	3.37	3.40	ns	ns	34.88	34.88
25	3.42	3.53	3.53	3.95	34.87	34.86
26	3.32	3.38	3.39	4.06	34.86	34.85
27	3.34	3.38	3.48	3.86	34.86	34.85
28	3.40	3.45	3.55	3.99	34.85	34.83
29	3.39	3.44	3.59	4.06	34.84	34.82
30	3.45	3.49	3.53	3.96	34.87	34.86
31	3.35	3.37	3.38	3.83	34.89	34.89
32	3.47	3.52	3.57	4.02	34.86	34.85
33	3.12	3.25	3.42	3.76	34.85	34.85
34	3.38	3.42	3.46	3.83	34.87	34.87
35	3.53	3.57	3.57	4.03	34.87	34.86
36	3.27	3.30	3.43	3.79	34.86	34.86
37	3.19	3.20	3.16	3.40	34.90	34.89
38	3.06	3.08	3.32	3.56	34.86	34.85
39	3.34	3.38	3.51	3.95	34.85	34.84
40	3.25	3.27	3.40	3.70	34.87	34.86
41	3.56	3.60	3.49	3.92	34.89	34.88
42	3.38	3.43	3.55	4.01	34.84	34.83
43	3.38	3.43	ns	ns	34.84	34.83
44	3.51	3.55	3.50	3.90	34.88	34.87
45	3.33	3.37	3.57	4.01	34.83	34.82
46	3.26	3.29	3.47	3.83	34.83	34.82
47	3.28	3.31	3.48	3.84	34.84	34.83
48	3.32	3.37	3.55	4.05	34.82	34.80
49	3.43	3.47	3.55	3.91	34.77	34.76
50	3.27	3.32	3.59	3.97	34.67	34.66
51	3.38	3.44	3.60	4.00	34.72	34.71
52	3.27	3.32	3.58	3.96	34.67	34.66
53	3.21	3.26	3.60	3.99	34.63	34.62
54	3.39	3.47	3.66	4.10	34.68	34.67
55	3.39	3.47	3.66	4.10	34.68	34.67
56	3.24	3.31	3.66	4.16	34.62	34.61
57	3.24	3.30	3.64	4.08	34.62	34.61
58	3.37	3.45	3.65	4.21	34.67	34.66
59	3.50	3.55	3.57	3.97	34.81	34.80
60	3.43	3.48	3.61	4.02	34.77	34.76
61	3.47	3.53	3.66	4.10	34.76	34.75
62	3.39	3.44	3.59	3.98	34.73	34.72
63	3.40	3.45	3.59	3.98	34.74	34.73
64	3.29	3.36	3.66	4.20	34.65	34.64
65	3.33	3.39	3.67	4.11	34.68	34.67
66	3.57	3.66	3.67	4.20	34.76	34.75
67	3.47	3.54	3.67	4.15	34.74	34.73
68	3.51	3.56	3.55	3.94	34.81	34.80
69	3.47	3.54	3.67	4.15	34.74	34.73
70	3.72	3.76	3.57	3.96	34.89	34.87
71	3.44	3.45	3.48	3.83	34.80	34.79
72	3.37	3.41	3.48	3.84	34.77	34.76
73	3.34	3.38	3.47	3.80	34.76	34.75
74	3.47	3.52	3.66	4.18	34.74	34.73
75	3.47	3.54	3.67	4.14	34.74	34.73
76	3.41	3.47	3.67	4.12	34.74	34.73
77	3.37	3.62	3.61	4.03	34.82	34.81
78	3.49	3.54	3.59	4.03	34.81	34.80
79	3.52	3.56	3.55	3.95	34.83	34.82
80	3.54	3.59	3.60	4.03	34.83	34.82
81	3.64	3.70	3.59	4.02	34.85	34.83
82	3.47	3.52	3.59	4.01	34.79	34.78
83	3.50	3.54	3.56	3.98	34.82	34.81
84	3.43	3.46	3.46	3.80	34.82	34.81
85	3.52	3.55	3.51	3.89	34.85	34.84
86	3.56	3.59	3.49	3.85	34.87	34.86

Box core number	Seafloor salinity 2010/ppt	Seafloor salinity average for collection year/ppt	Seafloor salinity average for collection and previous year/ppt	Seafloor zonal velocity 2008 m/s	Seafloor zonal velocity 2009 m/s	Seafloor zonal velocity 2010 m/s
1	34.83	34.81	34.82	0.0046	0.0056	-0.0241
2	34.83	34.81	34.82	0.0046	0.0056	-0.0241
3	34.83	34.81	34.81	0.0051	0.0062	-0.0213
4	34.85	34.84	34.85	0.0539	0.0561	0.3829
5	34.84	34.83	34.84	0.0769	0.0794	0.2349
6	34.85	34.84	34.84	0.0565	0.0596	0.2440
7	34.86	34.85	34.86	0.0615	0.0646	0.2412
8	34.89	34.88	34.88	0.0777	0.0807	0.1580
9	34.85	34.83	34.84	0.0240	0.0233	0.2179
10	34.86	34.85	34.86	0.0256	0.0240	0.2619
11	34.83	34.81	34.82	0.0137	0.0149	-0.0088
12	34.86	34.85	34.85	0.0392	0.0406	0.3467
13	34.85	34.84	34.84	0.0291	0.0298	0.2184
14	34.87	34.86	34.86	0.0679	0.0700	0.1620
15	34.86	34.84	34.85	0.0475	0.0493	0.3939
16	34.86	34.84	34.85	0.0475	0.0493	0.3939
17	34.86	34.85	34.85	0.0625	0.0634	0.1758
18	34.86	34.85	34.85	0.0533	0.0540	0.1827
19	34.83	34.81	34.82	0.0192	0.0205	0.0287
20	34.87	34.86	34.87	0.0568	0.0588	0.1581
21	34.87	34.87	34.87	0.0988	0.0995	0.1109
22	34.84	34.83	34.83	0.0187	0.0195	0.1460
23	34.86	34.84	34.85	0.0391	0.0408	0.3819
24	34.88	34.88	34.88	0.0260	0.0241	0.5138
25	34.87	34.86	34.86	0.0436	0.0449	0.4484
26	34.86	34.85	34.85	0.0205	0.0208	0.1256
27	34.86	34.85	34.85	0.0358	0.0363	0.3413
28	34.85	34.83	34.84	0.0292	0.0299	0.2573
29	34.84	34.82	34.83	0.0140	0.0145	0.1773
30	34.87	34.86	34.86	0.0344	0.0341	0.3487
31	34.89	34.89	34.89	0.0681	0.0671	0.1944
32	34.86	34.85	34.86	0.0119	0.0123	0.1497
33	34.86	34.85	34.85	0.0294	0.0292	0.2459
34	34.88	34.87	34.87	0.0421	0.0428	0.3907
35	34.87	34.86	34.87	-0.0091	-0.0090	-0.0849
36	34.86	34.86	34.86	0.0209	0.0203	0.1982
37	34.90	34.89	34.89	0.0361	0.0334	0.3235
38	34.86	34.85	34.85	0.0193	0.0182	0.1854
39	34.85	34.84	34.84	-0.0074	-0.0102	-0.0147
40	34.87	34.86	34.87	-0.0239	-0.0235	-0.2324
41	34.89	34.88	34.89	-0.0279	-0.0236	-0.2368
42	34.85	34.83	34.84	-0.0224	-0.0228	-0.2439
43	34.85	34.83	34.84	-0.0224	-0.0228	-0.2439
44	34.88	34.87	34.87	-0.0550	-0.0538	-0.1481
45	34.84	34.82	34.82	-0.0229	-0.0224	-0.2107
46	34.84	34.83	34.83	-0.0265	-0.0256	-0.1760
47	34.84	34.83	34.83	-0.0275	-0.0267	-0.1875
48	34.83	34.80	34.81	-0.0269	-0.0182	-0.1344
49	34.77	34.76	34.76	0.0918	0.0842	0.3704
50	34.69	34.66	34.66	0.1091	0.1149	0.3385
51	34.74	34.71	34.72	0.1104	0.1153	0.3028
52	34.69	34.66	34.66	0.1163	0.1227	0.2161
53	34.63	34.62	34.62	0.1002	0.1064	0.3312
54	34.70	34.67	34.68	0.0916	0.0968	0.1924
55	34.70	34.67	34.68	0.0916	0.0968	0.1924
56	34.63	34.61	34.62	0.1054	0.1093	0.2191
57	34.66	34.62	34.63	0.1109	0.1161	0.2190
58	34.69	34.66	34.67	0.0711	0.0749	0.3080
59	34.81	34.80	34.80	0.0473	0.0502	0.3273
60	34.77	34.76	34.76	0.0655	0.0679	0.1963
61	34.77	34.75	34.75	0.0763	0.0792	0.2013
62	34.74	34.72	34.72	0.0930	0.0979	0.2351
63	34.75	34.73	34.73	0.0891	0.0930	0.2478
64	34.67	34.64	34.64	0.0822	0.0863	0.1952
65	34.70	34.67	34.68	0.0950	0.0997	0.2023
66	34.77	34.75	34.75	0.0881	0.0882	0.1915
67	34.75	34.73	34.74	0.0732	0.0754	0.1660
68	34.82	34.80	34.81	0.0995	0.1020	0.2080
69	34.75	34.73	34.74	0.0732	0.0754	0.1660
70	34.88	34.87	34.88	0.1702	0.1785	0.1340
71	34.80	34.79	34.79	0.0727	0.0775	0.1994
72	34.78	34.77	34.77	0.0678	0.0693	0.2330
73	34.77	34.75	34.75	0.0736	0.0761	0.2321
74	34.75	34.73	34.73	0.0542	0.0544	0.1757
75	34.75	34.73	34.74	0.0732	0.0754	0.1660
76	34.75	34.73	34.73	0.0692	0.0715	0.2168
77	34.82	34.81	34.81	0.0510	0.0533	0.3884
78	34.81	34.80	34.80	0.0209	0.0232	0.0871
79	34.83	34.82	34.82	0.0339	0.0328	0.1708
80	34.83	34.82	34.82	0.0333	0.0197	-0.0006
81	34.85	34.83	34.84	0.0113	0.0071	0.1667
82	34.80	34.78	34.79	0.0347	0.0347	0.2147
83	34.82	34.81	34.81	0.0491	0.0498	0.1793
84	34.83	34.81	34.82	0.0418	0.0426	0.2253
85	34.85	34.84	34.84	0.0727	0.0740	0.1601
86	34.87	34.86	34.87	0.0338	0.0366	0.1460

Box core number	Seafloor zonal velocity average for collection year m/s	Seafloor zonal velocity average for collection and previous year m/s	Seafloor meridional velocity 2008 m/s	Seafloor meridional velocity 2009 m/s	Seafloor meridional velocity 2010 m/s
1	0.0056	0.0051	-0.0039	-0.0052	0.0163
2	0.0056	0.0051	-0.0039	-0.0052	0.0163
3	0.0062	0.0057	-0.0045	-0.0059	0.0143
4	0.0561	0.0509	-0.0478	-0.0509	-0.3549
5	0.0794	0.0782	-0.0295	-0.0311	-0.2755
6	0.0596	0.0581	-0.0536	-0.0584	-0.1394
7	0.0646	0.0631	-0.0552	-0.0606	-0.1821
8	0.0807	0.0792	-0.0434	-0.0468	-0.3880
9	0.0233	0.0237	-0.0206	-0.0211	-0.3052
10	0.0240	0.0248	-0.0227	-0.0225	-0.2549
11	0.0149	0.0143	-0.0144	-0.0165	-0.0440
12	0.0406	0.0399	-0.0477	-0.0506	-0.2630
13	0.0298	0.0295	-0.0333	-0.0344	-0.2633
14	0.0700	0.0689	-0.0803	-0.0849	-0.1548
15	0.0493	0.0484	-0.0453	-0.0487	-0.3668
16	0.0493	0.0484	-0.0453	-0.0487	-0.3668
17	0.0654	0.0639	-0.0456	-0.0491	-0.3261
18	0.0540	0.0532	-0.0560	-0.0590	-0.3388
19	0.0105	0.0109	-0.0236	-0.0255	-0.1114
20	0.0288	0.0278	-0.0682	-0.0732	-0.3199
21	0.0695	0.0697	-0.0630	-0.0683	-0.4073
22	0.0195	0.0191	-0.0398	-0.0356	-0.1852
23	0.0408	0.0400	-0.0884	-0.0914	-0.2726
24	0.0541	0.0530	-0.0884	-0.0891	-0.4439
25	0.0449	0.0443	-0.1015	-0.1046	-0.2061
26	0.0208	0.0207	-0.0513	-0.0526	-0.4004
27	0.0363	0.0360	-0.1054	-0.1087	-0.2279
28	0.0299	0.0296	-0.0714	-0.0738	-0.2101
29	0.0145	0.0142	-0.0462	-0.0480	-0.3394
30	0.0341	0.0343	-0.1182	-0.1197	-0.2257
31	0.0671	0.0676	-0.1045	-0.1001	-0.1818
32	0.0123	0.0121	-0.0954	-0.0942	-0.2113
33	0.0292	0.0293	-0.1155	-0.1141	-0.2249
34	0.0428	0.0425	-0.1138	-0.1109	-0.2079
35	-0.0090	-0.0090	-0.1189	-0.1171	-0.2185
36	0.0203	0.0206	-0.1389	-0.1379	-0.2398
37	0.0334	0.0347	-0.1855	-0.1811	-0.2739
38	0.0182	0.0188	-0.1328	-0.1216	-0.2397
39	-0.0102	-0.0088	-0.0691	-0.0690	-0.2212
40	-0.0235	-0.0237	-0.0841	-0.0846	-0.3551
41	-0.0236	-0.0258	-0.1756	-0.1696	-0.2540
42	-0.0228	-0.0226	-0.0599	-0.0590	-0.3834
43	-0.0228	-0.0226	-0.0599	-0.0590	-0.3834
44	-0.0536	-0.0544	-0.0804	-0.0780	-0.2131
45	-0.0234	-0.0227	-0.0531	-0.0533	-0.3431
46	-0.0245	-0.0261	-0.0559	-0.0532	-0.3437
47	-0.0167	-0.0171	-0.0514	-0.0538	-0.3378
48	-0.0132	-0.0157	-0.0482	-0.0451	-0.3662
49	0.0842	0.0830	0.0242	0.0251	0.2439
50	0.1149	0.1120	-0.0017	-0.0013	-0.0049
51	0.1153	0.1128	0.0059	0.0108	0.1158
52	0.1227	0.1196	-0.0024	-0.0019	-0.0061
53	0.1264	0.1233	-0.0063	-0.0058	0.0422
54	0.0968	0.0942	-0.0004	-0.0001	0.0063
55	0.0968	0.0942	-0.0004	-0.0001	0.0063
56	0.1093	0.1073	-0.0030	-0.0043	-0.0018
57	0.1161	0.1135	-0.0038	-0.0031	0.0022
58	0.0749	0.0730	0.0018	0.0028	0.0305
59	0.0502	0.0488	0.0419	0.0426	0.2796
60	0.0679	0.0667	0.0228	0.0231	0.1510
61	0.0792	0.0778	0.0096	0.0094	0.0540
62	0.0979	0.0955	0.0168	0.0172	0.1751
63	0.0580	0.0956	0.0180	0.0183	0.1884
64	0.0863	0.0842	-0.0031	-0.0031	-0.0264
65	0.0997	0.0973	0.0014	0.0015	0.0143
66	0.0882	0.0882	0.0078	0.0101	0.1300
67	0.0754	0.0743	0.0134	0.0141	0.1168
68	0.1030	0.1007	0.0454	0.0468	0.3961
69	0.0754	0.0743	0.0134	0.0141	0.1168
70	0.1785	0.1743	0.0608	0.0623	0.4417
71	0.0775	0.0751	0.0463	0.0480	0.1075
72	0.0682	0.0665	0.0364	0.0369	0.1882
73	0.0741	0.0749	0.0310	0.0311	0.1691
74	0.0344	0.0343	-0.0037	-0.0045	-0.0731
75	0.0734	0.0743	0.0134	0.0141	0.1168
76	0.0715	0.0704	0.0135	0.0137	0.1059
77	0.0533	0.0511	0.0158	0.0134	0.1016
78	0.0302	0.0305	0.0073	0.0051	0.0015
79	0.0328	0.0333	0.0494	0.0509	0.0953
80	0.0197	0.0215	0.0118	0.0095	0.1092
81	0.0071	0.0092	-0.0077	-0.0122	-0.1425
82	0.0347	0.0347	0.0173	0.0161	0.0740
83	0.0458	0.0485	0.0375	0.0377	0.2744
84	0.0425	0.0422	0.0668	0.0678	0.0864
85	0.0740	0.0734	0.0601	0.0615	0.1066
86	0.0366	0.0362	0.0774	0.0794	0.1288

Box core number	Seafloor meridional velocity average for collection year m/s	Seafloor meridional velocity average for collection and previous year m/s	Seafloor absolute speed 2008 m/s	Seafloor absolute speed 2009 m/s	Seafloor absolute speed 2010 m/s
1	-0.0052	-0.0046	0.0061	0.0076	0.0291
2	-0.0052	-0.0046	0.0061	0.0076	0.0291
3	-0.0059	-0.0052	0.0068	0.0086	0.0257
4	-0.0509	-0.0494	0.0720	0.0798	0.3220
5	-0.0311	-0.0303	0.0824	0.0853	0.3556
6	-0.0584	-0.0560	0.0779	0.0834	0.2909
7	-0.0606	-0.0579	0.0827	0.0886	0.3032
8	-0.0468	-0.0451	0.0889	0.0933	0.4189
9	-0.0212	-0.0209	0.0316	0.0315	0.2993
10	-0.0225	-0.0226	0.0342	0.0329	0.3654
11	-0.0145	-0.0125	0.0199	0.0221	0.0448
12	-0.0506	-0.0491	0.0617	0.0649	0.4352
13	-0.0344	-0.0338	0.0442	0.0455	0.3421
14	-0.0849	-0.0826	0.1052	0.1100	0.3019
15	-0.0487	-0.0470	0.0657	0.0693	0.5382
16	-0.0487	-0.0470	0.0657	0.0693	0.5382
17	-0.0491	-0.0473	0.0773	0.0818	0.3705
18	-0.0590	-0.0575	0.0746	0.0800	0.3897
19	-0.0255	-0.0247	0.0295	0.0330	0.4151
20	-0.0731	-0.0712	0.0895	0.0938	0.4111
21	-0.0693	-0.0642	0.0835	0.0897	0.4586
22	-0.0526	-0.0347	0.0386	0.0406	0.3370
23	-0.0514	-0.0899	0.0946	0.1001	0.4692
24	-0.0891	-0.0878	0.1008	0.1043	0.6861
25	-0.1046	-0.1031	0.1105	0.1139	0.4935
26	-0.0526	-0.0511	0.0534	0.0566	0.4599
27	-0.1087	-0.1070	0.1113	0.1146	0.4104
28	-0.0738	-0.0726	0.0771	0.0796	0.3840
29	-0.0490	-0.0486	0.0502	0.0511	0.2931
30	-0.1197	-0.1189	0.1231	0.1244	0.4162
31	-0.1001	-0.1023	0.1047	0.1105	0.2662
32	-0.0942	-0.0948	0.0961	0.0950	0.2590
33	-0.1141	-0.1148	0.1191	0.1178	0.3332
34	-0.1109	-0.1124	0.1214	0.1189	0.4435
35	-0.1171	-0.1180	0.1192	0.1174	0.2344
36	-0.1379	-0.1384	0.1404	0.1384	0.3111
37	-0.1811	-0.1833	0.1890	0.1842	0.4239
38	-0.1216	-0.1222	0.1243	0.1230	0.3031
39	-0.0690	-0.0691	0.0695	0.0688	0.2217
40	-0.0846	-0.0844	0.0874	0.0878	0.3451
41	-0.1696	-0.1726	0.1778	0.1713	0.3472
42	-0.0590	-0.0595	0.0640	0.0633	0.4544
43	-0.0590	-0.0595	0.0640	0.0633	0.4544
44	-0.0720	-0.0732	0.0874	0.0847	0.2593
45	-0.0515	-0.0518	0.0578	0.0571	0.3330
46	-0.0538	-0.0543	0.0620	0.0614	0.3697
47	-0.0538	-0.0546	0.0618	0.0601	0.3731
48	-0.0431	-0.0456	0.0594	0.0480	0.3481
49	0.0232	0.0247	0.0833	0.0878	0.4548
50	-0.0013	-0.0015	0.1091	0.1149	0.2085
51	0.0108	0.0104	0.1109	0.1158	0.2335
52	-0.0019	-0.0022	0.1165	0.1227	0.2162
53	-0.0058	-0.0061	0.1204	0.1265	0.2350
54	-0.0001	-0.0002	0.0916	0.0968	0.1935
55	-0.0001	-0.0002	0.0916	0.0968	0.1935
56	-0.0043	-0.0046	0.1055	0.1094	0.2191
57	-0.0031	-0.0035	0.1109	0.1161	0.2190
58	0.0028	0.0023	0.0712	0.0750	0.3095
59	0.0426	0.0423	0.0632	0.0658	0.4305
60	0.0231	0.0229	0.0694	0.0718	0.2477
61	0.0094	0.0095	0.0769	0.0798	0.2085
62	0.0172	0.0170	0.0945	0.0994	0.2931
63	0.0185	0.0183	0.0948	0.0997	0.3112
64	-0.0031	-0.0031	0.0823	0.0863	0.1969
65	0.0015	0.0014	0.0950	0.0987	0.2038
66	0.0101	0.0089	0.0694	0.0888	0.2260
67	0.0141	0.0137	0.0744	0.0767	0.2089
68	0.0468	0.0461	0.1093	0.1123	0.4474
69	0.0141	0.0137	0.0744	0.0767	0.2089
70	0.0633	0.0616	0.1807	0.1891	0.6830
71	0.0468	0.0461	0.0862	0.0901	0.2385
72	0.0469	0.0466	0.0799	0.0794	0.2996
73	0.0311	0.0311	0.0799	0.0832	0.2830
74	-0.0045	-0.0041	0.0543	0.0545	0.2857
75	0.0141	0.0137	0.0744	0.0767	0.2089
76	0.0137	0.0136	0.0705	0.0728	0.2440
77	0.0134	0.0136	0.0534	0.0555	0.4015
78	0.0031	0.0062	0.0221	0.0208	0.0871
79	0.0509	0.0502	0.0599	0.0605	0.1956
80	0.0095	0.0107	0.0261	0.0219	0.1092
81	-0.0122	-0.0099	0.0136	0.0141	0.2159
82	0.0161	0.0167	0.0387	0.0383	0.2271
83	0.0377	0.0376	0.0618	0.0625	0.3173
84	0.0678	0.0673	0.0788	0.0800	0.2413
85	0.0615	0.0608	0.0843	0.0863	0.1913
86	0.0754	0.0784	0.0842	0.0825	0.1437

Box core number	Seafloor absolute speed average for collection year m/s	Seafloor absolute speed average for collection and previous year m/s	10 year max seafloor absolute speed m/s	10 year average seafloor absolute speed m/s	MODIS surface Chlora 2008 mg/m^3
1	0.0076	0.0069	0.0534	0.0246	0.909
2	0.0076	0.0069	0.0534	0.0246	0.909
3	0.0086	0.0077	0.0557	0.0244	0.902
4	0.0758	0.0739	0.1519	0.1074	0.728
5	0.0853	0.0838	0.1721	0.1306	0.810
6	0.0834	0.0807	0.1796	0.1385	0.686
7	0.0886	0.0856	0.1765	0.1322	0.707
8	0.0933	0.0911	0.1667	0.1171	0.655
9	0.0315	0.0316	0.0946	0.0408	0.878
10	0.0329	0.0336	0.0951	0.0415	0.858
11	0.0222	0.0210	0.0696	0.0228	1.067
12	0.0649	0.0633	0.1464	0.0906	0.705
13	0.0455	0.0449	0.1186	0.0552	0.766
14	0.1100	0.1076	0.1807	0.1486	0.655
15	0.0693	0.0675	0.1358	0.0877	0.774
16	0.0693	0.0675	0.1358	0.0877	0.774
17	0.0818	0.0796	0.1713	0.1320	0.691
18	0.0800	0.0783	0.1656	0.1319	0.675
19	0.0330	0.0317	0.0859	0.0375	0.759
20	0.0928	0.0917	0.1906	0.1370	0.709
21	0.0897	0.0876	0.1815	0.1280	0.703
22	0.0406	0.0396	0.1008	0.0445	0.896
23	0.1001	0.0984	0.2058	0.1657	0.689
24	0.1043	0.1025	na	na	0.696
25	0.1139	0.1122	0.2364	0.1629	0.694
26	0.0566	0.0560	0.1275	0.0661	0.723
27	0.1146	0.1129	0.2477	0.1566	0.674
28	0.0796	0.0784	0.1834	0.1195	0.683
29	0.0511	0.0506	0.1465	0.0668	0.665
30	0.1244	0.1238	0.2524	0.1869	0.657
31	0.1205	0.1216	0.2380	0.1751	0.675
32	0.0930	0.0956	0.2180	0.1608	0.653
33	0.1178	0.1185	0.3043	0.2438	0.666
34	0.1189	0.1201	0.2596	0.1914	0.677
35	0.1174	0.1183	0.2305	0.1674	0.646
36	0.1394	0.1399	0.3356	0.2784	0.654
37	0.1842	0.1866	0.3608	0.2688	0.694
38	0.1230	0.1236	0.3503	0.2726	0.699
39	0.0698	0.0696	0.1480	0.1069	0.673
40	0.0878	0.0876	0.1911	0.1175	0.656
41	0.1713	0.1745	0.1647	0.2009	0.651
42	0.0633	0.0636	0.1461	0.1079	0.654
43	0.0633	0.0636	na	na	0.654
44	0.0947	0.0961	0.1450	0.1069	0.655
45	0.0571	0.0574	0.1364	0.1048	0.638
46	0.0564	0.0582	0.1468	0.1048	0.635
47	0.0601	0.0610	0.1464	0.1053	0.636
48	0.0490	0.0497	0.1303	0.0853	0.681
49	0.0878	0.0866	0.2104	0.1456	0.705
50	0.1149	0.1130	0.2907	0.1777	0.698
51	0.1138	0.1133	0.2484	0.1538	0.693
52	0.1227	0.1196	0.3017	0.1873	0.705
53	0.1265	0.1235	0.3154	0.1968	0.719
54	0.0968	0.0942	0.1914	0.1219	0.718
55	0.0968	0.0942	0.1914	0.1219	0.718
56	0.1094	0.1074	0.2641	0.1635	0.765
57	0.1161	0.1135	0.2881	0.1789	0.740
58	0.0750	0.0731	0.1947	0.1051	0.746
59	0.0658	0.0645	0.1524	0.1145	0.735
60	0.0718	0.0706	0.1438	0.1149	0.713
61	0.0758	0.0784	0.1656	0.1162	0.711
62	0.0994	0.0970	0.2158	0.1401	0.700
63	0.0997	0.0973	0.2155	0.1401	0.700
64	0.0863	0.0843	0.2008	0.1262	0.713
65	0.0997	0.0973	0.2439	0.1465	0.650
66	0.0888	0.0886	0.1593	0.0978	0.694
67	0.0767	0.0756	0.1606	0.1077	0.720
68	0.1123	0.1108	0.1886	0.1414	0.672
69	0.0767	0.0756	0.1611	0.1080	0.720
70	0.1891	0.1849	0.2063	0.1531	0.663
71	0.0901	0.0881	0.1768	0.1425	0.772
72	0.0784	0.0777	0.1908	0.1495	0.748
73	0.0832	0.0811	0.2085	0.1558	0.757
74	0.0545	0.0544	0.1263	0.0830	0.664
75	0.0767	0.0756	0.1613	0.1081	0.720
76	0.0728	0.0717	0.1734	0.1211	0.705
77	0.0555	0.0544	0.1266	0.0857	0.778
78	0.0208	0.0215	0.1068	0.0537	0.942
79	0.0605	0.0602	0.1446	0.1102	0.888
80	0.0219	0.0240	0.1125	0.0559	0.890
81	0.0141	0.0139	0.0975	0.0440	0.844
82	0.0383	0.0385	0.1445	0.0609	1.141
83	0.0625	0.0621	0.1427	0.0905	0.949
84	0.0800	0.0794	0.1760	0.1333	0.779
85	0.0563	0.0553	0.1681	0.1187	0.787
86	0.0875	0.0863	0.1935	0.1478	0.763

Box core number	MODIS surface Chloro a 2009 mg/m³	MODIS surface Chloro a 2010 mg/m³	MODIS surface Chloro a average for collection year mg/m³	MODIS surface Chloro a average for collection and previous year mg/m³	MODIS surface POC 2008 mg/m³
1	0.766	1.076	0.766	0.837	143.84
2	0.766	1.076	0.766	0.837	143.84
3	0.765	1.070	0.765	0.834	143.48
4	0.851	0.971	0.851	0.789	129.33
5	0.861	0.917	0.861	0.835	131.16
6	0.719	0.939	0.719	0.702	128.45
7	0.673	0.866	0.673	0.690	125.08
8	0.826	0.970	0.826	0.741	134.63
9	0.729	0.961	0.729	0.804	137.94
10	0.739	0.964	0.739	0.798	137.46
11	0.748	1.079	0.748	0.907	134.53
12	0.746	0.921	0.746	0.726	134.96
13	0.711	1.015	0.711	0.739	131.28
14	0.803	0.931	0.803	0.729	133.06
15	0.760	1.109	0.760	0.767	135.84
16	0.760	1.109	0.760	0.767	135.84
17	0.804	0.979	0.804	0.747	135.17
18	0.763	0.924	0.763	0.721	132.33
19	0.721	0.984	0.721	0.740	130.81
20	0.746	0.882	0.746	0.718	135.17
21	0.807	0.867	0.807	0.755	136.39
22	0.737	0.948	0.737	0.746	134.96
23	0.734	0.950	0.734	0.741	134.73
24	0.694	0.977	0.694	0.695	134.03
25	0.745	0.977	0.745	0.715	127.33
26	0.739	0.971	0.739	0.738	134.96
27	0.696	1.009	0.696	0.685	132.60
28	0.675	0.974	0.675	0.679	133.97
29	0.758	0.972	0.758	0.712	132.50
30	0.717	0.980	0.717	0.687	131.30
31	0.702	1.125	0.702	0.689	132.47
32	0.713	0.968	0.713	0.683	130.66
33	0.662	1.049	0.662	0.664	132.80
34	0.708	1.045	0.708	0.692	132.75
35	0.689	0.971	0.689	0.667	130.14
36	0.661	1.015	0.661	0.657	130.28
37	0.644	1.113	0.644	0.669	132.93
38	0.633	1.048	0.633	0.661	134.08
39	0.711	0.982	0.711	0.692	132.99
40	0.651	1.031	0.651	0.654	129.25
41	0.655	0.987	0.655	0.653	130.33
42	0.710	0.957	0.710	0.662	131.04
43	0.710	0.957	0.710	0.662	131.04
44	0.689	0.866	0.689	0.671	132.17
45	0.643	0.842	0.643	0.645	129.70
46	0.645	0.837	0.645	0.640	129.89
47	0.636	0.825	0.636	0.646	129.84
48	0.843	0.845	0.843	0.637	129.47
49	1.071	0.876	1.071	0.888	129.18
50	1.258	0.868	1.258	0.978	129.27
51	1.102	0.864	1.102	0.898	127.69
52	1.342	0.850	1.342	0.974	129.69
53	1.086	0.822	1.086	0.902	131.49
54	1.154	0.845	1.154	0.936	130.58
55	1.154	0.845	1.154	0.936	130.58
56	1.189	0.851	1.189	0.977	134.67
57	1.178	0.830	1.178	0.959	133.42
58	1.134	0.839	1.134	0.940	132.89
59	1.330	0.894	1.330	1.027	130.44
60	1.513	0.948	1.513	1.113	143.26
61	0.988	0.934	0.988	0.850	132.21
62	1.077	0.864	1.077	0.888	128.59
63	1.077	0.864	1.077	0.888	128.59
64	1.182	0.846	1.182	0.948	130.22
65	1.126	0.822	1.126	0.903	134.34
66	0.974	0.857	0.974	0.829	127.48
67	0.880	0.872	0.880	0.800	131.25
68	0.711	0.988	0.711	0.692	177.59
69	0.880	0.872	0.880	0.800	131.25
70	0.954	0.848	0.954	0.806	135.05
71	1.491	0.886	1.491	1.101	132.29
72	1.044	0.934	1.044	0.881	133.96
73	1.053	0.938	1.053	0.896	137.27
74	0.877	0.876	0.877	0.771	133.62
75	0.880	0.872	0.880	0.800	131.25
76	0.935	0.924	0.935	0.815	130.22
77	1.349	0.996	1.349	1.063	133.63
78	0.988	1.031	0.988	0.955	133.50
79	1.523	0.998	1.523	1.206	135.07
80	0.933	1.055	0.933	0.941	129.84
81	0.926	0.970	0.926	0.885	129.80
82	1.118	1.039	1.118	1.129	143.67
83	1.086	1.034	1.086	1.017	134.15
84	1.034	0.971	1.034	0.901	131.64
85	0.876	1.037	0.876	0.831	127.61
86	0.886	1.041	0.886	0.825	127.38

Box core number	MODIS surface POC 2009 mg/m³	MODIS surface POC 2010 mg/m³	MODIS surface POC average for collection year mg/m³	MODIS surface POC average for collection and previous year mg/m³	Lutz et al. 2002 NE Atlantic uncorrected POC at depth mg/m³
1	131.15	160.16	131.15	137.50	0.893
2	131.15	160.16	131.15	137.50	0.893
3	131.47	159.98	131.47	137.48	0.850
4	149.01	153.69	149.01	139.17	0.016
5	136.56	155.48	149.01	133.86	0.007
6	144.50	148.26	136.47	136.47	0.005
7	125.30	167.57	125.19	125.19	0.005
8	207.70	153.91	166.17	166.17	0.025
9	131.17	151.08	134.56	134.56	0.105
10	131.96	151.56	131.96	134.71	0.099
11	130.81	164.78	130.81	132.67	0.519
12	131.96	148.37	131.96	128.46	0.114
13	133.23	161.53	133.23	132.26	0.185
14	160.18	150.28	160.18	141.62	0.024
15	235.08	167.12	235.08	200.46	0.060
16	235.08	167.12	235.08	200.46	0.060
17	176.96	156.94	176.96	156.06	0.011
18	133.79	148.27	133.79	128.06	0.050
19	129.28	151.88	129.28	130.04	0.408
20	131.81	146.81	131.81	128.99	0.008
21	133.46	143.60	133.46	128.82	0.006
22	128.98	151.96	128.98	126.67	0.465
23	131.57	151.49	131.57	128.15	0.043
24	131.31	158.18	131.31	127.87	0.006
25	131.95	151.82	131.95	129.94	0.065
26	150.20	153.86	150.20	137.26	0.427
27	133.93	159.39	133.93	128.26	0.015
28	130.04	153.21	130.04	127.01	0.121
29	132.85	156.19	132.85	127.68	0.369
30	131.57	157.35	131.57	126.93	0.060
31	137.61	150.34	137.61	130.04	0.005
32	130.72	154.67	130.72	125.69	0.192
33	128.63	166.50	128.63	125.72	0.009
34	134.21	166.31	134.21	128.48	0.016
35	129.07	154.68	129.07	124.60	0.193
36	127.67	160.94	127.67	123.98	0.014
37	127.63	155.53	127.63	125.28	0.005
38	124.88	167.97	124.88	124.48	0.005
39	129.09	155.46	129.09	126.04	0.074
40	127.65	166.13	127.65	123.45	0.008
41	126.51	155.93	126.51	123.42	0.047
42	129.40	153.73	129.40	125.22	0.167
43	129.40	153.73	129.40	125.22	0.169
44	127.38	155.40	127.38	124.83	0.005
45	126.55	154.10	126.55	123.13	0.112
46	125.64	151.35	125.64	124.77	0.006
47	131.27	151.05	131.27	125.56	0.006
48	130.02	157.77	130.02	124.74	0.435
49	141.45	140.69	141.45	135.17	0.006
50	168.40	141.35	168.40	148.84	0.006
51	141.66	140.23	141.66	134.68	0.007
52	139.78	141.39	139.78	144.74	0.006
53	137.67	139.41	137.67	134.58	0.006
54	146.03	140.91	146.03	138.30	0.433
55	146.03	140.91	146.03	138.30	0.433
56	148.89	144.03	148.89	141.88	0.070
57	147.20	141.45	147.20	140.31	0.010
58	155.97	141.58	155.97	144.43	0.713
59	142.58	143.76	142.58	136.51	0.056
60	148.56	142.99	148.56	145.91	0.441
61	139.23	144.94	139.23	135.72	0.184
62	140.50	139.93	140.50	134.55	0.006
63	140.50	139.93	140.50	134.55	0.006
64	145.36	140.44	145.36	137.79	0.366
65	145.88	140.91	145.88	135.11	0.030
66	137.99	140.91	137.99	132.73	0.443
67	132.60	140.13	132.60	131.92	0.307
68	114.90	143.71	114.90	146.24	0.038
69	132.60	140.13	132.60	131.92	0.301
70	133.41	139.38	133.41	129.23	0.012
71	151.26	144.70	151.26	141.78	0.011
72	136.15	145.28	136.15	135.08	0.006
73	130.51	143.05	130.51	133.88	0.005
74	130.46	138.99	130.46	137.04	0.515
75	132.60	140.13	132.60	131.92	0.299
76	135.96	143.82	135.96	133.06	0.154
77	147.85	151.03	147.85	140.64	0.030
78	139.07	157.78	139.07	136.29	0.041
79	150.82	158.64	150.82	162.95	0.048
80	134.92	164.21	134.92	132.38	0.055
81	132.09	150.73	132.09	130.95	0.017
82	143.09	156.74	143.09	143.38	0.011
83	140.87	154.53	140.87	137.51	0.018
84	142.64	150.94	142.64	137.14	0.008
85	136.32	158.23	136.32	131.96	0.024
86	141.77	163.98	141.77	134.53	0.048

Box core number	Lutz et al. 2002 NE Atlantic radionuclide corrected POC at depth mg/m²	Lutz et al. 2002 Sargasso uncorrected POC at depth mg/m²	Lutz et al. 2002 Sargasso radionuclide corrected POC at depth mg/m²	Sediment total carbon %
1	7.874	7.501	0.256	ns
2	7.874	7.501	0.256	ns
3	7.924	7.747	0.274	ns
4	0.702	0.694	0.007	3.29
5	0.364	0.275	0.006	3.12
6	0.078	0.098	0.006	3.09
7	0.046	0.068	0.006	2.72
8	1.073	1.051	0.009	ns
9	2.374	2.314	0.026	3.91
10	2.302	2.244	0.025	3.52
11	5.968	5.838	0.157	3.81
12	2.440	2.379	0.028	4.10
13	3.281	3.198	0.047	3.84
14	0.954	0.937	0.009	4.39
15	2.034	1.977	0.015	ns
16	2.034	1.977	0.015	3.89
17	0.548	0.545	0.007	3.20
18	1.483	1.450	0.014	4.28
19	5.112	4.989	0.116	3.78
20	0.859	0.895	0.006	3.56
21	0.172	0.187	0.006	3.95
22	5.496	5.368	0.136	4.00
23	1.349	1.320	0.012	3.26
24	0.174	0.190	0.006	3.92
25	1.756	1.744	0.017	4.83
26	5.377	5.246	0.121	4.32
27	0.843	0.840	0.007	5.33
28	2.526	2.463	0.030	4.38
29	4.758	4.671	0.103	4.30
30	1.666	1.627	0.016	5.77
31	0.085	0.105	0.006	5.27
32	3.277	3.195	0.049	4.90
33	0.398	0.403	0.007	6.17
34	0.682	0.676	0.008	6.61
35	3.376	3.195	0.050	5.02
36	0.611	0.608	0.007	5.59
37	0.036	0.059	0.006	1.46
38	0.132	0.149	0.006	5.09
39	1.678	1.633	0.019	5.02
40	0.332	0.340	0.006	3.87
41	1.413	1.382	0.013	5.76
42	3.017	2.942	0.042	4.90
43	3.033	2.958	0.043	5.44
44	0.047	0.069	0.006	5.85
45	2.372	2.314	0.033	6.99
46	0.149	0.165	0.006	ns
47	0.158	0.174	0.006	4.47
48	5.301	5.078	0.136	5.60
49	0.432	0.168	0.006	ns
50	0.329	0.183	0.006	2.31
51	0.269	0.300	0.006	2.30
52	0.209	0.222	0.006	2.36
53	0.151	0.187	0.006	2.91
54	5.358	5.238	0.119	ns
55	5.358	5.238	0.119	ns
56	1.930	1.872	0.018	ns
57	0.469	0.471	0.007	2.51
58	7.333	7.169	0.210	0.68
59	1.652	1.613	0.015	2.46
60	2.991	2.854	0.035	2.08
61	3.301	3.217	0.046	2.00
62	0.210	0.223	0.006	ns
63	0.211	0.234	0.006	2.46
64	4.929	4.808	0.101	ns
65	1.104	1.082	0.010	ns
66	5.388	5.269	0.127	1.28
67	4.371	4.269	0.083	1.65
68	1.322	1.292	0.011	ns
69	4.324	4.217	0.081	1.83
70	0.516	0.516	0.007	2.91
71	0.484	0.485	0.007	2.62
72	0.217	0.230	0.006	2.85
73	0.101	0.130	0.006	1.49
74	5.833	5.698	0.157	1.17
75	4.511	4.395	0.080	1.72
76	3.374	3.289	0.049	2.77
77	1.111	1.089	0.010	3.52
78	1.355	1.334	0.012	2.62
79	1.653	1.582	0.013	2.85
80	1.610	1.572	0.015	3.36
81	0.731	0.733	0.008	3.36
82	0.872	0.858	0.008	3.04
83	0.776	0.766	0.008	2.87
84	0.164	0.179	0.006	3.10
85	0.592	0.516	0.009	2.79
86	0.773	0.764	0.008	2.84

Box core number	Sediment organic carbon %	Sediment inorganic carbon %	Sediment clay %	Sediment silt %	Sediment sand %	Shannon sediment PSD	Within NAFO closure as of 29-11-16?	Species in box core?	Porifera in density Kenchington et al. 2014 kg/km²
1	ns	ns	ns	ns	ns	ns	N	ns	0.080
2	ns	ns	ns	ns	ns	ns	N	ns	0.079
3	ns	ns	ns	ns	ns	ns	N	ns	0.081
4	0.41	2.88	26.95	55.59	17.43	2.13	N	Y	1.450
5	0.42	2.70	27.15	70.79	2.06	1.93	N	N	0.000
6	0.37	2.72	29.44	62.08	8.45	2.07	Y	Y	1.698
7	0.34	2.48	13.99	33.83	52.18	2.26	N	Y	0.000
8	ns	ns	ns	ns	ns	ns	Y	ns	2.236
9	0.36	3.36	28.62	55.14	16.20	2.16	N	Y	0.149
10	0.34	3.28	17.14	52.39	30.47	2.17	N	N	0.150
11	0.41	3.40	19.97	61.01	19.06	2.08	N	Y	0.053
12	0.35	3.85	18.42	53.07	28.49	2.15	N	Y	0.333
13	0.30	3.34	18.68	55.78	25.55	2.14	N	Y	1.031
14	0.33	4.06	22.76	52.16	25.13	2.20	Y	Y	5.318
15	ns	ns	ns	ns	ns	ns	N	ns	0.471
16	0.34	3.55	26.35	52.05	21.59	2.20	N	Y	0.471
17	0.64	2.56	40.10	59.88	0.00	1.83	Y	N	1.169
18	0.25	4.03	17.24	49.40	33.35	2.15	N	Y	2.413
19	0.32	3.46	16.45	56.13	27.42	2.08	N	Y	0.020
20	0.17	1.39	8.34	20.84	69.82	2.14	Y	Y	0.474
21	0.44	3.81	4.04	7.73	88.17	1.75	Y	Y	0.085
22	0.33	4.97	18.48	58.35	23.14	2.09	N	Y	0.208
23	0.29	4.97	13.33	48.56	38.10	2.09	N	Y	0.849
24	0.32	3.70	7.89	15.39	77.02	2.17	N	ns	0.091
25	0.28	4.55	15.55	43.17	40.88	2.27	N	ns	0.334
26	0.31	4.01	17.22	58.64	24.14	2.04	N	ns	0.028
27	0.21	5.14	7.24	12.04	80.72	2.12	N	ns	3.371
28	0.27	4.11	12.34	42.11	45.55	2.16	N	ns	0.024
29	0.29	4.01	15.34	51.52	33.14	2.03	N	ns	1.748
30	0.28	5.49	17.13	52.06	30.81	2.10	Y	ns	16.872
31	0.19	5.08	10.43	19.27	70.30	2.12	Y	Y	7.184
32	0.27	4.63	9.07	14.62	76.31	2.08	N	ns	15.569
33	0.21	5.96	8.04	12.21	79.74	2.10	Y	Y	19.255
34	0.27	6.34	8.68	11.65	79.67	1.96	Y	ns	19.897
35	0.30	4.72	18.43	58.22	23.34	2.10	N	Y	20.944
36	0.22	5.37	9.29	15.11	75.60	2.14	Y	N	22.573
37	0.15	1.31	8.03	7.29	84.68	1.64	N	Y	0.249
38	0.20	4.89	8.33	28.53	63.14	1.83	N	Y	2.661
39	0.40	4.62	22.05	38.16	39.79	2.01	Y	ns	13.663
40	0.17	3.70	4.97	29.56	65.47	1.73	Y	Y	13.339
41	0.33	5.43	9.49	24.31	66.20	2.15	Y	Y	31.946
42	0.42	4.48	11.02	44.48	44.50	2.32	Y	ns	8.367
43	0.60	4.84	11.03	49.84	39.13	2.29	Y	ns	8.385
44	0.23	5.72	6.72	4.13	78.75	1.96	Y	Y	1.993
45	0.27	6.72	4.13	18.66	77.21	1.94	Y	Y	1.472
46	ns	ns	ns	ns	ns	ns	N	ns	0.716
47	0.23	4.34	10.33	36.72	52.95	1.93	N	Y	0.755
48	0.57	5.03	13.70	59.13	28.17	2.23	N	ns	0.563
49	ns	ns	ns	ns	ns	ns	N	ns	0.085
50	0.48	2.33	20.14	74.72	5.14	1.52	N	Y	0.015
51	0.32	1.98	14.49	68.22	17.29	1.89	N	Y	0.017
52	0.30	2.36	21.55	72.44	6.01	1.96	N	Y	0.007
53	0.53	2.38	21.92	71.72	6.36	1.97	N	Y	0.000
54	ns	ns	ns	ns	ns	ns	N	ns	0.048
55	ns	ns	ns	ns	ns	ns	N	ns	0.048
56	ns	ns	ns	ns	ns	ns	N	ns	0.006
57	0.49	2.02	21.35	67.31	11.34	2.00	N	Y	0.004
58	0.11	0.57	2.63	5.53	91.84	1.75	N	N	0.027
59	0.49	1.97	19.08	65.38	15.53	2.04	N	Y	4.952
60	0.36	1.72	19.54	60.47	19.99	2.00	N	Y	4.641
61	0.39	1.61	14.17	56.75	29.08	1.98	N	N	3.154
62	ns	ns	ns	ns	ns	ns	N	ns	0.078
63	0.44	2.02	18.86	66.32	14.82	2.00	N	Y	0.079
64	ns	ns	ns	ns	ns	ns	N	Y	0.054
65	ns	ns	ns	ns	ns	ns	N	ns	0.039
66	ns	ns	ns	ns	ns	ns	N	ns	0.036
67	0.21	1.07	4.17	14.58	81.25	2.11	N	Y	0.056
68	0.29	1.36	8.30	45.33	46.37	2.03	N	Y	7.081
69	ns	ns	ns	ns	ns	ns	N	ns	0.057
70	0.34	1.48	12.33	51.50	36.16	2.24	N	Y	0.375
71	0.50	2.41	19.36	75.31	5.33	1.92	N	Y	12.037
72	0.45	2.17	21.46	70.06	8.48	1.99	Y	Y	4.618
73	0.54	2.31	25.06	70.61	4.33	1.97	Y	Y	6.400
74	0.36	1.13	11.39	41.11	47.50	2.24	N	ns	0.056
75	0.34	0.93	5.51	17.34	77.15	2.17	N	Y	0.057
76	0.38	1.34	12.04	53.13	34.73	1.91	N	Y	0.450
77	0.34	1.43	14.73	65.97	19.30	2.04	Y	N	4.482
78	0.20	3.32	12.72	54.44	32.84	1.99	Y	Y	0.050
79	0.31	3.31	14.17	67.62	18.21	1.97	N	Y	8.957
80	0.32	3.54	13.82	72.98	13.20	1.87	Y	Y	0.033
81	0.48	2.88	23.24	64.98	11.78	2.06	N	Y	0.084
82	0.55	2.49	21.75	70.90	7.35	1.98	N	Y	1.260
83	0.35	2.52	16.32	55.37	28.31	2.08	N	Y	0.211
84	0.74	2.36	21.09	59.21	19.70	2.21	Y	Y	7.108
85	0.27	2.52	11.88	58.05	30.07	2.09	Y	Y	2.879
86	0.40	2.24	23.18	71.57	5.26	1.95	N	N	12.116

Box core number	Pennatulacean density Kenchington et al. 2014 kg/km²	Gorgonian density Kenchington et al. 2014 kg/km²	Demosponge reletive biomass	Pennatulacean reletive biomass	Gorgonian reletive biomass	Geological environment
1	0.008	0.000	0.610	0.412	0.050	iceberg scours
2	0.008	0.000	0.607	0.413	0.050	iceberg scours
3	0.008	0.000	0.739	0.380	0.169	iceberg scours
4	0.001	0.000	2.318	0.107	0.036	draped over gullies
5	0.000	0.000	0.234	0.030	0.003	draped over MTDs
6	0.000	0.000	5.672	0.285	0.041	draped over MTDs
7	0.000	0.000	2.816	0.089	0.127	draped over MTDs
8	0.000	0.000	3.615	0.089	0.019	draped over failed seabed
9	0.006	0.000	0.853	0.425	0.003	draped over failed seabed
10	0.006	0.000	0.729	0.396	0.004	draped over failed seabed
11	0.003	0.000	0.310	0.489	0.000	smooth areas
12	0.002	0.000	0.315	0.255	0.009	smooth areas
13	0.004	0.000	0.877	0.457	0.001	smooth areas
14	0.000	0.000	3.234	0.100	0.001	draped over failed seabed
15	0.001	0.000	1.838	0.091	0.001	draped over gullies
16	0.001	0.000	1.338	0.080	0.001	draped over gullies
17	0.000	0.000	6.913	0.048	0.048	draped over gullies
18	0.001	0.000	1.159	0.117	0.007	smooth areas
19	0.007	0.000	0.252	0.229	0.009	draped over failed seabed
20	0.000	0.000	13.507	0.056	0.028	draped over failed seabed
21	0.000	0.000	15.015	0.053	0.025	draped over failed seabed
22	0.005	0.000	0.239	0.150	0.005	iceberg pits
23	0.000	0.000	8.036	0.086	0.018	draped over failed seabed
24	0.000	0.000	33.558	0.095	0.220	rough topography of MTDs
25	0.000	0.000	4.555	0.070	0.009	draped over failed seabed
26	0.003	0.000	0.246	0.161	0.004	smooth areas
27	0.000	0.000	33.852	0.058	0.089	rough topography of MTDs
28	0.001	0.000	1.220	0.114	0.009	draped over failed seabed
29	0.004	0.000	0.377	0.162	0.004	smooth areas
30	0.001	0.000	14.413	0.059	0.022	rough topography of MTDs
31	0.000	0.000	33.547	0.061	0.083	steep flanks>6.4deg
32	0.003	0.000	5.114	0.091	0.147	smooth areas
33	0.000	0.000	37.540	0.066	0.013	rough topography of MTDs
34	0.000	0.000	31.594	0.054	0.015	rough topography of MTDs
35	0.002	0.001	3.569	0.099	0.017	smooth areas
36	0.000	0.001	38.980	0.072	0.050	rough topography of MTDs
37	0.000	0.000	39.420	0.058	0.081	steep flanks>6.4deg
38	0.000	0.000	39.650	0.048	0.075	rough topography of MTDs
39	0.000	0.000	38.848	0.145	0.033	failed seabed mixed
40	0.000	0.054	31.301	0.061	0.147	failed seabed mixed
41	0.000	0.033	35.043	0.061	0.041	smooth areas
42	0.000	0.000	27.396	0.060	0.035	draped over MTDs
43	0.000	0.000	27.347	0.061	0.035	draped over MTDs
44	0.000	0.003	18.929	0.043	0.092	canyon head>400m wallls
45	0.001	0.007	16.122	0.068	0.030	failed seabed mixed
46	0.000	0.005	15.736	0.026	0.289	inter canyon area
47	0.001	0.004	15.914	0.043	0.188	inter canyon area
48	0.001	0.000	19.265	0.093	0.287	failed seabed mixed
49	0.000	0.000	2.679	0.059	0.016	failed seabed stepped
50	0.000	0.000	1.304	0.115	0.001	inter canyon area
51	0.000	0.000	0.119	0.034	0.004	inter canyon area
52	0.000	0.000	2.363	0.173	0.014	inter canyon area
53	0.000	0.000	2.593	0.316	0.011	gullies cutting smooth areas
54	0.000	0.000	0.296	0.075	0.005	gullies cutting smooth areas
55	0.000	0.000	0.295	0.075	0.005	gullies cutting smooth areas
56	0.000	0.000	0.648	0.041	0.012	gullies cutting smooth areas
57	0.000	0.000	1.223	0.043	0.002	gullies cutting smooth areas
58	0.000	0.000	0.285	0.075	0.005	iceberg pits
59	0.000	0.000	0.174	0.056	0.000	failed seabed stepped
60	0.000	0.000	0.109	0.093	0.012	draped over failed seabed
61	0.000	0.000	0.329	0.045	0.003	draped over failed seabed
62	0.000	0.000	1.080	0.075	0.010	failed seabed stepped
63	0.000	0.000	1.331	0.074	0.005	failed seabed stepped
64	0.000	0.000	0.367	0.070	0.005	inter canyon area
65	0.000	0.000	0.173	0.036	0.001	inter canyon area
66	0.000	0.000	0.475	0.066	0.001	inter canyon area
67	0.000	0.000	0.275	0.075	0.000	smooth areas
68	0.000	0.000	0.332	0.075	0.000	failed seabed stepped
69	0.000	0.000	0.248	0.066	0.000	smooth areas
70	0.000	0.000	0.338	0.066	0.000	gullies associated with failed seabed
71	0.000	0.000	1.352	0.108	0.002	failed seabed stepped
72	0.000	0.000	5.350	0.201	0.018	failed seabed stepped
73	0.000	0.000	5.034	0.185	0.028	gullies associated with failed seabed
74	0.000	0.000	0.341	0.078	0.000	draped over failed seabed
75	0.000	0.000	0.340	0.065	0.001	smooth areas
76	0.000	0.000	0.104	0.053	0.001	rough topography of MTDs
77	0.001	0.000	0.145	0.170	0.003	draped over failed seabed
78	0.016	0.000	0.623	0.653	0.001	rough topography of MTDs
79	0.001	0.000	0.308	0.112	0.001	draped over failed seabed
80	0.018	0.000	0.760	0.634	0.000	draped over failed seabed
81	0.024	0.000	0.773	0.582	0.001	rough topography of MTDs
82	0.002	0.000	0.906	0.259	0.005	draped over MTDs
83	0.003	0.000	0.841	0.178	0.004	rough topography of MTDs
84	0.000	0.000	4.282	0.231	0.028	failed seabed stepped
85	0.003	0.000	0.101	0.042	0.017	sediment drifts
86	0.000	0.000	0.129	0.028	0.001	failed seabed stepped

Box core number	VMS records 2003-2012 (5 km radius)	VMS records 2003-2012 (3 km radius)	VMS records 2003-2012 (1 km radius)	VMS density 2003-2012 (5 km radius)	VMS density 2003-2012 (3 km radius)	VMS density 2003-2012 (1 km radius)
1	17	7	2	0.22	0.25	0.64
2	17	7	2	0.22	0.25	0.64
3	16	5	1	0.21	0.18	0.32
4	82	31	3	1.04	1.09	0.92
5	146	53	4	1.87	1.89	1.27
6	9	2	0	0.11	0.07	0.00
7	6	4	0	0.08	0.14	0.00
8	23	2	0	0.29	0.07	0.00
9	28	11	1	0.36	0.39	0.32
10	29	14	4	0.36	0.47	1.27
11	34	8	0	0.43	0.28	0.00
12	91	31	8	1.16	1.10	2.55
13	30	9	0	0.37	0.32	0.00
14	24	7	0	0.32	0.25	0.00
15	143	52	2	1.83	1.84	0.64
16	143	51	2	1.83	1.84	0.64
17	2	2	0	0.03	0.07	0.00
18	153	53	12	1.95	1.90	3.82
19	52	37	6	0.66	1.31	1.98
20	7	2	0	0.09	0.07	0.00
21	5	1	0	0.06	0.04	0.00
22	64	26	3	0.81	0.92	0.96
23	62	20	4	0.81	0.71	1.27
24	4	1	0	0.05	0.04	0.00
25	72	29	4	0.92	1.03	1.27
26	76	34	9	0.97	1.20	2.86
27	3	2	1	0.04	0.07	0.32
28	41	16	7	0.52	0.56	2.23
29	49	20	2	0.62	0.72	0.64
30	6	1	0	0.08	0.04	0.00
31	2	2	0	0.03	0.07	0.00
32	12	7	2	0.15	0.25	0.64
33	5	2	0	0.06	0.07	0.00
34	5	1	0	0.06	0.04	0.00
35	9	2	0	0.11	0.08	0.00
36	3	1	1	0.07	0.07	0.32
37	3	1	1	0.04	0.04	0.32
38	2	0	0	0.03	0.00	0.00
39	7	3	0	0.09	0.11	0.00
40	1	1	0	0.01	0.04	0.00
41	1	1	0	0.01	0.07	0.00
42	5	4	2	0.06	0.14	0.64
43	5	4	2	0.06	0.14	0.64
44	10	2	1	0.13	0.04	0.00
45	8	5	1	0.10	0.18	0.32
46	3	0	0	0.04	0.00	0.00
47	3	0	0	0.04	0.00	0.00
48	15	4	0	0.19	0.14	0.00
49	87	20	2	1.10	0.71	0.64
50	331	101	1	4.60	3.88	0.32
51	1413	300	38	17.99	10.66	11.79
52	308	37	4	3.95	1.31	1.27
53	1451	231	20	18.46	8.21	6.33
54	3801	1408	112	48.41	49.87	35.51
55	3800	1408	113	48.38	49.86	35.48
56	8742	3357	351	112.35	127.07	176.18
57	5434	2088	139	69.41	73.94	44.63
58	2425	622	24	30.88	22.18	7.65
59	1507	465	23	19.45	16.43	7.38
60	4044	1504	143	51.45	53.57	45.64
61	2281	773	87	29.05	27.40	27.70
62	475	95	8	6.06	3.35	2.55
63	469	96	8	5.94	3.36	2.55
64	3704	1358	96	47.43	48.45	31.46
65	8011	2887	375	102.03	102.22	120.18
66	3806	1397	136	48.47	49.43	42.71
67	1538	485	41	19.74	17.21	12.72
68	1369	378	39	17.47	13.39	12.48
69	1570	493	38	19.83	17.47	11.79
70	289	98	2	3.69	2.08	0.46
71	188	30	2	2.37	1.06	0.64
72	45	6	1	0.57	0.21	0.32
73	24	9	1	0.31	0.31	0.31
74	443	223	40	8.18	7.89	12.72
75	1502	504	37	19.21	17.72	11.46
76	1378	579	67	17.56	20.50	21.15
77	319	88	5	4.04	3.12	1.59
78	7	3	0	0.52	0.72	2.23
79	2119	934	141	26.99	33.05	44.63
80	51	32	0	0.65	0.78	0.00
81	20	8	0	0.25	0.28	0.00
82	73	25	0	0.93	0.88	0.13
83	115	51	2	1.44	1.76	0.64
84	22	8	0	0.29	0.28	0.00
85	1629	689	130	20.59	24.32	40.09
86	633	214	28	8.33	7.61	8.70

Box core number	Trawl length/ km^2 2008-2012 (5 km radius)	Trawl length/ km^2 2008-2012 (3 km radius)	Trawl length/ km^2 2008-2012 (1 km radius)	Roughness 3x3 cell window	Standard deviation of bathymetry 3x3 cell window	Rugosity 5x5 cell window
1	0.40	0.11	0.00	2.97	0.88	0.0000014
2	0.40	0.11	0.00	2.97	0.88	0.0000014
3	0.26	0.00	0.00	3.79	1.11	0.0000006
4	1.12	1.60	2.69	6.84	1.98	0.0000003
5	4.64	4.02	5.03	2.49	0.72	0.0000001
6	0.00	0.00	0.00	4.14	1.54	0.0000156
7	0.00	0.00	0.00	3.90	1.13	0.0000008
8	0.00	0.00	0.00	3.15	0.91	0.0000006
9	0.28	0.21	0.63	4.17	1.21	0.0000005
10	0.32	0.31	0.63	5.33	1.54	0.0000005
11	1.26	1.64	0.45	4.18	1.22	0.0000005
12	0.76	0.61	0.56	5.54	1.77	0.0000003
13	0.51	0.21	0.00	4.32	1.28	0.0000002
14	0.00	0.00	0.00	5.01	1.47	0.0000005
15	1.14	0.63	0.00	2.46	0.81	0.0000027
16	1.14	0.63	0.00	2.46	0.81	0.0000027
17	0.00	0.00	0.00	8.02	3.33	0.0000171
18	0.91	1.46	2.17	4.02	1.24	0.0000089
19	2.28	3.32	4.90	6.95	1.75	0.0000045
20	0.00	0.00	0.00	8.42	2.83	0.0000059
21	0.00	0.00	0.00	3.96	1.37	0.0000074
22	2.33	3.17	3.89	3.05	0.97	0.0000115
23	0.02	0.00	0.00	4.99	1.62	0.0000006
24	0.00	0.00	0.00	na	na	na
25	0.14	0.05	0.00	5.97	1.88	0.0000009
26	2.85	3.86	5.30	3.91	1.35	0.0000001
27	0.00	0.00	0.00	17.99	5.57	0.0000187
28	0.40	0.36	0.10	5.64	1.92	0.0000003
29	1.48	2.05	2.97	3.30	1.19	0.0000001
30	0.00	0.00	0.00	5.79	1.76	0.0000014
31	0.00	0.00	0.00	46.15	14.23	0.0012525
32	0.13	0.21	0.59	3.19	1.23	0.0000001
33	0.00	0.00	0.00	8.97	3.15	0.0000034
34	0.00	0.00	0.00	13.23	4.79	0.0000019
35	0.12	0.19	0.00	3.12	1.05	0.0000001
36	0.00	0.00	0.00	11.48	3.96	0.0000089
37	0.00	0.00	0.00	45.68	14.01	0.0018255
38	0.00	0.00	0.00	15.36	5.32	0.0001189
39	0.00	0.00	0.00	8.90	2.66	0.0000266
40	0.00	0.00	0.00	6.80	2.37	0.0001554
41	0.00	0.00	0.00	4.97	1.49	0.0000111
42	0.00	0.00	0.00	3.70	1.19	0.0000024
43	0.00	0.00	0.00	na	na	na
44	0.00	0.00	0.00	41.55	14.83	0.0003130
45	0.06	0.11	0.00	15.01	5.07	0.0008147
46	0.06	0.00	0.00	19.47	7.44	0.0005154
47	0.00	0.00	0.00	10.01	6.38	0.0003111
48	0.00	0.00	0.00	12.16	3.51	0.0000388
49	1.27	0.61	1.03	6.34	2.32	0.0001092
50	38.77	11.71	1.44	9.70	3.27	0.0000128
51	42.52	31.92	15.59	9.92	3.40	0.0000466
52	15.21	2.72	1.86	3.02	0.89	0.0003063
53	15.83	10.46	3.81	2.87	0.92	0.0001032
54	100.19	87.66	81.71	8.29	2.57	0.0000864
55	100.11	87.53	81.63	8.29	2.57	0.0000864
56	273.92	317.96	338.38	19.35	5.77	0.0004469
57	201.94	218.08	184.04	17.47	5.12	0.0000017
58	62.15	43.90	21.16	12.36	3.69	0.0000131
59	44.71	37.21	19.89	9.26	2.93	0.0000302
60	60.12	64.53	44.86	0.78	0.26	0.0000144
61	47.83	45.01	34.31	4.24	1.29	0.0000002
62	13.33	7.26	2.43	9.11	3.36	0.0004161
63	13.15	7.65	2.39	10.23	3.40	0.0001558
64	97.15	91.30	64.54	8.76	2.94	0.0000005
65	275.64	300.90	313.03	6.99	2.41	0.0000133
66	46.71	40.49	42.05	6.50	2.19	0.0000010
67	35.25	33.57	29.17	4.79	1.42	0.0000015
68	15.48	14.59	18.80	6.11	1.82	0.0000075
69	35.17	34.65	28.43	4.94	1.46	0.0000017
70	6.97	4.10	2.43	13.94	4.17	0.0000046
71	4.60	1.40	1.08	19.85	6.00	0.0001160
72	0.00	0.00	0.00	19.01	5.74	0.0000113
73	0.02	0.00	0.00	16.20	4.82	0.0000026
74	16.58	13.61	14.59	5.42	1.66	0.0000163
75	33.11	35.15	27.28	4.95	1.48	0.0000022
76	34.98	39.35	30.12	4.99	1.05	0.0000042
77	8.66	8.36	5.78	2.80	0.75	0.0000018
78	0.00	0.00	0.00	5.14	1.49	0.0000001
79	76.10	93.19	91.72	0.48	0.15	0.0000014
80	0.00	0.00	0.00	5.26	1.53	0.0000004
81	0.00	0.00	0.00	2.54	0.83	0.0000016
82	0.34	0.00	0.00	1.76	0.53	0.0000008
83	1.32	1.28	1.48	0.32	0.10	0.0000002
84	0.35	0.39	0.01	17.46	5.08	0.0000075
85	54.73	74.14	143.16	1.85	0.54	0.0000003
86	24.96	23.93	4.87	4.55	1.61	0.0000011

Box core number	Rugosity 25x25 cell window	BPI 25 cell radius	BPI 50 cell radius	BPI 75 cell radius	BPI 100 cell radius	BPI 125 cell radius	BPI 150 cell radius	Slope	Radial aspect from -1 west to 1 east	Radial aspect from -1 south to 1 north
1	0.0000040	-0.44	10.40	24.79	39.03	53.27	67.43	0.80	0.696	0.716
2	0.0000040	-0.44	10.40	24.79	39.03	53.27	67.43	0.80	0.696	0.716
3	0.0000069	1.10	13.94	27.85	42.34	56.68	70.91	1.04	0.609	0.793
4	0.0000136	-0.37	2.51	6.78	10.68	17.68	31.70	1.85	0.650	0.760
5	0.0000050	0.49	0.12	-1.68	-3.61	-4.78	-5.75	0.67	0.663	0.748
6	0.0009413	-19.09	-61.14	-74.17	-77.29	-78.15	-78.23	1.44	0.994	-0.109
7	0.0000150	-0.77	-6.60	-13.25	-19.65	-22.38	-21.96	1.06	0.700	-0.714
8	0.0000091	-1.54	-3.85	-3.42	-0.92	10.33	44.81	0.85	0.727	0.686
9	0.0000039	1.26	0.63	-1.09	-1.48	-2.65	-2.37	1.13	0.644	0.765
10	0.0000037	-0.24	-1.25	-3.24	-4.40	-4.40	-3.88	1.44	0.655	0.756
11	0.0000211	4.60	16.16	33.38	52.16	70.79	89.95	1.14	0.797	0.604
12	0.0000037	0.40	1.77	2.86	4.35	6.24	9.17	1.65	0.941	0.339
13	0.0000036	-1.32	-1.40	-1.40	1.66	13.24	31.77	1.19	0.841	0.542
14	0.0000070	-0.90	-9.38	-1.89	6.26	13.45	51.56	1.37	0.817	0.577
15	0.0000153	1.35	-3.35	-3.48	-2.94	-2.86	-3.22	0.75	0.287	0.958
16	0.0000153	1.35	-3.35	-3.48	-2.94	-2.86	-3.22	0.75	0.287	0.958
17	0.0003351	7.90	42.59	97.64	161.64	200.41	196.53	2.17	0.648	0.762
18	0.0000054	1.03	1.28	1.54	3.24	6.28	11.11	1.16	0.913	0.409
19	0.0000558	-4.36	5.62	21.55	36.17	50.68	65.68	1.64	0.729	0.685
20	0.0000118	0.77	44.08	89.07	137.44	186.14	190.19	1.85	0.970	0.183
21	0.0839384	20.94	177.85	266.42	354.48	442.83	531.24	1.38	0.881	0.398
22	0.0000085	-3.28	-1.75	3.46	24.07	44.46	69.16	0.91	0.598	0.346
23	0.0000228	4.36	6.75	10.06	13.22	17.98	37.18	1.51	0.593	0.304
24	na	na	na	na	na	na	na	na	na	na
25	0.0000073	-0.32	-0.64	2.32	8.32	17.35	28.33	1.76	0.592	0.363
26	0.0000003	0.22	9.40	28.04	48.87	70.22	91.23	1.26	0.978	0.207
27	0.0004802	11.10	41.26	79.79	118.58	131.46	180.68	3.19	0.915	0.404
28	0.0000034	-1.59	-3.68	0.55	3.37	13.69	41.76	1.80	0.975	0.123
29	0.0000015	1.22	12.95	29.52	47.51	66.32	86.09	1.11	0.990	0.143
30	0.0000079	-3.33	-4.83	-3.89	2.38	13.62	25.43	1.65	0.892	0.451
31	0.0102865	93.11	161.23	135.01	84.33	63.95	35.47	13.06	0.909	0.447
32	0.0000015	0.69	3.09	7.11	12.01	26.32	44.77	1.15	0.998	0.064
33	0.0000658	-7.53	-9.56	-1.56	19.49	68.11	106.70	1.94	0.994	0.178
34	0.0000973	0.63	7.28	21.73	47.53	90.56	131.55	4.47	0.990	0.138
35	0.0000003	0.15	1.55	3.78	7.18	17.47	33.00	0.98	0.971	-0.140
36	0.0000908	1.73	6.15	13.07	23.39	37.01	53.87	3.70	0.978	0.208
37	0.0218472	59.48	114.89	165.87	175.08	147.28	102.89	12.85	0.432	0.902
38	0.0005033	-11.89	-5.68	3.85	24.08	94.06	188.04	4.97	0.979	-0.203
39	0.0004485	2.28	42.47	94.54	156.37	219.15	276.87	2.48	0.875	-0.485
40	0.0045201	50.20	115.04	206.60	285.19	322.73	315.69	2.20	0.191	-0.861
41	0.0000038	2.56	5.01	8.46	15.71	31.68	62.47	1.39	0.874	-0.488
42	0.0000454	1.66	13.15	58.97	124.11	192.91	274.99	1.12	0.951	-0.309
43	na	na	na	na	na	na	na	na	na	na
44	0.0037394	-32.67	-151.42	-206.01	-225.66	-300.83	-337.87	13.60	0.988	0.157
45	0.0031155	468.34	93.19	144.38	213.87	257.49	305.36	7.07	0.896	-0.477
46	0.0038867	80.54	171.76	239.78	273.90	228.77	170.21	6.92	0.068	-0.968
47	0.0029971	58.30	146.71	215.10	255.23	222.94	174.57	5.83	0.371	-0.839
48	0.0008518	28.47	86.92	181.62	268.73	411.89	536.91	3.18	0.681	-0.732
49	0.0010244	27.46	24.13	7.53	-4.98	-14.67	-24.86	3.16	-0.027	1.000
50	0.0003391	1.73	66.01	84.81	58.55	38.54	24.68	3.05	-0.241	0.971
51	0.0000221	-12.58	-3.81	-0.41	-0.42	-5.17	-11.55	3.18	-0.214	0.977
52	0.0438838	39.51	84.66	71.48	53.32	34.46	37.15	0.77	0.196	0.981
53	0.0000508	-25.79	-27.45	-42.49	-39.96	-74.32	-89.93	0.84	0.364	0.991
54	0.0000501	1.21	11.84	42.38	83.71	132.34	181.10	2.40	0.401	0.916
55	0.0000501	1.21	11.84	42.38	83.71	132.34	181.10	2.40	0.401	0.916
56	0.0013639	-34.50	-31.14	-22.69	1.18	50.79	101.67	5.36	0.330	0.854
57	0.0003842	7.40	3.20	1.02	-7.20	-19.70	-30.07	4.77	0.175	0.818
58	0.0003067	4.43	26.44	73.01	127.48	181.46	233.33	3.45	0.505	0.863
59	0.0002044	11.93	31.98	64.94	99.78	134.72	169.62	2.74	-0.331	0.936
60	0.0001420	10.76	27.72	52.20	78.20	110.02	144.30	0.22	0.983	-0.184
61	0.0000038	1.23	13.73	29.76	48.23	70.08	95.57	1.21	0.895	-0.446
62	0.0007742	-32.19	-45.56	-34.36	-64.19	-73.76	-80.54	3.13	0.115	0.993
63	0.0008013	-33.75	-48.05	-36.93	-66.26	-79.61	-81.96	3.17	-0.268	0.963
64	0.0000451	0.74	2.64	29.72	67.78	109.33	157.01	2.75	0.250	0.968
65	0.0001321	-10.55	-6.88	-9.22	-5.23	-3.15	21.33	2.25	-0.202	0.979
66	0.0000114	5.03	26.71	29.85	91.27	121.33	150.96	2.05	-0.240	0.971
67	0.0000996	14.45	40.79	51.54	61.16	75.51	101.66	1.33	-0.536	0.844
68	0.0001833	1.55	6.48	24.34	50.18	82.45	115.95	1.70	-0.516	0.857
69	0.0001308	14.63	40.60	51.72	61.60	73.90	101.85	1.36	-0.537	0.844
70	0.0000705	-2.83	-1.27	12.90	27.53	40.60	52.06	3.90	-0.498	0.867
71	0.0000780	20.04	26.60	34.29	49.46	69.43	89.85	5.58	-0.460	0.888
72	0.0000413	-7.25	-10.40	-5.82	-6.08	-2.54	4.13	5.36	-0.470	0.883
73	0.0000711	-6.91	-17.62	-26.01	-35.48	-44.70	-51.56	4.30	-0.514	0.858
74	0.0001736	3.95	21.37	41.58	57.19	75.36	93.65	1.35	0.598	0.429
75	0.0001379	15.15	41.13	51.40	62.35	74.48	102.27	1.40	-0.473	0.881
76	0.0000302	-1.71	0.86	14.02	34.20	57.05	85.13	0.98	-0.183	0.983
77	0.0000077	-2.14	-4.14	-7.07	-10.01	-12.03	-9.84	0.70	0.670	-0.748
78	0.0000041	-3.13	-16.58	-15.64	-12.51	-11.95	-13.04	1.40	-0.787	0.618
79	0.0000252	-1.82	4.07	21.70	49.45	83.74	118.92	0.14	-0.977	0.213
80	0.0000017	-0.08	1.79	4.27	6.21	8.90	11.01	1.43	-0.645	0.764
81	0.0000115	-4.26	-16.22	-27.97	-39.02	-50.57	-59.20	0.77	-0.954	0.301
82	0.0000092	-3.83	-3.97	-8.59	-14.45	-14.56	-17.90	0.50	0.884	-0.448
83	0.0000013	-0.45	-3.00	-3.07	-4.72	-11.00	-26.62	0.10	0.266	-0.964
84	0.0002989	-17.59	-39.47	-48.24	-48.87	-47.18	-39.37	4.74	-0.617	0.787
85	0.0000960	2.57	9.40	22.84	43.86	66.75	90.61	0.50	0.676	-0.737
86	0.0000924	3.85	16.35	34.68	52.08	72.61	101.43	1.51	-0.533	0.846

Box core number	Successful collection*	Latitude	Longitude	Multibeam bathymetry	Collection year	Collection month	Crew number	Seafloor temperature 2008/°C	Seafloor temperature 2009/°C	Seafloor temperature 2010/°C
87	Y	48.825	-5.446	1082.1	2009	July	2	3.56	3.47	3.62
88	Y	48.710	-5.334	1161.9	2009	July	2	3.79	3.69	3.86
89	Y	48.974	-5.273	1579.9	2009	July	2	3.37	3.31	3.40
90	Y	48.865	-5.384	1325.2	2009	July	2	3.43	3.37	3.47
91	Y	48.930	-5.190	1381.6	2009	July	2	3.44	3.38	3.48
92	Y	48.941	-5.054	1402.2	2009	July	2	3.39	3.33	3.43
93	Y	48.848	-5.272	1187.8	2009	July	2	3.54	3.47	3.59
94	Y	48.848	-5.176	1019.6	2009	July	2	3.65	3.55	3.71
95	Y	48.545	-5.328	836.8	2009	July	2	3.82	3.72	3.89
96	Y	48.608	-5.117	931.3	2009	July	2	3.57	3.47	3.62
97	Y	48.947	-4.947	879.0	2009	July	2	3.59	3.47	3.62
98	Y	48.411	-4.773	760.7	2009	July	2	3.60	3.48	3.64
99	Y	48.577	-4.763	1057.8	2009	July	2	3.59	3.50	3.64
100	Y	48.655	-4.892	1127.3	2009	July	2	3.55	3.46	3.60
101	Y	48.721	-5.143	1195.6	2009	July	2	3.51	3.43	3.56
102	Y	48.886	-4.799	1484.3	2009	July	2	3.38	3.31	3.42
103	Y	48.783	-4.800	1234.4	2009	July	2	3.45	3.38	3.50
104	Y	48.413	-4.996	890.3	2009	July	2	3.67	3.54	3.70
105	Y	48.593	-5.149	891.1	2009	July	2	3.63	3.51	3.67
106	Y	48.406	-5.442	738.7	2009	July	2	3.68	3.57	3.72
107	Y	48.189	-5.803	855.5	2009	July	2	3.67	3.56	3.71
108	Y	48.225	-5.611	707.3	2009	July	2	3.63	3.50	3.66
109	Y	48.408	-5.617	931.3	2009	July	2	3.59	3.49	3.64
110	Y	48.347	-5.086	1166.6	2009	July	2	3.75	3.64	3.82
111	Y	48.117	-5.209	1163.3	2009	July	2	3.61	3.50	3.67
112	Y	47.943	-5.191	1068.5	2009	July	2	3.61	3.51	3.67
113	Y	47.882	-5.387	1173.4	2009	July	2	3.65	3.54	3.71
114	Y	48.101	-5.489	1112.9	2009	July	2	3.69	3.74	3.95
115	Y	48.041	-5.407	1164.7	2009	July	2	3.80	3.68	3.87
116	Y	47.779	-5.491	1169.3	2009	July	2	3.63	3.52	3.69
117	Y	47.930	-5.483	1164.0	2009	July	2	4.03	3.90	4.10
118	Y	47.885	-5.621	1132.2	2009	July	2	3.62	3.49	3.68
119	Y	47.665	-5.737	1077.9	2009	July	2	3.62	3.49	3.68
120	Y	48.050	-5.835	814.9	2009	July	2	3.63	3.51	3.67
121	Y	48.114	-6.049	1060.9	2009	July	2	3.66	3.51	3.73
122	Y	47.973	-6.022	899.5	2009	July	2	3.62	3.51	3.67
123	Y	47.807	-5.970	735.2	2009	August	3	3.70	3.57	3.73
124	Y	47.955	-5.881	748.7	2009	August	3	3.93	3.79	3.97
125	Y	47.816	-6.191	1063.2	2009	August	3	3.63	3.53	3.69
126	Y	47.679	-6.317	1129.8	2009	August	3	3.62	3.51	3.68
127	N	47.710	-6.039	756.2	2009	August	3	3.82	3.68	3.84
128	N	47.709	-6.053	794.7	2009	August	3	3.73	3.60	3.76
129	Y	47.793	-6.077	868.3	2009	August	3	3.85	3.93	3.89
130	Y	47.667	-6.127	953.9	2009	August	3	3.88	3.77	3.94
131	Y	47.474	-6.332	1006.3	2009	August	3	3.83	3.92	3.88
132	Y	47.513	-6.233	1006.7	2009	August	3	3.83	3.93	3.89
133	Y	47.646	-6.546	1167.4	2009	August	3	4.05	3.93	4.11
134	Y	47.361	-6.500	1035.0	2009	August	3	3.85	3.94	3.71
135	Y	47.484	-6.591	1160.5	2009	August	3	3.69	3.93	3.70
136	Y	47.347	-6.687	1154.9	2009	August	3	3.84	3.93	3.88
137	Y	47.337	-6.927	1077.9	2009	August	3	3.57	3.44	3.64
138	Y	47.488	-6.812	1134.9	2009	August	3	3.57	3.45	3.64
139	Y	47.807	-6.760	896.2	2009	August	3	3.61	3.47	3.66
140	Y	47.987	-6.685	954.7	2009	August	3	4.02	3.86	4.07
141	Y	48.026	-6.554	1118.1	2009	August	3	3.63	3.50	3.69
142	Y	48.003	-6.790	720.2	2009	August	3	3.57	3.43	3.63
143	Y	47.842	-6.885	745.2	2009	August	3	3.58	3.42	3.63
144	Y	47.762	-6.882	794.8	2009	August	3	3.73	3.55	3.77
145	Y	47.946	-6.801	773.7	2009	August	3	3.63	3.47	3.68
146	Y	47.241	-6.547	875.7	2009	August	3	3.61	3.49	3.66
147	Y	47.124	-6.661	1116.9	2009	August	3	3.71	3.60	3.77
148	Y	47.288	-6.827	1150.8	2009	August	3	3.53	3.41	3.60
149	Y	47.118	-6.897	1160.2	2009	August	3	3.49	3.38	3.57
150	Y	47.214	-6.779	1153.9	2009	August	3	3.59	3.48	3.67
151	Y	47.240	-6.676	1148.1	2009	August	3	3.85	3.75	3.91
152	Y	47.129	-6.782	1161.0	2009	August	3	3.58	3.47	3.65
153	Y	47.404	-7.090	839.1	2009	August	3	3.47	3.30	3.54
154	Y	47.480	-6.954	987.2	2009	August	3	3.67	3.51	3.73
155	N	47.566	-7.011	826.6	2009	August	3	3.52	3.35	3.58
156	Y	47.566	-7.011	826.6	2009	August	3	3.52	3.35	3.58
157	Y	47.215	-7.122	909.2	2009	August	3	3.66	3.48	3.72
158	Y	47.226	-6.988	1105.7	2009	August	3	3.48	3.34	3.56
159	Y	47.039	-7.193	960.5	2009	August	3	3.58	3.31	3.46
160	Y	47.107	-7.089	1034.2	2009	August	3	3.61	3.48	3.69
161	Y	46.903	-7.117	1031.4	2009	August	3	3.57	3.32	3.46
162	Y	46.732	-6.779	1145.5	2009	August	3	3.69	3.38	3.56
163	Y	46.707	-6.959	1210.2	2009	August	3	3.44	3.32	3.53
164	Y	46.903	-6.684	741.4	2009	August	3	3.62	3.50	3.67
165	Y	46.919	-6.859	1192.4	2009	August	3	3.50	3.39	3.58
166	Y	46.765	-6.568	910.5	2009	August	3	3.77	3.64	3.79
167	Y	46.837	-6.706	1041.7	2009	August	3	3.53	3.42	3.59
168	Y	46.973	-6.832	1182.6	2009	August	3	3.54	3.44	3.62
169	Y	46.849	-6.830	1199.4	2009	August	3	3.52	3.42	3.60
170	Y	46.958	-7.002	1165.6	2009	August	3	3.61	3.49	3.69
171	Y	46.810	-7.076	1089.3	2009	August	3	3.73	3.57	3.80
172	Y	46.931	-6.738	1143.0	2009	August	3	3.58	3.48	3.65

Box core number	Seafloor temperature average for collection year/°C	Seafloor temperature average for collection and previous year/°C	Seafloor temperature 10 year minimum/°C	Seafloor temperature 10 year mean/°C	Seafloor salinity 2008/ppt	Seafloor salinity 2009/ppt
87	3.47	3.52	3.56	3.99	34.81	34.81
88	3.49	3.54	3.55	3.95	34.90	34.88
89	3.31	3.34	3.36	3.83	34.84	34.84
90	3.37	3.40	3.43	3.76	34.83	34.83
91	3.38	3.41	3.43	3.79	34.85	34.84
92	3.33	3.36	3.41	3.73	34.84	34.83
93	3.47	3.51	3.47	3.83	34.86	34.85
94	3.55	3.60	3.58	4.01	34.85	34.83
95	3.72	3.77	3.62	4.07	34.87	34.86
96	3.47	3.52	3.59	4.03	34.82	34.81
97	3.47	3.52	3.61	4.06	34.82	34.81
98	3.48	3.54	3.63	4.09	34.81	34.80
99	3.50	3.54	3.56	3.99	34.84	34.83
100	3.46	3.50	3.55	3.97	34.83	34.82
101	3.43	3.47	3.55	3.95	34.82	34.81
102	3.33	3.39	3.42	3.75	34.84	34.83
103	3.38	3.41	3.49	3.85	34.84	34.83
104	3.54	3.61	3.66	4.12	34.82	34.80
105	3.52	3.57	3.63	4.08	34.82	34.81
106	3.57	3.62	3.66	4.11	34.82	34.80
107	3.56	3.61	3.64	4.09	34.79	34.78
108	3.50	3.57	3.66	4.12	34.78	34.77
109	3.49	3.54	3.61	4.05	34.80	34.78
110	3.64	3.64	3.60	4.03	34.84	34.82
111	3.50	3.57	3.62	4.05	34.77	34.76
112	3.51	3.56	3.61	4.05	34.76	34.75
113	3.54	3.60	3.63	4.07	34.77	34.75
114	3.74	3.81	3.66	4.12	34.85	34.84
115	3.68	3.74	3.65	4.09	34.83	34.81
116	3.52	3.58	3.65	4.08	34.73	34.74
117	3.50	3.57	3.63	4.10	34.91	34.89
118	3.49	3.56	3.63	4.14	34.73	34.72
119	3.48	3.55	3.63	4.14	34.72	34.70
120	3.51	3.57	3.65	4.10	34.77	34.76
121	3.56	3.61	3.61	4.04	34.80	34.78
122	3.51	3.56	3.62	4.07	34.76	34.75
123	3.57	3.63	3.67	4.12	34.77	34.76
124	3.79	3.86	3.66	4.12	34.87	34.85
125	3.53	3.58	3.61	4.06	34.76	34.75
126	3.51	3.57	3.62	4.05	34.73	34.74
127	3.68	3.75	3.65	4.11	34.82	34.80
128	3.60	3.66	3.65	4.10	34.78	34.77
129	3.53	3.59	3.64	4.09	34.76	34.75
130	3.77	3.83	3.62	4.07	34.86	34.85
131	3.51	3.58	3.62	4.06	34.75	34.73
132	3.53	3.59	3.62	4.06	34.75	34.74
133	3.53	3.59	3.65	4.08	34.92	34.91
134	3.54	3.60	3.63	4.07	34.75	34.73
135	3.53	3.58	3.63	4.07	34.74	34.73
136	3.50	3.56	3.64	4.07	34.73	34.72
137	3.44	3.50	3.67	4.13	34.69	34.67
138	3.45	3.51	3.66	4.12	34.69	34.68
139	3.47	3.54	3.65	4.20	34.71	34.69
140	3.36	3.44	3.66	4.18	34.87	34.86
141	3.50	3.57	3.66	4.14	34.73	34.74
142	3.43	3.50	3.65	4.11	34.70	34.69
143	3.42	3.50	3.63	4.13	34.68	34.67
144	3.55	3.64	3.62	4.13	34.72	34.71
145	3.47	3.55	3.64	4.22	34.71	34.70
146	3.48	3.55	3.66	4.11	34.72	34.71
147	3.60	3.65	3.64	4.08	34.77	34.76
148	3.41	3.47	3.66	4.08	34.68	34.67
149	3.38	3.43	3.66	4.09	34.67	34.65
150	3.48	3.54	3.64	4.07	34.72	34.71
151	3.75	3.80	3.63	4.07	34.84	34.83
152	3.47	3.52	3.64	4.07	34.71	34.70
153	3.30	3.39	3.60	4.24	34.61	34.60
154	3.52	3.59	3.65	4.19	34.71	34.70
155	3.35	3.44	3.61	4.24	34.63	34.62
156	3.35	3.44	3.61	4.24	34.63	34.62
157	3.48	3.57	3.62	4.23	34.69	34.67
158	3.34	3.41	3.67	4.14	34.64	34.63
159	3.31	3.39	3.63	4.23	34.58	34.56
160	3.48	3.54	3.68	4.14	34.70	34.69
161	3.32	3.39	3.65	4.20	34.59	34.57
162	3.38	3.44	3.65	4.07	34.68	34.67
163	3.32	3.38	3.67	4.09	34.65	34.64
164	3.50	3.56	3.66	4.11	34.72	34.71
165	3.39	3.45	3.63	4.08	34.68	34.66
166	3.64	3.71	3.67	4.14	34.78	34.76
167	3.42	3.48	3.63	4.09	34.69	34.68
168	3.44	3.49	3.64	4.07	34.70	34.68
169	3.42	3.47	3.65	4.08	34.69	34.68
170	3.48	3.55	3.68	4.11	34.71	34.70
171	3.57	3.65	3.67	4.16	34.75	34.73
172	3.48	3.53	3.65	4.08	34.73	34.72

Box core number	Seafloor salinity 2010 /ppt	Seafloor salinity average for collection year/ppt	Seafloor salinity average for collection and previous year/ppt	Seafloor zonal velocity 2008 m/s	Seafloor zonal velocity 2009 m/s	Seafloor zonal velocity 2010 m/s
87	34.82	34.81	34.81	0.0425	0.0416	0.1683
88	34.89	34.89	34.89	0.0645	0.0633	0.6315
89	34.85	34.84	34.84	0.1208	0.1246	0.2142
90	34.84	34.83	34.83	0.0932	0.0970	0.2020
91	34.85	34.84	34.84	0.1342	0.1282	0.2255
92	34.85	34.83	34.84	0.1152	0.1182	0.2254
93	34.86	34.85	34.85	0.1079	0.1132	0.2436
94	34.85	34.83	34.84	0.0426	0.0390	0.3813
95	34.87	34.86	34.87	-0.0028	-0.0087	-0.1312
96	34.82	34.81	34.81	0.0278	0.0262	0.1526
97	34.82	34.81	34.81	0.0213	0.0196	0.1477
98	34.82	34.80	34.81	0.0106	0.0109	0.0947
99	34.84	34.83	34.83	0.0423	0.0412	0.3301
100	34.84	34.82	34.83	0.0484	0.0483	0.2883
101	34.83	34.81	34.82	0.0574	0.0562	0.2700
102	34.84	34.84	34.84	0.0873	0.0898	0.2063
103	34.84	34.83	34.83	0.0742	0.0764	0.2411
104	34.82	34.80	34.81	0.0035	0.0021	-0.0594
105	34.82	34.81	34.81	0.0106	0.0093	-0.0698
106	34.82	34.80	34.81	0.0032	0.0020	-0.0724
107	34.80	34.78	34.79	-0.0001	0.0011	-0.0869
108	34.79	34.77	34.77	0.0063	0.0073	-0.0655
109	34.80	34.78	34.79	0.0116	0.0120	-0.0070
110	34.84	34.82	34.83	0.0090	0.0084	-0.1232
111	34.78	34.76	34.77	0.0098	0.0097	0.0885
112	34.77	34.75	34.76	-0.0015	-0.0015	-0.1169
113	34.77	34.75	34.76	-0.0038	-0.0026	-0.1381
114	34.83	34.81	34.82	0.0190	0.0181	0.1732
115	34.83	34.81	34.82	0.0029	0.0004	-0.0644
116	34.76	34.74	34.74	0.0002	0.0001	-0.0947
117	34.90	34.89	34.90	-0.0075	-0.0108	-0.1509
118	34.74	34.72	34.73	0.0105	0.0104	-0.0843
119	34.73	34.70	34.71	0.0028	0.0028	-0.0402
120	34.78	34.76	34.76	0.0048	0.0057	-0.0580
121	34.80	34.78	34.79	-0.0042	-0.0040	-0.1543
122	34.78	34.75	34.76	0.0029	0.0032	-0.0917
123	34.79	34.76	34.77	0.0033	0.0035	-0.1041
124	34.87	34.85	34.86	0.0031	0.0030	0.1676
125	34.77	34.75	34.76	0.0016	0.0015	-0.1436
126	34.76	34.74	34.74	0.0026	0.0027	-0.0909
127	34.82	34.80	34.81	0.0011	0.0010	-0.1377
128	34.80	34.77	34.78	0.0023	0.0023	-0.0939
129	34.77	34.75	34.75	0.0034	0.0034	-0.1386
130	34.86	34.85	34.85	0.0039	0.0026	0.6159
131	34.77	34.73	34.74	-0.0026	-0.0056	-0.0885
132	34.76	34.74	34.75	-0.0003	-0.0004	0.0383
133	34.91	34.91	34.91	-0.0168	-0.0175	-0.2735
134	34.76	34.73	34.74	-0.0129	-0.0098	-0.1941
135	34.76	34.73	34.74	-0.0131	-0.0132	-0.1728
136	34.74	34.72	34.72	-0.0103	-0.0132	-0.2616
137	34.70	34.67	34.68	-0.0029	-0.0013	-0.0730
138	34.71	34.68	34.69	-0.0028	-0.0031	-0.0892
139	34.72	34.69	34.70	0.0095	0.0095	-0.0279
140	34.86	34.86	34.86	0.0002	-0.0016	-0.8027
141	34.76	34.74	34.74	0.0157	0.0193	0.0672
142	34.72	34.69	34.70	0.0310	0.0320	0.1487
143	34.70	34.67	34.67	0.0149	0.0147	-0.0330
144	34.74	34.71	34.72	0.0097	0.0094	0.0827
145	34.73	34.70	34.71	0.0207	0.0203	0.1175
146	34.74	34.71	34.71	-0.0028	-0.0026	-0.1428
147	34.78	34.76	34.76	-0.0049	-0.0059	-0.1043
148	34.70	34.67	34.67	-0.0098	-0.0088	-0.1540
149	34.69	34.65	34.66	-0.0050	-0.0049	-0.1154
150	34.73	34.71	34.71	-0.0140	-0.0140	-0.2047
151	34.84	34.83	34.83	-0.0179	-0.0192	-0.2801
152	34.73	34.70	34.71	-0.0081	-0.0088	-0.1386
153	34.64	34.60	34.60	0.0055	0.0057	0.0234
154	34.72	34.70	34.70	0.0001	-0.0002	-0.0753
155	34.66	34.62	34.63	0.0073	0.0071	-0.0189
156	34.66	34.63	34.63	0.0073	0.0071	-0.0189
157	34.71	34.67	34.68	0.0062	0.0067	0.0303
158	34.67	34.63	34.64	0.0026	0.0016	0.0274
159	34.61	34.56	34.57	0.0064	0.0067	0.0424
160	34.72	34.69	34.69	-0.0046	-0.0013	-0.1111
161	34.62	34.58	34.58	0.0034	0.0034	0.0595
162	34.70	34.67	34.67	0.0018	0.0026	-0.0096
163	34.67	34.64	34.64	0.0097	0.0100	0.0900
164	34.74	34.71	34.72	-0.0013	-0.0020	-0.3566
165	34.70	34.66	34.67	-0.0014	-0.0014	-0.2184
166	34.79	34.76	34.77	-0.0046	-0.0039	-0.4365
167	34.71	34.68	34.69	-0.0014	-0.0007	-0.1693
168	34.71	34.68	34.69	-0.0033	-0.0040	-0.1365
169	34.71	34.68	34.68	-0.0009	-0.0005	-0.1327
170	34.73	34.70	34.71	0.0005	0.0001	-0.1522
171	34.76	34.73	34.74	0.0055	0.0053	0.3756
172	34.74	34.72	34.72	-0.0044	-0.0044	-0.2284

Box core number	Seafloor zonal velocity average for collection year m/s	Seafloor zonal velocity average for collection and previous year m/s	Seafloor meridional velocity 2008 m/s	Seafloor meridional velocity 2009 m/s	Seafloor meridional velocity 2010 m/s
87	0.0416	0.0420	0.0195	0.0166	0.1177
88	0.0633	0.0639	0.0284	0.0300	0.2987
89	0.1246	0.1227	0.0391	0.0402	0.1898
90	0.0970	0.0951	0.0430	0.0441	0.2148
91	0.1282	0.1262	0.0209	0.0222	0.1918
92	0.1182	0.1167	0.0021	0.0039	-0.0035
93	0.1132	0.1105	0.0388	0.0409	0.3805
94	0.0390	0.0408	0.0030	0.0032	0.1743
95	-0.0087	-0.0058	-0.0010	-0.0016	-0.1887
96	0.0262	0.0270	-0.0011	-0.0019	0.0217
97	0.0196	0.0204	-0.0062	-0.0065	-0.0881
98	0.0109	0.0107	-0.0058	-0.0065	-0.0259
99	0.0412	0.0417	-0.0200	-0.0209	-0.1200
100	0.0483	0.0484	-0.0112	-0.0124	-0.0602
101	0.0582	0.0578	0.0041	0.0038	0.0877
102	0.0898	0.0885	-0.0196	-0.0204	-0.1636
103	0.0764	0.0753	-0.0199	-0.0210	-0.1605
104	0.0051	0.0043	-0.0015	-0.0024	0.1010
105	0.0093	0.0100	-0.0011	-0.0015	-0.0670
106	0.0050	0.0041	-0.0041	-0.0057	-0.1336
107	0.0011	0.0005	-0.0106	-0.0113	-0.1254
108	0.0073	0.0068	-0.0054	-0.0054	-0.1419
109	0.0120	0.0118	-0.0043	-0.0059	-0.1327
110	0.0084	0.0087	-0.0033	-0.0073	-0.1020
111	0.0057	0.0057	-0.0108	-0.0150	-0.1613
112	-0.0015	-0.0043	-0.0265	-0.0270	-0.3006
113	-0.0026	-0.0047	-0.0383	-0.0409	-0.3026
114	0.0181	0.0186	0.0002	-0.0039	-0.1325
115	0.0004	0.0017	-0.0228	-0.0277	-0.3497
116	0.0001	0.0001	-0.0342	-0.0372	-0.4473
117	-0.0108	-0.0091	-0.0250	-0.0306	-0.4065
118	0.0104	0.0105	-0.0229	-0.0264	-0.2066
119	0.0028	0.0028	-0.0285	-0.0316	-0.3768
120	0.0057	0.0053	-0.0082	-0.0085	-0.1594
121	-0.0040	-0.0041	-0.0238	-0.0255	-0.3129
122	0.0032	0.0030	-0.0140	-0.0142	-0.1630
123	0.0035	0.0034	-0.0078	-0.0069	0.0621
124	0.0030	0.0031	-0.0030	-0.0038	0.0739
125	0.0015	0.0015	-0.0226	-0.0236	-0.2099
126	0.0027	0.0026	-0.0179	-0.0297	-0.2928
127	0.0010	0.0011	-0.0069	-0.0046	0.2891
128	0.0023	0.0023	-0.0086	-0.0071	0.1628
129	0.0034	0.0034	-0.0119	-0.0115	-0.0549
130	0.0026	0.0048	-0.0081	-0.0041	0.5284
131	-0.0056	-0.0076	-0.0144	-0.0260	-0.2432
132	0.0004	0.0001	-0.0174	-0.0172	-0.1831
133	-0.0175	-0.0171	-0.0547	-0.0565	-0.7383
134	-0.0086	-0.0104	-0.0371	-0.0306	-0.2671
135	-0.0132	-0.0131	-0.0353	-0.0363	-0.3813
136	-0.0152	-0.0198	-0.0501	-0.0541	-0.3403
137	-0.0023	-0.0026	-0.0423	-0.0444	-0.4600
138	-0.0031	-0.0030	-0.0386	-0.0366	-0.3959
139	0.0095	0.0095	-0.0167	-0.0301	-0.3731
140	-0.0016	-0.0007	-0.0157	-0.0234	-0.3054
141	0.0193	0.0195	-0.0168	-0.0203	-0.1259
142	0.0320	0.0320	-0.0121	-0.0139	-0.2069
143	0.0147	0.0148	-0.0102	-0.0233	-0.2954
144	0.0094	0.0096	-0.0197	-0.0231	-0.3006
145	0.0203	0.0205	-0.0162	-0.0192	-0.2949
146	-0.0026	-0.0027	-0.0185	-0.0201	-0.2589
147	-0.0059	-0.0054	-0.0226	-0.0254	-0.1850
148	-0.0088	-0.0093	-0.0481	-0.0497	-0.3639
149	-0.0049	-0.0049	-0.0560	-0.0576	-0.2220
150	-0.0140	-0.0140	-0.0583	-0.0612	-0.2206
151	-0.0153	-0.0186	-0.0640	-0.0774	-0.1751
152	-0.0088	-0.0084	-0.0529	-0.0590	-0.1919
153	0.0057	0.0056	-0.0335	-0.0344	-0.3977
154	-0.0002	0.0000	-0.0337	-0.0364	-0.4416
155	0.0071	0.0072	-0.0282	-0.0309	-0.3682
156	0.0071	0.0072	-0.0282	-0.0309	-0.3682
157	0.0067	0.0065	-0.0341	-0.0340	-0.3769
158	0.0016	0.0012	-0.0440	-0.0448	-0.3491
159	0.0067	0.0066	-0.0450	-0.0443	-0.3963
160	-0.0013	-0.0014	-0.0510	-0.0511	-0.2719
161	0.0054	0.0054	-0.0344	-0.0356	-0.3106
162	0.0026	0.0022	-0.0433	-0.0473	-0.1928
163	0.0100	0.0098	-0.0663	-0.0681	-0.1960
164	-0.0020	-0.0022	-0.0082	-0.0071	0.0158
165	-0.0014	-0.0014	-0.0581	-0.0625	-0.1874
166	-0.0039	-0.0043	0.0002	0.0015	0.0894
167	-0.0007	-0.0011	-0.0337	-0.0257	-0.1445
168	-0.0040	-0.0037	-0.0575	-0.0617	-0.1970
169	-0.0005	-0.0007	-0.0582	-0.0638	-0.1773
170	0.0001	0.0003	-0.0748	-0.0749	-0.1953
171	0.0053	0.0054	-0.0769	-0.0748	-0.1875
172	-0.0014	-0.0042	-0.0332	-0.0350	-0.2378

Box core number	Seafloor meridional velocity average for collection year m/s	Seafloor meridional velocity average for collection and previous year m/s	Seafloor absolute speed 2008 m/s	Seafloor absolute speed 2009 m/s	Seafloor absolute speed 2010 m/s
87	0.0186	0.0190	0.0457	0.0456	0.2054
88	0.0300	0.0252	0.0704	0.0700	0.6986
89	0.0402	0.0397	0.1289	0.1310	0.2861
90	0.0441	0.0435	0.1026	0.1065	0.2949
91	0.0222	0.0216	0.1259	0.1301	0.2960
92	0.0029	0.0025	0.1152	0.1183	0.2254
93	0.0409	0.0404	0.1150	0.1209	0.4518
94	0.0022	0.0026	0.0427	0.0391	0.4159
95	-0.0026	-0.0018	0.0030	0.0091	0.3171
96	-0.0019	-0.0015	0.0178	0.0263	0.1541
97	-0.0065	-0.0063	0.0222	0.0206	0.1720
98	-0.0085	-0.0062	0.0121	0.0127	0.0454
99	-0.0029	-0.0205	0.0468	0.0462	0.3967
100	-0.0124	-0.0118	0.0497	0.0498	0.2945
101	0.0038	0.0039	0.0575	0.0583	0.2838
102	-0.0204	-0.0200	0.0894	0.0911	0.2632
103	-0.0210	-0.0205	0.0748	0.0793	0.2897
104	-0.0034	-0.0030	0.0698	0.0697	0.1152
105	-0.0015	-0.0013	0.0107	0.0094	0.0871
106	-0.0037	-0.0039	0.0052	0.0062	0.2445
107	-0.0113	-0.0110	0.0108	0.0113	0.2395
108	-0.0054	-0.0054	0.0033	0.0091	0.1658
109	-0.0059	-0.0051	0.0124	0.0134	0.1329
110	-0.0073	-0.0053	0.0096	0.0111	0.3454
111	-0.0130	-0.0119	0.0145	0.0162	0.1844
112	-0.0270	-0.0268	0.0265	0.0271	0.3225
113	-0.0409	-0.0396	0.0384	0.0410	0.3333
114	-0.0039	-0.0019	0.0150	0.0185	0.2181
115	-0.0277	-0.0252	0.0230	0.0277	0.3556
116	-0.0372	-0.0357	0.0342	0.0372	0.4572
117	-0.0306	-0.0278	0.0261	0.0335	0.4336
118	-0.0264	-0.0246	0.0252	0.0284	0.2231
119	-0.0316	-0.0301	0.0287	0.0318	0.3790
120	-0.0085	-0.0084	0.0096	0.0109	0.1696
121	-0.0255	-0.0347	0.0342	0.0258	0.3489
122	-0.0142	-0.0141	0.0142	0.0146	0.1862
123	-0.0069	-0.0074	0.0084	0.0077	0.2133
124	-0.0038	-0.0034	0.0043	0.0048	0.1832
125	-0.0236	-0.0231	0.0227	0.0236	0.2543
126	-0.0297	-0.0288	0.0281	0.0298	0.3066
127	-0.0046	-0.0057	0.0068	0.0047	0.3302
128	-0.0071	-0.0079	0.0088	0.0075	0.1880
129	-0.0141	-0.0147	0.0134	0.0140	0.1498
130	-0.0041	-0.0061	0.0060	0.0070	0.1145
131	-0.0260	-0.0252	0.0150	0.0186	0.2591
132	-0.0172	-0.0173	0.0174	0.0172	0.1870
133	-0.0585	-0.0566	0.0772	0.0611	0.7873
134	-0.0306	-0.0288	0.0192	0.0321	0.3260
135	-0.0383	-0.0368	0.0376	0.0405	0.4277
136	-0.0541	-0.0511	0.0541	0.0574	0.3605
137	-0.0444	-0.0433	0.0434	0.0444	0.4658
138	-0.0366	-0.0351	0.0337	0.0367	0.4058
139	-0.0301	-0.0284	0.0333	0.0316	0.3761
140	-0.0234	-0.0196	0.0157	0.0235	0.6737
141	-0.0203	-0.0185	0.0259	0.0280	0.2646
142	-0.0139	-0.0130	0.0342	0.0349	0.3548
143	-0.0233	-0.0217	0.0251	0.0275	0.3972
144	-0.0231	-0.0214	0.0220	0.0248	0.3118
145	-0.0192	-0.0177	0.0263	0.0279	0.3175
146	-0.0301	-0.0193	0.0187	0.0203	0.2957
147	-0.0234	-0.0240	0.0231	0.0261	0.2109
148	-0.0497	-0.0489	0.0491	0.0504	0.3951
149	-0.0576	-0.0568	0.0262	0.0578	0.2502
150	-0.0612	-0.0597	0.0600	0.0628	0.3009
151	-0.0774	-0.0707	0.0625	0.0797	0.3325
152	-0.0590	-0.0560	0.0535	0.0596	0.2372
153	-0.0344	-0.0339	0.0339	0.0348	0.3984
154	-0.0364	-0.0351	0.0337	0.0364	0.4480
155	-0.0309	-0.0295	0.0291	0.0317	0.3667
156	-0.0309	-0.0295	0.0291	0.0317	0.3667
157	-0.0340	-0.0341	0.0347	0.0347	0.3781
158	-0.0443	-0.0444	0.0440	0.0448	0.3502
159	-0.0443	-0.0446	0.0434	0.0448	0.3586
160	-0.0611	-0.0611	0.0611	0.0611	0.2947
161	-0.0536	-0.0540	0.0547	0.0539	0.3132
162	-0.0473	-0.0433	0.0434	0.0474	0.1930
163	-0.0681	-0.0672	0.0670	0.0689	0.2184
164	-0.0071	-0.0077	0.0085	0.0074	0.3570
165	-0.0625	-0.0603	0.0581	0.0625	0.2862
166	0.0015	0.0009	0.0046	0.0042	0.4456
167	-0.0257	-0.0247	0.0337	0.0257	0.2206
168	-0.0617	-0.0596	0.0576	0.0619	0.3078
169	-0.0638	-0.0610	0.0582	0.0638	0.2214
170	-0.0749	-0.0748	0.0748	0.0749	0.2476
171	-0.0748	-0.0759	0.0771	0.0750	0.4158
172	-0.0380	-0.0361	0.0331	0.0380	0.3335

Box core number	Seafloor absolute speed average for collection year m/s	Seafloor absolute speed average for collection and previous year m/s	10 year max seafloor absolute speed m/s	10 year average seafloor absolute speed m/s	MOSS surface Chlora 2008 mg/m³
87	0.0456	0.0462	0.1241	0.0638	0.858
88	0.0700	0.0702	0.1579	0.0930	0.843
89	0.1310	0.1289	0.2585	0.2163	0.693
90	0.1065	0.1046	0.2464	0.1784	0.753
91	0.1301	0.1280	0.2451	0.1992	0.774
92	0.1183	0.1167	0.2295	0.1899	0.775
93	0.1203	0.1177	0.2179	0.1719	0.767
94	0.0391	0.0409	0.1111	0.0462	0.873
95	0.0091	0.0060	0.0790	0.0345	0.933
96	0.0263	0.0270	0.0944	0.0338	0.838
97	0.0206	0.0214	0.0839	0.0303	0.841
98	0.0127	0.0134	0.0676	0.0315	0.791
99	0.0462	0.0465	0.1104	0.0564	0.836
100	0.0498	0.0498	0.1294	0.0721	0.836
101	0.0583	0.0579	0.1476	0.0853	0.851
102	0.0621	0.0608	0.1586	0.1615	0.745
103	0.0793	0.0781	0.1676	0.1376	0.787
104	0.0657	0.0647	0.0573	0.0813	0.881
105	0.0094	0.0100	0.0726	0.0325	0.955
106	0.0632	0.0637	0.0496	0.0389	0.843
107	0.0113	0.0111	0.0738	0.0387	0.813
108	0.0091	0.0087	0.0481	0.0457	0.856
109	0.0134	0.0129	0.0879	0.0430	1.019
110	0.0111	0.0104	0.0978	0.0385	0.840
111	0.0162	0.0154	0.0961	0.0448	0.731
112	0.0271	0.0268	0.1297	0.0733	0.839
113	0.0410	0.0397	0.1401	0.0887	0.746
114	0.0185	0.0188	0.0661	0.0363	0.669
115	0.0277	0.0253	0.0784	0.0435	0.733
116	0.0372	0.0357	0.1134	0.0791	0.697
117	0.0325	0.0293	0.0912	0.0498	0.708
118	0.0354	0.0268	0.0881	0.0449	0.657
119	0.0318	0.0302	0.0936	0.0481	0.608
120	0.0103	0.0099	0.0443	0.0180	0.845
121	0.0158	0.0150	0.1267	0.0722	0.767
122	0.0146	0.0144	0.0685	0.0302	0.793
123	0.0077	0.0081	0.0480	0.0141	0.882
124	0.0048	0.0046	0.0353	0.0052	0.850
125	0.0236	0.0232	0.0948	0.0410	0.753
126	0.0198	0.0189	0.1045	0.0565	0.713
127	0.0047	0.0058	0.0447	0.0142	0.848
128	0.0075	0.0082	0.0450	0.0148	0.846
129	0.0130	0.0132	0.0536	0.0184	0.838
130	0.0370	0.0380	0.0442	0.0184	0.838
131	0.0346	0.0338	0.0837	0.0458	0.771
132	0.0372	0.0373	0.0541	0.0276	0.818
133	0.0411	0.0391	0.1172	0.0721	0.687
134	0.0405	0.0391	0.0859	0.0443	0.740
135	0.0374	0.0358	0.1338	0.0787	0.673
136	0.0444	0.0434	0.1855	0.1105	0.636
137	0.0367	0.0352	0.1037	0.0571	0.638
138	0.0316	0.0299	0.0891	0.0456	0.589
139	0.0335	0.0196	0.0758	0.0406	0.621
140	0.0360	0.0269	0.0715	0.0382	0.720
141	0.0349	0.0346	0.0806	0.0475	0.769
142	0.0375	0.0263	0.0752	0.0351	0.683
143	0.0249	0.0234	0.0787	0.0357	0.633
144	0.0379	0.0271	0.0712	0.0372	0.636
145	0.0203	0.0195	0.0592	0.0204	0.608
146	0.0261	0.0246	0.0844	0.0310	0.755
147	0.0504	0.0498	0.1611	0.1034	0.696
148	0.0573	0.0570	0.1721	0.1121	0.635
149	0.0628	0.0614	0.1780	0.1154	0.612
150	0.0797	0.0731	0.1471	0.0977	0.669
151	0.0546	0.0566	0.1782	0.1114	0.679
152	0.0348	0.0344	0.0583	0.0408	0.596
153	0.0364	0.0351	0.0813	0.0435	0.596
154	0.0317	0.0304	0.0842	0.0379	0.616
155	0.0317	0.0304	0.0842	0.0379	0.597
156	0.0347	0.0347	0.1051	0.0494	0.597
157	0.0448	0.0444	0.1284	0.0748	0.568
158	0.0448	0.0451	0.1211	0.0642	0.582
159	0.0611	0.0611	0.1389	0.0858	0.548
160	0.0539	0.0543	0.1430	0.0860	0.567
161	0.0474	0.0454	0.1760	0.0843	0.621
162	0.0689	0.0680	0.1949	0.1404	0.614
163	0.0674	0.0680	0.0979	0.0971	0.594
164	0.0625	0.0603	0.2032	0.1252	0.610
165	0.0042	0.0044	0.0539	0.0171	0.639
166	0.0357	0.0247	0.0863	0.0384	0.636
167	0.0619	0.0597	0.1953	0.1128	0.613
168	0.0638	0.0610	0.2100	0.1245	0.604
169	0.0749	0.0748	0.1715	0.1141	0.591
170	0.0750	0.0761	0.1533	0.1020	0.583
171	0.0390	0.0361	0.1547	0.0658	0.604
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Box core number	MODIS surface Chloro a 2009 mg/m³	MODIS surface Chloro a 2010 mg/m³	MODIS surface Chloro a average for collection year mg/m³	MODIS surface Chloro a average for collection and previous year mg/m³	MODIS surface POC 2008 mg/m³
87	0.871	1.028	0.871	0.864	131.77
88	0.885	1.026	0.885	0.864	130.20
89	1.002	0.915	1.001	0.848	134.32
90	0.954	0.995	0.954	0.854	127.65
91	0.956	0.931	0.956	0.865	129.29
92	1.183	0.925	1.183	0.979	129.23
93	0.936	0.965	0.936	0.852	129.95
94	1.053	0.973	1.053	0.963	130.90
95	0.917	1.004	0.917	0.925	140.62
96	0.945	0.965	0.945	0.891	130.92
97	0.944	0.985	0.944	0.892	132.02
98	0.803	1.099	0.803	0.797	132.47
99	1.091	1.033	1.091	0.964	130.92
100	0.826	0.967	0.826	0.831	130.15
101	1.014	1.007	1.014	0.933	130.88
102	0.863	0.915	0.863	0.864	125.51
103	0.836	0.913	0.836	0.811	127.70
104	0.948	1.015	0.948	0.899	128.64
105	1.050	1.028	1.050	1.003	137.76
106	1.064	1.025	1.064	1.019	139.57
107	0.889	0.978	0.889	0.851	130.89
108	0.596	0.977	0.596	0.896	132.84
109	1.116	1.024	1.116	1.067	137.55
110	1.065	1.026	1.065	0.959	133.00
111	1.133	1.051	1.133	0.932	126.61
112	1.444	1.086	1.444	1.141	136.57
113	1.305	1.034	1.305	1.026	127.89
114	1.272	1.000	1.272	0.970	123.99
115	1.091	1.035	1.091	0.912	127.71
116	1.178	1.020	1.178	0.937	122.96
117	1.321	1.015	1.321	1.015	134.62
118	1.058	0.927	1.058	0.857	121.94
119	0.915	0.883	0.915	0.761	117.54
120	0.961	1.016	0.961	0.903	133.67
121	1.006	1.046	1.006	0.886	130.33
122	1.087	1.017	1.087	0.940	132.64
123	1.141	1.074	1.141	1.012	138.01
124	1.036	1.064	1.036	0.943	135.97
125	1.734	1.077	1.734	1.143	126.96
126	1.292	0.976	1.292	1.002	123.37
127	1.144	0.994	1.144	0.996	134.61
128	1.200	0.994	1.200	1.023	134.76
129	1.163	1.022	1.163	0.986	132.86
130	1.476	0.978	1.476	1.007	134.43
131	1.045	0.930	1.045	0.968	125.26
132	1.113	0.935	1.113	0.965	129.46
133	1.107	0.935	1.107	0.872	118.76
134	0.893	0.926	0.893	0.816	116.38
135	0.968	0.904	0.968	0.821	119.68
136	0.867	0.909	0.867	0.762	120.54
137	0.770	0.829	0.770	0.689	119.57
138	0.758	0.905	0.758	0.673	116.87
139	0.937	0.897	0.937	0.779	120.07
140	1.012	0.916	1.012	0.866	127.63
141	1.216	0.955	1.216	0.992	126.56
142	0.873	0.888	0.873	0.778	124.52
143	0.911	0.856	0.911	0.772	123.53
144	0.893	0.854	0.893	0.765	122.04
145	0.913	0.857	0.913	0.761	118.03
146	0.839	0.957	0.839	0.757	131.09
147	0.803	0.973	0.803	0.750	127.61
148	0.794	0.933	0.794	0.714	120.31
149	0.730	0.984	0.730	0.671	118.89
150	0.807	0.982	0.807	0.738	122.87
151	0.834	1.018	0.834	0.757	125.19
152	0.796	0.967	0.796	0.726	123.47
153	0.807	0.839	0.807	0.702	118.85
154	0.808	0.846	0.808	0.712	120.84
155	0.846	0.822	0.846	0.721	118.80
156	0.846	0.822	0.846	0.721	118.80
157	0.717	0.895	0.717	0.653	118.81
158	0.713	0.911	0.713	0.647	116.37
159	0.633	0.835	0.633	0.590	114.78
160	0.718	1.008	0.718	0.643	116.12
161	0.733	1.005	0.733	0.645	117.45
162	0.773	1.043	0.773	0.697	122.15
163	0.721	0.966	0.721	0.668	123.29
164	0.714	1.160	0.714	0.654	122.32
165	0.757	0.999	0.757	0.683	122.89
166	0.714	1.089	0.714	0.676	126.48
167	0.728	1.041	0.728	0.682	125.18
168	0.762	1.026	0.762	0.687	123.51
169	0.730	1.051	0.730	0.667	122.39
170	0.743	0.983	0.743	0.667	119.65
171	0.699	0.903	0.699	0.641	120.83
172	0.736	1.040	0.736	0.670	122.34

Box core number	MODIS surface POC 2009 mg/m³	MODIS surface POC 2010 mg/m³	MODIS surface POC average for collection year mg/m³	MODIS surface POC average for collection and previous year mg/m³	Lutz et al. 2002 NE Atlantic uncorrected POC at depth mg/m³
87	133.96	162.24	133.96	132.91	0.008
88	134.75	159.87	134.75	132.47	0.017
89	141.51	150.00	141.51	132.91	0.005
90	147.40	160.32	147.40	137.32	0.008
91	143.97	175.79	143.97	136.63	0.010
92	152.10	174.82	152.10	140.66	0.007
93	139.72	156.51	139.72	134.83	0.015
94	140.68	155.68	140.68	135.79	0.044
95	136.39	158.33	136.39	138.51	0.176
96	134.27	153.98	134.27	132.59	0.062
97	135.35	156.08	135.35	133.68	0.123
98	149.90	169.70	149.90	141.18	0.326
99	152.02	157.93	152.02	141.47	0.035
100	129.16	151.43	129.16	129.85	0.021
101	152.28	158.21	152.28	141.58	0.015
102	137.83	170.63	137.83	131.67	0.006
103	134.01	155.96	134.01	130.85	0.007
104	135.17	157.85	135.17	136.91	0.552
105	135.67	159.18	135.67	136.71	0.230
106	162.87	164.02	162.87	151.22	0.415
107	131.46	151.12	131.46	131.13	0.145
108	133.15	151.25	133.15	132.49	0.467
109	148.05	156.65	148.05	140.30	0.086
110	138.64	153.98	138.64	134.83	0.017
111	143.91	157.44	143.91	134.56	0.017
112	178.91	157.63	178.91	157.74	0.039
113	151.83	150.62	151.83	139.86	0.017
114	152.85	149.09	152.85	138.32	0.034
115	141.45	150.43	141.45	134.58	0.017
116	147.68	148.28	147.68	135.32	0.017
117	155.35	148.30	155.35	139.99	0.017
118	141.04	144.44	141.04	131.49	0.020
119	135.24	141.16	135.24	126.39	0.028
120	134.08	134.25	134.08	133.87	0.202
121	138.23	154.52	138.23	133.28	0.026
122	145.96	154.20	145.96	139.30	0.109
123	171.62	161.03	171.62	154.81	0.437
124	145.72	158.03	145.72	140.84	0.358
125	187.43	155.83	187.43	157.19	0.087
126	162.87	150.16	162.87	143.12	0.021
127	157.40	154.02	157.40	146.00	0.349
128	162.90	153.86	162.90	148.83	0.263
129	164.35	155.74	164.35	148.61	0.117
130	157.32	152.07	157.32	145.87	0.076
131	147.94	147.76	147.94	137.65	0.094
132	153.43	150.22	153.43	141.45	0.050
133	151.41	145.87	151.41	135.09	0.017
134	140.08	151.74	140.08	133.23	0.039
135	138.74	144.23	138.74	129.71	0.017
136	133.04	146.74	133.04	126.78	0.017
137	132.38	142.80	132.38	125.98	0.028
138	124.75	136.10	124.75	120.31	0.020
139	135.02	148.13	135.02	127.25	0.103
140	146.75	144.12	146.75	137.19	0.071
141	167.30	146.57	167.30	146.93	0.024
142	130.77	143.72	130.77	127.64	0.406
143	133.77	141.30	133.77	128.65	0.336
144	133.03	140.50	133.03	127.54	0.226
145	136.29	141.30	136.29	127.16	0.266
146	131.79	152.29	131.79	131.44	0.124
147	130.04	151.80	130.04	128.82	0.021
148	129.09	151.74	129.09	124.70	0.017
149	122.23	148.69	122.23	120.96	0.046
150	129.03	138.69	129.03	125.95	0.017
151	130.71	154.61	130.71	127.95	0.018
152	128.58	150.28	128.58	126.02	0.017
153	139.28	144.74	139.28	129.07	0.161
154	130.68	141.62	130.68	125.76	0.051
155	130.26	138.70	130.26	124.53	0.172
156	130.26	138.70	130.26	124.53	0.172
157	122.27	148.64	122.27	120.54	0.088
158	121.79	146.98	121.79	119.08	0.022
159	113.96	144.93	113.96	114.37	0.057
160	121.17	145.36	121.17	118.70	0.021
161	132.99	146.42	132.99	120.07	0.036
162	136.08	159.17	136.08	129.31	0.018
163	123.61	152.68	123.61	123.47	0.013
164	123.89	168.67	123.89	123.10	0.382
165	127.92	153.28	127.92	125.41	0.014
166	125.63	162.49	125.63	126.06	0.091
167	126.09	157.75	126.09	125.63	0.095
168	129.44	153.91	129.44	126.48	0.015
169	125.34	158.19	125.34	123.86	0.013
170	125.04	147.98	125.04	122.34	0.016
171	121.25	145.34	121.25	121.04	0.025
172	125.01	158.45	125.01	123.68	0.020

Box core number	Lutz et al. 2002 NE Atlantic radionuclide corrected POC at depth mg/m²	Lutz et al. 2002 Sargasso uncorrected POC at depth mg/m²	Lutz et al. 2002 Sargasso radionuclide corrected POC at depth mg/m²	Sediment total carbon %
87	1.042	1.022	0.009	3.31
88	0.728	0.720	0.008	3.32
89	0.118	0.136	0.006	3.26
90	0.366	0.372	0.006	2.85
91	0.441	0.444	0.007	2.89
92	0.366	0.377	0.006	2.89
93	0.660	0.654	0.007	3.25
94	1.408	1.377	0.012	3.41
95	3.154	3.170	0.044	3.82
96	2.041	1.991	0.021	3.58
97	2.600	2.594	0.030	3.57
98	4.664	4.547	0.088	3.83
99	1.137	1.210	0.011	3.55
100	0.831	0.820	0.008	3.36
101	0.670	0.663	0.007	3.66
102	0.467	0.182	0.006	2.83
103	0.306	0.315	0.006	3.39
104	6.300	6.053	0.164	3.59
105	3.798	3.679	0.159	3.72
106	5.514	5.376	0.144	3.66
107	2.834	2.759	0.036	3.37
108	5.561	5.429	0.135	3.14
109	2.160	2.105	0.021	3.34
110	0.731	0.722	0.008	3.07
111	0.730	0.722	0.008	3.39
112	1.149	1.134	0.009	3.55
113	0.730	0.721	0.008	3.12
114	0.548	0.539	0.009	na
115	0.730	0.722	0.008	3.00
116	0.720	0.711	0.008	2.64
117	0.762	0.752	0.008	2.99
118	0.825	0.813	0.008	2.67
119	1.011	0.993	0.009	2.62
120	3.470	3.382	0.051	3.10
121	1.005	0.987	0.009	3.31
122	2.471	2.408	0.027	3.14
123	5.733	5.589	0.121	3.09
124	4.909	4.788	0.098	3.09
125	1.341	1.310	0.011	3.63
126	0.907	0.892	0.008	3.03
127	4.922	4.798	0.084	3.14
128	4.223	4.114	0.068	3.27
129	2.651	2.581	0.028	3.11
130	4.029	3.977	0.048	3.28
131	1.545	1.519	0.019	3.38
132	1.354	1.317	0.013	3.38
133	0.734	0.716	0.008	2.98
134	1.595	1.582	0.011	3.59
135	0.727	0.710	0.008	2.96
136	0.719	0.711	0.008	3.02
137	1.007	0.989	0.009	2.47
138	0.783	0.774	0.008	2.77
139	2.298	2.241	0.026	2.25
140	1.901	1.854	0.018	2.48
141	0.581	0.563	0.009	2.77
142	5.056	4.935	0.116	1.13
143	4.557	4.446	0.093	1.13
144	3.617	3.557	0.059	1.57
145	3.564	3.867	0.071	1.70
146	2.355	2.329	0.031	2.90
147	0.863	0.851	0.008	3.26
148	0.720	0.713	0.008	2.72
149	0.668	0.663	0.008	3.12
150	0.717	0.710	0.008	3.07
151	0.748	0.739	0.008	3.12
152	0.696	0.689	0.008	3.12
153	3.001	2.926	0.041	1.38
154	1.508	1.474	0.014	2.32
155	3.063	2.987	0.044	1.39
156	3.063	2.987	0.044	2.06
157	2.049	2.000	0.032	1.68
158	0.841	0.830	0.008	2.86
159	1.546	1.512	0.015	1.61
160	0.844	0.832	0.009	2.46
161	1.182	1.158	0.011	2.18
162	0.765	0.755	0.008	3.33
163	0.548	0.547	0.007	3.38
164	4.433	4.329	0.092	4.05
165	0.603	0.599	0.007	2.58
166	2.130	2.077	0.033	3.17
167	1.181	1.157	0.011	2.63
168	0.634	0.630	0.007	2.76
169	0.576	0.574	0.007	2.80
170	0.662	0.657	0.008	2.40
171	0.920	0.906	0.009	2.02
172	0.803	0.794	0.008	3.05

Box core number	Sediment organic carbon %	Sediment inorganic carbon %	Sediment clay %	Sediment silt %	Sediment sand %	Shannon sediment PSD	Within NAFO closure as of 28-11-16?	Spicules in box core?	Porifera density (Kenchington et al. 2014 kJ/km^2
87	0.39	3.42	17.61	59.10	23.10	2.20	N	N	0.479
88	0.46	3.06	23.02	63.16	13.81	2.11	N	N	0.771
89	0.73	3.53	30.37	64.10	5.53	2.00	Y	Y	12.400
90	0.50	2.35	25.09	66.22	8.69	2.04	Y	Y	9.440
91	0.45	2.44	24.96	63.52	11.50	2.08	N	Y	10.934
92	0.45	2.44	24.45	61.01	14.54	2.14	N	Y	1.572
93	0.35	2.94	12.12	69.08	18.80	1.99	N	Y	10.484
94	0.27	3.14	11.92	45.39	42.69	2.12	Y	N	0.004
95	0.30	3.52	11.96	62.88	25.16	2.11	N	Y	0.003
96	0.25	3.33	12.82	53.37	33.81	1.93	Y	N	0.001
97	0.25	3.32	9.97	52.49	37.54	2.03	N	N	0.004
98	0.33	3.50	14.30	57.37	28.33	2.19	N	Y	0.042
99	0.34	3.21	13.32	35.71	50.97	2.32	N	Y	0.014
100	0.32	3.04	17.76	46.83	35.42	2.14	N	Y	0.000
101	0.53	3.13	ns	ns	ns	ns	N	N	0.023
102	0.42	2.41	25.05	64.82	10.14	2.07	N	N	0.000
103	0.46	2.93	21.39	70.41	8.20	2.01	N	N	0.000
104	0.34	3.25	13.45	54.97	31.58	2.15	Y	N	0.020
105	0.27	3.45	13.75	61.35	24.90	2.11	N	Y	0.001
106	0.38	3.38	11.60	63.48	24.91	2.06	N	N	0.010
107	0.34	3.06	18.72	68.47	12.81	2.10	N	N	0.003
108	0.39	2.80	18.87	61.97	19.16	2.04	N	Y	0.015
109	0.39	3.45	18.62	65.88	15.50	2.12	N	N	0.034
110	0.52	2.55	23.60	68.06	8.34	2.04	N	Y	0.254
111	0.67	2.72	25.04	69.23	5.72	1.99	N	Y	0.231
112	0.31	3.34	14.25	67.15	18.60	2.07	Y	N	0.038
113	0.43	2.79	17.64	58.48	23.88	2.10	Y	Y	0.378
114	ns	ns	ns	ns	ns	ns	N	N	0.012
115	0.48	2.52	19.98	69.65	16.37	2.03	N	Y	0.110
116	0.41	2.23	18.85	60.09	21.06	2.11	N	Y	0.240
117	0.63	2.36	21.49	67.25	11.26	2.08	N	Y	0.270
118	0.60	2.07	16.61	60.04	23.34	2.20	N	N	0.024
119	0.72	1.90	18.28	61.38	20.33	2.20	N	N	0.015
120	0.43	2.67	12.10	60.61	27.29	2.13	N	ns	0.281
121	0.38	2.93	14.23	70.57	15.19	2.04	Y	N	0.194
122	0.35	2.79	13.20	63.78	23.03	2.15	N	N	0.052
123	0.39	2.70	12.88	51.69	35.43	1.91	N	Y	0.333
124	0.37	2.72	10.28	59.92	27.80	1.94	N	Y	0.702
125	0.29	3.34	12.11	69.53	18.35	2.05	N	Y	0.014
126	0.34	2.69	13.64	63.30	22.56	2.05	N	Y	0.043
127	0.41	2.73	12.05	45.89	42.06	2.15	N	ns	0.023
128	0.45	2.82	10.93	49.44	39.63	2.15	N	ns	0.012
129	0.35	2.76	13.71	62.27	25.02	2.11	N	Y	0.039
130	0.44	2.84	14.41	67.06	18.53	2.05	N	N	0.004
131	0.40	2.89	14.03	64.76	21.22	2.11	Y	Y	0.013
132	0.41	2.98	13.31	69.16	18.53	2.09	N	N	0.003
133	0.40	3.17	13.31	48.77	37.92	2.19	N	Y	0.047
134	0.40	3.19	13.59	49.66	36.74	2.12	N	N	0.066
135	0.46	2.90	15.83	57.56	26.61	2.22	N	Y	0.137
136	0.32	2.80	21.81	67.22	10.97	2.06	N	Y	0.410
137	0.56	1.91	17.97	61.14	20.89	2.19	N	Y	0.069
138	0.64	2.13	18.88	59.73	21.37	2.22	N	N	0.042
139	0.64	1.61	14.92	63.46	21.63	2.15	N	Y	0.001
140	0.78	1.71	21.88	62.57	15.55	2.18	N	Y	0.000
141	0.60	2.17	21.16	68.90	9.94	2.06	N	Y	0.018
142	0.36	0.77	8.44	31.18	60.39	2.07	N	Y	0.007
143	0.41	0.82	9.19	33.71	57.10	1.93	N	Y	0.019
144	0.52	1.05	14.75	50.49	34.76	2.07	N	Y	0.018
145	0.52	1.18	14.01	55.37	30.63	1.97	N	Y	0.011
146	0.31	2.59	14.11	40.32	48.57	2.16	N	Y	0.105
147	0.35	2.91	14.81	64.88	20.31	2.15	N	Y	0.229
148	0.46	2.26	19.79	61.27	18.95	2.19	N	Y	0.356
149	0.50	2.62	21.61	64.26	13.13	2.12	Y	Y	0.621
150	0.56	2.51	22.70	69.48	7.81	2.02	N	Y	0.446
151	0.45	2.67	18.85	59.74	21.41	2.22	N	Y	0.381
152	0.51	2.61	20.47	59.49	20.04	2.22	N	Y	0.432
153	0.47	0.91	13.30	36.74	49.96	2.07	N	Y	0.012
154	0.63	1.69	18.89	60.08	21.03	2.13	N	N	0.008
155	0.52	0.87	12.62	43.36	44.03	2.12	N	ns	0.011
156	0.50	1.96	15.42	53.43	31.15	2.22	N	Y	0.011
157	0.53	1.15	14.27	40.90	44.83	2.22	N	Y	0.012
158	0.57	1.29	19.03	60.15	20.82	2.20	N	N	0.153
159	0.55	1.06	15.79	43.14	41.07	2.26	N	Y	0.108
160	0.45	1.01	15.91	54.67	29.42	2.21	N	N	0.396
161	0.67	1.51	16.57	44.90	38.53	2.29	N	Y	0.279
162	0.34	3.11	11.12	60.64	28.24	2.07	Y	Y	1.596
163	0.64	2.74	21.49	57.45	21.06	2.25	Y	Y	8.467
164	0.29	3.76	11.89	34.33	53.78	2.32	N	Y	0.189
165	0.38	2.20	17.52	69.52	12.96	1.98	Y	Y	1.430
166	0.32	2.85	13.37	50.30	36.42	2.00	N	Y	0.016
167	0.31	3.32	8.16	55.94	35.91	1.88	N	Y	0.130
168	0.43	3.33	16.57	68.47	14.97	2.01	Y	N	0.512
169	0.53	2.27	17.33	66.27	16.40	2.06	N	N	2.422
170	0.57	1.83	18.34	70.37	11.29	1.99	Y	Y	1.702
171	0.73	1.29	17.74	62.86	19.40	2.04	N	Y	2.826
172	0.34	2.71	14.31	83.76	1.93	1.73	N	Y	2.036

Box core number	Pennatulacean density Kenchington et al. 2014 kg/km²	Gorgonian density Kenchington et al. 2014 kg/km²	Demosponge relative biomass	Pennatulacean relative biomass	Gorgonian relative biomass	Geological environment
87	0.068	0.000	0.729	0.173	0.027	rough topography of MTDs
88	0.003	0.000	0.447	0.052	0.000	draped over MTDs
89	0.000	0.000	15.667	0.300	0.029	failed seabed stepped
90	0.000	0.000	7.491	0.070	0.017	failed seabed stepped
91	0.000	0.000	9.529	0.070	0.013	sediment drifts
92	0.000	0.000	6.091	0.107	0.001	sediment drifts
93	0.000	0.000	2.996	0.074	0.031	sediment drifts
94	0.009	0.000	0.384	0.374	0.001	smooth areas
95	0.004	0.000	0.135	0.254	0.001	smooth areas
96	0.009	0.000	0.674	0.285	0.003	smooth areas
97	0.003	0.000	0.450	0.294	0.003	smooth areas
98	0.006	0.000	0.681	0.338	0.000	smooth areas
99	0.001	0.000	1.130	0.143	0.002	smooth areas
100	0.001	0.000	0.420	0.100	0.000	smooth areas
101	0.006	0.000	0.267	0.075	0.006	draped over MTDs
102	0.000	0.000	3.441	0.071	0.008	sediment drifts
103	0.000	0.000	0.267	0.070	0.001	smooth areas
104	0.011	0.000	0.259	0.407	0.002	smooth areas
105	0.007	0.000	0.380	0.118	0.008	smooth areas
106	0.044	0.000	0.137	0.177	0.000	smooth areas
107	0.029	0.000	0.250	0.180	0.007	smooth areas
108	0.005	0.000	0.130	0.138	0.002	smooth areas
109	0.008	0.000	0.261	0.560	0.005	rough topography of MTDs
110	0.006	0.000	0.497	0.228	0.027	smooth areas
111	0.006	0.000	0.604	0.200	0.001	smooth areas
112	0.014	0.000	1.249	0.475	0.007	draped over MTDs
113	0.007	0.000	3.330	0.221	0.006	smooth areas
114	0.001	0.000	0.334	0.226	0.110	draped over MTDs
115	0.001	0.000	0.605	0.218	0.003	smooth areas
116	0.003	0.000	0.798	0.232	0.088	smooth areas
117	0.002	0.000	0.487	0.284	0.004	smooth areas
118	0.000	0.000	0.351	0.283	0.072	draped over failed seabed
119	0.000	0.000	0.134	0.304	0.001	draped over failed seabed
120	0.006	0.000	0.128	0.170	0.015	smooth areas
121	0.028	0.000	1.270	0.481	0.000	draped over MTDs
122	0.015	0.000	0.052	0.230	0.001	smooth areas
123	0.004	0.000	0.333	0.146	0.000	gullies cutting smooth areas
124	0.004	0.000	0.100	0.099	0.001	smooth areas
125	0.010	0.000	0.054	0.282	0.004	draped over MTDs
126	0.006	0.000	0.640	0.452	0.001	sediment waves
127	0.003	0.000	0.136	0.134	0.003	gullies cutting smooth areas
128	0.003	0.000	0.075	0.069	0.009	gullies cutting smooth areas
129	0.004	0.000	0.040	0.125	0.002	gullies cutting smooth areas
130	0.053	0.000	0.122	0.146	0.001	draped over MTDs
131	0.008	0.000	0.472	0.463	0.001	draped over MTDs
132	0.016	0.000	0.516	0.153	0.001	sediment waves
133	0.001	0.000	0.146	0.335	0.006	smooth areas
134	0.001	0.000	0.164	0.272	0.001	gullies cutting smooth areas
135	0.002	0.000	0.834	0.156	0.000	smooth areas
136	0.000	0.000	1.958	0.232	0.003	smooth areas
137	0.000	0.000	1.020	0.285	0.003	rough topography of MTDs
138	0.000	0.000	1.566	0.174	0.006	draped over MTDs
139	0.000	0.000	0.010	0.105	0.003	draped over failed seabed
140	0.000	0.000	0.053	0.104	0.000	draped over failed seabed
141	0.001	0.000	0.165	0.208	0.001	draped over failed seabed
142	0.000	0.000	0.041	0.062	0.007	draped over failed seabed
143	0.000	0.000	0.053	0.081	0.001	smooth areas
144	0.000	0.000	0.033	0.134	0.001	smooth areas
145	0.000	0.000	0.027	0.105	0.001	draped over failed seabed
146	0.000	0.000	0.131	0.136	0.000	gullies cutting smooth areas
147	0.001	0.000	0.118	0.343	0.000	draped over MTDs
148	0.000	0.000	1.345	0.211	0.046	smooth areas
149	0.000	0.000	3.057	0.251	0.382	smooth areas
150	0.000	0.000	1.675	0.277	0.004	smooth areas
151	0.000	0.000	3.382	0.628	0.001	draped over MTDs
152	0.000	0.000	3.288	0.269	0.160	smooth areas
153	0.000	0.000	0.077	0.151	0.030	draped over failed seabed
154	0.000	0.000	0.328	0.204	0.004	draped over gullies
155	0.000	0.000	0.062	0.146	0.001	draped over gullies
156	0.000	0.000	0.062	0.146	0.001	draped over gullies
157	0.000	0.000	0.096	0.144	0.000	draped over failed seabed
158	0.000	0.000	1.503	0.337	0.016	draped over MTDs
159	0.000	0.000	0.433	0.231	0.001	gullies associated with failed seabed
160	0.000	0.000	0.517	0.239	0.004	draped over MTDs
161	0.000	0.000	1.168	0.319	0.004	gullies associated with failed seabed
162	0.000	0.000	0.179	0.137	0.006	draped over failed seabed
163	0.000	0.000	4.331	0.161	0.040	smooth areas
164	0.001	0.000	0.333	0.335	0.007	failed seabed stepped
165	0.000	0.000	2.339	0.409	0.060	smooth areas
166	0.000	0.000	0.751	0.118	0.026	draped over MTDs
167	0.001	0.000	0.056	0.110	0.002	sediment drifts
168	0.000	0.000	2.459	0.290	0.118	smooth areas
169	0.000	0.000	1.054	0.360	0.010	smooth areas
170	0.000	0.000	2.827	0.242	0.013	draped over MTDs
171	0.000	0.000	2.158	0.283	0.003	gullies associated with failed seabed
172	0.000	0.000	0.740	0.081	0.004	draped over failed seabed

Box core number	VMS records 2003-2012 (5 km radius)	VMS records 2003-2012 (3 km radius)	VMS records 2003-2012 (1 km radius)	VMS density 2003-2012 (5 km radius)	VMS density 2003-2012 (3 km radius)	VMS density 2003-2012 (1 km radius)
87	69	28	1	0.88	0.97	0.32
88	195	72	3	2.48	2.56	0.95
89	2	1	0	0.03	0.04	0.00
90	39	5	1	0.50	0.18	0.32
91	68	14	0	0.86	0.47	0.00
92	85	34	3	1.08	1.21	0.95
93	584	227	32	7.43	8.01	10.11
94	56	15	6	0.72	0.68	1.91
95	121	42	5	1.55	1.46	1.59
96	73	31	1	0.94	1.10	0.32
97	48	16	2	0.61	0.57	0.64
98	29	7	0	0.37	0.26	0.00
99	88	26	1	1.12	0.91	0.32
100	84	31	0	1.06	1.09	0.03
101	121	50	6	1.53	1.80	1.76
102	66	16	3	0.86	0.57	0.95
103	148	46	8	1.88	1.63	2.55
104	22	3	0	0.28	0.27	0.32
105	50	12	2	0.63	0.42	0.64
106	270	86	8	3.44	3.09	2.34
107	338	131	24	4.06	4.55	7.91
108	661	254	25	8.41	8.96	7.96
109	154	24	1	1.95	0.86	0.32
110	34	3	1	0.31	0.18	0.32
111	27	9	0	0.34	0.32	0.00
112	107	27	3	1.35	0.95	1.01
113	55	15	2	0.70	0.53	0.64
114	179	69	8	2.28	2.48	2.55
115	45	12	0	0.57	0.42	0.00
116	92	33	3	1.17	1.18	0.95
117	64	34	3	0.82	0.85	0.95
118	245	105	20	3.10	3.71	6.37
119	163	60	10	2.08	2.08	3.29
120	627	341	41	7.99	8.53	12.70
121	94	29	3	1.18	1.03	0.95
122	275	106	3	3.49	3.74	0.95
123	286	107	10	3.64	3.79	3.18
124	761	326	58	9.69	11.54	18.22
125	143	51	9	1.82	1.80	3.66
126	41	21	4	0.52	0.74	1.27
127	279	108	12	3.56	3.81	3.82
128	334	126	6	4.26	4.47	1.98
129	326	128	11	4.12	4.50	3.50
130	322	148	8	4.09	5.08	2.55
131	78	19	0	1.00	0.71	0.00
132	155	48	8	1.96	1.67	2.55
133	52	10	2	0.66	0.37	0.64
134	289	159	18	3.66	5.57	5.94
135	60	18	0	0.75	0.64	0.00
136	68	13	1	0.85	0.81	0.32
137	52	16	3	0.66	0.56	0.95
138	67	18	4	0.86	0.63	1.27
139	1047	396	19	13.37	13.97	6.11
140	1266	506	99	16.37	18.30	31.48
141	137	45	3	1.75	1.61	0.95
142	638	218	17	8.11	7.69	5.96
143	619	229	9	7.88	8.07	2.96
144	605	255	32	7.64	9.01	9.81
145	771	282	45	9.80	9.96	14.49
146	461	83	5	5.88	2.91	1.76
147	671	296	23	8.52	10.47	7.48
148	74	29	4	0.94	1.07	1.41
149	50	16	2	0.63	0.56	0.67
150	59	22	1	0.76	0.78	0.32
151	63	19	0	0.79	0.67	0.01
152	67	33	4	0.86	1.17	1.36
153	605	185	12	7.70	6.58	4.16
154	147	48	7	1.84	1.70	1.97
155	558	206	35	7.11	7.64	11.07
156	558	206	35	7.11	7.64	11.07
157	298	144	26	3.78	5.08	8.31
158	53	15	0	0.67	0.53	0.00
159	233	79	13	2.97	2.82	4.11
160	63	20	2	0.80	0.71	0.64
161	118	38	9	1.50	1.36	2.86
162	1689	748	90	21.51	26.42	28.36
163	31	9	1	0.39	0.32	0.32
164	102	29	2	1.30	1.02	0.64
165	61	23	5	0.77	0.81	1.59
166	109	33	5	1.39	1.11	1.60
167	1361	492	68	17.33	17.39	21.62
168	109	44	4	1.37	1.56	1.27
169	107	28	2	1.35	0.99	0.64
170	51	26	1	0.66	0.91	0.32
171	49	10	2	0.62	0.36	0.54
172	2208	870	71	28.17	34.48	22.43

Box core number	Trawl length/ km² 2008-2012 (5 km radius)	Trawl length/ km² 2008-2012 (3 km radius)	Trawl length/ km² 2008-2012 (1 km radius)	Roughness 3x3 cell window	Standard deviation of bathymetry 3x3 cell window	Rugosity 5x5 cell window
87	0.33	0.42	1.15	3.71	1.31	0.0000310
88	3.28	2.15	0.92	1.02	0.31	0.0000001
89	0.00	0.00	0.00	8.96	3.31	0.0000078
90	1.39	0.00	0.00	12.43	3.60	0.0000252
91	2.34	0.57	0.00	3.98	1.60	0.0000004
92	1.13	1.19	2.08	5.26	1.67	0.0000009
93	26.06	30.34	34.91	0.54	0.20	0.0000002
94	0.25	0.41	0.55	3.33	1.34	0.0000002
95	1.34	1.62	1.91	1.35	0.81	0.0000001
96	0.12	0.20	0.00	3.46	1.24	0.0000000
97	0.48	0.20	0.00	2.38	0.73	0.0000003
98	0.32	0.26	0.53	2.46	0.73	0.0000003
99	0.33	0.19	0.00	5.00	1.48	0.0000005
100	0.67	0.74	0.83	4.03	1.26	0.0000012
101	0.99	1.26	2.03	1.37	0.49	0.0000008
102	1.06	0.79	1.23	4.60	1.37	0.0000002
103	4.55	5.47	4.82	1.85	0.54	0.0000006
104	0.28	0.32	0.00	4.90	0.67	0.0000001
105	1.02	0.86	0.34	1.51	0.58	-5.0000001
106	9.79	9.12	9.71	1.91	0.57	0.0000002
107	11.44	11.70	13.13	2.31	0.70	0.0000001
108	23.16	27.78	32.76	4.71	1.38	0.0000002
109	3.82	0.39	0.00	3.80	1.24	0.0000004
110	0.00	0.00	0.00	0.42	0.13	0.0000008
111	0.08	0.00	0.00	0.14	0.04	0.0000001
112	0.36	0.07	0.00	3.85	1.24	0.0000010
113	0.00	0.00	0.00	0.21	0.06	0.0000000
114	2.07	0.89	0.61	3.06	0.88	0.0000015
115	0.13	0.20	0.27	0.64	0.20	0.0000001
116	0.19	0.17	0.00	0.18	0.06	0.0000001
117	0.13	0.20	0.15	1.06	0.31	0.0000014
118	3.83	4.17	2.48	3.81	1.12	0.0000786
119	1.36	1.31	1.38	4.14	1.34	0.0000024
120	20.34	21.36	26.09	2.55	0.74	0.0000002
121	0.41	0.00	0.00	4.96	1.51	0.0000002
122	3.54	3.03	4.83	2.67	0.83	0.0000006
123	6.35	7.70	6.81	7.18	2.08	0.0000038
124	25.23	31.61	39.32	4.87	1.47	0.0000013
125	3.17	3.32	3.71	2.58	0.92	0.0000002
126	0.09	0.00	0.00	2.19	0.65	0.0000001
127	4.66	5.55	3.19	6.77	2.41	0.0000088
128	4.83	3.97	4.91	5.39	1.82	0.0000025
129	3.52	3.17	2.38	3.68	1.15	0.0000005
130	3.88	4.21	2.15	3.95	1.14	0.0000021
131	0.91	0.00	0.00	4.91	1.48	0.0000008
132	0.53	0.48	0.46	3.02	0.97	0.0000002
133	0.15	0.21	0.64	0.31	0.10	0.0000001
134	1.48	1.96	0.88	14.53	4.42	0.0000289
135	0.16	0.22	0.62	0.11	0.03	0.0000000
136	0.15	0.20	0.00	0.08	0.03	0.0000001
137	0.16	0.19	0.00	0.41	0.13	0.0000017
138	0.10	0.00	0.00	2.11	0.65	0.0000000
139	20.60	22.61	17.79	4.63	1.34	0.0000033
140	28.02	34.05	51.20	11.14	3.84	0.0007769
141	1.56	1.34	1.51	2.39	0.78	0.0000001
142	15.12	15.69	22.53	3.03	0.91	0.0000189
143	14.24	12.67	12.18	2.93	0.89	0.0000001
144	10.57	11.96	12.97	3.05	0.88	0.0000002
145	18.03	17.24	16.84	2.26	0.73	0.0000060
146	6.89	2.08	0.63	19.50	5.63	0.0000392
147	13.03	16.77	12.33	1.10	0.32	0.0000030
148	0.12	0.20	0.27	0.28	0.11	0.0000001
149	0.15	0.20	0.29	0.44	0.13	0.0000002
150	0.20	0.30	0.00	0.04	0.01	-0.0000001
151	0.00	0.00	0.00	1.38	0.49	0.0000005
152	0.02	0.00	0.00	0.18	0.07	0.0000005
153	6.72	5.55	2.79	4.40	1.72	0.0000069
154	1.09	0.45	0.00	4.00	1.46	0.0000005
155	7.33	8.10	8.66	3.88	1.33	0.0000016
156	7.33	8.10	8.66	3.88	1.33	0.0000016
157	3.44	4.17	6.04	5.04	1.76	0.0000016
158	0.21	0.00	0.00	3.26	0.74	0.0000011
159	1.44	1.98	1.20	7.06	2.22	0.0000128
160	0.33	0.22	0.61	1.35	0.68	0.0000206
161	0.26	0.31	0.80	14.98	5.16	0.0001489
162	56.56	68.12	66.11	4.90	1.50	0.0000011
163	0.00	0.00	0.00	1.33	0.50	0.0000001
164	0.59	0.29	0.87	5.43	1.50	0.0000111
165	0.12	0.17	0.00	0.20	0.06	0.0000001
166	2.35	1.14	0.64	11.04	3.34	0.0005343
167	27.75	31.80	40.00	4.04	1.54	0.0000093
168	0.35	0.31	0.00	0.26	0.09	0.0000000
169	1.25	0.32	0.00	0.72	0.22	0.0000002
170	0.00	0.00	0.00	1.49	0.54	0.0000000
171	0.08	0.00	0.00	5.50	1.65	0.0000086
172	73.23	86.45	86.79	7.31	2.55	0.0000045

Box core number	Rugosity 25x25 cell window	BPI 25 cell radius	BPI 50 cell radius	BPI 75 cell radius	BPI 100 cell radius	BPI 125 cell radius	BPI 150 cell radius	Slope	Radial aspect from -1 west to 1 east	Radial aspect from -1 south to 1 north
87	0.0000353	-3.54	-9.53	-19.34	-20.33	-25.44	-30.66	1.21	0.181	0.983
88	0.0000336	0.66	-0.20	-4.05	-9.63	-16.39	-23.93	0.29	0.494	0.869
89	0.0000541	-18.92	-28.04	-24.13	-15.77	-6.77	-5.95	3.10	-0.985	0.261
90	0.0000641	3.90	1.32	9.90	21.68	36.71	52.74	3.37	-0.725	0.689
91	0.0000983	3.29	9.47	19.66	32.53	48.43	70.05	1.50	-0.016	1.000
92	0.0000441	1.38	3.83	9.20	16.62	25.84	37.62	1.56	0.347	0.938
93	0.0000026	1.28	6.07	14.47	26.38	42.12	58.70	0.19	0.996	0.085
94	0.0000031	1.82	4.46	7.19	9.70	11.64	13.09	1.25	-0.016	1.000
95	0.0000005	0.84	3.12	7.08	11.95	18.15	25.49	0.76	-0.207	0.978
96	0.0000009	0.83	3.18	6.62	11.18	16.66	22.77	1.16	0.155	0.988
97	0.0000029	0.59	1.97	4.05	6.82	10.25	14.25	0.68	0.411	0.912
98	0.0000015	1.02	3.61	7.89	11.03	14.00	20.08	0.68	0.511	0.860
99	0.0000029	-0.07	0.30	1.41	2.48	3.90	6.03	1.39	0.325	0.851
100	0.0000052	1.08	1.80	2.20	2.71	3.01	2.82	1.18	0.374	0.927
101	0.0000049	-0.42	-3.41	-8.52	-14.74	-21.55	-28.94	0.46	-0.148	0.989
102	0.0000033	1.28	3.38	7.19	8.01	12.00	16.98	1.28	0.513	0.859
103	0.0000038	0.49	3.18	4.72	6.37	8.24	9.88	0.51	0.843	0.539
104	0.0000008	0.28	0.42	3.75	14.21	33.53	38.45	0.63	0.171	0.985
105	0.0000004	0.46	1.53	5.40	6.10	8.58	13.88	0.54	0.075	0.997
106	0.0000039	1.26	6.61	18.64	18.63	23.66	33.33	0.93	-0.304	0.951
107	0.0000017	0.72	1.87	2.54	3.12	3.04	2.74	0.85	-0.893	0.449
108	0.0000011	-0.93	3.78	17.43	31.38	44.73	57.85	1.29	-0.825	0.565
109	0.0004887	-15.10	-26.45	-28.97	-25.98	-19.99	-14.42	1.16	-0.955	0.296
110	0.0000027	-1.32	-2.74	-4.96	-7.94	-12.83	-20.01	0.12	0.498	-0.867
111	0.0000009	0.36	-0.56	-0.90	-1.80	-4.35	-8.61	0.04	0.668	0.734
112	0.0000017	0.78	-0.13	-1.13	-4.64	-8.80	-13.22	1.16	-0.945	0.327
113	0.0000008	-0.41	-0.78	-1.97	-3.48	-6.27	-9.97	0.06	0.851	0.515
114	0.0000026	0.91	-0.92	-2.46	-5.30	-9.87	-17.45	0.83	0.713	-0.701
115	0.0000009	-0.06	-0.87	-2.11	-4.13	-6.64	-10.09	0.19	-0.359	-0.933
116	0.0000004	0.27	0.55	0.30	0.30	-0.22	-2.35	0.06	0.988	-0.157
117	0.0000066	2.45	3.08	2.28	0.69	-2.12	-6.67	0.29	-0.759	0.651
118	0.0004156	-20.55	-31.13	-38.47	-46.27	-54.79	-63.43	1.01	0.707	-0.707
119	0.0000219	4.37	4.75	1.59	-2.51	-8.19	-14.39	1.25	0.951	-0.308
120	0.0000020	0.01	-2.55	-5.94	-11.08	-11.46	-4.05	0.69	-0.773	0.634
121	0.0000222	-2.06	-7.84	-12.77	-18.01	-23.64	-29.04	1.41	-0.893	0.450
122	0.0000018	0.29	2.33	4.10	6.48	10.21	13.97	0.78	-0.920	0.392
123	0.0000597	1.41	18.20	37.30	52.88	66.96	80.69	1.95	-0.773	0.635
124	0.0000147	-2.90	-6.52	-4.26	7.66	20.35	33.08	1.38	-0.883	0.469
125	0.0000026	1.52	1.61	-0.76	-4.26	-8.17	-12.40	0.86	-0.987	0.159
126	0.0000034	0.07	-0.49	-2.07	-4.60	-8.09	-12.21	0.61	-0.850	0.527
127	0.0000517	-3.80	15.91	42.76	69.57	93.39	114.67	2.26	-0.987	0.159
128	0.0000232	-3.95	-0.86	23.39	47.40	69.60	89.64	1.70	-0.973	0.232
129	0.0000052	1.51	3.21	1.68	-1.92	0.61	10.03	1.07	-0.923	0.385
130	0.0000049	-1.38	-4.39	-10.77	-26.66	-17.17	-5.76	1.07	-0.946	0.325
131	0.0000127	2.07	1.08	-1.77	-8.96	-18.38	-30.24	0.45	-0.933	0.359
132	0.0000297	3.57	1.28	-4.38	-14.62	-24.76	-35.63	0.91	-0.944	0.330
133	0.0000003	0.12	0.19	-0.27	-0.84	-1.83	-4.08	0.06	-0.916	0.402
134	0.0007338	13.50	7.66	-10.98	-31.78	-34.72	-26.30	4.12	-0.881	0.455
135	0.0000002	0.18	-0.61	-2.46	-5.45	-8.11	-11.74	0.03	0.686	0.728
136	0.0000160	0.36	0.43	0.25	-0.33	-2.64	-4.60	0.02	0.931	0.364
137	0.0000015	4.79	11.68	13.38	13.43	11.05	6.54	0.12	0.396	0.918
138	0.0000196	-0.96	-3.52	-7.09	-11.22	-16.24	-22.03	0.61	0.344	-0.406
139	0.0000393	1.27	3.21	4.35	7.36	11.44	16.38	1.25	0.686	-0.728
140	0.0000010	13.41	18.37	18.22	15.31	12.45	8.51	3.58	0.977	0.213
141	0.0000307	-0.11	-1.20	-4.50	-9.69	-17.26	-28.13	0.73	0.957	-0.289
142	0.0000011	7.56	18.03	31.11	42.99	53.72	63.18	0.85	0.885	0.465
143	0.0000031	-0.65	-3.07	5.36	15.63	27.53	41.84	0.84	0.900	-0.435
144	0.0000012	0.02	0.35	1.50	6.81	18.91	33.04	0.83	0.761	-0.648
145	0.0000717	-6.41	-10.03	-12.85	-9.25	3.99	23.34	0.68	0.943	0.333
146	0.0006741	10.00	8.82	28.51	51.61	75.66	95.89	5.25	-0.683	0.731
147	0.0000330	-21.84	-30.81	-77.67	-100.83	-101.26	-95.13	0.30	0.784	0.645
148	0.0000007	-0.31	-2.93	-5.06	-6.72	-8.26	-9.90	0.10	0.998	-0.059
149	0.0000011	-0.69	-1.20	-2.19	-3.80	-6.18	-9.39	0.12	0.716	-0.698
150	0.0000002	-0.18	-0.44	-0.61	-1.28	-3.06	-5.92	0.01	-0.374	-0.927
151	0.0000039	-1.09	-3.41	-6.39	-11.27	-23.94	-41.32	0.46	-0.985	0.170
152	0.0000009	-0.99	-2.37	-4.21	-6.14	-8.77	-14.32	0.06	-0.012	-1.000
153	0.0001349	8.24	7.44	3.22	4.34	14.34	28.86	1.61	1.000	-0.011
154	0.0000156	0.22	0.87	-0.93	-4.21	-8.52	-13.65	1.37	0.992	-0.124
155	0.0000055	1.17	-0.18	-1.05	5.74	17.46	31.01	1.24	0.976	-0.216
156	0.0000055	1.17	-0.18	-1.05	5.74	17.46	31.01	1.24	0.976	-0.216
157	0.0000076	-1.41	-3.76	-9.38	-14.50	-1.25	11.86	1.64	0.982	-0.191
158	0.0000036	0.61	-4.66	-10.54	-16.38	-22.16	-29.35	0.70	0.959	-0.284
159	0.0008910	-23.12	-39.88	-50.54	-61.13	-49.47	-34.01	2.08	0.372	0.928
160	0.0000063	-1.92	-4.38	-10.56	-17.26	-24.40	-33.32	0.64	0.749	-0.662
161	0.0000143	-12.14	-22.26	-30.93	-43.38	-51.91	-61.00	4.82	0.977	0.214
162	0.0000174	-4.53	-11.85	-18.62	-25.50	-31.85	-38.70	1.78	-0.999	0.053
163	0.0000034	-1.13	-3.06	-5.49	-7.96	-10.60	-13.37	0.47	0.995	-0.098
164	0.0000811	3.71	29.40	70.69	120.45	162.27	192.96	1.77	-0.983	0.185
165	0.0000007	-0.86	-1.75	-3.30	-5.42	-9.38	-20.07	0.06	-0.593	-0.805
166	0.0033782	-24.61	-87.05	-111.48	-108.94	-89.18	-67.23	2.97	-0.749	-0.663
167	0.0008903	-20.16	-51.81	-66.62	-77.74	-81.37	-71.49	1.44	-0.014	1.000
168	0.0000004	-0.36	-1.19	-3.88	-8.44	-15.04	-23.68	0.08	-0.352	-0.936
169	0.0000011	-0.88	-2.03	-3.53	-6.82	-13.67	-27.32	0.21	-0.896	-0.444
170	0.0000005	-0.31	-2.96	-6.74	-12.00	-19.33	-29.10	0.51	0.991	-0.132
171	0.0000633	-1.03	-7.44	-19.56	-25.81	-30.24	-30.87	1.54	0.872	0.490
172	0.0000135	2.14	4.32	1.82	-0.62	-2.67	-2.45	2.39	-0.983	-0.187

Box core number	Successful collection*	Latitude	Longitude	Multibeam bathymetry	Collection year	Collection month	Crew number	Seafloor temperature 2008/°C	Seafloor temperature 2009/°C	Seafloor temperature 2010/°C
173	Y	46.476	-6.478	739.7	2009	August	3	3.65	3.54	3.68
174	Y	46.474	-6.478	781.4	2009	August	3	3.65	3.54	3.68
175	Y	46.580	-6.526	1010.6	2009	August	3	3.56	3.46	3.60
176	Y	46.550	-6.748	1132.2	2009	August	3	3.52	3.42	3.59
177	Y	46.387	-6.743	1185.2	2009	August	3	3.49	3.39	3.56
178	N	46.388	-6.935	707.9	2009	August	3	3.49	3.37	3.56
179	N	46.388	-6.935	707.9	2009	August	3	3.49	3.37	3.56
180	Y	46.505	-7.049	723.1	2009	August	3	3.48	3.33	3.55
181	Y	46.348	-6.134	873.1	2010	June	4	3.61	3.54	3.65
182	Y	46.366	-6.523	891.3	2010	June	4	3.61	3.51	3.65
183	Y	46.405	-6.277	918.0	2010	June	4	3.63	3.54	3.66
184	N	46.262	-6.170	1316.8	2010	June	4	3.57	3.50	3.61
185	Y	46.262	-6.170	1316.8	2010	June	4	3.57	3.50	3.61
186	Y	46.349	-5.899	792.5	2010	June	4	3.50	3.43	3.54
187	Y	46.508	-5.542	990.4	2010	June	4	3.52	3.44	3.55
188	Y	46.396	-4.991	1206.3	2010	June	4	3.46	3.36	3.49
189	Y	46.401	-4.645	1836.1	2010	June	4	3.36	3.27	3.39
190	Y	46.355	-4.632	1467.2	2010	June	4	3.38	3.31	3.41
191	Y	46.402	-4.878	1458.5	2010	June	4	3.43	3.34	3.46
192	Y	46.368	-5.219	1338.3	2010	June	4	3.47	3.38	3.50
193	Y	46.337	-4.996	1574.4	2010	June	4	3.44	3.36	3.47
194	N	46.416	-5.065	907.9	2010	June	4	3.49	3.38	3.51
195	N	46.416	-5.065	907.9	2010	June	4	3.49	3.38	3.51
196	Y	46.314	-5.259	1602.0	2010	June	4	3.49	3.42	3.53
197	Y	46.302	-5.309	1442.2	2010	June	4	3.43	3.37	3.46
198	N	46.361	-5.703	783.6	2010	June	4	3.56	3.48	3.59
199	Y	46.361	-5.703	786.5	2010	June	4	3.56	3.48	3.59
200	Y	46.192	-5.973	938.4	2010	June	4	3.47	3.40	3.51
201	Y	46.137	-6.051	1369.1	2010	June	4	3.45	3.39	3.50
202	Y	46.171	-5.737	1196.5	2010	June	4	3.44	3.37	3.47
203	N	46.326	-6.283	1000.0	2010	June	4	4.02	3.92	4.05
204	Y	46.326	-6.283	1000.0	2010	June	4	4.02	3.92	4.05
205	N	46.340	-6.100	1094.5	2010	June	4	3.56	3.48	3.60
206	Y	46.340	-6.100	1094.5	2010	June	4	3.56	3.48	3.60
207	Y	46.274	-6.288	851.1	2010	June	4	3.81	3.73	3.84
208	Y	46.281	-6.596	988.8	2010	June	4	3.51	3.43	3.56
209	N	46.087	-6.668	1335.6	2010	June	4	3.50	3.42	3.55
210	Y	45.971	-6.705	811.7	2010	June	4	3.50	3.43	3.55
211	N	46.040	-6.726	1340.2	2010	June	4	3.43	3.35	3.48
212	Y	46.040	-6.726	1340.2	2010	June	4	3.43	3.35	3.48
213	Y	45.904	-6.796	728.0	2010	June	4	3.39	3.33	3.44
214	Y	45.941	-6.562	1516.4	2010	June	4	3.35	3.30	3.41
215	Y	46.326	-6.793	1382.2	2010	June	4	3.39	3.49	3.66
216	Y	46.404	-6.612	1061.6	2010	June	4	3.54	3.44	3.59
217	Y	45.853	-6.384	1907.3	2010	June	4	3.54	3.73	3.86
218	Y	45.932	-6.334	938.9	2010	June	4	3.51	3.36	3.57
219	Y	46.000	-6.316	1546.8	2010	June	4	3.42	3.37	3.47
220	Y	46.066	-5.878	1358.5	2010	June	4	3.33	3.28	3.37
221	Y	47.847	-6.231	1301.1	2010	June	4	3.30	3.25	3.34
222	Y	46.078	-6.236	1489.1	2010	June	4	3.44	3.38	3.49
223	Y	45.982	-6.214	1348.9	2010	June	4	3.27	3.23	3.32
224	Y	45.819	-6.473	1706.2	2010	June	4	3.31	3.26	3.36
225	Y	45.797	-6.763	1670.7	2010	June	4	3.42	3.37	3.47
226	Y	45.900	-6.906	1150.3	2010	June	4	3.33	3.28	3.40
227	Y	46.306	-6.727	1307.8	2010	June	4	3.50	3.41	3.55
228	Y	46.236	-6.885	1425.0	2010	June	4	3.58	3.49	3.65
229	Y	46.117	-6.860	1306.5	2010	June	4	3.69	3.60	3.74
230	Y	46.045	-7.017	1444.1	2010	June	4	3.41	3.34	3.48
231	Y	46.169	-7.123	1783.7	2010	July	5	3.68	3.57	3.74
232	N	45.873	-7.026	1929.5	2010	July	5	3.43	3.37	3.49
233	N	45.924	-7.231	1929.5	2010	July	5	3.34	3.18	3.32
234	Y	45.924	-7.231	1929.5	2010	July	5	3.34	3.18	3.32
235	Y	46.050	-7.064	1431.6	2010	July	5	3.33	3.26	3.41
236	Y	46.115	-7.265	688.4	2010	July	5	3.27	3.11	3.35
237	Y	46.003	-7.409	1320.1	2010	July	5	3.20	3.10	3.31
238	Y	46.117	-7.409	805.7	2010	July	5	3.15	3.00	3.25
239	Y	46.041	-7.556	801.2	2010	July	5	3.20	3.05	3.30
240	Y	45.981	-7.499	1346.5	2010	July	5	3.15	3.04	3.27
241	Y	45.992	-7.634	710.9	2010	July	5	3.33	3.16	3.41
242	Y	45.893	-7.505	1481.4	2010	July	5	3.22	3.11	3.33
243	Y	45.893	-7.393	1639.7	2010	July	5	3.31	3.14	3.31
244	Y	45.810	-7.266	1869.7	2010	July	5	3.46	3.35	3.40
245	Y	45.773	-7.679	1833.6	2010	July	5	3.35	3.16	3.52
246	Y	45.772	-7.569	1893.3	2010	July	5	3.34	3.19	3.36
247	Y	45.675	-7.591	1871.4	2010	July	5	3.15	3.10	3.41
248	Y	45.946	-7.844	706.1	2010	July	5	3.13	2.98	3.25
249	Y	45.742	-7.863	938.4	2010	July	5	3.16	3.00	3.33
250	Y	45.693	-7.899	1315.5	2010	July	5	3.31	3.43	3.79
251	Y	45.591	-7.865	1790.1	2010	July	5	3.33	3.29	3.59
252	Y	45.449	-7.688	2121.9	2010	July	5	3.22	3.19	3.40
253	Y	45.539	-7.800	1501.3	2010	July	5	3.10	3.05	3.28
254	Y	45.405	-8.473	991.3	2010	July	5	2.80	2.75	3.21
255	Y	45.541	-8.301	841.9	2010	July	5	2.77	2.70	2.98
256	Y	45.681	-7.995	797.9	2010	July	5	3.01	2.91	2.94
257	Y	45.583	-8.007	1332.7	2010	July	5	3.30	3.21	3.15
258	Y	45.346	-8.225	1429.8	2010	July	5	2.93	2.86	3.41
										3.08

Box core number	Seafloor temperature average for collection year/°C	Seafloor temperature average for collection and previous year/°C	Seafloor temperature 10 year minimum/°C	Seafloor temperature 10 year mean/°C	Seafloor salinity 2008/ppt	Seafloor salinity 2009/ppt
173	3.54	3.60	3.64	4.12	34.73	34.74
174	3.54	3.60	3.64	4.12	34.73	34.74
175	3.46	3.51	3.65	4.11	34.71	34.70
176	3.42	3.47	3.65	4.08	34.70	34.69
177	3.39	3.44	3.64	4.08	34.70	34.69
178	3.37	3.43	3.69	4.13	34.68	34.66
179	3.37	3.43	3.69	4.13	34.68	34.66
180	3.33	3.40	3.65	4.21	34.64	34.63
181	3.85	3.59	3.63	4.14	34.77	34.75
182	3.85	3.58	3.64	4.11	34.75	34.74
183	3.66	3.60	3.64	4.15	34.76	34.74
184	3.61	3.55	3.58	4.07	34.77	34.76
185	3.61	3.55	3.58	4.07	34.77	34.76
186	3.54	3.48	3.57	4.08	34.76	34.75
187	3.55	3.50	3.54	4.02	34.79	34.78
188	3.49	3.43	3.53	3.96	34.80	34.79
189	3.39	3.33	3.48	3.88	34.81	34.80
190	3.31	3.26	3.42	3.73	34.82	34.80
191	3.46	3.40	3.52	3.94	34.80	34.79
192	3.50	3.44	3.54	3.97	34.79	34.78
193	3.47	3.42	3.54	3.97	34.83	34.82
194	3.51	3.45	3.57	4.02	34.79	34.78
195	3.51	3.45	3.57	4.02	34.79	34.78
196	3.53	3.47	3.57	3.94	34.82	34.81
197	3.46	3.41	3.43	3.76	34.81	34.80
198	3.59	3.53	3.54	4.02	34.80	34.78
199	3.59	3.53	3.54	4.02	34.80	34.78
200	3.51	3.46	3.53	4.00	34.77	34.76
201	3.50	3.44	3.49	3.92	34.77	34.76
202	3.47	3.42	3.48	3.88	34.79	34.78
203	4.05	3.99	3.62	4.12	34.90	34.89
204	4.05	3.99	3.62	4.12	34.90	34.89
205	3.60	3.54	3.56	4.05	34.77	34.76
206	3.60	3.54	3.56	4.05	34.77	34.76
207	3.84	3.79	3.60	4.10	34.84	34.82
208	3.56	3.50	3.63	4.10	34.72	34.71
209	3.55	3.48	3.60	4.09	34.73	34.72
210	3.55	3.49	3.56	4.06	34.75	34.74
211	3.48	3.42	3.57	4.05	34.71	34.70
212	3.48	3.42	3.57	4.05	34.71	34.70
213	3.44	3.39	3.52	3.99	34.73	34.72
214	3.41	3.35	3.50	3.94	34.74	34.73
215	3.66	3.57	3.64	4.07	34.74	34.73
216	3.79	3.72	3.64	4.08	34.72	34.71
217	3.86	3.78	3.65	4.14	34.83	34.81
218	3.97	3.91	3.68	4.19	34.94	34.93
219	3.47	3.41	3.55	4.04	34.75	34.74
220	3.47	3.41	3.53	3.72	34.73	34.73
221	3.34	3.30	3.46	3.84	34.76	34.75
222	3.49	3.43	3.52	3.97	34.76	34.75
223	3.32	3.27	3.44	3.79	34.77	34.76
224	3.36	3.31	3.48	3.87	34.75	34.74
225	3.47	3.42	3.46	3.83	34.77	34.76
226	3.40	3.34	3.46	3.84	34.71	34.70
227	3.55	3.48	3.59	4.04	34.72	34.71
228	3.85	3.57	3.62	4.05	34.74	34.73
229	3.74	3.67	3.53	3.97	34.81	34.80
230	3.48	3.41	3.50	3.91	34.70	34.69
231	3.74	3.66	3.68	4.11	34.76	34.75
232	3.49	3.43	3.44	3.78	34.76	34.75
233	3.32	3.25	3.48	3.82	34.64	34.63
234	3.32	3.25	3.48	3.82	34.64	34.63
235	3.41	3.33	3.51	3.93	34.66	34.65
236	3.35	3.24	3.62	4.23	34.55	34.54
237	3.31	3.20	3.68	4.11	34.56	34.55
238	3.25	3.13	3.63	4.24	34.50	34.48
239	3.30	3.18	3.59	4.23	34.51	34.50
240	3.27	3.16	3.68	4.16	34.53	34.51
241	3.41	3.28	3.51	4.19	34.54	34.53
242	3.33	3.22	3.68	4.09	34.57	34.56
243	3.31	3.23	3.55	3.93	34.60	34.59
244	3.51	3.46	3.43	3.73	34.77	34.76
245	3.36	3.26	3.68	4.12	34.58	34.57
246	3.41	3.35	3.45	3.76	34.71	34.70
247	3.25	3.17	3.51	3.87	34.60	34.59
248	3.23	3.11	3.54	4.20	34.46	34.45
249	3.79	3.69	3.65	4.22	34.72	34.70
250	3.59	3.51	3.63	4.04	34.71	34.70
251	3.40	3.34	3.45	3.76	34.71	34.70
252	3.28	3.23	3.39	3.65	34.69	34.68
253	3.21	3.13	3.53	3.90	34.56	34.55
254	2.98	2.86	3.63	4.35	34.29	34.29
255	2.94	2.82	3.48	4.18	34.29	34.28
256	3.15	3.03	3.65	4.35	34.42	34.41
257	3.41	3.31	3.69	4.14	34.57	34.56
258	3.08	2.97	3.67	4.35	34.37	34.37

Box core number	Seafloor salinity 2010/ppt	Seafloor salinity average for collection year/ppt	Seafloor salinity average for collection and previous year/ppt	Seafloor zonal velocity 2008 m/s	Seafloor zonal velocity 2009 m/s	Seafloor zonal velocity 2010 m/s
173	34.77	34.74	34.75	-0.0046	-0.0047	-0.2869
174	34.77	34.74	34.75	-0.0046	-0.0047	-0.2869
175	34.73	34.70	34.71	-0.0054	-0.0049	-0.1718
176	34.72	34.69	34.70	-0.0001	0.0003	-0.1385
177	34.72	34.69	34.69	-0.0027	-0.0038	-0.0680
178	34.70	34.66	34.67	-0.0057	-0.0061	-0.0099
179	34.70	34.66	34.67	-0.0057	-0.0061	-0.0099
180	34.67	34.63	34.63	0.0073	0.0073	0.0795
181	34.78	34.78	34.77	-0.0113	-0.0066	-0.1331
182	34.76	34.76	34.75	-0.0026	-0.0008	0.0754
183	34.77	34.77	34.76	-0.0085	-0.0055	-0.1212
184	34.78	34.78	34.77	-0.0135	-0.0096	-0.1572
185	34.78	34.78	34.77	-0.0135	-0.0096	-0.1572
186	34.78	34.78	34.76	-0.0253	-0.0178	-0.2358
187	34.80	34.80	34.79	-0.0297	-0.0247	-0.1718
188	34.81	34.81	34.80	-0.0338	-0.0317	-0.1779
189	34.81	34.82	34.81	-0.0438	-0.0414	-0.1498
190	34.82	34.82	34.81	-0.0432	-0.0430	-0.1695
191	34.81	34.81	34.80	-0.0338	-0.0345	-0.2793
192	34.80	34.80	34.79	-0.0280	-0.0294	-0.3150
193	34.83	34.83	34.82	-0.0443	-0.0440	-0.3227
194	34.80	34.80	34.79	-0.0278	-0.0257	-0.2063
195	34.80	34.80	34.79	-0.0278	-0.0257	-0.2063
196	34.83	34.83	34.82	-0.0403	-0.0370	-0.1881
197	34.82	34.82	34.81	-0.0359	-0.0327	-0.3533
198	34.81	34.81	34.80	-0.0218	-0.0174	-0.3271
199	34.81	34.81	34.80	-0.0218	-0.0174	-0.3271
200	34.78	34.78	34.77	-0.0291	-0.0217	-0.3842
201	34.78	34.78	34.77	-0.0288	-0.0227	-0.3880
202	34.80	34.80	34.79	-0.0412	-0.0345	-0.3204
203	34.90	34.90	34.89	0.0014	0.0025	0.4340
204	34.90	34.90	34.89	0.0014	0.0025	0.4340
205	34.78	34.78	34.77	-0.0175	-0.0125	-0.1965
206	34.78	34.78	34.77	-0.0175	-0.0125	-0.1965
207	34.84	34.84	34.83	-0.0087	-0.0071	-0.6026
208	34.73	34.73	34.72	-0.0026	-0.0014	0.0361
209	34.74	34.74	34.73	-0.0102	-0.0080	-0.2260
210	34.76	34.76	34.75	-0.0203	-0.0148	-0.2241
211	34.73	34.73	34.71	-0.0139	-0.0110	-0.3480
212	34.73	34.73	34.71	-0.0139	-0.0110	-0.3480
213	34.74	34.74	34.73	-0.0291	-0.0229	-0.2917
214	34.76	34.76	34.74	-0.0534	-0.0435	-0.4574
215	34.76	34.76	34.74	-0.0689	-0.0614	-0.4457
216	34.74	34.74	34.72	-0.0017	-0.0013	0.0112
217	34.83	34.83	34.82	-0.0190	-0.0162	-0.1670
218	34.93	34.93	34.93	-0.1180	-0.0953	-0.1411
219	34.76	34.76	34.75	-0.0289	-0.0172	-0.1490
220	34.79	34.79	34.79	-0.0499	-0.0427	-0.2222
221	34.77	34.77	34.77	-0.0337	-0.0296	-0.2516
222	34.77	34.77	34.76	-0.0170	-0.0142	-0.2254
223	34.78	34.78	34.77	-0.0363	-0.0323	-0.3388
224	34.76	34.76	34.75	-0.0551	-0.0455	-0.1824
225	34.78	34.78	34.77	-0.0463	-0.0386	-0.3701
226	34.73	34.73	34.71	-0.0258	-0.0212	-0.2684
227	34.73	34.73	34.72	-0.0052	-0.0053	-0.0683
228	34.76	34.76	34.74	-0.0128	-0.0158	-0.1687
229	34.82	34.82	34.81	-0.0034	-0.0070	-0.2933
230	34.72	34.72	34.71	-0.0208	-0.0191	-0.2729
231	34.77	34.77	34.76	-0.0350	-0.0386	-0.4554
232	34.77	34.77	34.76	-0.0348	-0.0277	-0.4142
233	34.67	34.67	34.65	-0.0209	-0.0192	-0.2693
234	34.67	34.67	34.65	-0.0209	-0.0192	-0.2693
235	34.69	34.69	34.67	-0.0211	-0.0206	-0.2709
236	34.59	34.59	34.57	-0.0175	-0.0178	-0.2482
237	34.60	34.60	34.58	-0.0164	-0.0165	-0.1768
238	34.55	34.55	34.53	-0.0161	-0.0162	-0.1343
239	34.56	34.56	34.53	-0.0214	-0.0214	-0.1961
240	34.57	34.57	34.54	-0.0188	-0.0188	-0.2539
241	34.59	34.59	34.56	-0.0221	-0.0217	-0.3118
242	34.61	34.61	34.59	-0.0215	-0.0215	-0.2827
243	34.64	34.64	34.62	-0.0208	-0.0204	-0.2669
244	34.78	34.78	34.77	-0.0148	-0.0173	-0.4456
245	34.61	34.61	34.59	-0.0242	-0.0239	-0.2621
246	34.73	34.73	34.72	-0.0219	-0.0191	-0.2897
247	34.63	34.63	34.61	-0.0270	-0.0260	-0.2644
248	34.51	34.51	34.48	-0.0143	-0.0139	-0.3607
249	34.73	34.73	34.72	-0.0324	-0.0295	-0.4383
250	34.73	34.73	34.71	-0.0614	-0.0613	-0.1901
251	34.73	34.73	34.72	-0.0554	-0.0542	-0.1882
252	34.71	34.71	34.70	-0.0400	-0.0385	-0.3471
253	34.60	34.60	34.58	-0.0314	-0.0316	-0.3452
254	34.37	34.37	34.33	-0.0145	-0.0144	-0.2665
255	34.37	34.37	34.33	-0.0152	-0.0169	-0.2809
256	34.48	34.48	34.45	-0.0183	-0.0171	-0.2568
257	34.61	34.61	34.59	-0.0325	-0.0316	-0.4340
258	34.44	34.44	34.41	-0.0222	-0.0212	-0.3221

Box core number	Seafloor zonal velocity average for collection year m/s	Seafloor zonal velocity average for collection and previous year m/s	Seafloor meridional velocity 2008 m/s	Seafloor meridional velocity 2009 m/s	Seafloor meridional velocity 2010 m/s
173	-0.0047	-0.0047	-0.0017	-0.0012	0.0516
174	-0.0047	-0.0047	-0.0017	-0.0012	0.0516
175	-0.0049	-0.0051	-0.0086	-0.0086	0.0051
176	0.0003	0.0001	-0.0385	-0.0434	-0.2182
177	-0.0038	-0.0032	-0.0294	-0.0315	-0.0038
178	-0.0061	-0.0059	-0.0803	-0.0814	-0.1347
179	-0.0061	-0.0059	-0.0803	-0.0814	-0.1347
180	0.0073	0.0073	-0.0700	-0.0671	-0.1155
181	-0.1331	-0.0698	-0.0098	-0.0095	0.0284
182	0.0754	0.0373	-0.0103	-0.0117	-0.0451
183	-0.1212	-0.0633	-0.0082	-0.0078	-0.1175
184	-0.1572	-0.0834	-0.0158	-0.0143	-0.1432
185	-0.1572	-0.0834	-0.0158	-0.0143	-0.1432
186	-0.2238	-0.1198	-0.0190	-0.0171	-0.2096
187	-0.1718	-0.0962	-0.0295	-0.0264	-0.3513
188	-0.2779	-0.1548	-0.0211	-0.0205	-0.2573
189	-0.1486	-0.0956	-0.0336	-0.0311	-0.3426
190	-0.1685	-0.1098	-0.0337	-0.0311	-0.3413
191	-0.2193	-0.1599	-0.0330	-0.0322	-0.2776
192	-0.2150	-0.1302	-0.0345	-0.0337	-0.2534
193	-0.3427	-0.1834	-0.0249	-0.0244	-0.2546
194	-0.2063	-0.1160	-0.0354	-0.0198	-0.2527
195	-0.2063	-0.1160	-0.0204	-0.0198	-0.2527
196	-0.1881	-0.1126	-0.0382	-0.0307	-0.3724
197	-0.3533	-0.1930	-0.0440	-0.0406	-0.4895
198	-0.1271	-0.1222	-0.0317	-0.0270	-0.3612
199	-0.1271	-0.1222	-0.0317	-0.0270	-0.3612
200	-0.2842	-0.1529	-0.0113	-0.0190	-0.2043
201	-0.2880	-0.1553	-0.0239	-0.0209	-0.2226
202	-0.2204	-0.1275	-0.0330	-0.0286	-0.3654
203	0.4240	0.2133	-0.0052	-0.0021	-0.6135
204	0.4240	0.2133	-0.0052	-0.0021	-0.6135
205	-0.1865	-0.1045	-0.0143	-0.0128	-0.1332
206	-0.1865	-0.1045	-0.0143	-0.0128	-0.1332
207	-0.6056	-0.3064	-0.0153	-0.0126	-0.1736
208	0.0362	0.0174	-0.0092	-0.0080	-0.0004
209	-0.2260	-0.1170	-0.0096	-0.0066	-0.0135
210	-0.2241	-0.1195	-0.0034	-0.0023	0.0278
211	-0.2480	-0.1295	-0.0102	-0.0074	-0.0226
212	-0.2480	-0.1295	-0.0102	-0.0074	-0.0226
213	-0.2317	-0.1373	-0.0080	-0.0071	-0.0448
214	-0.1874	-0.1166	-0.0334	-0.0241	-0.2336
215	-0.1437	-0.0780	-0.0459	-0.0341	-0.3249
216	0.0412	0.0049	-0.0153	-0.0141	-0.1691
217	-0.1870	-0.0866	0.0016	0.0031	0.0833
218	-0.1411	-0.1102	-0.0601	-0.0468	-0.7025
219	-0.2490	-0.1331	-0.0389	-0.0312	-0.2777
220	-0.2222	-0.1324	-0.0348	-0.0319	-0.3299
221	-0.2146	-0.1406	-0.0516	-0.0434	-0.3140
222	-0.1254	-0.1198	-0.0365	-0.0294	-0.2992
223	-0.1388	-0.1355	-0.0511	-0.0448	-0.3318
224	-0.1834	-0.1139	-0.0301	-0.0269	-0.2571
225	-0.3701	-0.2043	-0.0193	-0.0172	-0.1937
226	-0.2884	-0.1448	-0.0078	-0.0072	-0.0869
227	-0.0633	-0.0368	-0.0128	-0.0106	-0.0340
228	-0.1837	-0.0913	-0.0331	-0.0343	-0.3454
229	-0.2933	-0.1502	-0.0023	-0.0034	0.0351
230	-0.2729	-0.1460	-0.0218	-0.0214	-0.2403
231	-0.4554	-0.2470	-0.0606	-0.0671	-0.6646
232	-0.4142	-0.2210	-0.0061	-0.0050	-0.0716
233	-0.2693	-0.1442	-0.0330	-0.0312	-0.3352
234	-0.2693	-0.1442	-0.0330	-0.0312	-0.3352
235	-0.2709	-0.1457	-0.0279	-0.0283	-0.2606
236	-0.2492	-0.1335	-0.0497	-0.0508	-0.4455
237	-0.1768	-0.0966	-0.0490	-0.0520	-0.4341
238	-0.2342	-0.1252	-0.0487	-0.0502	-0.4613
239	-0.2581	-0.1398	-0.0490	-0.0483	-0.5177
240	-0.2238	-0.1364	-0.0491	-0.0511	-0.4796
241	-0.3118	-0.1668	-0.0486	-0.0479	-0.5480
242	-0.3227	-0.1701	-0.0533	-0.0543	-0.4839
243	-0.3489	-0.1836	-0.0596	-0.0555	-0.3551
244	-0.4456	-0.2315	-0.0287	-0.0253	-0.2642
245	-0.3821	-0.1980	-0.0349	-0.0297	-0.5374
246	-0.3897	-0.1444	-0.0416	-0.0389	-0.3629
247	-0.3944	-0.1452	-0.0518	-0.0527	-0.3834
248	-0.3907	-0.1868	-0.0448	-0.0415	-0.4289
249	-0.4363	-0.2329	-0.0518	-0.0484	-0.6673
250	-0.1901	-0.1262	-0.0921	-0.0948	-0.3094
251	-0.1862	-0.1202	-0.0868	-0.0850	-0.2560
252	-0.3471	-0.1928	-0.0538	-0.0511	-0.4809
253	-0.2452	-0.1884	-0.0529	-0.0527	-0.4193
254	-0.2865	-0.1405	-0.0383	-0.0365	-0.4094
255	-0.2809	-0.1469	-0.0389	-0.0358	-0.4162
256	-0.2568	-0.1369	-0.0433	-0.0409	-0.4626
257	-0.4240	-0.2278	-0.0531	-0.0507	-0.6327
258	-0.3221	-0.1717	-0.0423	-0.0398	-0.4636

Box core number	Seafloor meridional velocity average for collection year m/s	Seafloor meridional velocity average for collection and previous year m/s	Seafloor absolute speed 2008 m/s	Seafloor absolute speed 2009 m/s	Seafloor absolute speed 2010 m/s
173	-0.0012	-0.0015	0.0049	0.0048	0.2915
174	-0.0012	-0.0015	0.0049	0.0048	0.2915
175	-0.0086	-0.0086	0.0101	0.0098	0.1718
176	-0.0434	-0.0410	0.0385	0.0434	0.2384
177	-0.0315	-0.0304	0.0295	0.0317	0.0867
178	-0.0814	-0.0809	0.0805	0.0817	0.2349
179	-0.0814	-0.0809	0.0805	0.0817	0.2348
180	-0.0671	-0.0685	0.0704	0.0675	0.2297
181	0.0284	0.0095	0.0149	0.0116	0.1361
182	-0.0451	-0.0284	0.0106	0.0118	0.0879
183	-0.1175	-0.0627	0.0118	0.0095	0.1688
184	-0.1432	-0.0778	0.0207	0.0156	0.2127
185	-0.1432	-0.0778	0.0207	0.0156	0.2127
186	-0.2096	-0.1133	0.0317	0.0246	0.3291
187	-0.3513	-0.1889	0.0418	0.0361	0.3911
188	-0.2573	-0.1369	0.0394	0.0377	0.3787
189	-0.3426	-0.1868	0.0546	0.0517	0.3739
190	-0.3413	-0.1861	0.0558	0.0532	0.3806
191	-0.2776	-0.1498	0.0491	0.0385	0.3816
192	-0.2934	-0.1596	0.0372	0.0347	0.3638
193	-0.2916	-0.1580	0.0598	0.0503	0.4349
194	-0.2527	-0.1362	0.0445	0.0324	0.3282
195	-0.2527	-0.1362	0.0445	0.0324	0.3282
196	-0.3724	-0.2016	0.0516	0.0481	0.4472
197	-0.4895	-0.2651	0.0548	0.0521	0.5037
198	-0.3612	-0.1941	0.0385	0.0321	0.4266
199	-0.3612	-0.1941	0.0385	0.0321	0.4266
200	-0.3043	-0.1116	0.0361	0.0288	0.3300
201	-0.2226	-0.1217	0.0374	0.0308	0.3640
202	-0.3654	-0.1976	0.0528	0.0456	0.4267
203	-0.6135	-0.3078	0.0054	0.0032	0.7458
204	-0.6135	-0.3078	0.0054	0.0032	0.7458
205	-0.1332	-0.0725	0.0225	0.0179	0.2368
206	-0.1332	-0.0725	0.0225	0.0179	0.2368
207	-0.1736	-0.0931	0.0176	0.0145	0.6300
208	-0.0004	-0.0041	0.0096	0.0081	0.0362
209	-0.0135	-0.0101	0.0140	0.0104	0.2264
210	0.0278	0.0128	0.0206	0.0150	0.2238
211	-0.0226	-0.0150	0.0172	0.0132	0.2490
212	-0.0226	-0.0150	0.0172	0.0132	0.2490
213	-0.0449	-0.0260	0.0302	0.0239	0.2557
214	-0.2336	-0.1274	0.0583	0.0475	0.3058
215	-0.3249	-0.1885	0.0497	0.0355	0.3753
216	-0.1681	-0.0916	0.0154	0.0162	0.1695
217	0.0033	0.0253	0.0336	0.0197	0.1884
218	-0.2703	-0.1444	0.0442	0.0256	0.2745
219	-0.2577	-0.1459	0.0698	0.0533	0.3453
220	-0.3599	-0.1797	0.0634	0.0541	0.4034
221	-0.3140	-0.1643	0.0403	0.0326	0.3746
222	-0.2582	-0.1383	0.0627	0.0551	0.4087
223	-0.3318	-0.1620	0.0618	0.0529	0.3486
224	-0.2971	-0.1055	0.0501	0.0422	0.4177
225	-0.1937	-0.0220	0.0289	0.0224	0.2709
226	-0.0389	-0.0173	0.0138	0.0119	0.0734
227	-0.0340	-0.1389	0.0355	0.0378	0.2978
228	-0.3454	0.0163	0.0041	0.0074	0.2954
229	0.0351	-0.2403	0.0301	0.0287	0.3636
230	-0.2403	-0.3658	0.0700	0.0774	0.8005
231	-0.6646	-0.0383	0.0353	0.0281	0.4204
232	-0.0716	-0.1831	0.0382	0.0367	0.4299
233	-0.3352	-0.1831	0.0382	0.0367	0.4299
234	-0.3352	-0.1444	0.0350	0.0350	0.3729
235	-0.2606	-0.2481	0.0527	0.0538	0.5104
236	-0.4455	-0.2430	0.0517	0.0545	0.4687
237	-0.4341	-0.3557	0.0513	0.0527	0.5173
238	-0.4613	-0.2835	0.0534	0.0537	0.5974
239	-0.5177	-0.2653	0.0537	0.0544	0.5426
240	-0.4796	-0.2965	0.0534	0.0536	0.6314
241	-0.5490	-0.2716	0.0575	0.0603	0.5647
242	-0.4089	-0.2043	0.0547	0.0573	0.4443
243	-0.3552	-0.1547	0.0533	0.0506	0.5185
244	-0.3842	-0.2945	0.0690	0.0686	0.5979
245	-0.5574	-0.3069	0.0470	0.0435	0.4532
246	-0.3629	-0.2080	0.0593	0.0587	0.4484
247	-0.3634	-0.2657	0.0470	0.0444	0.6073
248	-0.4889	-0.3578	0.0611	0.0566	0.7972
249	-0.6673	-0.2021	0.1106	0.1134	0.3832
250	-0.3094	-0.1805	0.0867	0.0846	0.3497
251	-0.2960	-0.2860	0.0670	0.0640	0.5930
252	-0.4809	-0.2360	0.0615	0.0615	0.4857
253	-0.4193	-0.2230	0.0409	0.0393	0.4885
254	-0.4094	-0.2260	0.0429	0.0429	0.5021
255	-0.4162	-0.2518	0.0470	0.0444	0.5291
256	-0.4626	-0.3417	0.0614	0.0597	0.7616
257	-0.6327	-0.4312	0.0478	0.0451	0.4632
258	-0.4626				

Box core number	Seafloor absolute speed average for collection year m/s	Seafloor absolute speed average for collection and previous year m/s	10 year max seafloor absolute speed m/s	10 year average seafloor absolute speed m/s	MODIS surface Chloro a 2008 mg/m³
173	0.0048	0.0049	0.0728	0.0265	0.637
174	0.0048	0.0049	0.0724	0.0262	0.637
175	0.0098	0.0100	0.0588	0.0257	0.654
176	0.0434	0.0410	0.1707	0.0792	0.630
177	0.0817	0.0306	0.1338	0.0652	0.639
178	0.0817	0.0611	0.2465	0.1777	0.635
179	0.0817	0.0811	0.2465	0.1777	0.635
180	0.0675	0.0689	0.2115	0.1274	0.632
181	0.1361	0.0738	0.0411	0.0143	0.719
182	0.0879	0.0488	0.0569	0.0173	0.629
183	0.1688	0.0892	0.0540	0.0179	0.734
184	0.2127	0.1141	0.0522	0.0194	0.726
185	0.2127	0.1141	0.0522	0.0194	0.726
186	0.3281	0.1769	0.1047	0.0548	0.693
187	0.3911	0.2136	0.1444	0.0661	0.704
188	0.3797	0.2082	0.1318	0.0711	0.691
189	0.3739	0.2128	0.1866	0.1137	0.738
190	0.3806	0.2169	0.1867	0.1166	0.718
191	0.3916	0.2151	0.1295	0.0676	0.687
192	0.3938	0.1992	0.1483	0.0690	0.645
193	0.4349	0.2435	0.1561	0.0834	0.741
194	0.3262	0.1793	0.1099	0.0587	0.678
195	0.3262	0.1793	0.1099	0.0587	0.678
196	0.4172	0.2327	0.1895	0.0733	0.695
197	0.6037	0.3279	0.1564	0.0829	0.711
198	0.4266	0.2294	0.1045	0.0555	0.709
199	0.4266	0.2294	0.1047	0.0556	0.709
200	0.3500	0.1894	0.1091	0.0589	0.652
201	0.3640	0.1974	0.1027	0.0511	0.715
202	0.4267	0.2362	0.1531	0.0843	0.699
203	0.7458	0.3745	0.0632	0.0162	0.732
204	0.7458	0.3745	0.0632	0.0162	0.732
205	0.2368	0.1273	0.0629	0.0166	0.742
206	0.2368	0.1273	0.0629	0.0166	0.742
207	0.6300	0.3222	0.0576	0.0196	0.712
208	0.0362	0.0222	0.0698	0.0196	0.696
209	0.2264	0.1184	0.0626	0.0199	0.679
210	0.2258	0.1204	0.0917	0.0373	0.674
211	0.2490	0.1311	0.0683	0.0260	0.674
212	0.2490	0.1311	0.0683	0.0260	0.674
213	0.2557	0.1398	0.1108	0.0490	0.659
214	0.3058	0.1767	0.2183	0.0986	0.681
215	0.3552	0.2054	0.1618	0.0859	0.659
216	0.1655	0.0928	0.0704	0.0176	0.676
217	0.1864	0.0986	0.0639	0.0238	0.714
218	0.7145	0.4120	0.1938	0.0965	0.715
219	0.3583	0.1970	0.1476	0.0738	0.718
220	0.4239	0.2381	0.1733	0.1008	0.706
221	0.4024	0.2283	0.1827	0.1029	0.719
222	0.3746	0.2036	0.1173	0.0606	0.731
223	0.4687	0.2330	0.1823	0.1042	0.719
224	0.3486	0.2007	0.2170	0.1066	0.688
225	0.4177	0.2300	0.1526	0.0732	0.695
226	0.2709	0.1466	0.0824	0.0422	0.708
227	0.0734	0.0421	0.0566	0.0160	0.748
228	0.3978	0.1678	0.1145	0.0560	0.720
229	0.2954	0.1514	0.0685	0.0198	0.713
230	0.3636	0.1962	0.0882	0.0408	0.726
231	0.8056	0.4415	0.1422	0.0834	0.688
232	0.4204	0.2243	0.0841	0.0386	0.803
233	0.4299	0.2333	0.1039	0.0433	0.808
234	0.4299	0.2333	0.1039	0.0433	0.808
235	0.3759	0.2054	0.0971	0.0450	0.753
236	0.2604	0.2821	0.1361	0.0817	0.618
237	0.4687	0.2616	0.1412	0.0778	0.672
238	0.2173	0.2850	0.1302	0.0744	0.620
239	0.1974	0.3256	0.1221	0.0680	0.641
240	0.5426	0.2985	0.1418	0.0778	0.672
241	0.6314	0.3420	0.1224	0.0678	0.646
242	0.5647	0.3125	0.1526	0.0835	0.715
243	0.4443	0.2508	0.1349	0.0717	0.800
244	0.5285	0.2796	0.0972	0.0394	0.896
245	0.5979	0.3352	0.1563	0.0911	0.715
246	0.4522	0.2478	0.1256	0.0605	0.845
247	0.4494	0.2541	0.1428	0.0828	0.848
248	0.6075	0.3259	0.1162	0.0698	0.695
249	0.7972	0.4289	0.1271	0.0724	0.829
250	0.3632	0.2363	0.1563	0.0922	0.938
251	0.3497	0.2172	0.1493	0.0814	1.185
252	0.5930	0.3285	0.1420	0.0790	0.919
253	0.4857	0.2736	0.1491	0.0903	1.318
254	0.4885	0.2639	0.0997	0.0497	0.723
255	0.5021	0.2708	0.1059	0.0518	0.753
256	0.3291	0.2867	0.1150	0.0605	0.804
257	0.7615	0.4107	0.1363	0.0726	1.003
258	0.7637	0.3044	0.1918	0.0638	0.731

Box core number	MODIS surface Chloro a 2009 mg/m³	MODIS surface Chloro a 2010 mg/m³	MODIS surface Chloro a average for collection year mg/m³	MODIS surface Chloro a average for collection and previous year mg/m³	MODIS surface POC 2008 mg/m³
173	0.777	1.063	0.777	0.707	127.18
174	0.777	1.063	0.777	0.707	127.18
175	0.747	1.029	0.747	0.701	128.06
176	0.728	0.993	0.728	0.679	125.01
177	0.764	1.041	0.764	0.711	126.72
178	0.688	0.948	0.688	0.662	134.65
179	0.688	0.948	0.688	0.662	134.65
180	0.696	0.933	0.696	0.664	134.40
181	0.704	1.069	1.069	0.887	135.09
182	0.731	1.155	1.155	0.943	125.50
183	0.682	1.064	1.064	0.873	138.68
184	0.676	1.072	1.072	0.874	137.07
185	0.676	1.072	1.072	0.874	137.07
186	0.655	1.027	1.027	0.841	138.38
187	0.656	1.046	1.046	0.851	136.43
188	0.630	1.023	1.023	0.826	131.40
189	0.705	0.926	0.926	0.815	137.54
190	0.685	0.934	0.934	0.810	131.66
191	0.647	0.988	0.988	0.833	130.55
192	0.827	1.094	1.094	0.890	133.78
193	0.829	0.995	0.995	0.841	132.71
194	0.827	1.064	1.064	0.946	129.94
195	0.827	1.064	1.064	0.946	129.94
196	0.677	1.041	1.041	0.859	132.80
197	0.647	1.043	1.043	0.845	140.11
198	0.650	1.020	1.020	0.835	138.94
199	0.650	1.020	1.020	0.835	138.94
200	0.636	1.181	1.181	0.918	138.24
201	0.693	1.112	1.112	0.907	140.43
202	0.645	1.010	1.010	0.828	141.41
203	0.678	1.070	1.070	0.874	136.56
204	0.678	1.070	1.070	0.874	136.56
205	0.687	1.105	1.105	0.896	143.70
206	0.687	1.105	1.105	0.896	143.70
207	0.669	1.071	1.071	0.870	132.63
208	0.739	1.179	1.179	0.959	131.00
209	0.675	1.075	1.075	0.875	130.70
210	0.661	0.944	0.944	0.803	131.84
211	0.673	1.051	1.051	0.862	130.09
212	0.673	1.051	1.051	0.862	130.09
213	0.640	0.878	0.878	0.759	133.10
214	0.651	0.917	0.917	0.784	134.08
215	0.759	1.024	1.024	0.891	129.19
216	0.804	1.106	1.106	0.955	133.33
217	0.772	1.048	1.048	0.885	137.40
218	0.661	1.009	1.009	0.836	138.29
219	0.648	1.082	1.082	0.871	141.81
220	0.663	1.034	1.034	0.843	140.36
221	0.662	1.032	1.032	0.837	138.97
222	0.673	1.169	1.169	0.911	140.60
223	0.668	1.054	1.054	0.861	139.30
224	0.666	0.959	0.959	0.810	135.51
225	0.634	0.865	0.865	0.760	136.32
226	0.648	0.894	0.894	0.771	133.33
227	0.720	1.112	1.112	0.916	131.28
228	0.759	1.039	1.039	0.899	148.68
229	0.721	1.042	1.042	0.882	130.95
230	0.698	0.973	0.973	0.835	134.47
231	0.686	0.973	0.973	0.829	128.94
232	0.663	0.915	0.915	0.788	143.10
233	0.683	0.971	0.971	0.827	141.16
234	0.683	0.971	0.971	0.827	141.16
235	0.707	0.991	0.991	0.849	136.93
236	0.632	0.920	0.920	0.786	134.48
237	0.632	0.913	0.913	0.783	131.80
238	0.642	0.900	0.900	0.771	125.67
239	0.633	0.880	0.880	0.767	129.42
240	0.657	0.901	0.901	0.779	132.92
241	0.662	0.878	0.878	0.770	130.39
242	0.660	0.932	0.932	0.796	139.03
243	0.632	1.018	1.018	0.825	138.75
244	0.673	1.016	1.016	0.844	143.15
245	0.668	0.910	0.910	0.788	141.75
246	0.677	0.957	0.957	0.817	135.38
247	0.697	0.900	0.900	0.799	133.57
248	0.632	0.827	0.827	0.729	137.54
249	0.684	0.837	0.837	0.761	137.26
250	0.714	0.883	0.883	0.798	142.08
251	0.669	0.857	0.857	0.763	133.01
252	0.629	0.850	0.850	0.739	174.68
253	0.742	0.852	0.852	0.797	160.81
254	0.726	0.831	0.831	0.778	144.91
255	0.745	0.827	0.827	0.788	148.03
256	0.802	0.821	0.821	0.812	159.15
257	0.816	0.859	0.859	0.837	150.05
258	0.772	0.830	0.830	0.801	148.75

Box core number	MODIS surface POC 2009 mg/m³	MODIS surface POC 2010 mg/m³	MODIS surface POC average for collection year mg/m³	MODIS surface POC average for collection and previous year mg/m³	Lutz et al. 2002 NE Atlantic uncorrected POC at depth mg/m³
173	131.45	152.42	131.45	129.32	0.238
174	131.45	152.42	131.45	129.32	0.254
175	129.30	159.26	129.30	128.68	0.045
176	134.86	157.39	134.86	124.94	0.019
177	128.37	160.78	128.37	127.54	0.015
178	130.56	151.80	130.56	122.61	0.430
179	130.56	151.80	130.56	122.61	0.430
180	130.27	149.84	130.27	122.34	0.381
181	127.35	172.35	172.35	148.95	0.144
182	128.32	173.45	173.45	150.83	0.126
183	125.24	167.42	167.42	146.33	0.099
184	124.67	170.98	170.98	147.92	0.008
185	124.67	170.98	170.98	147.92	0.008
186	125.46	164.82	164.82	145.14	0.261
187	127.13	168.69	168.69	147.91	0.058
188	123.65	166.92	166.92	145.28	0.014
189	125.31	146.51	146.51	140.91	0.005
190	131.67	151.11	151.11	141.40	0.006
191	125.91	164.57	164.57	145.18	0.006
192	132.97	164.24	164.24	143.61	0.011
193	124.96	163.03	163.03	144.00	0.005
194	122.84	168.45	168.45	145.85	0.108
195	122.84	168.45	168.45	145.85	0.108
196	125.17	168.23	168.23	146.70	0.005
197	127.61	177.91	177.91	152.76	0.006
198	125.52	164.77	164.77	145.29	0.280
199	125.52	164.77	164.77	145.29	0.274
200	125.80	159.18	159.18	159.48	0.091
201	127.21	165.14	165.14	146.18	0.007
202	124.96	175.52	175.52	150.24	0.015
203	124.91	167.69	167.69	146.30	0.054
204	124.91	167.69	167.69	146.30	0.054
205	126.07	171.30	171.30	148.68	0.038
206	126.07	171.30	171.30	148.68	0.038
207	123.85	171.87	171.87	147.86	0.168
208	126.70	177.48	177.48	151.09	0.070
209	123.53	173.01	173.01	148.27	0.012
210	122.25	158.24	158.24	140.25	0.117
211	122.73	166.52	166.52	144.65	0.008
212	122.73	166.52	166.52	144.65	0.008
213	121.26	154.98	154.98	138.12	0.413
214	121.60	158.54	158.54	140.07	0.006
215	125.94	159.26	159.26	142.60	0.011
216	129.90	161.97	161.97	146.93	0.015
217	128.74	160.98	160.98	144.25	0.073
218	121.68	158.80	158.80	156.37	0.028
219	126.38	186.13	186.13	154.41	0.096
220	123.23	172.24	172.24	149.31	0.005
221	123.50	186.21	186.21	154.72	0.011
222	123.64	174.66	174.66	149.08	0.005
223	121.41	157.31	157.31	160.48	0.006
224	121.90	171.90	171.90	146.66	0.008
225	121.97	147.83	147.83	134.90	0.005
226	120.75	151.17	151.17	136.46	0.005
227	125.39	172.85	172.85	149.12	0.020
228	125.16	164.02	164.02	144.59	0.009
229	125.24	164.02	164.02	144.63	0.006
230	123.16	155.34	155.34	139.25	0.009
231	120.74	152.91	152.91	136.83	0.006
232	120.94	150.70	150.70	135.52	0.005
233	120.89	152.99	152.99	136.94	0.005
234	120.89	152.99	152.99	136.94	0.005
235	123.28	155.76	155.76	139.52	0.006
236	118.14	148.71	148.71	133.42	0.640
237	118.42	148.33	148.33	133.37	0.006
238	117.88	147.63	147.63	132.75	0.216
239	119.76	147.02	147.02	133.39	0.124
240	118.84	147.71	147.71	133.27	0.011
241	120.12	147.17	147.17	133.65	0.458
242	119.99	148.43	148.43	134.21	0.006
243	116.12	153.77	153.77	134.94	0.005
244	119.67	151.98	151.98	136.33	0.005
245	119.17	145.17	145.17	132.17	0.008
246	120.30	150.57	150.57	135.43	0.005
247	121.67	146.66	146.66	134.16	0.007
248	118.17	140.78	140.78	129.48	0.479
249	111.23	142.58	142.58	131.91	0.089
250	111.55	144.61	144.61	133.08	0.008
251	120.40	143.77	143.77	132.09	0.005
252	118.70	143.39	143.39	131.05	0.005
253	122.32	143.59	143.59	133.06	0.006
254	124.17	147.71	147.71	140.94	0.087
255	144.16	152.08	152.08	148.12	0.181
256	123.96	142.10	142.10	133.03	0.230
257	136.70	143.96	143.96	140.33	0.012
258	144.38	142.88	142.88	143.63	0.023

Box core number	Lutz et al. 2002 NE Atlantic radionuclide corrected POC at depth mg/m³	Lutz et al. 2002 Sargasso uncorrected POC at depth mg/m³	Lutz et al. 2002 Sargasso radionuclide corrected POC at depth mg/m³	Sediment total carbon %
173	3.752	3.659	0.062	3.91
174	3.895	3.798	0.067	2.94
175	1.380	1.359	0.013	3.54
176	0.784	0.774	0.008	3.26
177	0.632	0.628	0.007	3.77
178	5.131	5.011	0.125	ns
179	5.131	5.011	0.125	ns
180	4.783	4.689	0.108	1.13
181	2.994	2.915	0.035	ns
182	2.776	2.702	0.030	3.42
183	2.390	2.327	0.024	3.57
184	0.390	0.395	0.007	ns
185	0.390	0.395	0.007	5.52
186	4.157	4.051	0.067	6.01
187	1.747	1.704	0.015	5.47
188	0.685	0.649	0.007	5.89
189	0.080	0.053	0.006	5.47
190	0.201	0.245	0.006	5.63
191	0.214	0.227	0.006	5.73
192	0.562	0.559	0.007	ns
193	0.127	0.145	0.006	6.16
194	2.499	2.434	0.026	ns
195	2.499	2.434	0.026	ns
196	0.116	0.134	0.006	5.54
197	0.242	0.154	0.006	5.40
198	4.332	4.221	0.073	ns
199	4.277	4.167	0.071	5.49
200	2.377	2.314	0.022	5.35
201	0.320	0.328	0.006	5.11
202	0.707	0.699	0.007	5.44
203	1.655	1.615	0.014	3.21
204	1.655	1.615	0.014	3.21
205	1.103	1.080	0.009	4.56
206	1.103	1.080	0.009	4.51
207	3.258	3.173	0.041	3.51
208	1.975	1.928	0.018	3.35
209	0.587	0.583	0.007	ns
210	3.687	3.592	0.055	4.71
211	0.360	0.366	0.006	4.80
212	0.360	0.366	0.006	4.74
213	5.282	5.154	0.116	5.59
214	0.461	0.477	0.006	5.05
215	0.501	0.501	0.007	2.98
216	1.283	1.234	0.011	3.29
217	1.586	1.596	0.018	3.28
218	0.450	0.452	0.007	4.26
219	2.390	2.327	0.023	3.56
220	0.150	0.166	0.006	6.17
221	0.503	0.550	0.007	4.99
222	0.130	0.147	0.006	4.32
223	0.198	0.212	0.006	4.99
224	0.349	0.356	0.006	5.09
225	0.069	0.090	0.006	5.16
226	0.081	0.101	0.006	5.52
227	0.862	0.848	0.008	3.21
228	0.415	0.419	0.007	3.08
229	0.248	0.259	0.006	4.24
230	0.402	0.407	0.007	3.84
231	0.216	0.229	0.006	2.97
232	0.050	0.072	0.006	5.68
233	0.029	0.052	0.006	ns
234	0.029	0.052	0.006	4.53
235	0.232	0.244	0.006	4.08
236	6.666	6.513	0.196	1.15
237	0.151	0.167	0.006	3.28
238	3.565	3.495	0.055	1.11
239	3.676	3.593	0.058	0.92
240	0.503	0.503	0.007	2.41
241	5.518	5.386	0.133	1.15
242	0.172	0.187	0.006	3.48
243	0.061	0.111	0.006	3.41
244	0.023	0.047	0.006	5.84
245	0.339	0.346	0.006	2.19
246	0.028	0.051	0.006	4.87
247	0.291	0.301	0.006	3.37
248	5.587	5.455	0.140	0.78
249	2.012	1.962	0.030	1.61
250	0.370	0.376	0.007	2.61
251	0.061	0.082	0.006	3.55
252	0.014	0.039	0.006	4.83
253	0.163	0.179	0.006	3.49
254	2.169	2.114	0.021	0.96
255	3.401	3.312	0.045	0.99
256	3.720	3.627	0.059	0.86
257	0.563	0.560	0.007	1.83
258	0.873	0.825	0.008	1.44

Box core number	Sediment organic carbon %	Sediment inorganic carbon %	Sediment clay %	Sediment silt %	Sediment sand %	Shannon sediment PSD	Within NAFO closure as of 28-11-16?	Spicules in box core?	Porifera density Kenchington et al. 2014 k/km²
173	0.27	3.64	5.79	27.57	66.34	2.23	N	Y	0.039
174	0.30	2.64	5.14	19.82	75.04	2.19	N	Y	0.039
175	0.37	3.17	12.02	66.77	21.21	1.86	N	Y	0.029
176	0.33	3.23	10.41	77.21	12.37	1.80	N	N	2.103
177	0.46	3.31	13.11	81.44	5.46	1.80	N	N	3.067
178	ns	ns	ns	ns	ns	ns	N	ns	12.270
179	ns	ns	ns	ns	ns	ns	N	ns	12.253
180	0.46	0.77	4.96	15.99	79.05	2.08	N	Y	2.366
181	ns	ns	ns	ns	ns	ns	N	Y	0.078
182	0.20	3.23	12.98	40.26	46.76	2.27	N	Y	0.045
183	0.39	3.18	12.50	49.97	37.53	2.11	N	Y	0.061
184	ns	ns	ns	ns	ns	ns	N	ns	0.236
185	1.19	4.33	ns	ns	ns	ns	N	Y	0.236
186	0.35	5.66	8.51	20.74	70.75	2.02	Y	N	0.258
187	0.22	5.15	8.73	27.06	64.21	2.01	N	Y	0.641
188	0.43	5.36	6.41	26.97	66.62	2.11	N	Y	0.000
189	0.45	5.02	11.74	27.21	61.05	2.11	N	Y	0.000
190	0.31	2.31	13.16	26.16	60.68	2.21	N	Y	0.000
191	0.37	2.36	9.50	26.61	63.48	2.07	N	Y	0.000
192	ns	ns	14.13	38.06	31.81	2.21	N	Y	0.000
193	0.47	5.69	9.00	24.27	66.73	2.05	N	ns	0.000
194	ns	ns	ns	ns	ns	ns	N	ns	0.000
195	ns	ns	ns	ns	ns	ns	N	ns	0.000
196	0.24	5.30	8.28	21.81	69.90	1.99	N	Y	0.000
197	0.18	5.23	10.07	30.37	59.57	2.13	N	Y	0.541
198	ns	ns	ns	ns	ns		Y	ns	0.618
199	0.13	5.36	6.84	22.71	70.45	1.98	Y	Y	0.618
200	0.17	5.18	9.53	33.28	57.19	2.06	N	Y	0.259
201	0.11	5.00	9.00	32.56	58.44	2.06	N	N	0.195
202	0.15	5.28	8.33	28.41	63.26	1.99	N	Y	0.549
203	0.10	3.11	10.62	42.45	46.93	2.05	N	ns	0.109
204	0.15	3.07	11.08	44.14	44.78	2.15	N	Y	0.109
205	0.13	4.43	5.82	31.83	62.36	1.87	N	ns	0.252
206	0.18	4.34	10.50	45.04	44.46	2.09	N	Y	0.252
207	0.10	3.41	10.68	31.15	58.17	2.14	N	Y	0.188
208	0.20	3.05	9.97	39.57	50.45	2.16	N	Y	0.023
209	ns	ns	ns	ns	ns	ns	N	ns	0.141
210	0.16	4.56	ns	ns	ns	ns	N	Y	0.074
211	0.35	4.45	16.06	66.40	17.54	1.97	N	ns	0.134
212	0.40	4.34	14.86	67.22	17.92	1.92	N	Y	0.134
213	0.15	5.45	ns	ns	ns	ns	N	Y	0.017
214	0.15	4.80	13.52	67.14	19.34	1.86	N	Y	0.134
215	0.44	3.94	15.61	66.79	17.60	2.04	N	Y	4.832
216	0.30	3.09	14.76	65.34	19.91	1.98	N	Y	0.047
217	0.34	3.04	14.85	48.47	36.68	2.03	N	Y	0.091
218	0.25	4.01	11.17	43.32	44.51	2.13	N	Y	2.111
219	0.21	3.35	12.63	47.77	39.60	1.94	N	Y	1.855
220	0.37	3.80	ns	ns	ns	ns	N	Y	0.091
221	0.54	4.45	13.36	39.46	47.18	2.27	Y	Y	6.137
222	0.49	3.83	15.28	56.30	28.42	2.01	N	Y	1.148
223	0.63	4.36	ns	ns	ns	ns	Y	Y	5.906
224	0.27	4.82	10.60	38.72	50.68	2.13	N	Y	0.233
225	0.60	5.26	15.48	62.87	21.65	2.01	N	Y	0.000
226	0.63	4.87	15.16	66.39	18.45	2.05	N	Y	0.061
227	0.40	2.81	11.30	50.82	37.88	1.97	N	Y	0.408
228	0.80	2.28	19.84	65.83	14.34	2.08	N	Y	20.978
229	0.80	3.44	18.70	71.87	9.43	1.99	N	N	5.630
230	0.75	3.09	18.99	63.66	17.35	2.05	N	N	5.781
231	2.00	0.97	23.36	56.17	20.47	2.23	Y	Y	21.165
232	0.82	4.85	22.56	64.49	12.95	2.04	N	Y	0.042
233	ns	ns	ns	ns	ns	ns	N	ns	1.075
234	0.59	3.94	16.05	57.73	26.21	2.09	N	Y	1.071
235	0.95	3.13	21.36	72.53	6.11	1.96	N	Y	5.941
236	0.41	0.74	9.90	34.78	55.33	2.38	Y	Y	16.580
237	1.65	1.63	21.08	52.83	26.10	2.25	Y	Y	34.741
238	0.28	0.83	10.98	36.93	52.10	2.18	Y	Y	34.741
239	0.26	0.66	8.76	25.21	66.03	1.97	N	Y	15.525
240	0.95	1.46	15.73	65.26	19.01	2.13	Y	Y	24.616
241	1.32	0.85	8.00	25.33	66.77	2.17	N	Y	9.839
242	1.33	1.16	16.76	68.10	15.14	2.09	Y	Y	13.198
243	0.32	1.59	18.36	59.62	22.02	2.25	Y	Y	10.492
244	0.76	2.07	15.73	53.91	30.36	2.25	N	Y	0.000
245	0.83	1.36	14.72	49.84	35.44	2.21	Y	Y	5.201
246	0.55	4.32	13.83	48.77	37.40	2.27	N	Y	0.000
247	1.06	2.31	16.32	68.77	14.91	2.10	N	Y	0.271
248	0.22	0.56	7.32	20.83	71.85	2.02	N	Y	2.758
249	0.35	1.26	8.27	38.72	53.01	2.17	N	Y	3.604
250	0.74	1.87	15.15	48.07	36.78	2.24	Y	Y	4.485
251	0.82	2.73	21.77	62.38	15.85	2.19	N	Y	0.649
252	0.90	3.94	17.53	57.73	24.75	2.27	N	Y	0.079
253	1.33	2.16	14.42	71.78	13.81	2.06	N	Y	3.334
254	0.55	0.41	8.93	39.47	51.60	1.99	N	Y	2.092
255	0.52	0.47	8.81	32.27	58.92	1.91	N	N	1.628
256	0.29	0.57	5.01	15.59	79.40	2.03	N	Y	2.461
257	0.74	1.09	14.17	49.03	36.81	2.20	Y	Y	4.377
258	0.33	0.80	8.47	33.81	57.73	2.08	N	Y	3.819

Box core number	Pennatulacean density Kenchington et al. 2014 kg/km²	Gorgonian density Kenchington et al. 2014 kg/km²	Downie porifera relative biomass	Downie pennatulacean relative biomass	Downie gorgonian relative biomass	Geological environment
173	0.000	0.000	0.712	0.075	0.009	failed zebed mixed
174	0.000	0.000	0.711	0.071	0.008	failed zebed mixed
175	0.000	0.000	0.493	0.023	0.014	draped over MTDs
176	0.000	0.000	1.489	0.031	0.000	draped over failed zebed
177	0.000	0.000	0.510	0.118	0.015	sediment drifts
178	0.000	0.000	12.167	0.137	0.012	canyon head-400m walls
179	0.000	0.000	12.211	0.137	0.012	canyon head-400m walls
180	0.000	0.000	4.858	0.061	0.048	canyon head-400m walls
181	0.000	0.000	5.942	0.163	0.075	canyon head-400m walls
182	0.000	0.000	0.114	0.071	0.009	draped over MTDs
183	0.000	0.000	0.747	0.164	0.035	draped over MTDs
184	0.000	0.000	3.308	0.204	0.079	canyon head-400m walls
185	0.000	0.000	3.319	0.204	0.079	canyon head-400m walls
186	0.000	0.000	1.661	0.105	0.066	draped over failed zebed
187	0.000	0.000	10.150	0.075	0.069	canyon head-400m walls
188	0.000	0.000	13.114	0.083	0.029	inter canyon area
189	0.000	0.000	11.254	0.156	0.042	canyon head-400m floor
190	0.000	0.000	28.429	0.043	0.084	inter canyon area
191	0.000	0.000	17.237	0.048	0.065	inter canyon area
192	0.000	0.000	24.429	0.079	0.073	inter canyon area
193	0.000	0.000	26.739	0.074	0.055	canyon head-400m walls
194	0.000	0.000	10.913	0.121	0.182	canyon head-400m walls
195	0.000	0.000	10.910	0.121	0.182	canyon head-400m walls
196	0.000	0.000	34.122	0.047	0.261	gullies associated with failed zebed
197	0.000	0.000	26.462	0.083	0.249	draped over failed zebed
198	0.000	0.000	10.844	0.091	0.141	draped over failed zebed
199	0.000	0.000	10.844	0.091	0.141	draped over failed zebed
200	0.000	0.000	1.871	0.050	0.053	draped over failed zebed
201	0.000	0.000	8.705	0.082	0.194	gullies cutting smooth areas
202	0.000	0.000	16.545	0.088	0.035	draped over failed zebed
203	0.000	0.000	0.740	0.059	0.022	draped over MTDs
204	0.000	0.000	0.743	0.059	0.033	draped over MTDs
205	0.000	0.000	0.403	0.119	0.035	gullies associated with failed zebed
206	0.000	0.000	0.404	0.119	0.035	gullies associated with failed zebed
207	0.000	0.000	0.871	0.064	0.019	failed zebed mixed
208	0.000	0.000	0.214	0.059	0.076	draped over MTDs
209	0.000	0.000	1.895	0.105	0.005	failed zebed stepped
210	0.000	0.000	7.437	0.212	0.069	failed zebed stepped
211	0.000	0.000	1.956	0.054	0.015	failed zebed stepped
212	0.000	0.000	1.956	0.054	0.015	failed zebed stepped
213	0.000	0.000	3.004	0.148	0.204	smooth areas
214	0.000	0.000	7.167	0.189	0.019	failed zebed stepped
215	0.000	0.000	1.614	0.144	0.005	smooth areas
216	0.000	0.000	0.186	0.050	0.013	draped over MTDs
217	0.000	0.000	14.739	0.113	0.110	sediment drifts
218	0.000	0.000	6.402	0.048	0.214	failed zebed stepped
219	0.000	0.000	30.009	0.068	0.255	failed zebed stepped
220	0.000	0.000	14.740	0.062	0.164	inter canyon area
221	0.000	0.000	4.206	0.045	0.169	failed zebed stepped
222	0.000	0.000	12.089	0.055	0.036	canyon head-400m floor
223	0.000	0.000	12.879	0.047	0.131	failed zebed stepped
224	0.000	0.000	4.340	0.042	0.145	failed zebed stepped
225	0.000	0.000	9.389	0.033	0.273	failed zebed stepped
226	0.000	0.000	0.188	0.039	0.109	rough topography of MTDs
227	0.000	0.000	0.794	0.188	0.001	failed zebed stepped
228	0.000	0.000	1.874	0.139	0.033	smooth areas
229	0.000	0.000	2.325	0.018	0.032	failed zebed stepped
230	0.000	0.000	13.192	0.116	0.068	failed zebed stepped
231	0.000	0.000	3.669	0.178	0.076	canyon head-400m floor
232	0.000	0.000	4.772	0.292	0.089	rough topography of MTDs
233	0.000	0.000	4.774	0.134	0.142	canyon head-400m floor
234	0.000	0.000	3.990	0.135	0.142	canyon head-400m floor
235	0.000	0.000	6.888	0.310	0.081	rough topography of MTDs
236	0.000	0.000	12.083	0.016	0.006	iceberg pits
237	0.000	0.000	12.689	0.205	0.088	failed zebed stepped
238	0.000	0.000	7.652	0.023	0.134	rough topography of MTDs
239	0.000	0.000	17.115	0.029	0.129	rough topography of MTDs
240	0.000	0.000	2.600	0.017	0.138	rough topography of MTDs
241	0.000	0.000	10.855	0.024	0.007	rough topography of MTDs
242	0.000	0.000	6.596	0.194	0.225	rough topography of MTDs
243	0.000	0.000	3.513	0.140	0.185	failed zebed stepped
244	0.000	0.000	11.744	0.176	0.082	failed zebed stepped
245	0.000	0.001	5.553	0.018	0.070	draped over MTDs
246	0.000	0.000	6.529	0.193	0.271	failed zebed stepped
247	0.000	0.000	0.825	0.080	0.241	draped over MTDs
248	0.000	0.000	0.913	0.047	0.000	failed zebed stepped
249	0.000	0.001	12.073	0.101	0.002	failed zebed stepped
250	0.000	0.000	13.822	0.032	0.187	draped over MTDs
251	0.000	0.000	0.825	0.203	0.075	failed zebed stepped
252	0.000	0.000	10.412	0.174	0.154	failed zebed stepped
253	0.000	0.000	8.370	0.163	0.130	failed zebed stepped
254	0.000	0.010	0.103	0.090	0.000	failed zebed stepped
255	0.000	0.011	0.559	0.072	0.005	failed zebed stepped
256	0.000	0.000	0.714	0.140	0.009	failed zebed stepped
257	0.000	0.000	14.789	0.056	0.113	failed zebed stepped
258	0.000	0.000	0.346	0.072	0.001	failed zebed stepped

Box core number	VMS records 2003-2012 [5 km radius]	VMS records 2003-2012 [3 km radius]	VMS records 2003-2012 [1 km radius]	VMS density 2003-2012 [5 km radius]	VMS density 2003-2012 [3 km radius]	VMS density 2003-2012 [1 km radius]
173	68	17	1	0.87	0.62	0.32
174	68	16	1	0.87	0.57	0.32
175	1343	609	63	17.26	21.53	19.94
176	2104	1041	157	26.76	36.85	50.12
177	2225	989	100	28.34	34.97	30.51
178	72	16	0	0.92	0.58	0.00
179	73	17	0	0.92	0.57	0.00
180	29	9	0	0.37	0.31	0.00
181	59	21	1	0.76	0.74	0.32
182	518	235	36	6.59	8.24	11.15
183	97	38	0	1.23	1.34	0.00
184	36	6	1	0.44	0.21	0.32
185	36	6	1	0.44	0.21	0.32
186	21	4	3	0.26	0.14	0.95
187	41	12	1	0.51	0.42	0.32
188	20	9	1	0.26	0.32	0.56
189	12	2	0	0.15	0.08	0.00
190	8	3	3	0.10	0.11	0.95
191	9	4	1	0.11	0.14	0.48
192	25	16	2	0.32	0.57	0.64
193	10	6	1	0.13	0.21	0.32
194	25	8	0	0.32	0.28	0.00
195	25	8	0	0.33	0.28	0.00
196	17	8	1	0.22	0.27	0.32
197	29	9	1	0.37	0.32	0.32
198	22	10	0	0.28	0.35	0.10
199	22	10	0	0.29	0.35	0.08
200	59	19	3	0.76	0.82	0.95
201	30	8	0	0.39	0.28	0.00
202	54	23	3	0.67	0.81	0.95
203	27	12	1	0.34	0.42	0.32
204	27	12	1	0.34	0.42	0.32
205	85	41	2	1.07	1.45	0.64
206	85	41	2	1.07	1.45	0.64
207	24	10	0	0.30	0.34	0.05
208	694	309	33	8.88	10.95	10.52
209	386	220	35	4.92	7.77	11.26
210	21	4	1	0.28	0.14	0.30
211	56	12	2	0.71	0.44	0.64
212	56	12	2	0.71	0.44	0.64
213	10	5	1	0.13	0.18	0.32
214	22	15	1	0.28	0.53	0.32
215	1220	207	7	15.40	7.27	2.23
216	1633	481	67	20.66	17.04	21.06
217	100	41	14	1.26	1.45	4.54
218	17	4	0	0.22	0.14	0.00
219	18	3	0	0.23	0.12	0.00
220	8	3	0	0.10	0.11	0.00
221	9	1	0	0.11	0.04	0.00
222	20	10	0	0.25	0.35	0.00
223	9	6	1	0.11	0.21	0.32
224	24	3	0	0.31	0.10	0.00
225	18	10	2	0.23	0.35	0.64
226	12	6	1	0.15	0.21	0.32
227	209	30	1	2.66	1.80	0.58
228	446	100	12	5.70	3.49	3.91
229	37	12	2	0.47	0.47	0.64
230	34	18	2	0.43	0.64	0.58
231	33	17	2	0.42	0.60	0.64
232	20	5	0	0.25	0.18	0.00
233	66	47	0	0.84	1.68	0.00
234	66	47	0	0.84	1.68	0.00
235	48	16	0	0.62	0.57	0.00
236	24	10	2	0.31	0.35	0.64
237	73	30	2	0.92	1.06	0.64
238	21	8	0	0.27	0.28	0.00
239	43	14	1	0.55	0.50	0.32
240	54	16	3	0.68	0.57	0.95
241	92	37	3	1.17	1.30	0.95
242	55	30	1	0.70	1.05	0.32
243	44	8	0	0.56	0.27	0.00
244	20	9	1	0.25	0.32	0.20
245	49	19	1	0.62	0.67	0.32
246	14	4	0	0.17	0.14	0.00
247	21	8	1	0.26	0.28	0.32
248	201	80	7	2.56	2.84	2.23
249	253	115	8	3.73	4.07	2.58
250	23	6	1	0.29	0.19	0.32
251	16	4	0	0.20	0.14	0.00
252	12	5	0	0.15	0.18	0.00
253	17	5	0	0.22	0.18	0.00
254	618	254	20	7.87	8.99	6.31
255	517	243	30	6.60	8.62	9.78
256	344	131	15	4.37	4.62	4.75
257	45	21	1	0.57	0.74	0.32
258	131	59	7	1.67	2.08	2.07

Box core number	Trawl length/ km² 2008-2012 (5 km radius)	Trawl length/ km² 2008-2012 (3 km radius)	Trawl length/ km² 2008-2012 (1 km radius)	Roughness 3x3 cell window	Standard deviation of bathymetry 3x3 cell window	Rugosity 5x5 cell window
173	0.67	0.41	0.00	8.70	2.70	0.0000351
174	0.63	0.31	0.00	7.98	2.40	0.0000324
175	31.54	85.13	90.12	0.18	0.06	0.0000001
176	77.59	104.28	131.11	7.33	2.27	0.0000914
177	84.58	99.55	110.97	6.64	2.57	0.0000336
178	0.00	0.00	0.00	6.82	2.14	0.0000384
179	0.00	0.00	0.00	6.82	2.14	0.0000384
180	0.12	0.14	0.00	8.72	2.58	0.0000441
181	1.00	0.19	0.00	8.61	2.85	0.0000451
182	38.95	50.17	50.44	3.68	1.13	0.0000104
183	2.58	3.69	4.42	3.41	1.01	0.0000011
184	0.33	0.00	0.00	11.61	3.36	0.0000023
185	0.33	0.00	0.00	11.61	3.36	0.0000023
186	0.20	0.21	0.63	9.83	3.39	0.0000020
187	0.29	0.17	0.00	10.71	3.31	0.0000965
188	0.18	0.33	0.83	25.39	8.86	0.0000542
189	0.11	0.02	0.00	13.83	4.32	0.0001440
190	0.00	0.00	0.00	10.10	3.21	0.0000254
191	0.09	0.04	0.00	12.74	7.25	0.0001898
192	0.00	0.00	0.00	23.53	6.94	0.0002461
193	0.00	0.00	0.00	20.29	6.02	0.0001673
194	0.26	0.29	0.63	29.66	11.55	0.0000392
195	0.26	0.29	0.63	29.66	11.55	0.0000392
196	0.04	0.02	0.00	9.64	3.60	0.0000834
197	0.00	0.00	0.00	20.51	5.98	0.0002090
198	0.20	0.20	0.00	7.70	2.43	0.0000161
199	0.20	0.20	0.00	8.08	2.56	0.0000128
200	0.92	0.97	0.61	8.92	3.23	0.0000125
201	0.00	0.00	0.00	18.16	5.76	0.0000586
202	0.35	0.32	0.64	8.53	3.09	0.0000156
203	0.11	0.14	0.00	3.27	1.09	0.0000052
204	0.11	0.14	0.00	3.27	1.09	0.0000052
205	2.02	2.96	1.91	9.68	2.81	0.0000100
206	2.02	2.96	1.91	9.68	2.81	0.0000100
207	0.21	0.11	0.00	18.26	5.54	0.0000054
208	57.78	74.45	70.66	2.45	0.71	0.0000048
209	11.75	15.93	21.94	23.00	7.47	0.0000995
210	0.00	0.00	0.00	17.08	6.11	0.0000853
211	0.13	0.21	0.48	4.40	1.49	0.0000033
212	0.13	0.21	0.48	4.40	1.49	0.0000033
213	0.00	0.00	0.00	2.54	0.73	0.0000015
214	0.00	0.00	0.00	5.15	1.49	0.0000017
215	43.79	28.15	8.37	0.71	0.22	0.0000013
216	79.19	51.91	43.71	0.41	0.11	0.0000008
217	3.13	0.53	6.38	4.94	0.66	0.0000045
218	0.00	0.00	0.00	10.60	3.86	0.0000215
219	0.00	0.00	0.00	4.86	1.78	0.0000169
220	0.00	0.00	0.00	7.28	2.61	0.0000176
221	0.00	0.00	0.00	8.70	2.64	0.0000181
222	0.00	0.00	0.00	2.09	0.72	0.0000314
223	0.00	0.00	0.00	3.00	1.12	0.0000124
224	0.00	0.00	0.00	8.17	2.87	0.0000211
225	0.00	0.00	0.00	4.30	1.53	0.0000111
226	0.00	0.00	0.00	3.74	1.09	0.0000124
227	6.38	2.38	0.00	5.58	2.18	0.0000125
228	9.95	7.17	5.96	1.97	0.74	0.0000002
229	0.15	0.21	0.55	6.01	1.74	0.0000192
230	0.12	0.20	0.00	5.17	1.65	0.0000918
231	0.00	0.00	0.00	4.31	1.48	0.0000321
232	0.00	0.00	0.00	2.25	0.76	0.0000175
233	0.00	0.00	0.00	10.11	3.20	0.0010780
234	0.00	0.00	0.00	10.11	3.20	0.0010780
235	0.09	0.00	0.00	3.17	1.25	0.0000046
236	0.00	0.00	0.00	6.43	1.87	0.0000055
237	0.00	0.00	0.00	2.47	0.84	0.0000479
238	0.00	0.00	0.00	9.48	2.85	0.0000204
239	0.06	0.00	0.00	9.95	2.87	0.0000215
240	0.00	0.00	0.00	16.56	4.79	0.0000135
241	0.15	0.19	0.00	13.05	3.84	0.0000038
242	0.00	0.00	0.00	6.82	1.97	0.0000011
243	0.00	0.00	0.00	2.62	0.98	0.0000103
244	0.00	0.00	0.00	7.47	2.27	0.0000480
245	0.00	0.00	0.00	3.73	1.14	0.0000046
246	0.00	0.00	0.00	10.83	3.13	0.0003341
247	0.00	0.00	0.00	3.96	1.15	0.0000059
248	2.39	1.99	1.33	9.88	3.06	0.0003302
249	5.34	7.19	8.33	11.15	3.85	0.0000164
250	0.00	0.00	0.00	2.48	0.83	0.0000001
251	0.00	0.00	0.00	17.15	5.38	0.0000377
252	0.00	0.00	0.00	10.80	3.98	0.0003103
253	0.00	0.00	0.00	3.57	0.92	0.0000109
254	9.27	10.63	6.16	15.59	4.62	0.0000319
255	13.92	20.46	26.27	11.54	3.40	0.0000088
256	5.46	3.71	0.00	27.06	7.83	0.0002415
257	0.05	0.00	0.00	4.79	1.47	0.0000454
258	2.36	2.79	3.44	16.73	5.64	0.0000335

Box core number	Rugosity 25x25 cell window	BPI 25 cell radius	BPI 50 cell radius	BPI 75 cell radius	BPI 100 cell radius	BPI 125 cell radius	BPI 150 cell radius	Slope	Radial aspect from -1 west to 1 east	Radial aspect from -1 south to 1 north
173	0.0000292	2.72	34.15	61.20	94.03	108.38	111.28	2.12	0.400	0.916
174	0.0000417	1.10	23.13	64.10	98.77	114.30	118.93	2.24	0.489	0.873
175	0.0000307	-0.81	-6.18	-12.72	-28.27	-31.80	-45.70	0.05	-0.447	-0.884
176	0.0000485	3.12	3.36	-0.34	-4.81	-5.77	-10.26	2.12	-0.913	-0.407
177	0.0001245	9.85	7.25	2.69	0.19	-3.81	-17.06	2.40	-0.999	0.038
178	0.0015754	69.42	151.13	176.80	210.25	239.55	269.40	2.00	-0.928	-0.371
179	0.0015754	69.42	151.13	176.80	210.25	239.55	269.40	2.00	-0.928	-0.371
180	0.0001879	7.18	15.79	12.67	8.04	32.87	76.06	2.41	-0.538	-0.843
181	0.0004881	20.85	22.00	1.09	-7.34	1.28	9.78	2.66	-0.963	-0.271
182	0.0000595	5.20	-3.75	-34.65	-41.46	-57.01	-66.56	1.05	-0.898	0.440
183	0.0000412	-1.43	-7.13	-26.28	-59.64	-80.10	-89.79	0.95	-0.813	-0.583
184	0.0011961	-28.54	-79.81	-122.40	-161.17	-210.30	-262.55	3.14	-0.757	-0.654
185	0.0011961	-28.54	-79.81	-122.40	-161.17	-210.30	-262.55	3.14	-0.757	-0.654
186	0.0000622	-4.08	-1.20	4.62	10.62	21.67	47.46	3.17	0.203	-0.979
187	0.0004147	-15.84	-17.08	-0.96	-14.68	23.64	35.13	3.09	0.415	0.910
188	0.0135731	103.75	115.27	87.79	62.96	96.04	151.63	8.34	-0.192	-0.981
189	0.0175960	-137.48	-320.80	-418.46	-455.12	-445.59	-420.89	4.01	-0.918	-0.397
190	0.0003010	12.40	100.88	327.55	311.37	356.08	404.32	3.00	0.348	-0.938
191	0.0016692	34.02	46.390	38.83	27.48	38.44	68.45	6.75	-0.348	-0.937
192	0.0014393	14.55	30.31	54.41	57.83	115.07	200.59	6.47	0.332	-0.369
193	0.0010283	-41.58	36.16	150.92	217.30	256.98	275.09	5.60	0.350	-0.327
194	0.0005943	25.33	77.21	136.71	221.00	307.15	370.37	10.68	0.050	-0.999
195	0.0005943	25.33	77.21	136.71	221.00	307.15	370.37	10.68	0.050	-0.999
196	0.0009372	26.74	67.31	143.11	180.86	228.13	264.55	3.36	0.097	-0.995
197	0.0004028	-9.64	0.74	14.48	34.83	58.91	73.92	5.57	0.607	-0.795
198	0.0001866	12.54	22.92	39.42	51.34	74.08	106.34	2.27	-0.363	-0.932
199	0.0001867	11.95	23.36	34.92	51.05	73.40	105.55	2.40	-0.352	-0.936
200	0.0015988	37.57	60.92	78.44	93.96	116.29	148.79	3.02	-0.135	-0.991
201	0.0009866	24.48	52.32	78.49	96.71	102.82	130.31	5.37	-0.336	-0.935
202	0.0000720	1.24	21.64	50.38	82.25	110.78	130.75	2.89	0.137	-0.991
203	0.0001301	-14.30	-34.91	-39.09	-109.72	-133.63	-136.46	1.02	0.962	-0.274
204	0.0001301	-14.30	-34.91	-39.09	-109.72	-133.63	-136.46	1.02	0.962	-0.274
205	0.0001314	-1.79	12.50	12.93	6.17	-4.32	-16.70	2.62	-0.650	-0.760
206	0.0001314	-1.79	12.50	12.93	6.17	-4.32	-16.70	2.62	-0.650	-0.760
207	0.0003898	19.03	16.51	18.78	19.74	20.68	17.89	5.17	0.892	0.452
208	0.0000311	-4.15	-39.52	-176.93	-394.47	-271.56	-290.84	6.95	-0.952	0.306
209	0.0013649	-33.76	-98.60	-176.93	-394.47	-271.56	-290.84	6.95	-0.952	0.306
210	0.0036078	12.45	26.85	64.00	91.32	111.13	134.75	5.70	-0.988	-0.154
211	0.0001239	-1.13	-57.45	-146.50	-187.06	-212.04	-232.64	1.40	0.231	-0.973
212	0.0001239	-1.13	-57.45	-146.50	-187.06	-212.04	-232.64	1.40	0.231	-0.973
213	0.0000416	6.24	118.88	236.52	236.52	351.34	431.37	0.69	-0.686	-0.728
214	0.0001744	-9.16	-39.60	-98.94	-149.20	-166.41	-208.00	1.40	-0.755	0.655
215	0.0000121	-1.88	-6.66	-13.48	-33.43	-67.18	-101.68	0.20	-0.919	-0.395
216	0.0000026	0.61	-8.29	-21.96	-30.13	-47.20	-60.93	0.11	-0.727	-0.676
217	0.0003584	4.30	-15.36	-60.27	-203.25	-131.08	-140.23	0.37	-0.918	-0.394
218	0.0003584	-24.09	-35.38	-21.26	-37.74	-3.03	20.13	3.41	-0.207	-0.978
219	0.0001816	1.32	7.68	14.44	18.16	15.76	57.13	1.67	0.987	-0.161
220	0.0001963	23.14	26.66	29.81	30.76	267.94	238.25	2.43	-0.275	-0.961
221	0.0017752	31.67	36.94	57.23	32.44	31.70	157.67	2.47	0.454	-0.891
222	0.0013228	-43.27	-170.60	-238.16	-277.46	-298.44	-315.53	0.68	0.379	-0.206
223	0.0001377	9.95	-30.68	-39.36	-36.86	23.69	99.31	1.04	0.996	-0.062
224	0.0000362	1.13	-4.17	-11.79	-31.38	-45.28	-48.63	1.51	0.085	-0.996
225	0.0000346	1.81	0.38	-5.12	-29.14	-61.04	-79.39	1.02	0.582	-0.813
226	0.0004164	-12.79	-39.50	-36.89	-39.13	-12.61	-10.77	2.03	-0.999	0.048
227	0.0000097	-0.62	-27.22	-34.89	-67.74	-68.10	-70.64	0.69	-0.995	-0.095
228	0.0003203	-18.00	-44.62	-85.83	-85.94	-101.61	-105.54	1.62	0.733	-0.681
229	0.0003677	25.37	86.67	88.41	106.74	122.88	138.80	1.54	-0.940	-0.341
230	0.0039249	-48.64	-103.13	-131.96	-158.63	-182.82	-203.15	1.38	0.974	0.226
231	0.0002757	-4.11	4.53	-1.86	-9.74	-15.57	-16.36	0.70	-0.964	-0.267
232	0.0025853	-72.40	-103.11	-151.01	-175.84	-190.15	-193.57	2.92	-0.909	-0.416
233	0.0025853	-72.40	-103.11	-151.01	-175.84	-190.15	-193.57	2.92	-0.909	-0.416
234	0.0004164	-12.79	-39.50	-36.89	-39.13	-12.61	-10.77	2.03	-0.999	0.048
235	0.0000963	1.27	1.27	5.48	12.29	18.82	27.27	1.17	-0.999	0.038
236	0.0000940	1.57	22.45	55.10	97.40	156.31	212.56	1.75	0.788	-0.616
237	0.0006286	-26.33	-68.53	-106.53	-138.31	-162.97	-183.92	0.76	0.969	-0.246
238	0.0001911	8.81	7.96	6.26	30.81	73.10	116.35	2.66	0.480	-0.877
239	0.0000909	2.32	-13.54	1.76	44.17	90.99	139.42	2.68	0.690	-0.724
240	0.0003122	-17.20	-21.57	-23.82	-31.71	-44.53	-58.30	4.47	0.676	-0.737
241	0.0000980	9.46	46.34	77.30	114.83	158.60	203.56	3.59	0.828	-0.560
242	0.0000480	5.43	9.27	-3.25	-31.93	-62.84	-83.61	1.84	0.678	-0.735
243	0.0001271	-3.93	-11.87	-10.90	-7.05	-1.59	-0.28	0.92	0.096	-0.995
244	0.0000343	-4.34	1.99	16.58	15.03	7.42	3.04	2.13	0.879	-0.476
245	0.0000820	-4.38	-13.13	-48.53	-71.34	-81.75	-110.83	1.56	0.440	0.898
246	0.0017907	-36.07	-43.33	-43.42	-48.26	-54.97	-59.47	1.98	0.598	-0.269
247	0.0003500	16.02	43.86	88.47	94.07	118.20	144.29	1.08	0.850	-0.760
248	0.0001513	-11.06	-7.64	23.78	68.24	116.02	161.90	2.26	0.915	-0.404
249	0.0000869	1.29	4.24	6.30	3.43	10.25	31.76	3.60	0.979	-0.203
250	0.0000017	0.55	0.73	1.51	3.45	4.63	5.77	0.78	0.218	-0.976
251	0.0019991	-4.80	7.08	3.30	-10.91	14.38	22.29	5.02	0.926	0.377
252	0.0034809	-34.77	-72.31	-89.94	-115.06	-131.82	-156.08	3.71	0.993	-0.116
253	0.0001036	8.07	-5.77	-4.41	1.80	8.83	18.33	0.86	0.990	0.143
254	0.0000733	-7.91	-10.95	23.01	69.17	105.24	151.84	4.31	0.847	-0.531
255	0.0000724	-0.74	28.58	66.23	106.82	145.82	182.01	3.18	0.550	-0.835
256	0.0018116	33.02	42.25	46.29	76.68	116.99	157.48	7.28	-0.663	-0.748
257	0.0008578	17.32	17.31	9.45	-7.23	-28.54	-47.85	1.36	0.437	0.899
258	0.0006357	-5.65	-13.16	-21.99	-29.23	-17.30	-0.94	5.27	0.975	-0.218

Box core number	Successful collection?	Latitude	Longitude	Multibeam bathymetry	Collection year	Collection month	Crew number	Seafloor temperature 2008/°C	Seafloor temperature 2009/°C	Seafloor temperature 2010/°C
259	Y	45.494	-47.903	-1926.5	2010	July	5	3.20	3.16	3.30
260	Y	45.313	-48.288	-1463.8	2010	July	5	3.05	3.01	3.19
261	N	45.485	-48.027	-1400.7	2010	July	5	3.15	3.09	3.27
262	Y	45.485	-48.027	-1400.7	2010	July	5	3.15	3.09	3.27
263	Y	45.441	-48.106	-1447.6	2010	July	5	3.44	3.36	3.53
264	Y	45.441	-48.106	-1447.6	2010	July	5	3.44	3.36	3.53
265	Y	45.342	-48.579	-994.4	2010	July	5	2.91	2.85	3.06
266	Y	45.394	-48.574	-720.9	2010	July	5	2.75	2.71	2.93
267	Y	45.261	-48.394	-1784.6	2010	July	5	3.08	3.04	3.22
268	Y	45.197	-48.575	-1482.0	2010	July	5	3.76	3.66	3.83
269	N	45.287	-48.544	-1609.6	2010	July	5	2.91	2.86	3.08
270	N	45.287	-48.544	-1609.6	2010	July	5	2.91	2.86	3.08
271	Y	45.290	-48.546	-1615.2	2010	July	5	2.91	2.86	3.08
272	Y	45.174	-48.433	-1349.8	2010	July	5	3.07	3.05	3.21
273	N	45.146	-48.426	-1442.4	2010	July	5	3.29	3.27	3.40
274	Y	45.293	-48.643	-700.7	2010	July	5	2.78	2.74	2.96
275	Y	45.061	-48.764	-1007.6	2010	July	5	3.30	3.13	3.31
276	Y	44.876	-48.876	-1413.4	2010	July	5	3.07	2.95	3.13
277	Y	45.162	-48.856	-1031.6	2010	July	5	3.05	2.99	3.19
278	Y	45.045	-48.471	-1844.6	2010	July	5	3.18	3.16	3.29
279	Y	44.956	-48.849	-1486.9	2010	July	5	3.08	3.79	3.33
280	Y	44.755	-48.929	-1483.6	2010	July	5	2.99	2.98	3.14
281	Y	44.652	-48.923	-1618.2	2010	July	5	3.04	3.03	3.14
282	Y	44.583	-48.987	-1038.9	2010	July	5	3.04	3.03	2.89
283	Y	44.710	-48.833	-1650.3	2010	July	5	3.03	3.02	3.17
284	Y	44.757	-48.646	-1647.1	2010	July	5	3.16	3.15	3.27
285	Y	44.592	-48.808	-1827.6	2010	July	5	3.71	3.67	3.80
286	Y	44.441	-48.875	-1444.6	2010	July	5	3.19	3.18	3.31
287	Y	44.337	-48.913	-759.3	2010	July	5	3.07	3.07	3.20
288	Y	44.527	-48.812	-1970.1	2010	July	5	3.38	3.37	3.49
289	Y	44.403	-48.926	-835.6	2010	July	5	3.07	3.07	3.20
290	N	44.165	-48.905	-896.2	2010	July	5	3.13	3.13	3.25
291	Y	44.165	-48.905	-896.2	2010	July	5	3.13	3.13	3.25
292	Y	44.334	-48.789	-1756.8	2010	July	5	3.18	3.18	3.29
293	Y	44.221	-48.800	-1654.1	2010	July	5	3.21	3.21	3.31
294	Y	44.055	-48.882	-1538.3	2010	July	5	3.26	3.25	3.36
295	Y	44.043	-48.955	-730.8	2010	July	5	3.44	3.39	3.50
296	Y	44.009	-48.844	-1434.6	2010	July	5	3.38	3.35	3.47
297	Y	43.796	-48.980	-633.5	2010	August	6	3.34	3.24	3.32
298	Y	43.644	-48.855	-2394.3	2010	August	6	3.36	3.36	3.43
299	Y	43.702	-48.973	-1784.8	2010	August	6	3.36	3.36	3.34
300	Y	43.374	-49.044	-1864.3	2010	August	6	3.30	3.30	3.37
301	Y	43.467	-48.946	-2087.9	2010	August	6	3.25	3.25	3.32
302	Y	43.347	-48.863	-2216.7	2010	August	6	3.20	3.20	3.28
303	Y	43.603	-49.040	-1774.9	2010	August	6	3.36	3.35	3.44
304	Y	43.268	-49.135	-1757.6	2010	August	6	3.28	3.29	3.35
305	Y	43.310	-49.048	-1390.5	2010	August	6	3.29	3.29	3.37
306	Y	43.320	-49.040	-1812.7	2010	August	6	3.31	3.30	3.37
307	Y	43.405	-49.180	-969.8	2010	August	6	3.42	3.41	3.48
308	Y	43.333	-49.211	-841.5	2010	August	6	3.36	3.36	3.41
309	Y	43.264	-49.259	-1389.4	2010	August	6	3.65	3.62	3.65
310	Y	43.210	-49.055	-1361.5	2010	August	6	3.49	3.47	3.53
311	N	43.138	-48.883	-2261.6	2010	August	6	3.25	3.25	3.29
312	N	43.340	-48.882	-2353.0	2010	August	6	3.25	3.25	3.29
313	Y	43.147	-48.988	-1964.6	2010	August	6	3.90	3.85	3.91
314	Y	43.239	-48.884	-2254.3	2010	August	6	3.25	3.25	3.29
315	Y	43.356	-48.768	-1889.2	2010	August	6	3.15	3.16	3.18
316	Y	43.037	-49.348	-1186.6	2010	August	6	3.50	3.49	3.54
317	Y	43.198	-49.284	-863.2	2010	August	6	3.37	3.38	3.42
318	Y	43.107	-49.179	-1315.1	2010	August	6	3.36	3.35	3.41
319	Y	43.000	-49.131	-2070.8	2010	August	6	3.36	3.36	3.40
320	Y	43.173	-49.427	-589.0	2010	August	6	3.36	3.40	3.40
321	N	43.061	-49.474	-917.4	2010	August	6	3.55	3.54	3.56
322	N	43.061	-49.474	-917.4	2010	August	6	3.55	3.54	3.56
323	Y	42.887	-49.348	-1671.4	2010	August	6	3.91	3.91	3.95
324	N	42.879	-49.852	-1503.5	2010	August	6	3.81	3.76	3.84
325	N	42.880	-49.852	-1496.2	2010	August	6	3.81	3.76	3.84
326	Y	42.946	-49.698	-561.8	2010	August	6	3.95	3.89	3.98
327	Y	43.090	-49.497	-593.5	2010	August	6	3.60	3.59	3.60
328	Y	42.773	-49.728	-1603.4	2010	August	6	3.67	3.65	3.71
329	Y	43.015	-49.633	-785.7	2010	August	6	3.53	3.53	3.58
330	Y	42.899	-49.642	-1276.3	2010	August	6	3.77	3.73	3.80
331	Y	42.810	-49.601	-1877.5	2010	August	6	3.30	3.32	3.34
332	Y	42.860	-49.711	-1456.9	2010	August	6	3.40	3.41	3.43
333	Y	42.879	-49.808	-700.9	2010	August	6	3.99	3.90	3.88
334	N	42.654	-50.066	-1889.8	2010	August	6	3.43	3.45	3.43
335	N	42.745	-49.989	-1691.2	2010	August	6	3.46	3.47	3.47
336	N	42.750	-49.964	-1716.6	2010	August	6	3.63	3.61	3.60
337	N	42.695	-49.815	-2002.1	2010	August	6	3.53	3.52	3.54
338	Y	42.808	-49.888	-734.0	2010	August	6	3.72	3.68	3.66
339	Y	42.733	-50.392	-1071.0	2010	August	6	3.69	3.70	3.63
340	Y	42.698	-50.314	-1948.8	2010	August	6	3.81	3.80	3.81
341	Y	42.739	-50.176	-1456.6	2010	August	6	3.45	3.51	3.41
342	Y	42.678	-50.208	-1371.8	2010	August	6	3.47	3.47	3.47
343	Y	42.633	-50.526	-1852.3	2010	August	6	3.40	3.50	3.40

Box core number	Seafloor temperature average for collection year/°C	Seafloor temperature average for collection and previous year/°C	Seafloor temperature 10 year minimum/°C	Seafloor temperature 10 year mean/°C	Seafloor salinity 2008/ppt	Seafloor salinity 2009/ppt
259	3.30	3.23	3.52	3.87	34.61	34.60
260	3.19	3.10	3.60	3.98	34.48	34.48
261	3.27	3.18	3.65	4.06	34.53	34.53
262	3.27	3.18	3.65	4.06	34.53	34.53
263	3.53	3.45	3.65	4.07	34.65	34.64
264	3.53	3.45	3.65	4.07	34.65	34.64
265	3.06	2.96	3.64	4.26	34.32	34.32
266	2.93	2.82	3.46	4.18	34.24	34.25
267	3.22	3.13	3.58	3.93	34.49	34.48
268	3.83	3.74	3.68	4.12	34.76	34.75
269	3.08	2.97	3.69	4.17	34.34	34.34
270	3.08	2.97	3.69	4.17	34.34	34.34
271	3.08	2.97	3.69	4.17	34.34	34.34
272	3.21	3.13	3.54	3.86	34.50	34.50
273	3.40	3.33	3.51	3.82	34.63	34.63
274	2.96	2.85	3.63	4.26	34.25	34.26
275	3.31	3.22	3.63	4.25	34.43	34.43
276	3.13	3.04	3.70	4.21	34.32	34.32
277	3.19	3.09	3.68	4.20	34.39	34.39
278	3.29	3.22	3.49	3.79	34.58	34.57
279	3.93	3.86	3.62	4.02	34.85	34.84
280	3.34	3.06	3.71	4.23	34.32	34.33
281	3.34	3.89	3.69	4.17	34.37	34.37
282	2.89	2.96	3.63	4.26	34.33	34.33
283	3.17	3.10	3.65	4.04	34.39	34.39
284	3.27	3.21	3.46	3.71	34.57	34.57
285	3.80	3.73	3.55	3.84	34.85	34.84
286	3.31	3.24	3.65	4.05	34.48	34.48
287	3.20	3.14	3.73	4.21	34.39	34.39
288	3.49	3.43	3.55	3.83	34.66	34.65
289	3.20	3.13	3.72	4.23	34.38	34.38
290	3.25	3.19	3.71	4.22	34.43	34.43
291	3.25	3.19	3.71	4.22	34.43	34.43
292	3.29	3.23	3.53	3.84	34.55	34.55
293	3.31	3.26	3.56	3.90	34.56	34.56
294	3.35	3.31	3.62	4.00	34.56	34.56
295	3.36	3.31	3.67	4.13	34.52	34.52
296	3.50	3.45	3.67	4.25	34.53	34.53
297	3.47	3.41	3.61	3.99	34.61	34.61
298	3.32	3.28	3.67	4.24	34.46	34.46
299	3.43	3.39	3.54	3.83	34.66	34.66
300	3.34	3.30	3.69	4.17	34.50	34.50
301	3.37	3.33	3.61	3.99	34.56	34.56
302	3.32	3.29	3.54	3.82	34.58	34.58
303	3.26	3.23	3.45	3.70	34.59	34.59
304	3.44	3.40	3.67	4.09	34.56	34.56
305	3.35	3.32	3.67	4.24	34.44	34.44
306	3.37	3.33	3.66	4.05	34.51	34.51
307	3.37	3.34	3.60	3.98	34.58	34.57
308	3.48	3.44	3.69	4.14	34.53	34.53
309	3.41	3.39	3.68	4.26	34.48	34.48
310	3.63	3.63	3.68	4.27	34.61	34.61
311	3.59	3.50	3.61	4.00	34.68	34.67
312	3.29	3.27	3.46	3.72	34.65	34.65
313	3.29	3.27	3.46	3.72	34.65	34.65
314	3.91	3.88	3.54	3.89	34.94	34.93
315	3.29	3.27	3.46	3.72	34.65	34.65
316	3.18	3.17	3.36	3.58	34.65	34.65
317	3.54	3.51	3.67	4.11	34.63	34.63
318	3.42	3.40	3.70	4.25	34.50	34.50
319	3.41	3.38	3.64	4.06	34.58	34.58
320	3.40	3.38	3.54	3.89	34.65	34.65
321	3.40	3.40	3.61	4.31	34.43	34.44
322	3.56	3.55	3.72	4.27	34.55	34.55
323	3.56	3.55	3.72	4.27	34.55	34.55
324	3.35	3.34	3.54	3.89	34.60	34.60
325	3.94	3.80	3.68	4.11	34.76	34.75
326	3.94	3.80	3.68	4.11	34.76	34.75
327	3.38	3.38	3.71	4.35	34.42	34.42
328	3.60	3.60	3.68	4.31	34.55	34.55
329	3.71	3.68	3.58	3.94	34.77	34.76
330	3.53	3.53	3.68	4.33	34.49	34.49
331	3.80	3.76	3.70	4.15	34.74	34.73
332	3.34	3.33	3.54	3.87	34.56	34.56
333	3.43	3.42	3.70	4.16	34.52	34.52
334	3.88	3.89	3.73	4.35	34.68	34.67
335	3.43	3.44	3.54	3.88	34.63	34.63
336	3.47	3.47	3.63	4.05	34.59	34.59
337	3.60	3.61	3.71	4.47	34.62	34.61
338	3.34	3.33	3.49	3.78	34.73	34.72
339	3.66	3.67	3.76	4.31	34.60	34.59
340	3.63	3.66	3.72	4.22	34.59	34.59
341	3.31	3.30	3.65	4.10	34.76	34.75
342	3.41	3.46	3.73	4.25	34.47	34.47
343	3.47	3.49	3.62	4.02	34.58	34.58
344	3.50	3.43	3.55	3.90	34.56	34.56

Box core number	Seafloor salinity 2010/ppt	Seafloor salinity average for collection year/ppt	Seafloor salinity average for collection and previous year/ppt	Seafloor zonal velocity 2008 m/s	Seafloor zonal velocity 2009 m/s	Seafloor zonal velocity 2010 m/s
259	34.64	34.64	34.62	-0.0438	-0.0430	-0.3359
260	34.54	34.54	34.51	-0.0254	-0.0257	-0.3022
261	34.58	34.58	34.55	-0.0288	-0.0302	-0.3493
262	34.58	34.58	34.55	-0.0288	-0.0302	-0.3493
263	34.68	34.68	34.66	-0.0376	-0.0379	-0.4753
264	34.68	34.68	34.66	-0.0376	-0.0379	-0.4753
265	34.40	34.40	34.36	-0.0118	-0.0121	-0.3554
266	34.33	34.33	34.29	-0.0111	-0.0112	-0.2164
267	34.54	34.54	34.51	-0.0252	-0.0262	-0.3174
268	34.77	34.77	34.76	-0.0228	-0.0243	-0.3420
269	34.42	34.42	34.38	-0.0176	-0.0183	-0.2903
270	34.42	34.42	34.38	-0.0176	-0.0183	-0.2903
271	34.42	34.42	34.38	-0.0176	-0.0183	-0.2903
272	34.55	34.55	34.53	-0.0240	-0.0250	-0.3064
273	34.67	34.67	34.65	-0.0314	-0.0320	-0.3955
274	34.34	34.34	34.30	-0.0124	-0.0123	-0.2397
275	34.48	34.48	34.46	-0.0112	-0.0110	-0.1972
276	34.40	34.40	34.36	-0.0147	-0.0144	-0.3193
277	34.46	34.46	34.42	-0.0145	-0.0151	-0.3391
278	34.62	34.62	34.60	-0.0254	-0.0256	-0.3318
279	34.85	34.85	34.85	-0.0133	-0.0134	-0.1409
280	34.41	34.41	34.37	-0.0087	-0.0095	-0.2513
281	34.42	34.42	34.40	-0.0044	-0.0049	-0.2149
282	34.29	34.29	34.31	0.0028	0.0022	-0.0206
283	34.46	34.46	34.43	-0.0075	-0.0084	-0.1578
284	34.62	34.62	34.59	-0.0177	-0.0184	-0.2560
285	34.85	34.85	34.84	0.0041	0.0058	0.7851
286	34.54	34.54	34.51	0.0079	0.0083	0.0959
287	34.47	34.47	34.43	0.0072	0.0070	0.0736
288	34.69	34.69	34.67	0.0007	0.0009	0.1468
289	34.45	34.45	34.42	0.0072	0.0068	0.0690
290	34.50	34.50	34.46	0.0045	0.0044	0.0804
291	34.50	34.50	34.46	0.0045	0.0044	0.0804
292	34.60	34.60	34.57	0.0094	0.0101	0.0956
293	34.61	34.61	34.58	0.0081	0.0088	0.0941
294	34.61	34.61	34.58	-0.0012	-0.0010	-0.1021
295	34.58	34.58	34.55	0.0025	0.0036	0.1649
296	34.58	34.58	34.56	0.0050	0.0046	0.0202
297	34.65	34.65	34.63	0.0000	0.0003	-0.1427
298	34.52	34.52	34.49	-0.0011	-0.0011	-0.1233
299	34.70	34.70	34.68	0.0010	0.0021	0.1087
300	34.55	34.55	34.53	-0.0028	-0.0028	-0.0992
301	34.61	34.61	34.58	-0.0029	-0.0033	-0.0552
302	34.63	34.63	34.60	-0.0018	-0.0014	-0.0254
303	34.63	34.63	34.61	0.0041	0.0050	0.0773
304	34.60	34.60	34.58	0.0041	0.0035	0.0773
305	34.51	34.51	34.47	-0.0041	-0.0039	-0.1775
306	34.58	34.58	34.55	-0.0026	-0.0025	-0.1150
307	34.62	34.62	34.60	-0.0030	-0.0024	-0.0145
308	34.58	34.58	34.55	-0.0019	-0.0019	-0.0683
309	34.55	34.55	34.52	-0.0043	-0.0037	-0.0586
310	34.64	34.64	34.62	-0.0101	-0.0084	-0.1794
311	34.70	34.70	34.69	-0.0039	-0.0035	-0.3413
312	34.68	34.68	34.66	0.0000	0.0001	0.0661
313	34.68	34.68	34.66	0.0000	0.0001	0.0661
314	34.93	34.93	34.93	0.0003	0.0018	-0.2360
315	34.68	34.68	34.66	0.0000	0.0001	0.0661
316	34.69	34.69	34.67	0.0025	0.0026	0.0302
317	34.66	34.66	34.64	-0.0168	-0.0160	-0.2549
318	34.56	34.56	34.53	-0.0094	-0.0052	-0.1954
319	34.63	34.63	34.60	-0.0125	-0.0119	-0.2094
320	34.68	34.68	34.66	-0.0169	-0.0165	-0.2613
321	34.50	34.50	34.47	-0.0086	-0.0068	-0.2298
322	34.60	34.60	34.58	-0.0113	-0.0097	-0.1576
323	34.60	34.60	34.58	-0.0113	-0.0097	-0.1576
324	34.64	34.64	34.61	-0.0230	-0.0233	-0.1546
325	34.77	34.77	34.76	-0.0138	-0.0133	-0.1532
326	34.77	34.77	34.76	-0.0138	-0.0133	-0.1532
327	34.49	34.49	34.46	-0.0146	-0.0120	-0.2651
328	34.60	34.60	34.58	-0.0108	-0.0087	-0.2444
329	34.78	34.78	34.77	-0.0251	-0.0263	-0.4227
330	34.55	34.55	34.51	-0.0081	-0.0066	-0.0107
331	34.75	34.75	34.74	-0.0136	-0.0130	-0.1503
332	34.61	34.61	34.59	-0.0127	-0.0116	-0.1328
333	34.58	34.58	34.55	-0.0204	-0.0179	-0.3447
334	34.69	34.69	34.68	-0.0130	-0.0101	-0.1946
335	34.67	34.67	34.65	-0.0660	-0.0581	-0.2300
336	34.63	34.63	34.61	-0.0338	-0.0306	-0.4122
337	34.85	34.85	34.83	-0.0303	-0.0263	-0.4688
338	34.75	34.75	34.74	-0.0577	-0.0572	-0.2383
339	34.84	34.84	34.81	-0.0257	-0.0224	-0.4717
340	34.63	34.63	34.61	-0.0313	-0.0212	-0.4212
341	34.77	34.77	34.75	-0.0539	-0.0337	-0.1773
342	34.52	34.52	34.50	-0.0304	-0.0216	-0.1384
343	34.62	34.62	34.60	-0.0490	-0.0365	-0.2117
344	34.60	34.60	34.58	-0.0498	-0.0344	-0.4658

Box core number	Seafloor zonal velocity average for collection year m/s	Seafloor zonal velocity average for collection and previous year m/s	Seafloor meridional velocity 2008 m/s	Seafloor meridional velocity 2009 m/s	Seafloor meridional velocity 2010 m/s
259	-0.2359	-0.1404	-0.0678	-0.0681	-0.3731
260	-0.3022	-0.1655	-0.0464	-0.0457	-0.4654
261	-0.3493	-0.1897	-0.0526	-0.0521	-0.5529
262	-0.3493	-0.1897	-0.0526	-0.0521	-0.5529
263	-0.4753	-0.2566	-0.0583	-0.0578	-0.8877
264	-0.4753	-0.2566	-0.0583	-0.0578	-0.8877
265	-0.2254	-0.1337	-0.0355	-0.0342	-0.3867
266	-0.2164	-0.1138	-0.0336	-0.0314	-0.3604
267	-0.3174	-0.1718	-0.0511	-0.0516	-0.5144
268	-0.3430	-0.1832	-0.0542	-0.0565	-0.7029
269	-0.2503	-0.1543	-0.0422	-0.0418	-0.4361
270	-0.2503	-0.1543	-0.0422	-0.0418	-0.4361
271	-0.2503	-0.1543	-0.0422	-0.0418	-0.4361
272	-0.3064	-0.1857	-0.0615	-0.0618	-0.4137
273	-0.3855	-0.2138	-0.0590	-0.0596	-0.3048
274	-0.3397	-0.1960	-0.0363	-0.0346	-0.3764
275	-0.1872	-0.1041	-0.0407	-0.0385	-0.4511
276	-0.3193	-0.1758	-0.0384	-0.0379	-0.3648
277	-0.3391	-0.1471	-0.0438	-0.0436	-0.4376
278	-0.3918	-0.1768	-0.0940	-0.0943	-0.3033
279	-0.1409	-0.0771	-0.0831	-0.0854	-0.8175
280	-0.2513	-0.1304	-0.0453	-0.0454	-0.2834
281	-0.2149	-0.1099	-0.0457	-0.0460	-0.2962
282	-0.0306	-0.0092	-0.0444	-0.0429	-0.2718
283	-0.2578	-0.1331	-0.0465	-0.0479	-0.3305
284	-0.2580	-0.1382	-0.0558	-0.0557	-0.3668
285	0.7852	0.3955	-0.0553	-0.0581	-0.5520
286	0.0939	0.0521	-0.0735	-0.0774	-0.2940
287	0.0736	0.0403	-0.0749	-0.0794	-0.2218
288	0.1468	0.1238	-0.0860	-0.0897	-0.1981
289	0.0690	0.0379	-0.0697	-0.0678	-0.2221
290	0.0804	0.0424	-0.0816	-0.0790	-0.1345
291	0.0804	0.0424	-0.0816	-0.0790	-0.1345
292	0.0956	0.0539	-0.0932	-0.0966	-0.2452
293	0.0941	0.0514	-0.1012	-0.1040	-0.2363
294	-0.1031	-0.0516	-0.0808	-0.0815	-0.2632
295	0.1649	0.0838	-0.0632	-0.0627	-0.3812
296	0.0202	0.0124	-0.0533	-0.0494	-0.4012
297	-0.1427	-0.0712	-0.0827	-0.0852	-0.2611
298	-0.1233	-0.0622	-0.0565	-0.0529	-0.2771
299	0.1087	0.0554	-0.0562	-0.0594	-0.4071
300	-0.0982	-0.0510	-0.0468	-0.0470	-0.3170
301	-0.0553	-0.0288	-0.0475	-0.0449	-0.3554
302	-0.0834	-0.0184	-0.0518	-0.0507	-0.3645
303	-0.0573	-0.0134	-0.0483	-0.0441	-0.3831
304	-0.1773	-0.0984	-0.0369	-0.0377	-0.3837
305	-0.1150	-0.0607	-0.0354	-0.0371	-0.3940
306	-0.0125	-0.0075	-0.0513	-0.0337	-0.3585
307	-0.0633	-0.0351	-0.0322	-0.0485	-0.1240
308	-0.0598	-0.0312	-0.0321	-0.0283	-0.3496
309	-0.1794	-0.0939	-0.0340	-0.0278	-0.3607
310	0.1413	0.1189	-0.0635	-0.0599	-0.4679
311	0.0661	0.0331	-0.0645	-0.0614	-0.3058
312	0.0661	0.0331	-0.0645	-0.0614	-0.2725
313	0.0661	0.0331	-0.0645	-0.0614	-0.2725
314	0.2360	-0.1171	-0.1289	-0.1238	-0.2115
315	0.0661	0.0331	-0.0645	-0.0614	-0.2725
316	0.0302	0.0164	-0.0776	-0.0720	-0.2144
317	-0.2549	-0.1554	-0.0298	-0.0276	-0.4121
318	-0.1554	-0.1018	-0.0282	-0.0248	-0.3176
319	-0.2034	-0.1076	-0.0386	-0.0364	-0.3440
320	-0.2613	-0.1389	-0.0455	-0.0447	-0.3731
321	-0.2286	-0.1183	-0.0209	-0.0175	-0.3529
322	-0.2576	-0.1336	-0.0220	-0.0185	-0.3116
323	-0.2576	-0.1336	-0.0220	-0.0185	-0.3116
324	-0.2246	-0.1389	-0.0815	-0.0307	-0.3712
325	-0.2532	-0.1332	-0.0283	-0.0249	-0.4670
326	-0.2532	-0.1332	-0.0283	-0.0249	-0.4670
327	-0.2651	-0.1385	-0.0218	-0.0187	-0.3046
328	-0.3444	-0.1266	-0.0204	-0.0167	-0.2955
329	-0.4227	-0.1245	-0.0407	-0.0396	-0.6195
330	-0.0107	-0.0086	-0.0181	-0.0157	-0.2741
331	-0.2503	-0.1317	-0.0276	-0.0244	-0.4532
332	-0.3428	-0.1712	-0.0288	-0.0276	-0.3939
333	-0.3447	-0.1813	-0.0265	-0.0238	-0.3868
334	-0.2346	-0.1324	-0.0253	-0.0207	-0.4526
335	-0.2300	-0.1440	-0.0247	-0.0241	-0.3634
336	-0.4122	-0.2214	-0.0306	-0.0286	-0.4650
337	-0.4658	-0.2466	-0.0300	-0.0269	-0.4970
338	-0.2233	-0.1427	-0.0367	-0.0373	-0.5389
339	-0.4717	-0.2471	-0.0298	-0.0256	-0.5105
340	-0.4212	-0.2212	-0.0053	-0.0058	-0.3254
341	-0.1773	-0.1055	-0.0049	-0.0061	-0.4724
342	-0.2284	-0.1405	-0.0108	-0.0106	-0.1983
343	-0.2117	-0.1241	-0.0147	-0.0146	-0.2452
344	-0.2573	-0.1487	-0.0086	-0.0084	-0.4171

Box core number	Seafloor meridional velocity average for collection year m/s	Seafloor meridional velocity average for collection and previous year m/s	Seafloor absolute speed 2008 m/s	Seafloor absolute speed 2009 m/s	Seafloor absolute speed 2010 m/s
259	-0.3731	-0.2206	0.0807	0.0816	0.4414
260	-0.4694	-0.2575	0.0529	0.0540	0.3583
261	-0.5529	-0.3025	0.0605	0.0603	0.6539
262	-0.5529	-0.3025	0.0605	0.0603	0.6539
263	-0.6877	-0.3727	0.0693	0.0691	0.8339
264	-0.6877	-0.3727	0.0693	0.0691	0.8339
265	-0.3867	-0.2105	0.0374	0.0363	0.4634
266	-0.3604	-0.1959	0.0354	0.0334	0.4203
267	-0.5144	-0.2830	0.0569	0.0579	0.6045
268	-0.7029	-0.3797	0.0588	0.0615	0.7817
269	-0.4361	-0.2389	0.0457	0.0456	0.5239
270	-0.4361	-0.2389	0.0457	0.0456	0.5239
271	-0.4361	-0.2389	0.0457	0.0456	0.5239
272	-0.4137	-0.2377	0.0661	0.0666	0.5148
273	-0.3048	-0.1972	0.0544	0.0553	0.4493
274	-0.3794	-0.2055	0.0383	0.0367	0.4462
275	-0.4511	-0.2453	0.0422	0.0410	0.4913
276	-0.3648	-0.2013	0.0401	0.0386	0.4256
277	-0.4076	-0.2436	0.0452	0.0461	0.4867
278	-0.3033	-0.1938	0.0377	0.0381	0.4495
279	-0.8173	-0.4429	0.0644	0.0697	0.8256
280	-0.2834	-0.1644	0.0461	0.0464	0.3788
281	-0.2562	-0.1741	0.0459	0.0465	0.3659
282	-0.4718	-0.2574	0.0445	0.0430	0.4726
283	-0.3505	-0.1992	0.0471	0.0448	0.4331
284	-0.3668	-0.2112	0.0585	0.0586	0.4485
285	-0.5530	-0.3051	0.0555	0.0585	0.5598
286	-0.1940	-0.1857	0.0799	0.0778	0.3092
287	-0.1218	-0.1476	0.0752	0.0737	0.2336
288	-0.1981	-0.1439	0.0860	0.0897	0.3165
289	-0.2221	-0.1450	0.0701	0.0681	0.2926
290	-0.1345	-0.1567	0.0817	0.0791	0.2478
291	-0.1345	-0.1567	0.0817	0.0791	0.2478
292	-0.2452	-0.1709	0.0937	0.0972	0.2631
293	-0.2363	-0.1702	0.1015	0.1044	0.2543
294	-0.2632	-0.1723	0.0808	0.0815	0.2833
295	-0.3812	-0.2220	0.0632	0.0628	0.4154
296	-0.4012	-0.2253	0.0527	0.0496	0.4017
297	-0.2611	-0.1731	0.0827	0.0852	0.2976
298	-0.2771	-0.1650	0.0565	0.0529	0.3033
299	-0.4071	-0.2303	0.0562	0.0533	0.4214
300	-0.3170	-0.1820	0.0488	0.0470	0.3321
301	-0.3954	-0.1701	0.0476	0.0450	0.3905
302	-0.3565	-0.1496	0.0518	0.0507	0.3668
303	-0.3321	-0.1707	0.0582	0.0581	0.3583
304	-0.3837	-0.1982	0.0592	0.0582	0.3957
305	-0.2940	-0.1590	0.0199	0.0274	0.3408
306	-0.2585	-0.1661	0.0595	0.0838	0.3213
307	-0.2240	-0.1362	0.0544	0.0485	0.2243
308	-0.3496	-0.1890	0.0342	0.0284	0.3582
309	-0.2607	-0.1445	0.0334	0.0185	0.2672
310	-0.4679	-0.2478	0.0355	0.0190	0.3611
311	-0.3058	-0.1319	0.0636	0.0600	0.3171
312	-0.2725	-0.1669	0.0645	0.0614	0.2804
313	-0.2725	-0.1669	0.0645	0.0614	0.2804
314	-0.2115	-0.1677	0.1189	0.1139	0.3169
315	-0.2725	-0.1669	0.0645	0.0614	0.2804
316	-0.2144	-0.1432	0.0776	0.0720	0.2166
317	-0.4121	-0.2198	0.0342	0.0319	0.5067
318	-0.3176	-0.1711	0.0297	0.0262	0.3729
319	-0.3440	-0.1901	0.0406	0.0383	0.3996
320	-0.3731	-0.2089	0.0485	0.0476	0.4555
321	-0.2529	-0.1351	0.0236	0.0188	0.3417
322	-0.3116	-0.1651	0.0248	0.0209	0.4043
323	-0.3116	-0.1651	0.0248	0.0209	0.4043
324	-0.3712	-0.2010	0.0390	0.0386	0.4501
325	-0.4670	-0.2459	0.0315	0.0282	0.5312
326	-0.4670	-0.2459	0.0315	0.0282	0.5312
327	-0.3046	-0.1616	0.0262	0.0222	0.4037
328	-0.2955	-0.1561	0.0231	0.0188	0.3834
329	-0.6185	-0.3295	0.0478	0.0475	0.7500
330	-0.3741	-0.1948	0.0107	0.0170	0.3743
331	-0.4532	-0.2285	0.0340	0.0477	0.5173
332	-0.3939	-0.1097	0.0350	0.0350	0.5092
333	-0.3868	-0.2053	0.0194	0.0297	0.5181
334	-0.4526	-0.2366	0.0185	0.0130	0.5400
335	-0.3634	-0.1957	0.0705	0.0629	0.4300
336	-0.4650	-0.2468	0.0456	0.0419	0.6214
337	-0.4970	-0.2620	0.0426	0.0376	0.6819
338	-0.5389	-0.2881	0.0683	0.0683	0.5852
339	-0.5105	-0.2681	0.0400	0.0340	0.6951
340	-0.2254	-0.1156	0.0317	0.0219	0.4777
341	-0.4704	-0.2393	0.0541	0.0342	0.5046
342	-0.1983	-0.1045	0.0323	0.0249	0.3257
343	-0.2492	-0.1319	0.0512	0.0393	0.3269
344	-0.1171	-0.0647	0.0026	0.0036	0.2878

Box core number	Seafloor absolute speed average for collection year m/s	Seafloor absolute speed average for collection and previous year m/s	10 year max seafloor absolute speed m/s	10 year average seafloor absolute speed m/s	MODIS surface Chlorophyll a 2008 mg/m³
259	0.4414	0.2615	0.1516	0.0938	1.305
260	0.5583	0.3061	0.1333	0.0751	1.138
261	0.6539	0.3571	0.1486	0.0876	1.995
262	0.6539	0.3571	0.1486	0.0876	1.995
263	0.8359	0.4535	0.1452	0.0842	1.409
264	0.8359	0.4535	0.1452	0.0842	1.409
265	0.4634	0.2499	0.0917	0.0430	0.777
266	0.4203	0.2268	0.0838	0.0358	0.741
267	0.6045	0.3312	0.1390	0.0813	1.002
268	0.7817	0.4216	0.1424	0.0701	0.807
269	0.5139	0.2847	0.1223	0.0654	0.795
270	0.5139	0.2847	0.1223	0.0654	0.795
271	0.5139	0.2847	0.1211	0.0644	0.796
272	0.5148	0.2907	0.1623	0.0940	0.954
273	0.4993	0.2972	0.1686	0.0852	0.939
274	0.4462	0.2415	0.0951	0.0431	0.762
275	0.4923	0.2666	0.0977	0.0525	0.822
276	0.4256	0.2317	0.0977	0.0464	0.901
277	0.4687	0.2734	0.1275	0.0680	0.804
278	0.4495	0.2688	0.1452	0.1006	0.818
279	0.8296	0.4496	0.1532	0.0832	1.176
280	0.3788	0.2126	0.1131	0.0517	0.855
281	0.3629	0.2061	0.1803	0.0584	0.856
282	0.2726	0.1578	0.1241	0.0634	0.782
283	0.4351	0.2418	0.1329	0.0566	1.001
284	0.4485	0.2536	0.1342	0.0666	1.232
285	0.5598	0.3091	0.1569	0.0635	1.000
286	0.3092	0.1935	0.2000	0.1041	0.954
287	0.2336	0.1537	0.2261	0.1289	0.881
288	0.3185	0.2031	0.1804	0.0754	0.928
289	0.1316	0.1504	0.1002	0.1136	0.833
290	0.1478	0.1635	0.1505	0.1348	0.879
291	0.1478	0.1635	0.1505	0.1348	0.879
292	0.2631	0.1802	0.1357	0.1298	1.037
293	0.2543	0.1794	0.1658	0.1469	1.079
294	0.2823	0.1819	0.1519	0.1091	1.028
295	0.4154	0.2391	0.1888	0.0917	0.940
296	0.4017	0.2257	0.1477	0.0764	0.866
297	0.2976	0.1914	0.1969	0.0898	0.957
298	0.3033	0.1781	0.1644	0.0825	0.936
299	0.4214	0.2374	0.1307	0.0452	1.234
300	0.3321	0.1896	0.1256	0.0596	0.934
301	0.3005	0.1727	0.1561	0.0607	0.830
302	0.3688	0.1988	0.1477	0.0555	0.905
303	0.3683	0.1939	0.1172	0.0405	0.941
304	0.3657	0.1938	0.0837	0.0429	0.941
305	0.3408	0.1841	0.0963	0.0336	0.794
306	0.3213	0.1776	0.0790	0.0320	0.857
307	0.2243	0.1364	0.1662	0.0717	0.839
308	0.3562	0.1913	0.0888	0.0312	0.732
309	0.1672	0.1478	0.1043	0.0434	0.741
310	0.5011	0.2651	0.0950	0.0406	0.722
311	0.3171	0.1886	0.1985	0.0836	0.804
312	0.2804	0.1709	0.2021	0.0986	0.872
313	0.2804	0.1709	0.2030	0.0941	0.869
314	0.3169	0.2304	0.2162	0.0815	0.834
315	0.2804	0.1709	0.2042	0.0962	0.881
316	0.2166	0.1448	0.1885	0.0860	1.052
317	0.5067	0.2693	0.0971	0.0396	0.739
318	0.3729	0.1995	0.0782	0.0321	0.711
319	0.3996	0.2190	0.1181	0.0521	0.745
320	0.4555	0.2516	0.1489	0.0695	0.791
321	0.3417	0.1803	0.0678	0.0310	0.734
322	0.4043	0.2126	0.0773	0.0271	0.717
323	0.4043	0.2126	0.0773	0.0271	0.717
324	0.4501	0.2443	0.1355	0.0643	0.756
325	0.5312	0.2797	0.1004	0.0434	0.765
326	0.5312	0.2797	0.1012	0.0431	0.765
327	0.4037	0.2130	0.0962	0.0330	0.712
328	0.3834	0.2011	0.0712	0.0337	0.738
329	0.7500	0.3987	0.1335	0.0581	0.703
330	0.1743	0.1456	0.0791	0.0344	0.726
331	0.2178	0.1727	0.0965	0.0388	0.721
332	0.5092	0.2721	0.1207	0.0529	0.847
333	0.5181	0.2739	0.1072	0.0476	0.783
334	0.5400	0.2815	0.1063	0.0421	0.766
335	0.4300	0.2465	0.1886	0.1037	0.720
336	0.6214	0.3316	0.1579	0.0730	0.732
337	0.6819	0.3597	0.1479	0.0641	0.744
338	0.7832	0.3288	0.1496	0.0617	0.679
339	0.6921	0.3646	0.1284	0.0581	0.859
340	0.4777	0.2498	0.1210	0.0393	0.687
341	0.5046	0.2694	0.1523	0.0600	0.653
342	0.3257	0.1753	0.1374	0.0500	0.667
343	0.3269	0.1831	0.1811	0.0838	0.690
344	0.2473	0.1646	0.1666	0.0673	0.664

Box core number	MODIS surface Chloro a 2009 mg/m³	MODIS surface Chloro a 2010 mg/m³	MODIS surface Chloro a average for collection year mg/m³	MODIS surface Chloro a average for collection and previous year mg/m³	MODIS surface POC 2008 mg/m³
259	0.711	0.824	0.824	0.767	229.13
260	0.739	0.820	0.820	0.779	201.36
261	0.762	0.853	0.853	0.807	419.72
262	0.762	0.853	0.853	0.807	419.72
263	0.721	0.811	0.811	0.766	392.96
264	0.721	0.811	0.811	0.766	392.96
265	0.661	0.825	0.825	0.743	151.84
266	0.674	0.821	0.821	0.748	147.15
267	0.735	0.817	0.817	0.776	181.88
268	0.659	0.809	0.809	0.734	152.39
269	0.668	0.814	0.814	0.741	153.22
270	0.668	0.814	0.814	0.741	153.22
271	0.670	0.816	0.816	0.743	153.46
272	0.830	0.832	0.831	0.831	152.09
273	0.815	0.847	0.847	0.831	205.56
274	0.642	0.821	0.821	0.732	148.77
275	0.652	0.672	0.672	0.752	158.14
276	0.647	0.829	0.829	0.738	162.06
277	0.844	0.860	0.860	0.724	151.18
278	0.868	0.883	0.883	0.745	151.66
279	0.894	0.849	0.849	0.777	173.86
280	0.842	0.891	0.891	0.736	154.71
281	0.842	0.838	0.838	0.740	151.24
282	0.833	0.854	0.854	0.743	148.21
283	0.843	0.843	0.843	0.743	147.61
284	0.719	0.815	0.815	0.767	196.26
285	0.636	0.869	0.869	0.753	163.89
286	0.662	0.871	0.871	0.766	157.10
287	0.674	0.874	0.874	0.774	150.80
288	0.573	0.875	0.875	0.724	154.33
289	0.655	0.847	0.847	0.751	146.92
290	0.673	0.930	0.930	0.802	146.97
291	0.673	0.930	0.930	0.802	146.97
292	0.668	0.898	0.898	0.783	161.48
293	0.659	0.921	0.921	0.790	162.67
294	0.703	0.861	0.861	0.782	160.20
295	0.661	0.871	0.871	0.766	150.68
296	0.676	0.886	0.886	0.781	147.02
297	0.677	0.869	0.869	0.773	151.95
298	0.668	0.840	0.840	0.754	151.95
299	0.718	0.902	0.902	0.810	152.33
300	0.667	0.859	0.859	0.763	148.08
301	0.684	0.888	0.888	0.786	147.17
302	0.673	0.936	0.936	0.805	150.07
303	0.695	0.960	0.960	0.828	151.91
304	0.674	0.899	0.899	0.787	148.31
305	0.672	0.859	0.859	0.760	151.12
306	0.680	0.870	0.870	0.775	154.68
307	0.706	0.915	0.915	0.810	145.67
308	0.664	0.826	0.826	0.745	142.48
309	0.676	0.897	0.897	0.786	142.71
310	0.677	0.817	0.817	0.747	141.19
311	0.735	0.879	0.879	0.817	149.40
312	0.853	0.893	0.893	0.873	149.18
313	0.847	0.890	0.890	0.868	148.30
314	0.765	0.872	0.872	0.818	148.11
315	0.882	0.910	0.910	0.896	148.04
316	0.794	1.113	1.113	0.959	148.73
317	0.752	0.829	0.829	0.790	145.29
318	0.688	0.799	0.799	0.744	140.85
319	0.777	0.804	0.804	0.791	139.80
320	0.768	0.853	0.853	0.810	160.58
321	0.717	0.839	0.839	0.778	148.84
322	0.724	0.825	0.825	0.775	202.91
323	0.724	0.825	0.825	0.775	202.91
324	0.826	0.833	0.833	0.829	158.43
325	0.731	0.875	0.875	0.803	144.90
326	0.731	0.875	0.875	0.803	144.90
327	0.778	0.859	0.859	0.819	171.55
328	0.736	0.852	0.852	0.794	166.61
329	0.648	0.837	0.837	0.743	132.62
330	0.811	0.859	0.859	0.836	156.35
331	0.678	0.882	0.882	0.770	136.73
332	0.749	0.840	0.840	0.794	140.02
333	0.736	0.882	0.882	0.809	144.42
334	0.777	0.872	0.872	0.824	148.67
335	0.670	1.046	1.046	0.858	134.91
336	0.715	0.947	0.947	0.831	139.30
337	0.731	0.931	0.931	0.835	140.71
338	0.684	0.858	0.858	0.771	131.98
339	0.767	0.886	0.886	0.827	156.44
340	0.889	1.341	1.341	1.115	128.85
341	0.818	1.319	1.319	1.068	127.79
342	0.835	1.284	1.284	1.060	137.65
343	0.743	1.154	1.154	0.948	132.70
344	0.771	0.953	0.953	0.867	127.69

Box core number	MODIS surface POC 2009 mg/m³	MODIS surface POC 2010 mg/m³	MODIS surface POC average for collection year mg/m³	MODIS surface POC average for collection and previous year mg/m³	Lutz et al. 2002 NE Atlantic uncorrected POC at depth mg/m³
259	125.41	140.83	140.83	133.12	0.006
260	137.82	143.01	143.01	140.41	0.006
261	155.77	141.37	141.37	148.57	0.007
262	155.77	141.37	141.37	148.57	0.007
263	135.09	137.92	137.92	136.50	0.006
264	135.09	137.92	137.92	136.50	0.006
265	133.87	148.33	148.33	136.60	0.053
266	125.31	148.02	148.02	137.17	0.434
267	138.93	143.69	143.69	141.31	0.005
268	123.96	158.49	158.49	141.22	0.006
269	125.10	147.07	147.07	136.09	0.005
270	125.10	147.07	147.07	136.09	0.005
271	125.25	147.39	147.39	136.32	0.005
272	138.36	155.89	155.89	147.12	0.005
273	129.78	153.93	153.93	141.86	0.005
274	121.47	149.38	149.38	135.43	0.503
275	121.28	170.69	170.69	145.99	0.051
276	120.91	155.30	155.30	138.10	0.013
277	121.53	158.55	158.55	140.04	0.036
278	123.37	148.11	148.11	135.24	0.005
279	125.68	145.42	145.42	135.55	0.006
280	120.48	149.87	149.87	135.18	0.006
281	121.12	148.49	148.49	134.80	0.005
282	120.69	148.31	148.31	134.60	0.041
283	120.86	149.38	149.38	135.12	0.005
284	127.60	145.62	145.62	136.61	0.005
285	122.94	158.32	158.32	140.63	0.005
286	123.33	152.49	152.49	137.91	0.006
287	125.83	156.66	156.66	141.24	0.344
288	117.16	147.28	147.28	132.22	0.005
289	123.25	148.53	148.53	136.39	0.175
290	127.58	178.20	178.20	152.89	0.123
291	127.58	178.20	178.20	152.89	0.123
292	124.25	159.39	159.39	141.82	0.005
293	126.21	158.80	158.80	142.50	0.005
294	129.20	153.00	153.00	141.10	0.005
295	123.90	158.67	158.67	141.29	0.005
296	124.70	160.49	160.49	142.59	0.417
297	126.60	156.45	156.45	141.52	0.006
298	125.13	157.56	157.56	141.34	0.976
299	125.29	166.09	166.09	145.69	0.005
300	148.87	169.29	169.29	159.08	0.005
301	124.89	149.82	149.82	137.35	0.005
302	125.09	148.90	148.90	137.00	0.005
303	127.70	153.34	153.34	140.62	0.005
304	126.15	170.03	170.03	148.08	0.007
305	124.79	165.85	165.85	145.32	0.005
306	124.67	162.99	162.99	144.33	0.007
307	126.46	154.38	154.38	140.42	0.007
308	123.36	141.59	141.59	132.77	0.062
309	126.25	146.74	146.74	136.48	0.168
310	126.07	145.69	145.69	135.88	0.007
311	131.26	151.86	151.86	141.96	0.011
312	131.63	144.68	144.68	138.66	0.005
313	132.96	144.85	144.85	138.91	0.005
314	130.99	151.96	151.96	141.47	0.005
315	131.79	143.49	143.49	137.64	0.005
316	138.53	131.63	131.63	135.08	0.005
317	130.31	145.58	145.58	138.14	0.015
318	126.00	145.19	145.19	135.60	0.142
319	130.48	141.79	141.79	136.13	0.009
320	132.16	153.10	153.10	142.63	0.005
321	129.25	152.91	152.91	141.08	1.273
322	131.16	169.08	169.08	150.12	0.101
323	131.16	169.08	169.08	150.12	0.101
324	141.62	145.84	145.84	143.73	0.005
325	128.16	154.36	154.36	141.26	0.006
326	128.16	154.36	154.36	141.26	0.006
327	130.84	175.09	175.09	152.97	1.461
328	130.38	156.30	156.30	143.34	0.922
329	120.25	139.97	139.97	130.11	0.005
330	132.54	170.70	170.70	151.62	0.287
331	124.74	145.43	145.43	135.08	0.010
332	126.31	148.90	148.90	137.61	0.005
333	128.55	155.55	155.55	142.05	0.006
334	131.03	157.96	157.96	144.38	0.516
335	126.19	146.79	146.79	136.48	0.005
336	129.12	161.87	161.87	145.50	0.005
337	130.00	162.28	162.28	146.14	0.014
338	123.89	142.75	142.75	133.32	0.005
339	131.44	157.60	157.60	144.52	0.446
340	143.16	198.37	198.37	170.76	0.096
341	143.07	200.51	200.51	171.79	0.005
342	141.97	176.55	176.55	159.26	0.006
343	132.40	166.83	166.83	149.61	0.007
344	131.92	181.22	181.22	156.60	0.005

Box core number	Lutz et al. 2002 NE Atlantic radionuclidite corrected POC at depth mg/m³	Lutz et al. 2002 Sargasso uncorrected POC at depth mg/m³	Lutz et al. 2002 Sargasso radionuclidite corrected POC at depth mg/m³	Sediment total carbon %
259	0.147	0.163	0.006	3.24
260	0.201	0.215	0.006	2.67
261	0.283	0.292	0.006	ns
262	0.283	0.292	0.006	2.98
263	0.212	0.225	0.006	ns
264	0.212	0.225	0.006	2.75
265	1.366	1.548	0.014	1.47
266	5.415	5.384	0.123	0.60
267	0.052	0.074	0.006	2.09
268	0.188	0.203	0.006	1.23
269	0.105	0.123	0.006	ns
270	0.105	0.123	0.006	0.60
271	0.088	0.117	0.006	0.99
272	0.146	0.162	0.006	2.18
273	0.095	0.114	0.006	ns
274	5.354	5.715	0.147	0.84
275	1.397	1.558	0.014	1.32
276	0.693	0.800	0.007	0.91
277	1.153	1.236	0.011	0.84
278	0.076	0.096	0.006	2.87
279	0.193	0.207	0.006	2.06
280	0.179	0.194	0.006	2.37
281	0.096	0.115	0.006	2.66
282	1.339	1.310	0.011	1.71
283	0.087	0.107	0.006	1.82
284	0.089	0.109	0.006	3.16
285	0.044	0.066	0.006	2.54
286	0.217	0.230	0.006	2.25
287	4.813	4.693	0.093	0.52
288	0.024	0.048	0.006	1.40
289	3.221	3.139	0.044	0.45
290	2.753	2.680	0.030	ns
291	2.753	2.680	0.030	0.57
292	0.066	0.087	0.006	1.38
293	0.090	0.110	0.006	2.73
294	0.059	0.081	0.006	2.33
295	0.147	0.164	0.006	1.92
296	5.383	5.153	0.116	0.42
297	0.132	0.144	0.006	1.81
298	8.673	8.482	0.322	0.33
299	0.010	0.034	0.006	2.06
300	0.063	0.084	0.006	2.66
301	0.037	0.060	0.006	2.31
302	0.041	0.041	0.006	2.76
303	0.016	0.036	0.006	2.84
304	0.316	0.334	0.006	1.41
305	0.060	0.081	0.006	2.57
306	0.287	0.296	0.006	1.54
307	0.240	0.299	0.006	2.29
308	1.721	1.680	0.016	0.83
309	3.140	3.059	0.041	0.81
310	0.297	0.307	0.006	1.09
311	0.499	0.500	0.007	1.23
312	0.010	0.035	0.006	1.54
313	0.010	0.035	0.006	1.34
314	0.132	0.149	0.006	2.73
315	0.010	0.035	0.006	1.90
316	0.033	0.056	0.006	2.79
317	0.880	0.873	0.007	1.37
318	2.844	2.771	0.035	0.73
319	0.379	0.384	0.007	1.90
320	0.018	0.042	0.006	2.85
321	10.061	9.848	0.444	ns
322	2.459	2.394	0.025	ns
323	2.459	2.394	0.025	ns
324	0.037	0.060	0.006	2.39
325	0.172	0.187	0.006	ns
326	0.177	0.192	0.006	ns
327	11.266	11.028	0.516	0.52
328	8.450	8.261	0.300	0.76
329	0.080	0.055	0.006	2.15
330	4.477	4.362	0.475	1.12
331	0.446	0.448	0.007	1.77
332	0.035	0.056	0.006	2.01
333	0.211	0.225	0.006	2.23
334	6.118	5.970	0.149	0.53
335	0.033	0.056	0.006	ns
336	0.093	0.113	0.006	ns
337	0.629	0.634	0.007	2.49
338	0.021	0.045	0.006	ns
339	5.629	5.491	0.125	0.81
340	1.381	1.348	0.011	1.46
341	0.048	0.070	0.006	1.58
342	0.237	0.248	0.006	0.83
343	0.323	0.331	0.006	2.69
344	0.039	0.061	0.006	3.04

Box core number	Sediment organic carbon %	Sediment inorganic carbon %	Sediment clay %	Sediment silt %	Sediment sand %	Shannon sediment PSD	Within NAFO closure as of 28-11-18?	Spicules in box core?	Porifera density Kenchington et al. 2014 kJ/km^2
259	0.85	2.39	16.17	84.91	15.92	2.16	N	Y	1.465
260	0.88	1.99	18.41	54.63	26.96	2.24	Y	Y	6.334
261	ns	ns	ns	ns	ns	ns	Y	ns	3.361
262	0.97	2.01	15.65	51.90	32.55	2.18	Y	Y	3.362
263	ns	ns	ns	ns	ns	ns	Y	Y	3.819
264	0.90	1.85	13.16	62.15	24.59	2.14	Y	ns	3.819
265	0.69	0.78	7.94	36.94	55.13	2.16	N	Y	5.285
266	0.23	0.37	6.20	20.45	73.35	2.14	N	Y	2.593
267	0.38	1.71	12.10	40.92	46.98	2.25	Y	Y	5.382
268	0.41	0.82	10.96	56.36	32.68	2.18	Y	Y	12.694
269	ns	ns	ns	ns	ns	ns	N	ns	9.024
270	0.25	0.35	8.50	25.32	66.18	2.01	N	ns	9.023
271	0.32	0.67	ns	ns	ns	ns	N	N	8.861
272	0.48	1.70	15.24	35.91	48.85	2.32	Y	Y	5.076
273	ns	ns	ns	ns	ns	ns	Y	ns	3.531
274	0.43	0.41	6.41	25.96	67.64	1.90	N	Y	6.092
275	0.56	0.77	8.27	36.01	55.72	1.95	N	Y	7.473
276	0.45	0.46	8.38	38.54	53.09	2.08	N	Y	14.129
277	0.37	0.57	8.27	29.87	61.87	2.00	N	Y	9.906
278	0.73	2.08	16.77	53.12	30.11	2.31	Y	Y	1.188
279	1.01	1.05	18.53	47.76	33.71	2.28	Y	Y	15.597
280	1.37	0.00	9.63	63.28	27.08	2.12	N	Y	1.932
281	1.83	1.08	16.05	63.46	20.48	2.14	N	Y	0.246
282	0.93	0.96	8.88	43.48	48.65	2.14	N	Y	0.098
283	0.99	1.50	19.67	28.82	51.51	2.16	N	Y	1.771
284	1.90	2.46	19.32	60.47	20.21	2.21	N	Y	0.777
285	1.94	1.50	13.47	58.09	28.44	2.24	N	Y	0.039
286	1.84	0.62	16.59	50.90	32.77	2.27	N	N	2.027
287	0.23	0.29	5.63	17.49	76.88	2.08	N	N	3.386
288	0.33	1.07	10.42	39.73	49.84	2.16	N	Y	0.163
289	0.20	0.26	5.44	23.66	70.90	1.89	N	Y	2.155
290	ns	ns	ns	ns	ns	ns	N	ns	2.192
291	0.21	0.36	7.82	25.51	66.67	1.92	N	Y	2.195
292	0.44	0.94	12.06	33.25	51.68	2.26	Y	Y	4.525
293	1.56	1.17	16.33	64.24	19.42	2.16	Y	Y	3.881
294	1.27	1.06	ns	ns	ns	ns	N	Y	0.122
295	1.34	0.58	10.81	47.95	41.24	2.19	N	ns	1.605
296	0.13	0.30	4.54	16.47	79.00	1.95	N	N	0.955
297	0.99	0.83	13.91	55.38	30.71	2.21	N	Y	1.410
298	0.15	0.18	3.74	13.94	82.33	1.87	N	N	0.097
299	1.14	0.92	11.30	56.09	32.61	2.20	N	N	0.099
300	1.96	0.70	13.67	55.13	31.20	2.26	N	N	0.135
301	1.21	1.10	19.03	55.70	25.28	2.21	N	N	0.010
302	1.60	1.16	22.41	60.88	16.71	2.16	N	N	0.002
303	1.30	1.45	21.49	63.30	13.21	2.07	N	Y	0.027
304	0.67	0.75	12.32	45.22	42.26	2.14	N	Y	0.079
305	1.47	1.10	12.94	59.35	27.81	2.15	N	Y	0.144
306	0.61	0.93	10.86	50.01	39.13	2.01	N	Y	0.054
307	1.65	0.95	22.13	61.81	15.06	2.06	N	Y	0.001
308	0.47	0.36	8.60	31.18	60.22	1.83	N	Y	0.061
309	0.94	0.47	8.83	28.92	62.25	1.77	N	Y	0.040
310	0.74	0.35	10.78	38.77	50.45	1.92	N	Y	0.035
311	0.89	0.55	13.88	44.67	41.45	2.17	N	Y	0.000
312	0.93	0.61	14.48	49.69	35.82	2.27	N	ns	0.000
313	0.77	0.57	14.61	50.24	35.15	2.22	N	ns	0.000
314	2.73	0.00	21.38	56.46	22.16	2.25	N	Y	0.000
315	1.21	0.69	14.60	44.16	41.25	2.26	N	Y	0.000
316	2.11	0.68	19.25	61.52	19.24	2.19	N	Y	0.000
317	1.19	0.18	13.98	43.68	42.34	1.97	N	Y	0.022
318	0.66	0.07	7.68	24.30	68.02	2.11	N	Y	0.040
319	1.90	0.00	17.97	54.52	27.51	2.19	N	Y	0.000
320	2.85	0.00	17.60	57.54	24.86	2.22	N	Y	0.000
321	ns	ns	ns	ns	ns	ns	N	ns	0.185
322	ns	ns	ns	ns	ns	ns	N	ns	0.216
323	ns	ns	ns	ns	ns	ns	N	ns	0.216
324	2.04	0.35	17.49	60.50	22.01	2.19	N	Y	0.000
325	ns	ns	ns	ns	ns	ns	N	ns	0.025
326	ns	ns	ns	ns	ns	ns	N	ns	0.025
327	0.51	0.00	5.95	21.75	72.30	1.84	N	Y	0.053
328	0.85	0.12	8.04	26.90	65.06	1.93	N	Y	0.248
329	2.15	0.00	17.58	54.06	28.36	2.24	N	Y	0.001
330	0.99	0.13	7.99	32.74	59.28	1.99	N	Y	0.136
331	1.65	0.12	14.94	49.35	35.71	2.15	N	Y	0.035
332	1.87	0.14	17.01	55.09	27.90	2.20	N	Y	0.007
333	2.23	0.00	15.74	54.25	30.01	2.18	N	Y	0.013
334	0.89	0.34	11.12	37.36	51.48	2.10	N	Y	0.008
335	ns	ns	ns	ns	ns	ns	N	ns	0.045
336	ns	ns	ns	ns	ns	ns	N	ns	0.026
337	2.49	0.00	17.08	50.44	31.48	2.27	N	N	0.028
338	ns	ns	ns	ns	ns	ns	N	ns	0.002
339	0.83	0.18	4.85	15.41	79.74	2.05	N	Y	0.015
340	1.11	0.35	13.92	43.02	43.06	2.18	N	Y	0.041
341	1.58	0.00	11.47	46.59	41.94	2.16	N	N	0.021
342	0.60	0.33	9.53	36.64	53.82	2.05	N	Y	0.026
343	0.77	1.52	15.58	38.47	45.95	2.27	N	Y	0.011
344	1.34	0.71	17.21	38.63	44.16	2.21	N	Y	0.004

Box core number	Pennatulacean density Kenchington et al. 2014 kg/km²	Gorgonian density Kenchington et al. 2014 kg/km²	Downie porifera relative biomass	Downie pennatulacean relative biomass	Downie gorgonian relative biomass	Geological environment
259	0.000	0.000	7.481	0.144	0.140	flatsed seabed stepped
260	0.000	0.000	8.405	0.050	0.146	canyon head–400m walls
261	0.000	0.000	17.025	0.025	0.188	flatsed seabed stepped
262	0.000	0.000	17.023	0.025	0.187	flatsed seabed stepped
263	0.000	0.000	11.217	0.021	0.181	flatsed seabed stepped
264	0.000	0.000	11.219	0.021	0.181	flatsed seabed stepped
265	0.000	0.000	0.559	0.151	0.012	flatsed seabed stepped
266	0.000	0.000	2.082	0.166	0.030	inter canyon area
267	0.000	0.000	15.371	0.198	0.105	flatsed seabed stepped
268	0.001	0.000	1.828	0.057	0.115	canyon head–400m floor
269	0.000	0.000	5.791	0.113	0.061	shelf indenting canyon walls
270	0.000	0.000	5.795	0.112	0.061	shelf indenting canyon walls
271	0.000	0.000	5.137	0.094	0.074	canyon head–400m floor
272	0.000	0.000	12.817	0.053	0.206	inter canyon area
273	0.000	0.000	13.943	0.052	0.185	inter canyon area
274	0.000	0.000	0.172	0.045	0.075	inter canyon area
275	0.000	0.000	0.137	0.027	0.002	canyon head–400m walls
276	0.003	0.000	0.488	0.126	0.005	shelf indenting canyon walls
277	0.001	0.000	0.121	0.095	0.000	shelf indenting canyon walls
278	0.000	0.000	8.187	0.179	0.197	shelf indenting canyon walls
279	0.000	0.000	16.116	0.043	0.097	canyon head–400m walls
280	0.005	0.000	2.894	0.253	0.054	canyon head–400m floor
281	0.005	0.000	3.163	0.263	0.054	canyon head–400m floor
282	0.000	0.000	1.685	0.446	0.009	shelf indenting canyon walls
283	0.005	0.000	8.980	0.236	0.098	inter canyon area
284	0.000	0.000	7.439	0.220	0.101	inter canyon area
285	0.000	0.000	8.569	0.202	0.092	inter canyon area
286	0.000	0.000	5.279	0.060	0.052	inter canyon area
287	0.000	0.000	0.215	0.098	0.021	inter canyon area
288	0.000	0.000	14.825	0.201	0.145	inter canyon area
289	0.000	0.000	0.819	0.115	0.011	canyon head–400m walls
290	0.000	0.000	0.498	0.093	0.032	canyon head–400m walls
291	0.000	0.000	0.533	0.093	0.029	canyon head–400m walls
292	0.000	0.000	15.342	0.136	0.094	canyon head–400m floor
293	0.000	0.000	8.301	0.098	0.048	canyon head–400m floor
294	0.001	0.000	17.621	0.138	0.105	canyon head–400m walls
295	0.000	0.000	3.432	0.153	0.033	canyon head–400m floor
296	0.000	0.000	1.410	0.107	0.011	inter canyon area
297	0.000	0.000	14.639	0.052	0.104	inter canyon area
298	0.001	0.000	0.113	0.038	0.015	iceberg pits
299	0.000	0.000	3.962	0.197	0.035	shelf indenting canyon walls
300	0.001	0.000	2.767	0.252	0.038	shelf indenting canyon walls
301	0.001	0.000	5.244	0.208	0.111	shelf indenting canyon floor
302	0.000	0.000	6.130	0.147	0.088	shelf indenting canyon walls
303	0.001	0.000	8.167	0.141	0.139	canyon head–400m walls
304	0.001	0.000	0.356	0.174	0.033	shelf indenting canyon floor
305	0.001	0.000	3.718	0.306	0.047	shelf indenting canyon floor
306	0.001	0.000	0.988	0.303	0.043	shelf indenting canyon walls
307	0.001	0.000	1.779	0.285	0.031	inter canyon area
308	0.002	0.000	1.518	0.093	0.019	shelf indenting canyon walls
309	0.003	0.000	0.268	0.085	0.011	inter canyon area
310	0.004	0.000	2.857	0.344	0.032	shelf indenting canyon walls
311	0.003	0.000	3.339	0.334	0.032	inter canyon area
312	0.000	0.000	10.599	0.173	0.122	shelf indenting canyon floor
313	0.000	0.000	11.046	0.167	0.120	shelf indenting canyon floor
314	0.001	0.000	4.450	0.194	0.047	inter canyon area
315	0.000	0.000	11.185	0.167	0.120	shelf indenting canyon floor
316	0.000	0.000	8.287	0.177	0.085	inter canyon area
317	0.004	0.000	0.185	0.190	0.042	inter canyon area
318	0.004	0.000	0.188	0.122	0.015	inter canyon area
319	0.004	0.000	4.709	0.214	0.162	inter canyon area
320	0.000	0.000	9.951	0.198	0.078	shelf indenting canyon walls
321	0.003	0.000	1.734	0.061	0.024	inter canyon area
322	0.004	0.000	0.269	0.326	0.024	canyon head–400m walls
323	0.004	0.000	0.269	0.325	0.024	canyon head–400m walls
324	0.001	0.000	2.078	0.164	0.017	canyon head–400m floor
325	0.000	0.000	1.468	0.217	0.019	canyon head–400m walls
326	0.000	0.000	1.538	0.217	0.019	canyon head–400m walls
327	0.001	0.000	0.114	0.120	0.002	iceberg pits
328	0.004	0.003	0.549	0.107	0.085	iceberg pits
329	0.000	0.000	7.655	0.223	0.367	canyon head–400m walls
330	0.001	0.000	0.593	0.338	0.136	shelf indenting canyon floor
331	0.000	0.000	1.232	0.281	0.161	inter canyon area
332	0.000	0.000	1.236	0.133	0.046	inter canyon area
333	0.000	0.000	10.142	0.244	0.254	inter canyon area
334	0.000	0.000	0.161	0.157	0.000	shelf indenting canyon walls
335	0.000	0.000	6.168	0.143	0.183	canyon head–400m walls
336	0.000	0.000	3.894	0.216	0.102	canyon head–400m floor
337	0.000	0.000	1.377	0.274	0.069	canyon head–400m floor
338	0.000	0.000	15.758	0.177	0.283	canyon head–400m floor
339	0.000	0.000	0.705	0.250	0.007	inter canyon area
340	0.000	0.000	1.135	0.305	0.036	inter canyon area
341	0.000	0.000	2.044	0.204	0.022	shelf indenting canyon walls
342	0.000	0.000	1.587	0.250	0.076	shelf indenting canyon floor
343	0.000	0.000	2.755	0.246	0.009	inter canyon area
344	0.000	0.000	5.184	0.230	0.079	canyon head–400m walls

Box core number	VMS records 2003-2012 (5 km radius)	VMS records 2003-2012 (3 km radius)	VMS records 2003-2012 (1 km radius)	VMS density 2003-2012 (5 km radius)	VMS density 2003-2012 (3 km radius)	VMS density 2003-2012 (1 km radius)
259	18	9	0	0.23	0.31	0.00
260	18	8	0	0.23	0.28	0.00
261	21	5	2	0.27	0.16	0.62
262	21	5	2	0.27	0.17	0.64
263	30	5	0	0.39	0.18	0.08
264	30	5	0	0.39	0.18	0.08
265	571	123	13	7.27	4.35	4.23
266	79	14	0	1.01	0.51	0.00
267	19	7	0	0.24	0.25	0.00
268	42	12	1	0.54	0.42	0.32
269	211	30	3	2.69	1.08	0.95
270	211	30	3	2.69	1.07	0.95
271	238	48	1	3.04	1.68	0.64
272	15	9	0	0.19	0.32	0.00
273	24	8	0	0.30	0.28	0.00
274	1441	365	9	18.34	12.92	2.86
275	2371	1037	111	30.18	36.62	34.96
276	506	205	2	11.52	7.18	0.89
277	1117	311	11	14.22	10.96	3.52
278	20	8	0	0.25	0.28	0.00
279	31	11	1	0.27	0.39	0.32
280	305	99	11	3.89	3.36	3.53
281	200	27	12	2.56	1.70	3.82
282	382	112	11	4.87	4.00	3.50
283	28	8	1	0.36	0.28	0.32
284	26	10	0	0.33	0.33	0.00
285	28	4	0	0.36	0.14	0.00
286	132	34	1	1.68	0.87	0.40
287	497	175	16	6.31	6.28	8.28
288	31	7	1	0.39	0.25	0.38
289	418	175	38	5.31	6.21	12.10
290	551	292	53	6.79	10.30	17.02
291	532	292	53	6.78	10.31	17.21
292	28	12	1	0.36	0.42	0.44
293	33	14	1	0.42	0.50	0.32
294	71	13	4	0.91	0.46	1.27
295	273	85	7	3.47	3.00	2.23
296	383	150	0	4.86	5.32	0.13
297	42	8	1	0.54	0.29	0.27
298	677	218	29	8.57	7.47	9.23
299	18	8	1	0.24	0.28	0.32
300	534	158	27	6.70	5.86	8.39
301	51	4	0	0.65	0.14	0.00
302	17	6	2	0.21	0.21	0.64
303	12	5	1	0.15	0.18	0.32
304	977	335	35	12.40	12.20	11.40
305	245	68	6	3.13	2.39	1.96
306	518	107	3	6.59	3.77	0.95
307	99	40	2	1.26	1.41	0.64
308	205	18	4	2.60	0.65	1.27
309	269	60	0	3.34	2.12	0.00
310	552	217	43	7.01	7.94	14.59
311	51	19	2	0.65	0.67	0.61
312	5	1	0	0.06	0.04	0.00
313	6	1	1	0.08	0.04	0.32
314	14	4	1	0.18	0.14	0.32
315	5	1	0	0.06	0.04	0.00
316	6	1	0	0.08	0.04	0.00
317	153	65	15	2.00	2.29	4.71
318	537	255	11	6.81	8.64	3.69
319	99	21	0	1.26	0.73	0.00
320	3	0	0	0.04	0.00	0.00
321	113	26	3	1.44	0.96	0.95
322	132	56	10	1.68	1.98	2.93
323	132	56	10	1.68	1.98	2.92
324	10	3	0	0.11	0.11	0.00
325	19	8	1	0.24	0.28	0.37
326	19	8	1	0.24	0.28	0.48
327	339	131	14	4.33	4.58	4.47
328	74	16	0	0.93	0.57	0.00
329	8	2	0	0.10	0.07	0.00
330	245	75	3	3.11	2.64	0.95
331	13	11	0	0.28	0.38	0.13
332	6	1	0	0.08	0.04	0.00
333	23	8	0	0.36	0.28	0.00
334	300	94	3	3.80	3.34	0.98
335	16	6	1	0.20	0.21	0.32
336	319	134	15	4.07	4.76	4.77
337	177	60	1	2.25	2.13	0.32
338	4	2	0	0.05	0.07	0.00
339	192	47	2	2.45	1.67	0.64
340	76	29	2	0.97	1.04	0.64
341	309	74	22	3.93	2.60	7.00
342	312	46	3	4.10	1.61	0.82
343	295	54	0	3.76	1.91	0.02
344	3	2	0	0.04	0.07	0.00

Box core number	Trawl length/ km^2 2008-2012 [5 km radius]	Trawl length/ km^2 2008-2012 [3 km radius]	Trawl length/ km^2 2008-2012 [1 km radius]	Roughness 3x3 cell window	Standard deviation of bathymetry 3x3 cell window	Rugosity 5x5 cell window
259	0.00	0.00	0.00	4.03	1.21	0.0000107
260	0.00	0.00	0.00	5.03	1.61	0.0000085
261	0.00	0.00	0.00	3.61	1.32	0.0000365
262	0.00	0.00	0.00	3.61	1.32	0.0000365
263	0.00	0.00	0.00	3.67	1.06	0.0000045
264	0.00	0.00	0.00	3.67	1.06	0.0000045
265	5.82	4.96	2.44	42.36	13.31	0.0016134
266	0.21	0.13	0.00	42.12	12.73	0.0003400
267	0.00	0.00	0.00	29.16	8.45	0.0000659
268	0.19	0.13	0.00	8.81	2.98	0.0032343
269	1.45	0.38	0.00	29.61	8.69	0.0009533
270	1.45	0.38	0.00	29.61	8.69	0.0009533
271	1.71	0.56	0.00	8.69	2.61	0.0010104
272	0.00	0.00	0.00	11.43	4.40	0.0000744
273	0.00	0.00	0.00	16.30	4.96	0.0001134
274	61.09	61.33	16.08	13.75	3.28	0.0001747
275	106.62	141.47	133.32	16.73	3.36	0.0001185
276	19.97	2.34	0.34	20.86	6.49	0.0001935
277	34.85	26.45	31.18	9.06	2.71	0.0000960
278	0.00	0.00	0.00	22.31	8.60	0.0000038
279	0.00	0.00	0.00	12.29	4.29	0.0002156
280	1.18	0.38	0.00	28.84	9.28	0.0016062
281	0.55	0.08	0.00	19.72	6.53	0.0009218
282	3.70	2.38	0.00	72.93	21.51	0.0004809
283	0.00	0.00	0.00	20.50	7.01	0.0000985
284	0.00	0.00	0.00	25.62	7.78	0.0001959
285	0.00	0.00	0.00	18.99	6.64	0.0001234
286	1.97	0.33	0.00	31.96	10.36	0.0026979
287	7.75	7.33	4.28	13.57	5.16	0.0000411
288	0.00	0.00	0.00	16.78	6.21	0.0007060
289	7.19	7.44	7.68	23.86	6.95	0.0023082
290	8.58	12.59	19.66	21.78	8.37	0.0000696
291	8.58	12.60	19.96	21.78	8.37	0.0000696
292	0.00	0.00	0.00	11.77	3.81	0.0001709
293	0.12	0.18	0.00	20.03	6.00	0.0010178
294	0.02	0.00	0.00	39.88	11.55	0.0004056
295	2.30	1.35	0.00	23.06	7.29	0.0029909
296	2.58	2.05	1.66	29.15	8.55	0.0027142
297	0.10	0.00	0.00	15.45	5.73	0.0003044
298	13.90	10.75	7.09	16.56	4.98	0.0000153
299	0.28	0.32	0.00	16.51	5.02	0.0014729
300	8.50	6.84	7.33	5.18	1.72	0.0011548
301	0.76	0.00	0.00	5.54	1.79	0.0003144
302	0.00	0.00	0.00	22.88	8.22	0.0000471
303	0.00	0.00	0.00	34.77	11.58	0.0048808
304	34.08	34.29	43.00	12.32	4.00	0.0034973
305	2.33	2.91	3.69	10.28	6.35	0.0059702
306	4.54	2.09	0.00	22.95	7.81	0.0075959
307	2.39	1.07	0.00	5.54	2.07	0.0001172
308	6.16	0.21	0.51	28.69	8.76	0.0002201
309	4.87	3.52	0.91	6.98	2.18	0.0004033
310	6.18	5.18	2.91	13.61	4.05	0.0016169
311	0.83	0.29	0.00	15.23	5.01	0.0007528
312	0.00	0.00	0.00	3.59	1.17	0.0007557
313	0.00	0.00	0.00	8.59	2.59	0.0011047
314	0.00	0.00	0.00	2.62	0.77	0.0000076
315	0.00	0.00	0.00	16.84	4.97	0.0013335
316	0.00	0.00	0.00	4.95	1.62	0.0000281
317	2.57	3.88	5.88	5.34	1.54	0.0000014
318	8.03	9.46	5.49	5.05	1.60	0.0001351
319	0.87	0.41	0.38	12.90	4.48	0.0000613
320	0.00	0.00	0.00	45.09	15.11	0.0001771
321	0.44	0.20	0.00	4.10	1.31	0.0001199
322	1.30	1.83	3.81	11.32	3.52	0.0005078
323	1.30	1.83	3.81	11.32	3.52	0.0005078
324	0.24	0.38	0.00	3.08	0.96	0.0000376
325	0.12	0.18	0.00	16.80	5.97	0.0000327
326	0.12	0.19	0.00	17.18	6.17	0.0000319
327	5.10	3.97	0.45	21.75	7.00	0.0000439
328	0.54	0.14	0.00	5.03	1.53	0.0000823
329	0.06	0.00	0.00	12.93	6.67	0.0002128
330	1.25	0.96	0.63	12.41	4.58	0.0018841
331	0.12	0.49	0.00	18.13	7.05	0.0002103
332	0.12	0.17	0.00	8.21	3.01	0.0001644
333	0.09	0.00	0.00	34.11	11.53	0.0006992
334	3.35	2.63	3.07	28.10	8.19	0.0001189
335	0.13	0.20	0.15	14.04	9.03	0.0006896
336	5.12	2.47	0.00	31.44	11.19	0.0011300
337	0.48	0.24	0.61	16.17	5.34	0.0028377
338	0.00	0.00	0.00	25.05	7.35	0.0021331
339	2.36	1.03	0.32	32.01	9.25	0.0000480
340	1.74	1.30	0.00	22.73	7.70	0.0004133
341	5.79	1.68	0.65	8.90	2.89	0.0002275
342	9.65	3.29	0.43	45.80	13.49	0.0026527
343	14.97	6.57	0.64	23.51	6.92	0.0002403
344	0.00	0.00	0.00	16.88	4.93	0.0000102

Box core number	Rugosity 25x25 cell window	BPI 25 cell radius	BPI 50 cell radius	BPI 75 cell radius	BPI 100 cell radius	BPI 125 cell radius	BPI 150 cell radius	Slope	Radial aspect from -1 west to 1 east	Radial aspect from -1 south to 1 north
259	0.0000939	-3.27	4.34	13.69	19.84	44.05	61.68	1.13	0.473	-0.881
260	0.0001621	-5.97	-9.19	-11.30	-2.45	18.64	47.98	1.51	-0.331	-0.944
261	0.0001594	12.50	15.70	16.96	15.49	12.12	7.95	1.24	0.124	-0.992
262	0.0001594	12.50	15.70	16.96	15.49	12.12	7.95	1.24	0.124	-0.992
263	0.0000814	-7.02	-7.77	-12.46	-17.50	-20.05	-17.28	0.99	0.642	-0.766
264	0.0000814	-7.02	-7.77	-12.46	-17.50	-20.05	-17.28	0.99	0.642	-0.766
265	0.0070745	108.21	99.20	75.83	63.88	91.36	124.93	12.24	-0.929	-0.369
266	0.0068377	65.81	127.44	161.05	207.23	260.42	306.63	11.74	-0.882	-0.472
267	0.0008091	-14.31	-61.43	-119.71	-137.49	-154.67	-184.30	7.85	-0.776	-0.630
268	0.0096095	-100.12	-148.05	-170.00	-185.63	-195.89	-191.82	2.41	0.817	-0.577
269	0.0125620	-147.87	-250.45	-297.41	-323.33	-334.48	-325.45	8.04	0.598	0.802
270	0.0125620	-147.87	-250.45	-297.41	-323.33	-334.48	-325.45	8.04	0.598	0.802
271	0.0207813	-155.51	-273.39	-324.55	-350.08	-358.63	-348.73	2.34	0.903	0.429
272	0.0018019	55.16	131.77	138.14	151.35	155.30	158.48	4.11	1.000	-0.037
273	0.0033265	46.45	103.18	126.05	110.73	117.09	119.67	4.63	-0.465	-0.885
274	0.0016127	61.42	194.98	314.95	374.67	400.26	412.30	4.92	0.999	0.048
275	0.0008466	13.30	-17.07	-25.82	-4.63	16.32	41.40	4.59	0.942	-0.335
276	0.0005580	28.64	85.46	89.03	60.59	17.65	12.19	5.77	0.848	-0.538
277	0.0009285	5.98	16.30	31.74	57.62	87.62	109.17	1.33	0.886	-0.500
278	0.0008945	21.34	47.86	71.44	72.38	83.62	89.07	8.00	0.998	-0.061
279	0.0016390	-3.65	-17.47	-36.85	-44.19	-41.79	-34.18	8.99	0.990	0.200
280	0.0059888	-112.71	-223.54	-281.89	-342.95	-357.66	-358.46	8.38	0.944	0.330
281	0.0179710	-141.41	-248.14	-287.13	-317.26	-298.43	-240.04	8.06	0.961	0.275
282	0.0112203	-36.16	-119.11	-97.85	-36.44	31.61	101.68	1.38	0.345	0.838
283	0.0004857	-14.97	48.74	97.48	98.94	33.78	-34.10	6.53	0.975	-0.211
284	0.0013884	13.09	110.10	183.35	216.15	266.30	316.77	7.24	0.460	0.888
285	0.0010642	27.17	24.59	36.70	40.23	9.84	-38.31	6.19	0.983	0.184
286	0.0183175	-109.37	-67.52	-60.48	-58.66	-37.35	-113.29	9.53	0.328	0.945
287	0.0005905	34.15	51.41	116.77	153.60	226.09	298.16	4.82	0.994	0.114
288	0.0189853	132.84	118.84	11.08	-79.40	-181.96	-282.99	5.77	0.997	-0.074
289	0.0144824	93.87	78.35	66.04	70.97	137.01	222.21	6.41	0.690	0.724
290	0.0011681	-12.78	-33.83	-36.18	7.02	93.18	190.31	7.80	0.997	0.079
291	0.0011681	-12.78	-33.83	-36.18	7.02	93.18	190.31	7.80	0.997	0.079
292	0.0015421	-42.11	-68.55	-63.30	-32.99	-45.66	-75.51	3.36	0.949	-0.314
293	0.0033833	-72.80	-61.62	-78.21	-92.13	-103.19	-133.41	5.57	0.857	0.515
294	0.0041969	39.73	-22.51	-60.55	-105.95	-155.40	-137.96	10.68	0.790	0.613
295	0.0434569	-211.27	-354.00	-356.39	-369.38	-259.54	-200.23	6.63	0.393	0.930
296	0.0185143	163.36	164.18	165.55	245.01	329.42	395.13	7.90	0.774	0.633
297	0.0019861	30.07	92.42	89.18	157.54	185.43	190.88	5.34	0.994	0.111
298	0.0007426	40.18	151.91	260.16	387.73	519.18	619.02	4.65	0.878	-0.478
299	0.0219900	-158.74	-297.77	-340.50	-336.13	-339.93	-375.93	4.59	0.849	0.528
300	0.0475024	-217.45	-396.37	-453.46	-442.37	-421.11	-381.25	1.49	0.898	-0.440
301	0.0015985	0.90	-186.24	-305.90	-360.16	-364.72	-358.93	1.65	0.943	-0.334
302	0.0014711	32.26	-12.46	-72.86	-126.50	-147.88	-170.81	7.64	0.187	0.991
303	0.0218946	152.76	151.02	101.37	34.83	-21.82	-61.94	11.53	0.145	-0.989
304	0.0134067	-137.76	-167.79	-131.13	-5.53	121.26	205.99	3.34	0.983	0.185
305	0.0458783	-245.05	-457.92	-568.18	-563.88	-567.80	-527.61	5.55	-0.214	-0.977
306	0.0407966	240.69	364.47	351.63	360.78	172.89	138.16	7.01	-0.998	0.066
307	0.0015933	91.83	111.83	151.93	174.36	183.95	164.85	1.92	0.096	-0.995
308	0.0033330	29.99	111.80	119.67	97.78	97.98	128.84	8.12	0.360	-0.933
309	0.0015911	-29.11	-36.99	-33.52	-30.36	-32.97	-115.89	1.00	0.952	0.306
310	0.0081723	-112.47	-279.39	-377.24	-404.11	-384.38	-353.43	3.86	0.807	-0.960
311	0.0131423	98.50	151.78	183.88	189.19	179.30	170.67	4.86	0.593	0.304
312	0.0815055	-168.47	-275.53	-312.19	-325.94	-317.68	-382.29	0.89	0.819	0.574
313	0.0287513	-166.98	-270.39	-308.58	-318.77	-311.89	-380.51	3.30	0.881	-0.556
314	0.0010359	-33.14	-36.94	-11.82	-0.31	5.23	31.23	0.72	0.819	0.574
315	0.0293509	-164.68	-270.39	-307.64	-320.55	-312.10	-327.95	4.55	0.812	-0.583
316	0.0096287	1.16	-19.67	13.25	91.74	150.34	177.83	1.52	0.308	0.952
317	0.0002304	-11.45	-16.67	9.80	53.83	109.65	143.42	1.44	0.688	-0.728
318	0.0013790	4.51	102.93	169.28	199.24	230.85	231.02	1.49	0.375	-0.927
319	0.0009814	-4.03	25.11	79.54	94.12	77.07	57.76	4.18	-0.196	-0.981
320	0.0043431	-25.19	-164.54	-218.30	-261.96	-295.48	-324.48	13.86	0.968	0.251
321	0.0000000	58.80	189.30	353.30	396.84	396.76	391.95	1.21	0.940	-0.341
322	0.0077191	-58.48	-51.38	-48.43	-2.97	68.93	123.40	3.29	-0.430	-0.909
323	0.0077191	-58.48	-51.38	-48.43	-2.97	68.93	123.40	3.29	-0.430	-0.909
324	0.0030722	-57.63	-143.26	-191.51	-214.72	-217.10	-198.25	0.88	-0.431	-0.909
325	0.0008703	-18.15	-45.64	-44.05	-43.88	23.00	61.20	5.57	-0.164	-0.986
326	0.0009421	-17.94	-44.12	-42.16	-41.30	-66.84	-57.14	5.76	-0.148	-0.989
327	0.0025102	35.33	103.38	204.76	306.05	410.36	506.09	6.53	0.945	-0.327
328	0.0026295	45.66	131.18	168.87	204.49	278.74	333.62	1.42	0.440	-0.898
329	0.0016451	-14.50	-30.91	-48.01	-89.65	-103.87	-156.57	6.21	0.614	-0.789
330	0.0194387	-25.20	64.43	148.51	179.64	207.35	239.11	7.91	0.061	-0.998
331	0.0016751	5.75	78.64	88.48	69.23	73.60	115.76	6.56	0.026	-1.000
332	0.0004796	27.22	43.26	44.46	23.00	11.60	-13.54	2.79	-0.131	-0.991
333	0.0045543	77.11	38.49	34.74	-85.04	-86.84	-51.83	10.64	0.140	-0.971
334	0.0043431	-25.19	-164.54	-218.30	-261.96	-295.48	-324.48	13.86	0.968	0.251
335	0.0037932	-21.02	-131.18	-168.87	-204.49	-278.74	-333.62	1.42	0.440	-0.898
336	0.0112236	-99.32	-207.06	-250.61	-259.80	-280.77	-330.76	10.32	-0.208	-0.978
337	0.0218010	-96.98	-214.07	-214.30	-38.67	-34.83	35.11	4.88	0.125	-0.992
338	0.0023227	-72.48	-39.12	-49.41	-39.53	-118.20	-164.05	6.78	0.701	-0.713
339	0.0008007	-3.69	12.16	38.76	219.26	329.05	411.99	8.38	0.748	-0.664
340	0.0037280	-13.39	6.55	8.26	61.09	126.67	181.40	7.15	-0.137	-0.971
341	0.0122774	-34.86	-279.98	-354.54	-469.57	-471.32	-460.09	2.63	0.391	-0.957
342	0.0314143	-99.16	-356.36	-398.93	-391.01	-303.39	-250.64	1234	0.562	-0.827
343	0.0037871	60.00	97.44	116.40	144.93	151.19	149.47	6.44	-0.823	-0.568
344	0.0030758	-17.82	-107.82	-132.82	-143.26	-177.58	-193.25	4.60	-0.770	-0.638

Box core number	Successful collection?	Latitude	Longitude	Multibeam bathymetry	Collection year	Collection month	Crew number	Seafloor temperature 2008/°C	Seafloor temperature 2009/°C	Seafloor temperature 2010/°C
345	Y	42.745	-50.444	1920.1	2010	August	6	3.49	3.56	3.44
346	Y	42.809	-50.684	1323.2	2010	August	6	3.59	3.63	3.49
347	Y	42.899	-50.648	1339.2	2010	August	6	3.62	3.65	3.61
348	Y	42.687	-50.954	1474.7	2010	August	6	3.46	3.51	3.45
349	N	42.638	-50.728	1866.3	2010	August	6	3.54	3.59	3.55
350	Y	42.638	-50.728	1866.3	2010	August	6	3.54	3.59	3.55
351	Y	42.781	-50.804	1269.7	2010	August	6	3.62	3.67	3.58
352	Y	42.820	-50.991	1407.2	2010	August	6	3.58	3.65	3.55
353	Y	42.891	-51.028	1483.8	2010	August	6	3.55	3.65	3.48
354	Y	43.822	-51.130	1983.5	2010	August	6	3.49	3.57	3.45
355	N	42.969	-50.836	778.5	2010	August	6	3.89	3.96	3.88
356	Y	42.969	-50.836	778.5	2010	August	6	3.89	3.96	3.88
357	Y	42.974	-51.001	1004.8	2010	August	6	4.02	4.01	3.89
358	Y	42.804	-50.635	1616.5	2010	August	6	3.47	3.51	3.48
359	N	42.805	-50.360	1774.5	2010	August	6	3.34	3.40	3.34
360	N	42.805	-50.360	1774.5	2010	August	6	3.34	3.40	3.34
361	Y	42.598	-50.178	1988.6	2010	August	6	3.28	3.31	3.29
362	Y	42.710	-50.133	1130.9	2010	August	6	3.55	3.57	3.54
363	Y	42.659	-50.121	1674.1	2010	August	6	3.38	3.42	3.39
364	Y	43.605	-50.359	1774.5	2010	August	6	3.34	3.40	3.34
365	Y	43.672	-50.040	1598.5	2010	August	6	3.38	3.41	3.39
366	Y	42.717	-49.991	1614.0	2010	August	6	3.48	3.44	3.48
367	Y	42.731	-49.866	1638.3	2010	August	6	3.35	3.37	3.37
368	N	42.773	-49.966	1001.1	2010	August	6	3.64	3.62	3.60
369	Y	42.940	-49.568	1183.4	2010	August	6	3.71	3.68	3.72
370	Y	42.835	-49.409	1633.4	2010	August	6	3.47	3.47	3.49
371	Y	43.005	-48.935	1966.9	2010	August	6	3.22	3.22	3.24

Box core number	Seafloor temperature average for collection year/°C	Seafloor temperature average for collection and previous year/°C	Seafloor temperature 10 year minimum/°C	Seafloor temperature 10 year mean/°C	Seafloor salinity 2008/ppt	Seafloor salinity 2009/ppt
345	3.44	3.50	3.73	4.14	34.48	34.48
346	3.49	3.58	3.76	4.30	34.46	34.47
347	3.61	3.63	3.63	4.05	34.64	34.64
348	3.45	3.49	3.55	3.90	34.58	34.58
349	3.55	3.57	3.55	3.91	34.67	34.67
350	3.55	3.57	3.55	3.91	34.67	34.67
351	3.58	3.61	3.68	4.14	34.56	34.56
352	3.55	3.60	3.61	4.02	34.56	34.57
353	3.48	3.57	3.65	4.05	34.47	34.48
354	3.45	3.51	3.58	3.93	34.51	34.52
355	3.48	3.62	3.73	4.39	34.52	34.53
356	3.48	3.62	3.74	4.39	34.52	34.53
357	3.39	3.55	3.76	4.28	34.68	34.68
358	3.48	3.50	3.52	3.84	34.64	34.64
359	3.34	3.37	3.50	3.80	34.57	34.57
360	3.34	3.37	3.50	3.80	34.57	34.57
361	3.29	3.31	3.47	3.73	34.56	34.57
362	3.54	3.55	3.67	4.13	34.60	34.60
363	3.39	3.41	3.56	3.92	34.58	34.58
364	3.34	3.37	3.50	3.80	34.57	34.57
365	3.39	3.40	3.56	3.93	34.57	34.57
366	3.43	3.44	3.64	4.06	34.57	34.56
367	3.37	3.37	3.60	3.99	34.54	34.55
368	3.60	3.61	3.73	4.36	34.60	34.59
369	3.72	3.70	3.68	4.14	34.69	34.68
370	3.49	3.48	3.48	3.79	34.71	34.71
371	3.34	3.23	3.43	3.69	34.66	34.66

Box core number	Seafloor salinity 2010/ppt	Seafloor salinity average for collection year/ppt	Seafloor salinity average for collection and previous year/ppt	Seafloor zonal velocity 2008 m/s	Seafloor zonal velocity 2009 m/s	Seafloor zonal velocity 2010 m/s
345	34.53	34.59	34.50	-0.0262	-0.0182	-0.2578
346	34.51	34.51	34.49	-0.0203	-0.0121	-0.2562
347	34.67	34.67	34.65	-0.0452	-0.0280	-0.3205
348	34.62	34.62	34.60	-0.0436	-0.0303	-0.2770
349	34.69	34.69	34.68	-0.0673	-0.0447	-0.2268
350	34.69	34.69	34.68	-0.0673	-0.0447	-0.2268
351	34.60	34.60	34.58	-0.0232	-0.0138	-0.2853
352	34.60	34.60	34.58	-0.0238	-0.0153	-0.3446
353	34.52	34.52	34.50	-0.0181	-0.0109	-0.3118
354	34.56	34.56	34.54	-0.0264	-0.0170	-0.3345
355	34.55	34.55	34.54	-0.0116	-0.0025	-0.4793
356	34.55	34.55	34.54	-0.0116	-0.0025	-0.4793
357	34.69	34.69	34.69	-0.0076	-0.0040	-0.2721
358	34.67	34.67	34.65	-0.0649	-0.0443	-0.3352
359	34.61	34.61	34.59	-0.0532	-0.0399	-0.2281
360	34.61	34.61	34.59	-0.0532	-0.0399	-0.2281
361	34.61	34.61	34.59	-0.0484	-0.0391	-0.2395
362	34.64	34.64	34.62	-0.0497	-0.0362	-0.2125
363	34.63	34.62	34.60	-0.0538	-0.0440	-0.2336
364	34.61	34.61	34.59	-0.0532	-0.0399	-0.2281
365	34.62	34.62	34.60	-0.0487	-0.0419	-0.2452
366	34.61	34.61	34.59	-0.0332	-0.0257	-0.3878
367	34.60	34.60	34.57	-0.0258	-0.0236	-0.3326
368	34.64	34.64	34.61	-0.0289	-0.0249	-0.4630
369	34.71	34.71	34.70	-0.0223	-0.0192	-0.4092
370	34.74	34.74	34.73	-0.0590	-0.0599	-0.2097
371	34.69	34.69	34.68	-0.0172	-0.0167	-0.2262

Box core number	Seafloor zonal velocity average for collection year m/s	Seafloor zonal velocity average for collection and previous year m/s	Seafloor meridional velocity 2008 m/s	Seafloor meridional velocity 2009 m/s	Seafloor meridional velocity 2010 m/s
345	-0.2978	-0.1560	-0.0078	-0.0077	-0.1487
346	-0.2562	-0.1341	-0.0037	-0.0049	-0.0399
347	-0.3205	-0.1743	-0.0009	-0.0032	0.2239
348	-0.2770	-0.1536	0.0069	0.0028	0.1619
349	-0.2268	-0.1358	0.0011	-0.0019	0.3090
350	-0.2268	-0.1358	0.0011	-0.0019	0.3090
351	-0.2853	-0.1496	-0.0010	-0.0023	0.0661
352	-0.3446	-0.1800	0.0075	0.0021	0.1888
353	-0.3118	-0.1613	0.0004	-0.0012	0.1777
354	-0.3545	-0.1858	0.0030	0.0011	0.1501
355	-0.4793	-0.2409	-0.0010	-0.0051	0.1948
356	-0.4793	-0.2409	-0.0010	-0.0051	0.1948
357	-0.2721	-0.1381	0.0005	-0.0001	0.1344
358	-0.2352	-0.1398	-0.0054	-0.0063	-0.0570
359	-0.2281	-0.1340	-0.0133	-0.0129	-0.1859
360	-0.2281	-0.1340	-0.0133	-0.0129	-0.1859
361	-0.2395	-0.1393	-0.0203	-0.0191	-0.2807
362	-0.2125	-0.1253	-0.0196	-0.0191	-0.3428
363	-0.2236	-0.1338	-0.0111	-0.0205	-0.3204
364	-0.2281	-0.1340	-0.0133	-0.0129	-0.1859
365	-0.2452	-0.1435	-0.0237	-0.0223	-0.3220
366	-0.3673	-0.2067	-0.0289	-0.0270	-0.4351
367	-0.3326	-0.1781	-0.0292	-0.0276	-0.4229
368	-0.4630	-0.2440	-0.0290	-0.0259	-0.4654
369	-0.4092	-0.2142	-0.0282	-0.0245	-0.4612
370	-0.2097	-0.1348	-0.0397	-0.0389	-0.2589
371	-0.2262	-0.1215	-0.0600	-0.0564	-0.2964

Box core number	Seafloor meridional velocity average for collection year m/s	Seafloor meridional velocity average for collection and previous year m/s	Seafloor absolute speed 2008 m/s	Seafloor absolute speed 2009 m/s	Seafloor absolute speed 2010 m/s
345	-0.1667	-0.0872	0.0273	0.0158	0.3412
346	-0.0399	-0.0224	0.0206	0.0130	0.1593
347	0.2239	0.1103	0.0452	0.0282	0.2666
348	0.1619	0.0824	0.0441	0.0304	0.3208
349	0.3090	0.1536	0.0673	0.0448	0.3833
350	0.3090	0.1536	0.0673	0.0448	0.3833
351	0.0461	0.0319	0.0232	0.0140	0.2929
352	0.1888	0.0954	0.0268	0.0154	0.3929
353	0.1777	0.0882	0.0181	0.0110	0.3588
354	0.1502	0.0737	0.0245	0.0170	0.3350
355	0.1548	0.0949	0.0116	0.0057	0.5173
356	0.1548	0.0949	0.0116	0.0057	0.5173
357	0.1344	0.0671	0.0076	0.0040	0.3035
358	-0.0070	-0.0316	0.0632	0.0448	0.1420
359	-0.1839	-0.0994	0.0548	0.0420	0.1542
360	-0.1839	-0.0994	0.0548	0.0420	0.1542
361	-0.2807	-0.1500	0.0525	0.0436	0.1690
362	-0.3428	-0.1809	0.0534	0.0427	0.4033
363	-0.3104	-0.1705	0.0573	0.0486	0.3907
364	-0.1839	-0.0994	0.0548	0.0420	0.1542
365	-0.3320	-0.1874	0.0542	0.0477	0.4250
366	-0.4351	-0.2311	0.0440	0.0401	0.5828
367	-0.4329	-0.2253	0.0390	0.0363	0.5380
368	-0.4854	-0.2556	0.0409	0.0359	0.6708
369	-0.4612	-0.2418	0.0360	0.0311	0.6165
370	-0.2389	-0.1484	0.0711	0.0719	0.3332
371	-0.2964	-0.1764	0.0624	0.0589	0.3728

Box core number	Seafloor absolute speed average for collection year m/s	Seafloor absolute speed average for collection and previous year m/s	10 year max seafloor absolute speed m/s	10 year average seafloor absolute speed m/s	MODIS surface Chlora a 2008 mg/m^3
345	0.3412	0.1805	0.0990	0.0504	0.699
346	0.2593	0.1362	0.0685	0.0175	0.771
347	0.2666	0.2374	0.1469	0.0492	0.661
348	0.3208	0.1756	0.1469	0.0514	0.688
349	0.3833	0.2141	0.1859	0.0721	0.688
350	0.3833	0.2141	0.1859	0.0721	0.688
351	0.2929	0.1535	0.0793	0.0229	0.747
352	0.3929	0.2042	0.0949	0.0247	0.704
353	0.3588	0.1849	0.0513	0.0147	0.679
354	0.3850	0.2040	0.0882	0.0274	0.651
355	0.3173	0.2615	0.0541	0.0101	0.749
356	0.3173	0.2615	0.0539	0.0101	0.749
357	0.3035	0.1537	0.0299	0.0075	0.715
358	0.3420	0.1434	0.1048	0.0843	0.667
359	0.1942	0.1681	0.1811	0.0848	0.643
360	0.1942	0.1681	0.1811	0.0848	0.643
361	0.3690	0.2063	0.1885	0.0934	0.686
362	0.4033	0.2230	0.1813	0.0840	0.713
363	0.3907	0.2196	0.1679	0.0972	0.713
364	0.1942	0.1681	0.1811	0.0848	0.643
365	0.4250	0.2383	0.1789	0.0984	0.725
366	0.3828	0.3115	0.1580	0.0730	0.732
367	0.5380	0.2872	0.1413	0.0690	0.733
368	0.6708	0.3394	0.1428	0.0607	0.745
369	0.6165	0.3238	0.0948	0.0417	0.702
370	0.3332	0.2025	0.1696	0.0873	0.731
371	0.3728	0.2159	0.1719	0.0735	0.742

Box core number	MODIS surface Chloro a 2009 mg/m³	MODIS surface Chloro a 2010 mg/m³	MODIS surface Chloro a average for collection year mg/m³	MODIS surface Chloro a average for collection and previous year mg/m³	MODIS surface POC 2008 mg/m³
345	0.866	1.089	1.089	0.977	131.29
346	0.938	0.992	0.992	0.965	133.92
347	0.878	0.881	0.881	0.880	125.59
348	1.177	0.910	0.910	1.043	129.88
349	0.824	0.912	0.912	0.868	128.72
350	0.824	0.912	0.912	0.868	128.72
351	0.922	0.948	0.948	0.935	133.69
352	1.014	0.925	0.925	0.969	131.00
353	0.933	1.015	1.015	0.969	128.75
354	0.804	0.960	0.960	0.882	126.55
355	0.941	1.046	1.046	0.994	138.39
356	0.941	1.046	1.046	0.994	138.39
357	1.595	1.142	1.142	1.368	135.19
358	0.770	0.909	0.909	0.840	126.02
359	0.713	1.592	1.592	1.152	122.94
360	0.713	1.592	1.592	1.152	122.94
361	0.718	1.090	1.090	0.904	131.94
362	0.712	1.106	1.106	0.909	135.37
363	0.715	1.110	1.110	0.912	137.19
364	0.713	1.592	1.592	1.152	122.94
365	0.708	0.997	0.997	0.853	138.00
366	0.718	0.942	0.942	0.830	139.31
367	0.677	0.891	0.891	0.784	138.76
368	0.742	0.912	0.912	0.827	143.21
369	0.772	0.853	0.853	0.812	136.50
370	0.756	0.845	0.845	0.800	163.45
371	0.804	0.806	0.806	0.805	106.07

Box core number	MODIS surface POC 2009 mg/m³	MODIS surface POC 2010 mg/m³	MODIS surface POC average for collection year mg/m³	MODIS surface POC average for collection and previous year mg/m³	Lutz et al. 2002 NE Atlantic uncorrected POC at depth mg/m³
345	141.05	194.19	167.62	170.12	0.113
346	143.48	158.30	150.89	170.89	0.014
347	136.72	168.79	152.75	152.75	0.008
348	145.75	177.62	161.68	161.68	0.005
349	132.55	168.29	150.42	150.42	0.005
350	132.55	168.29	150.42	150.42	0.005
351	142.00	185.93	163.96	163.96	0.011
352	143.93	188.25	166.09	166.09	0.007
353	141.83	187.46	164.65	164.65	0.006
354	135.97	187.41	161.69	161.69	0.005
355	143.85	221.02	182.44	182.44	0.379
356	143.85	221.02	182.44	182.44	0.365
357	163.54	209.10	186.32	186.32	0.065
358	129.90	170.91	150.40	150.40	0.005
359	129.60	148.98	139.29	139.29	0.005
360	129.60	148.98	139.29	139.29	0.005
361	130.62	154.93	142.78	142.78	0.005
362	133.96	166.34	150.15	150.15	0.023
363	129.47	156.37	142.92	142.92	0.005
364	129.60	148.98	139.29	139.29	0.005
365	128.33	153.49	140.91	140.91	0.005
366	129.40	163.06	146.23	146.23	0.005
367	124.03	151.14	137.58	137.58	0.005
368	130.77	161.46	146.12	146.12	0.053
369	140.97	144.28	142.62	142.62	0.016
370	128.01	146.96	137.48	137.48	0.005
371	131.12	141.21	136.17	136.17	0.005

Box core number	Lutz et al. 2002 NE Atlantic radionuclide corrected POC at depth mg/m³	Lutz et al. 2002 Sargasso uncorrected POC at depth mg/m³	Lutz et al. 2002 Sargasso radionuclide corrected POC at depth mg/m³	Sediment total carbon %
345	2.791	2.676	0.027	1.05
346	0.713	0.704	0.007	1.41
347	0.381	0.387	0.006	2.34
348	0.222	0.234	0.006	2.14
349	0.040	0.062	0.006	ns
350	0.040	0.062	0.006	2.62
351	0.557	0.534	0.007	2.45
352	0.307	0.315	0.006	2.04
353	0.217	0.230	0.006	1.62
354	0.027	0.050	0.006	2.90
355	5.889	5.538	0.099	ns
356	5.564	5.416	0.095	1.77
357	2.063	1.006	0.016	2.25
358	0.112	0.130	0.006	2.02
359	0.054	0.075	0.006	ns
360	0.054	0.075	0.006	ns
361	0.024	0.047	0.006	2.10
362	0.947	0.930	0.008	1.01
363	0.094	0.110	0.006	2.51
364	0.054	0.075	0.006	2.43
365	0.148	0.164	0.006	1.89
366	0.110	0.128	0.006	2.78
367	0.093	0.113	0.006	2.67
368	1.646	1.606	0.014	1.06
369	0.712	0.704	0.007	1.65
370	0.095	0.114	0.006	2.48
371	0.025	0.048	0.006	2.51

Box core number	Sediment organic carbon %	Sediment inorganic carbon %	Sediment clay %	Sediment silt %	Sediment sand %	Shannon sediment PSD	Within NaRSO closure as of 28-11-16?	Spicules in box core*	Porifera an density Kenchington et al. 2014 N/km²
345	0.69	0.37	12.00	44.34	43.65	2.13	N	Y	0.047
346	0.98	0.43	9.54	50.95	39.51	2.11	N	Y	0.042
347	1.71	0.63	12.03	58.88	29.29	2.15	N	N	0.006
348	1.37	0.78	16.47	52.99	30.55	2.20	N	Y	0.000
349	ns	ns	ns	ns	ns	ns	N	ns	0.000
350	2.12	0.50	16.54	55.96	27.50	2.24	N	ns	0.000
351	2.24	0.21	16.90	62.45	20.65	2.15	N	ns	0.005
352	0.91	1.13	15.86	51.98	32.16	2.22	N	N	0.001
353	0.96	0.66	13.89	39.75	46.36	2.28	N	N	0.002
354	2.00	0.90	21.52	55.34	23.14	2.29	Y	Y	0.000
355	ns	ns	ns	ns	ns	ns	N	ns	0.010
356	1.47	0.31	9.99	46.90	43.11	2.06	N	Y	0.010
357	1.29	0.96	13.66	55.74	30.60	2.03	N	Y	0.003
358	1.27	0.75	19.03	59.63	27.34	2.23	N	Y	0.000
359	ns	ns	ns	ns	ns	ns	N	ns	0.004
360	ns	ns	ns	ns	ns	ns	N	ns	0.004
361	1.34	0.76	16.30	50.58	33.12	2.22	N	Y	0.000
362	0.66	0.35	10.15	38.67	51.18	2.07	N	Y	0.022
363	2.09	0.41	17.15	54.50	28.35	2.26	N	Y	0.013
364	1.37	0.05	17.04	64.33	18.65	2.10	N	N	0.004
365	1.21	0.68	12.16	50.96	36.88	2.28	N	Y	0.030
366	2.78	0.00	21.22	57.16	21.63	2.18	N	N	0.027
367	2.41	0.26	18.36	36.41	45.23	2.22	N	Y	0.010
368	0.79	0.27	ns	ns	ns	ns	N	ns	0.030
369	1.16	0.48	11.79	50.25	37.96	2.19	N	Y	0.082
370	1.83	0.65	19.19	60.54	20.27	2.17	N	Y	0.000
371	1.54	0.96	16.66	57.73	25.61	2.22	N	Y	0.000

Box core number	Pennatulacean density Kenchington et al. 2014 kg/km²	Gorgonian density Kenchington et al. 2014 kg/km²	Downie porifera relative biomass	Downie pennatulacean relative biomass	Downie gorgonian relative biomass	Geological environment
345	0.000	0.000	7.591	0.371	0.139	canyon head-400m walls
346	0.002	0.000	10.354	0.254	0.252	canyon head-400m floor
347	0.000	0.000	2.985	0.228	0.124	inter canyon area
348	0.000	0.000	4.104	0.187	0.306	inter canyon area
349	0.000	0.000	8.397	0.190	0.237	canyon head-400m floor
350	0.000	0.000	8.632	0.191	0.226	canyon head-400m floor
351	0.002	0.000	1.956	0.233	0.009	inter canyon area
352	0.000	0.000	4.464	0.373	0.104	inter canyon area
353	0.001	0.000	8.466	0.147	0.142	canyon head-400m floor
354	0.000	0.000	4.271	0.481	0.073	canyon head-400m walls
355	0.001	0.000	1.401	0.315	0.073	canyon head-400m floor
356	0.001	0.000	1.288	0.314	0.035	canyon head-400m floor
357	0.001	0.000	0.860	0.266	0.035	canyon head-400m floor
358	0.000	0.000	10.064	0.193	0.172	inter canyon area
359	0.000	0.000	10.221	0.176	0.145	inter canyon area
360	0.000	0.000	10.191	0.176	0.145	inter canyon area
361	0.000	0.000	10.712	0.141	0.150	inter canyon area
362	0.000	0.000	1.983	0.187	0.008	canyon head-400m walls
363	0.000	0.000	11.148	0.208	0.248	canyon head-400m walls
364	0.000	0.000	10.352	0.184	0.126	inter canyon area
365	0.000	0.000	10.362	0.210	0.139	inter canyon area
366	0.000	0.000	3.554	0.206	0.051	canyon head-400m floor
367	0.000	0.000	7.668	0.229	0.128	canyon head-400m floor
368	0.000	0.000	0.738	0.304	0.027	canyon head-400m floor
369	0.001	0.000	7.458	0.266	0.390	inter canyon area
370	0.000	0.000	8.728	0.181	0.214	inter canyon area
371	0.000	0.000	7.278	0.165	0.238	inter canyon area

Box core number	VMS records 2003-2012 (5 km radius)	VMS records 2003-2012 (3 km radius)	VMS records 2003-2012 (1 km radius)	VMS density 2003-2012 (5 km radius)	VMS density 2003-2012 (3 km radius)	VMS density 2003-2012 (1 km radius)
345	73	3	0	0.83	0.11	0.00
346	89	15	1	0.89	0.54	0.32
347	12	5	0	0.15	0.18	0.00
348	6	3	0	0.08	0.11	0.00
349	2	0	0	0.03	0.00	0.00
350	2	0	0	0.03	0.00	0.00
351	101	48	1	1.29	1.70	0.32
352	23	6	2	0.29	0.21	0.64
353	59	16	1	0.75	0.57	0.32
354	9	1	0	0.11	0.04	0.00
355	100	21	2	1.28	0.75	0.64
356	100	21	2	1.30	0.76	0.64
357	174	65	5	2.22	2.30	1.59
358	3	1	0	0.03	0.04	0.00
359	2	1	0	0.03	0.04	0.00
360	2	1	0	0.03	0.04	0.00
361	6	0	0	0.08	0.00	0.00
362	399	197	6	5.10	6.96	1.92
363	51	6	0	0.64	0.21	0.00
364	2	1	0	0.03	0.04	0.00
365	35	9	0	0.67	0.32	0.00
366	327	198	16	4.17	6.94	3.08
367	14	5	0	0.18	0.18	0.00
368	196	42	1	2.50	1.48	0.32
369	25	6	0	0.32	0.21	0.00
370	14	6	0	0.18	0.21	0.00
371	3	2	0	0.04	0.07	0.00

Box core number	Trawl length/ km^2 2008-2012 [5 km radius]	Trawl length/ km^2 2008-2012 [3 km radius]	Trawl length/ km^2 2008-2012 [1 km radius]	Roughness 3x3 cell window	Standard deviation of bathymetry 3x3 cell window	Rugosity 5x5 cell window
345	0.93	0.00	0.00	24.07	7.17	0.0018277
346	0.85	0.06	0.00	13.04	3.87	0.0018423
347	0.00	0.00	0.00	2.18	0.77	0.0000089
348	0.00	0.00	0.00	14.85	5.17	0.0010043
349	0.00	0.00	0.00	7.17	2.02	0.0020291
350	0.00	0.00	0.00	7.17	2.02	0.0020291
351	0.79	1.13	0.19	9.55	1.71	0.0002527
352	0.00	0.00	0.00	8.49	2.83	0.0001643
353	0.00	0.00	0.00	54.60	16.14	0.0054123
354	0.08	0.05	0.00	10.94	4.18	0.0013046
355	0.57	0.20	0.00	14.88	5.19	0.0025151
356	0.57	0.20	0.00	19.10	6.09	0.0019180
357	2.37	2.81	0.64	18.03	5.45	0.0068643
358	0.00	0.00	0.00	10.07	3.12	0.0001380
359	0.00	0.00	0.00	13.58	4.08	0.0000669
360	0.00	0.00	0.00	13.58	4.08	0.0000669
361	0.00	0.00	0.00	17.09	5.83	0.0014049
362	23.96	31.60	21.43	43.39	13.60	0.0002134
363	0.36	0.00	0.00	19.46	5.88	0.0000276
364	0.00	0.00	0.00	13.58	4.08	0.0000669
365	0.14	0.00	0.00	15.18	5.01	0.0010294
366	5.76	4.27	0.02	29.79	10.55	0.0032510
367	0.00	0.00	0.00	16.06	5.24	0.0004058
368	1.21	0.51	0.14	18.82	6.24	0.0114446
369	0.05	0.00	0.00	12.21	4.77	0.0001760
370	0.04	0.00	0.00	4.26	1.50	0.0000227
371	0.00	0.00	0.00	11.82	3.44	0.0000271

Box core number	Rugosity 25x25 cell window	BPI 25 cell radius	BPI 50 cell radius	BPI 75 cell radius	BPI 100 cell radius	BPI 125 cell radius	BPI 150 cell radius	Slope	Radial aspect from -1 west to 1 east	Radial aspect from -1 south to 1 north
345	0.0158557	151.32	137.29	145.75	180.38	127.80	278.64	6.62	-0.843	-0.539
346	0.0303312	-159.13	-254.83	-272.02	-269.37	-233.60	-191.74	3.57	0.676	-0.737
347	0.0003449	-4.81	42.31	92.06	102.01	116.93	119.47	0.72	-0.178	-0.984
348	0.0053217	23.64	111.71	156.46	184.35	198.82	211.45	4.73	-0.042	-0.999
349	0.0073820	-83.73	-133.04	-153.59	-167.08	-172.72	-167.50	1.63	0.339	-0.842
350	0.0073820	-83.73	-133.04	-153.59	-167.08	-172.72	-167.50	1.63	0.339	-0.842
351	0.0016885	-6.78	-30.61	-47.70	-34.13	-37.71	-29.44	1.56	-0.888	-0.459
352	0.0004987	4.44	2.19	11.69	25.16	33.67	39.17	2.61	-0.960	-0.279
353	0.0312128	-70.18	-60.39	-95.89	-127.65	-161.96	-187.93	14.57	-0.801	-0.599
354	0.0130134	-81.25	-141.76	-174.54	-205.68	-235.20	-267.15	3.83	-0.998	0.061
355	0.0058136	-43.44	-56.96	-13.84	36.33	85.90	125.47	4.71	-0.099	-0.995
356	0.0056978	-43.40	-56.80	-14.72	34.71	84.01	127.39	5.63	0.353	-0.936
357	0.0174190	-135.49	-148.81	-111.50	-57.53	-6.36	33.91	4.56	-0.112	-0.994
358	0.0009724	-1.18	47.45	94.93	144.73	168.99	189.47	2.90	-0.411	-0.912
359	0.0020148	47.44	66.01	81.64	109.55	102.90	79.08	3.81	0.489	-0.872
360	0.0020148	47.44	66.01	81.64	109.55	102.90	79.08	3.81	0.489	-0.872
361	0.0131974	133.10	199.25	155.48	76.89	18.36	-45.27	5.39	0.131	-0.973
362	0.0019508	-20.50	-31.69	-29.82	5.93	82.53	175.00	12.53	-0.408	-0.913
363	0.0004857	15.41	38.33	18.38	-2.37	-16.11	-48.51	5.29	0.606	-0.796
364	0.0020148	47.44	66.01	81.64	109.55	102.90	79.08	3.81	0.489	-0.872
365	0.0056074	91.79	135.37	157.28	143.93	104.39	36.64	4.64	-0.299	-0.954
366	0.0119376	-107.35	-202.28	-244.63	-271.28	-284.18	-209.92	9.72	0.169	-0.986
367	0.0019335	-16.89	-12.08	-39.33	-80.24	-66.72	-84.84	4.86	0.952	-0.307
368	0.0306876	-143.16	-173.12	-130.05	-84.23	-44.34	133.02	5.14	0.810	-0.587
369	0.0094073	96.10	218.61	271.53	238.05	190.19	151.70	4.44	0.053	-0.999
370	0.0004560	30.28	79.11	100.28	167.21	206.23	213.29	1.40	0.175	-0.985
371	0.0003325	-13.04	-19.96	-21.41	-21.34	-26.47	-47.97	3.21	0.608	-0.794

Appendix 4

References for peracarid functional trait table

A: Dauvin and Bellan-Santini, (1990).

B: MarLIN BIOTIC trait database, (2006).

C: Thiel, (1998).

D: Aoki and Kikuchi, (1991).

E: Aoki, (1997).

F: Guerra-Garcia et al. (2014).

G: Scipione, (2013).

H: Mattson and Cedhagen, (1989).

I: Thiel, (1999).

J: Harrison, (1940).

K: Laval, (1980).

L: Svavarsson and Davidsdottir, (1995).

M: Legezynska et al. (2012).

N: Dixon and Moore, (1997).

O: Lewis, (1992).

P: Sainte-Marie, (1986).

Q: Oliver et al. (1982).

R: Oakden, (1984).

S: Dauby et al. (2001).

T: Borowsky, (1983).

U: Shillaker and Moore, (1987).

V: Nyssen et al. (2002).

W: Krishnan and John, (1974).

X: Dunbar, (1957).

Y: Bruce, (1986).

Z: Kaim-Malka, (1997).

A1: Soto and Mincarone, (2001).

B1: Svavarsson et al. (1993).

C1: Hessler and Stromberg, (1989).

D1: Poore and Bruce, (2012).

F1: Smit and Davies, (2004).

G1: Menzies, (1962).

H1: Sheader et al. (2000).

I1: Lorz, (2010).

J1: Dahl, (1964).

K1: Ansell, (1969).

L1: Kilgallen, (2010).

M1: Costello and Myers, (1987)

N1: Johansen and Vader, (2015).

O1: Cunha and Wilson, (2003).

P1: Harrison, (1987).

Q1: Wilson, (1976).

R1: George, (2004).

S1: Wurzberg et al. (2011).

T1: Blankenship and Levin, (2007).

U1: Blazewicz-Paszkowycz and Ligowski, (2004).

V1: Cartes et al. (2001).

W1: Sainte-Marie, (1992).

X1: De Broyer et al. (2004).

Y1: Dixon, (1944).

Z1: Bird and Holdich, (1985).

A2: Foxon, (1936).

B2: Hassack and Holdich, (1987).

C2: Gardiner, (1975).

D2: Johnson et al. (2001).

E2: Greve, (1967).

F2: Holdich and Jones, (1983).

G2: Reidenauer and Thistle, (1985).

H2: Thistle et al. (1985).

I2: Holdich and Bird, (1986).

J2: Buhl-Mortensen et al. (2016).

K2: Coleman, (1989).

L2: Barnard and Karaman, (1991a, 1991b).

M2: Coleman, (1998).

N2: Jones, (1948).

O2: Poulin and Hamilton, (1995).

P2: Lincoln, (1979).

Q2: Schultz, (1969).

R2: Frutos et al. (2011).

S2: Larsen, (2007).

T2: Larsen, (2011).

U2: Bird, (2007).

V2: McLelland, (2008).

W2: Guerrero Kommritz, (2004).

X2: Blazewicz-Paszkowycz, (2005).

Y2: Gutu, (1980).

Z2: Muradian-Ciamician, (1980).

A3: Ariyama, (1996).

B3: Kim and Lee, (2010).

C3: Bird and Holdich, (1988).

D3: Stoddart and Lowry, (2012).

E3: Bousfield and Hendrycks, (1997).

F3: White, (2011).

G3: Tandberg et al. (2012).

H3: D'Udekem D'Acoz, (2006).

I3: Bousfield and Hendrycks, (1995).

J3: Just, (2013).

K3: Enequist, (1949).

L3: Sainte-Marie, (1991).

M3: Bousfield, (1982).

N3: Riehl et al. (2016).

O3: Aumack et al. (2016).

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Peracarid functional trait table

Expert opinion colour key:

Dr Tammy Horton (Amphipoda) = Red.

Prof. Angelika Brandt (Isopoda) = Green.

Dr Graham Bird (Tanaidacea) = Blue.

Dr Sarah Gerken (Cumacea) = Yellow.

My conjecture = Orange.

	Maximum adult length						Fragility		
Taxon	Very small (0 to <4.7 mm)	Small (4.7 to <9.5 mm)	Medium (9.5 to <22.2 mm)	Large (22.2 to <45 mm)	Very large (>45 mm)	Fragile	Medium	Robust
Acidostomatidae	0 3^{L1}	2^{L3}		0	0	0	0	5
Amathillopsidae	1	1	$2\ 1^{M2}$		0	0	5	0
Ampeliscidae	0 2^{L3}	2^{L3}	$1^{A,B,S}$		0	0	5^{B}	0
Amphilochidae	4^{D2} 1^{M3}		0	0	0	0	4	1
Aoridae	0 2^{L3}	3^{A3}		0	0	1	4	0
Argissidae	1 $4^{D2,P2}$		0	0	0	1	4	0
Aristiidae	0	$3\ 2^{P2}$		0	0	0	3	2
Calliopiidae	0	$1\ 2^{D2,L3}$		$1\ 1^{L3}$	3	2	0	0
Caprellidae	0	2	$2\ 1^{D2}$		0	0	$0\ 5^{H}$	
Corophiidae	1^{L3} 2^{L3}	1^{L3}	1^{J}		0	2	3	0
Cressidae	2 3^{P2}		0		0	0	4	1
Cyproideidae	3 2^{P2}		0		0	1	4	0
Dexaminidae	1^{P2} 2^{L3}	2^{B}			0	0	$1\ 4^{B}$	0
Dulichiidae	0	$3\ 2^{D2,L3}$			0	0	$4\ 1^{H}$	
Epimeriidae	0	0	$2\ 2^{L3}$	1^{S}	0	0	0	5
Eusiridae	0	2	$1\ 1^{L3}$	1^{S}		0	5	0
Hyperiidae	0 3^{L3}	$2\ 3^{D2}$		0		0	1	4	0
Ischyroceridae	0 3^{L3}	$2^{L1,L3}$		0		0	2	3	0
Lepechinellidae	0 5^{W1}		0	0		0	2	3	0
Leucothoidae	0	$3\ 2^{B,L3}$		0		0	0	4	1
Lysianassidae	0 1^{L3}	2^{L3}	1^{D2}	1^{L3}		0	0	1	4
Maeridae	0 1^{L3}	$1\ 2^{S}$	$2\ 1^{R3}$		1		$0\ 5^{B}$		0
Melitidae	0	$1\ 2^{S}$	$1^{D2,L3}$	1^{D3}		0	$0\ 5^{B}$		0
Melphidippidae	0	1	$3\ 1^{S}$			0	3	2	0
Oedicerotidae	0 1^{L3}	2^{L3}		$1\ 1^{S}$			1	4	0
Pardaliscidae	0	2	1	$1\ 1^{I1}$			1	4	
Photidae	0 $3^{D2,L3}$	1^{L3}		0		0	$2\ 3^{B}$		0
Phoxocephalidae	1 3^{L3}	$1^{B,S,L3}$		0		0	$0\ 5^{B}$		0
Pleustidae	0	$1\ 3^{D2}$	1^{L3}			0	1	4	0
Podoceridae	1 4^{P2}		0			0	1	4	0
Pontogeneiidae	0	$1\ 2^{L3}$	1^{L3}	$1^{D2,L3}$		0	0	4	1
Stegocephalidae	0	3	$1\ 1^{D2,L3}$			0	0	3	2
Stenothoidae	3^{D}	$1\ 1^{Z1,L3}$		0		0	$0\ 5^{B}$		0
Synopiidae	$2\ 2^{D2}$	1^{L3}		0		0	0	5	0
Unciolidae	0	2	$2\ 1^{I2}$			0	2	3	0
Uristidae	0 2^{L3}	1^{L3}	1^{L3}	$1^{D2,L3}$		0	0	2	3
Urothoidae	3 $2^{D2,L3}$		0	0		0	$0\ 5^{B}$		0
Arcturidae	0	1	$3\ 1^{D2}$			0	0	1	4
Cirolanidae	0	1	2	$1\ 1^{A1}$		0	$0\ 2^{B}$		3
Dendrotioniidae	5^{D2}	0	0	0		0	5	0	
Desmosomatidae	5^{D2}	0	0	0		0	2	3	0
Gnathiidae	0	$3\ 2^{D2}$		0		0	0	2	3
Haplomunnidae	$1\ 4^{D2}$		0	0		0	3^{G1}	2	0
Haploniscidae	$2\ 3^{G1}$		0	0		0	0	2	3
Ischnomesidae	0	$3\ 2^{G1}$		0		0	3	2	0
Janirellidae	$0\ 5^{D2}$		0	0		0	0	4	1
Janiridae	1	$2\ 2^{D2}$		0		0	0	5	0
Leptanthuridae	0	0	$3\ 2^{D2}$			0	0	4	1
Macrostylidae	$0\ 4^{D2}$		1	0		0	2	3	0
Munnidae	3^{D2}	2	0	0		0	3^{C1}	2	0
Munnopsidae	1	$2\ 2^{D2}$		0		0	3^{C1}	2	0
Nannoniscidae	3^{D2}	2	0	0		0	2	3	0
Paramunnidae	$3\ 2^{G1}$		0	0		0	0	5^{C1}	

	Maximum fecundity (number of eggs)					Feeding group	
Taxon	Very low (0 to <18)	Low (18 to <31)	Medium (31 to <65)	High (65 to <135)	Very high (>135)	Deposit feeder	Suspension feeder
Acidostomatidae	5[H1]	0	0	0	0	0	0
Amathillopsidae	0	0	5	0	0	2	0
Ampelisciidae	0	0	0	5[A]	0	1[B,F,G,M,S,K3]	4[A,B,F,G,M,S,V,K3]
Amphilochidae	0	0	5[D2]	0	0	3[F]	0
Aoridae	0	5[L3]	0	0	0	3[F,G,U,K3]	2[F,G,U,L8]
Argissidae	0	0	5	0	0	3	2
Aristidae	0	0	5	0	0	0	3[M1,L3]
Calliopiidae	0	0	0	5[D2,L3]	0	5[B,F,G,M,K3,O3]	0
Caprellidae	0	0	0	0	5[D2]	1[D,E,F,G,M,V1]	2[D,E,F,M]
Corophiidae	0	0	0	5[D2]	0	1[F,G,N,B,K3]	4[C,F,G,I,N,B,K3]
Cressidae	0	5	0	0	0	5[G]	0
Cyproideidae	0	5	0	0	0	4[F]	0
Dexaminidae	0	0	0	5[D2]	0	3[F,K3,O3]	1[M1,K3]
Dulichiidae	0	0	0	0	5[D2,L3]	0	5[H,I,K3]
Epimeriidae	0	0	5[L3]	0	0	2[J]	0
Eusiridae	0	0	0	0	5[D2,L3]	0	0
Hyperiidae	0	0	0	0	5[K,D2]	0	0
Ischyroceridae	0	0	0	5[D2,L3]	0	2[F,G,N,K3,O3]	2[G,N,L8]
Lepechinellidae	0	5	0	0	0	0	5
Leucothoidae	0	5[L3]	0	0	0	1[F]	2[M1]
Lysianassidae	0	0	0	5[D2,L3]	0	1[F,G,M,P,V,W1,K3]	0
Maeridae	0	5[L3]	0	0	0	4[F,H2,K3]	1[K2]
Melitidae	0	0	5[D2,L3]	0	0	5[F,G,M,S,B,K3]	0
Melphidippidae	0	0	0	5	0	0	5[K3]
Oedicerotidae	0	0	0	0	5[D2,L3]	3[F,G,M,S,V1,B,K3]	0
Pardaliscidae	0	5[H1]	0	0	0	0	0
Photidae	0	0	5[B]	0	0	3[F,G,N]	2[G,N]
Phoxocephalidae	0	0	5[D2]	0	0	2[F,G,Q,S]	0
Pleustidae	0	0	0	5	0	0	4
Podoceridae	0	5[H]	0	0	0	3[F,G]	2[G,K3]
Pontogeneiidae	0	0	0	0	5[D2,L3]	2[F,O3]	0
Stegocephalidae	0	0	0	5[D2,L3]	0	3[V1,M]	0
Stenothoidae	5[D2,L3]	0	0	0	0	1[F]	1[O]
Synopiidae	0	5[L3]	0	0	0	4[V1]	0
Unciolidae	0	5[D2]	0	0	0	2[M,J2,K3]	3[M,J2,B,K3]
Uristidae	0	0	0	0	5[D2,L3]	1[S,W1,X1]	0
Urothoidae	0	0	5[D2]	0	0	3[F,G,B]	2[G,B]
Arcturidae	0	0	5[D2]	0	0	1[I1]	4[I,D1,O2]
Cirolanidae	0	0	0	5[Z,D2]	0	0	0
Dendrotioniidae	5	0	0	0	0	0	5
Desmosomatidae	0	5	0	0	0	4[V1]	0
Gnathiidae	0	0	0	0	5[F1]	0	0
Haplomunnidae	5	0	0	0	0	3[O1]	2[O1]
Haploniscidae	5	0	0	0	0	3[G1,O2]	0
Ischnomesidae	0	5	0	0	0	4[G1,V1]	0
Janirellidae	0	5	0	0	0	1[G1]	0
Janiridae	0	0	0	5[D2]	0	5[C1]	0
Leptanthuridae	0	0	5	0	0	0	0
Macrostylidae	5	0	0	0	0	5[G1,S1]	0
Munnidae	5	0	0	0	0	5[C1]	0
Munnopsidae	0	0	0	5[D2]	0	2[B1,C1,V1]	0
Nannoniscidae	5[D2]	0	0	0	0	0	3
Paramunnidae	5[D2]	0	0	0	0	4[C1,G1]	0

				Habitat space					Living habit	
Taxon	Active predator (including foraminifera)	Scavenger	Parasitic	Infaunal	Epibenthic	Benthopelagic	Epibiotic (benthic)	Free	Tube/burrow dweller
Acidostomatidae	0	0	5 A1,K1	0	0	0	5 K1	0	0
Amathillopsidae	1	2	0	0	2 L2	3 L2	0	5	0
Ampeliscidae	0	0	0	2 A,B,G,M	2 B,K3	0	1 O2	1 B	4 A,B,G,M,S,K3
Amphilochidae	2 F	0	0	0	2 F	0	3 F	3 G	0
Aoridae	0	0	0	2 F,G,N,K3	3 G,N,K3	0	0	0	5 G,N,T,B,P2,K3
Argissidae	0	0	0	4 M3	1	0	0	4 M3	1
Aristidae	0	0	2 M1,L2	0	0	0	5 L1,M1,L2	0	0
Calliopiidae	0	0	0	0	2 F,M,B	0	3 F,M	4 G	1 B
Caprellidae	1 B,F,G	0	0	0	1 F,M	0	4 C,F,M,O2	1 G	1 B
Corophiidae	0	0	0	2 C,F,G,N	3 C,F,G,N	0	0	0	5 C,G,L,N,B,K2,P2,K3
Cressidae	0	0	0	0	2 N2	0	3 F,G	3 G	0
Cyproideidae	1 F	0	0	0	1 G	0	4 F,G,L2	2 G	0
Dexaminidae	1 F,K3,O3	0	0	0	0	0	5 F,G,S,M1,O2,K3	2 G,B	0
Dulichiidae	0	0	0	0	4 C,H	0	1 H,K3	4 C,H	0
Epimeriidae	1 V	2 K1	0	0	4 S	0	1 S	4 S	0
Eusiridae	4 M,S,V,V1,X1,K3	1 K1	0	0	3 M,S	2 M,S	0	5 M,S	0
Hyperiidae	3 K	0	2 K,O2	0	0	5 K	0	2 K	0
Ischyroceridae	1 N,B	0	0	0	3 F,G	0	2 F,N,S,O2,K3	1 G	3 G,N,T,B,P2,K3
Lepechinellidae	0	0	0	0	5 N1	0	0	0	5
Leucothoidae	1 F	0	1 F3	0	2 F	0	3 F,M1,O2	1 G	1 G
Lysianassidae	1 M,S,S1,W1,K3	3 F,G,M,P,S,V,S1,W1,X1,K	0	1 G,K3	3 F,G,M	0	1 M,O2	4 G,P	1 G,W1,K3
Maeridae	0	0	0	1 K3	4 F	0	0	3 G,B	2 K2,K3
Melitidae	0	0	0	0	4 F,M,S	0	1 O2	4 M,S,W,B	1 B
Melphidippidae	0	0	0	0	5 S	0	0	0 S	0
Oedicerotidae	2 F,G,M,V1	0	0	1 G	3 F,G,M	0	1 F,M	4 G,M,F	1 K2,B,K3
Pardaliscidae	4 I1	1 I1	0	0	3 H1,I1,I2	2 H1,I1,I2	0	5 H1,I1	0
Photidae	0	0	0	0	3 F,G	0	2 F,N,K3	2 G,B	2 G,N,K3
Phoxocephalidae	3 F,G,Q,R,S	0	0	2 QR	3 FR	0	0	3 G,R,B	2 G,R,X2,K3
Pleustidae	1	0	0	0	3 M	0	2 M,O2	0	4
Podoceridae	0	0	0	0	3 F,G	0	2 F,O2	4 G	0
Pontogeneiidae	3 F,O3	0	0	0	3 G	0	2 F	5 G	0
Stegocephalidae	1 K1	1 M,X1	0	0	4 M	0	1 K3	4 K3	0
Stenothoidae	2 F,B	1 B	0	0	1 O	0	4 F,O	2 G,B	0
Synopiidae	1 V1	0	0	0	4	0	0	1	4
Unciolidae	0	0	0	2 I2,K3	3 M	0	0	0	5 I2,K3
Uristidae	1 T1,W1,X1	3 G,P,S,V,S1,W1,X1	0	0	4 G,P,S	1 S	0	5 G,P,S	0
Urothoidae	0	0	0	3 G	2 F,G,B	0	0	3 G,B	2 G
Arcturidae	0	0	0	0	0	1	4 K1,O1	0	0
Cirolanidae	2 V,D1,V1,B	3 V,D1,V1,B	0	1 B	2 V	1 Z	1 V	5 V,Z,B	0
Dendrotioniidae	0	0	0	0	0	1	0	4 B1	0
Desmosomatidae	1 V1	0	0	4 C1	1 C1	0	0	4 C1	1 C1
Gnathiidae	0	0	5 F1,G2	0	1 F1	0	4 D1	1 F1	0
Haplomunnidae	0	0	0	0	3 O1	0	2 O1	4 O1	0
Haploniscidae	2 O1,S1	0	0	0	5 O2	0	0	5 O2	0
Ischnomesidae	1 G1	0	0	3 C1	2 C1	0	0	2 C1	3 C1,H2
Janirellidae	4 G1	0	0	0	5 G1	0	0	5 G1	0
Janiridae	0	0	0	0	3 C1	0	2 C1	4 C1	0
Leptanthuridae	5 D1	0	0	5 D1	0	0	0	0	5 D1,O2
Macrostylidae	0	0	0	4 C1	1 C1	0	0	1 C1	4 C1,H2
Munnidae	0	0	0	0	5 C1	0	0	5 C1	0
Munnopsidae	3 B1,S1,V1, N3	0	0	1 C1	3 B1,C1	1 G1	0	5 B1,C1	0
Nannoniscidae	2	0	0	0	2	3	0	0	2 3 H2
Paramunnidae	1 C1,G1	0	0	3 C1	2 C1	0	0	5 C1	0

	Motility				Bioturbation/sediment transport potential			
Taxon	Parasite/direct commensal	Fast swimmer	Slow swimmer/crawler	Crawler/limited swimmer	Crawler (no swim)	Burrower	Limited	
Acidostomatidae	5[A1]	0	0	5	0	0	5	5
Amathillopsidae	0	2	3	0	0	0	0	5
Ampeliscidae	0	0	2[A,B,E,K3]	0	0	3[A,B,K3]	0	0
Amphilochidae	2[G]	0	0	5	0	0	0	4
Aoridae	0	0	0	3[N,B]	0	2[B]	1[N]	0
Argissidae	0	0	3	0	0	0	2	2
Aristidae	5[L1,M1,L2]	0	0	5[M1]	0	0	0	5
Calliopiidae	0	0	4[B,K3]	0	0	1[B]	0	4
Caprellidae	4[C,E,G]	0	0	1[D]	4[D]	0	5[C]	0
Corophiidae	0	0	0	4[C,N,B]	0	1[B]	1[N]	0
Cressidae	2	0	5	0	0	0	0	5
Cyproideidae	3	0	3	2	0	0	0	5
Dexaminidae	3[G,S,M1]	0	0	0	0	0	0	5
Dulichiidae	1[H]	0	3[K,K3]	2[H]	0	0	5[C]	0
Epimeriidae	1[J]	0	1	4[J]	0	0	0	5
Eusiridae	0	3[M,S]	0	2[S]	0	0	0	5
Hyperiidae	3[K]	5[K]	0	0	0	0	0	5[K]
Ischyroceridae	1[J]	0	0	4[K,T]	1[K2]	0	3[N]	0
Lepechinellidae	0	0	5	0	0	0	0	5
Leucothoidae	3[G,M1]	0	3	2	0	0	0	5
Lysianassidae	0	1[P]	3[P]	0	0	0	1[K3]	0
Maeridae	0	0	0	3[K2,K3]	1[K2]	0	1[K2,K3]	0
Melitidae	0	0	2[M,S]	2[S,W]	0	0	1[B]	1
Meliphidippidae	0	2[K3]	2[K3]	1[S]	0	0	0	4
Oedicerotidae	0	2[M,K3]	2[M,B]	0	0	0	1[S,K3]	0
Pardaliscidae	0	3[H2,J1]	2[H1]	0	0	0	0	5
Photidae	1[G,N,K3]	0	0	5[N,B]	0	0	3[N]	0
Phoxocephalidae	0	0	2[K,B]	0	0	0	3[S,S,B,K3]	0
Pleustidae	1	0	4	1	0	0	0	5
Podoceridae	1[G]	0	0	2[K3]	0	0	0	5
Pontogeneiidae	0	3	2	0	0	0	0	5
Stegocephalidae	1[K3]	3[M,K3]	0	2[M,K3]	0	0	0	5
Stenothoidae	3[G,O,K2]	0	0	4[O,B]	0	0	1[B]	4
Synopiidae	1	0	5	0	0	0	0	5
Unciolidae	0	0	0	2[O,B,K3]	0	0	3[O,B]	0
Uristidae	0	2[P]	3[P]	0	0	0	0	1
Urothoidae	0	0	0	2[B]	0	0	3[B]	0
Arcturidae	5[H,L,D1]	0	0	0	1	4[D1,O,O2]	0	5
Cirolanidae	0	0	1 3[B]	0	0	0	1[B]	2
Dendrotioniidae	1[E1]	1	0	0	0	5[E1,O2]	0	4
Desmosomatidae	0	0	0 3[C1]	0	0	1[C1]	1[C1]	0
Gnathiidae	4[F1]	2[F1]	3[F1]	0	0	0	5[F1]	0
Haplomunnidae	1[O1]	0	0	0	0	5[O1]	0	4
Haploniscidae	0	0	0	5[O1,O2]	0	0	0	3
Ischnomesidae	0	0	0	0	0	3[C1,O1]	0	0
Janirellidae	0	0	0	0	0	5[O1]	0	3
Janiridae	1	0	0	1[O2]	0	4[C1,O2]	0	4
Leptanthuridae	0	0	0	0	0	2	3[O2]	0
Macrostylidae	0	0	0	0	0	1[C1]	4[C1]	0
Munnidae	0	0	0	0	0	5[C1]	0	4[C1]
Munnopsidae	0	2[E1,C1]	3[E1,C1]	0	0	0	1[C1]	0
Nannoniscidae	0	0	0	2[O2]	0	0	3	0
Paramunnidae	0	0	0	0	0	3[C1]	2[C1]	0

Taxon	Low-level incidental diffusive mixing	Active significant sediment transport	Sociability		Swarming	Parental care	
			Solitary	Gregarious		Limited	Extended
Acidostomatidae	0	0	5[A1]	0	0	4	1
Amathillopsidae	0	0	5	0	0	5	0
Ampelisciidae	5	0	2[B]	3[A]	0	3	2
Amphilochidae	1	0	5	0	0	5	0
Aoridae	4[N]	0	5[B]	0	0	3[U]	2[U]
Argissidae	3	0	5	0	0	5	0
Aristidae	0	0	5	0	0	4	1
Calliopiidae	1	0	5[B]	0	0	4	1
Caprellidae	0	0	1[E]	4[E]	0	1[E]	4[C,D,E,J,D2]
Corophiidae	4[C,N]	0	2[B]	3[B]	0	2[U]	3[C]
Cressidae	0	0	5	0	0	4	1
Cyproideidae	0	0	5	0	0	4	1
Dexaminidae	0	0	2	3	0	4	1
Dulichiidae	0	0	5[H]	0	0	5[C,D,E,J,D2]	0
Epimeriidae	0	0	5	0	0	5	0
Eusiridae	0	0	5	0	0	5	0
Hyperiidae	0	0[K]	2	0[K]	3[K]	3[E,K]	0
Ischyroceridae	2[N]	0	3	3[B,K3]	0	5[T]	0
Lepechinellidae	0	0	5	0	0	5	0
Leucothoidae	0	0	2	3	0	3	2[D2]
Lysianassidae	4 1[K3]	0	2	0	3	5	0
Maeridae	4	1[B]	5	0	0	2	3[K2]
Melitidae	4	0[B]	5[B]	0	0	4[W]	1[W]
Melphidippidae	1	0	4 1[H3]	0	0	5	0
Oediceratidae	3[M]	2[M]	4 1[B]	0	0	5	0
Pardaliscidae	0	0	3[H1]	0	2[H1]	5	0
Photidae	2[N]	0	2	3	0	3	2
Phoxocephalidae	2[R]	3[K,K3]	3[K,B]	0	2[R]	5	0
Pleustidae	0	0	5	0	0	4	1 4
Podoceridae	0	0	0	0	0	1	4
Pontogeneiidae	0	0	5	0	0	4	1
Stegocephalidae	0	0	5	0	0	4	1
Stenothoidae	1	0[O,B]	5	0	0	4	1
Synopiidae	0	0	5	0	0	5	0
Unciolidae	2	3	3[J2,B]	2[J2]	0	3	2
Uristidae	4	0	1	1	0	4	5
Urothoidae	2	3[B]	5	0	0	4	1
Arcturidae	0	0	4	4	1	0	5[L]
Cirolanidae	3	0	2[Y]	1[B]	2[Y,D1]	5	0
Dendrotioniidae	1	0	5	5	0	3	2
Desmosomatidae	3[C]	2[C]	3	2	0	3	2
Gnathiidae	0	0	5	0[F1]	0	5[F1]	0
Haplomunnidae	1	0	5	0	0	2	3
Haploniscidae	2	0	4	4	1	5	0
Ischnomesidae	2[C]	3[C]	4	4	1	3	2
Janirellidae	2	0	5	5	0	5	0
Janiridae	1	0	5	5	0	5	0
Leptanthuridae	1	4	1	1	4	5	0
Macrostylidae	2[C]	3[C]	3	3	2	5	0
Munnidae	1[C]	0	4	4	1	5	0
Munnopsidae	3[C]	1[C]	4	4	1	5	0
Nannoniscidae	2	3	4	4	1	5	0
Paramunnidae	2[C]	3[C]	5	5	0	5	0

Taxon	Maximum adult length						Fragility		
	Very small (0 to <4.7 mm)	Small (4.7 to <9.5 mm)	Medium (9.5 to <22.2 mm)	Large (22.2 to <45 mm)	Very large (>45 mm)	Fragile	Medium	Robust
Paranthuridae	0	3 [A2]	2	0	0	0	5	0
Thambematidae	3	2 [F1]	0	0	0	0	5	0
Agathotanaidae	5 [L2]	0	0	0	0	0	1	4
Akanthophoreidae	5 [W2]	0	0	0	0	0	3	2
Anarthruridae	5 [L2]	0	0	0	0	2	3	0
Apseudidae	0	2	3 [W2]	0	0	0	3	2
Colletteidae	5 [F2]	0	0	0	0	0	3	2
Cryptocopidae	5 [V2]	0	0	0	0	0	2	3
Leptochelíidae	2	3 [D2]	0	0	0	0	2	3
Leptognathiidae	3	2 [W2]	0	0	0	0	3	2
Neotanaidae	0	0	3	2 [C2]	0	0	3	2
Pseudotanaidae	5 [V2]	0	0	0	0	2	3	0
Sphyrapodidae	1	4 [Y2]	0	0	0	0	3	2
Typhlotanaidae	3	1	1 [D2]	0	0	1	3	1
Leptognathioides	5 [I2]	0	0	0	0	0	3	2
Portoratrum	5 [W2]	0	0	0	0	0	3	2
Singula	5 [K2]	0	0	0	0	0	3	2
Bodotriidae	2 [D2]	2	1	0	0	0	3 [B]	2
Diastylidae	1	2 [D2]	0	0	0	0	2	3
Lampropidae	1	3 [A2]	1	0	0	1	3	1
Leuconidae	4 [D2]	1	0	0	0	0	3	2
Nannastacidae	3	2 [Z2]	0	0	0	0	3	2
Pseudocumatidae	5 [A2]	0	0	0	0	0	3 [B]	2
Gynodiastylidae	4	1	0	0	0	0	3	2
Ceratocumatidae	3	2	0	0	0	3	2	0
Mysida	0	1	1	2 [D2]	1	0	5 [B]	0

Taxon	Maximum fecundity (number of eggs)				Feeding group	
	Very low (0 to <18)	Low (18 to <31)	Medium (31 to <65)	High (65 to <135)	Very high (>135)	Deposit feeder	Suspension feeder
Paranthuridae	5 [E2]	0	0	0	0	0	0
Thambematidae	5	0	0	0	0	0	0
Agathotanaidae	5	0 [C3] 5	0	0	0	0	0
Akanthophoreidae	5	0	5	0	0	0	0
Anarthruridae	5	0	5	0	0	0 [A2] 5	0
Apseudidae	5	0	0 [D2] 5	0	0	0 [V1] 3	1 [U1,C2]
Colletteidae	5 [D2]	0	0	0	0	0	0
Cryptocopidae	5	0	0	0	0	0	0
Leptochelliidae	5	0	0 [D2] 5	0	0	0	0
Leptognathiidae	5 [D2]	0	0	0	0	0 [V2,G2] 5	0
Neotanaidae	5	0	0	5	0	0 [U1,C2] 3	0
Pseudotanaidae	5	0	0	0	0	0 [A2] 4	0
Sphyrapodidae	5	0	0	5	0	0	0
Typhlotanaidae	5	0	0	0 [D2] 5	0	0 [V1] 4	0
Leptognathioides	5	0	5	0	0	0	0
Portaratrum	5	0	5	0	0	0	0
Singula	5	0	5	0	0	0	0
Bodotriidae	5	0	0	0 [A] 5	0	0 [U1,Y1,A2,B] 5	0
Diastylidae	5	0	0	0	0 [D2] 5	0 [U1,V1,B] 4	1 [U1]
Lampropidae	5	0	0	0	0 [D2] 5	0 [V1,A2] 5	0
Leuconidae	5	0	0	0 [D2] 5	0	0 [U1,V1,B] 5	0
Nannastacidae	5	0	0	5	0	0	0
Pseudocumatidae	5	0	0	0	5	0 [Y1,A2,B] 5	0
Gynodiastylidae	5	0	1	4	0	0	3
Ceratocumatidae	5	0	1	4	0	0	5
Mysida	5	0	0	0	0 [D2] 5	0 [B] 2	0 [B] 2

Taxon	Active predator (including foraminifera)	Scavenger	Parasitic	Habitat space: Infaunal	Habitat space: Epibenthic	Benthopelagic	Epibiotic (benthic)	Living habit: Free	Living habit: Tube/burrow dweller
Paranthuridae	5	0	0	3 U1	2 B2	0	0	1 B2	4 J1
Thambematidae	2	0	0	3	2	0	0	0	2 3
Agathotanaidae	1 U1	0	0	4	1	0	0	0	1 4
Akanthophoreidae	0	0	0	4	1	0	0	0	1 4
Anarthruridae	0	0	0	4 B2	1 B2	0	0	0	5 B2
Apseudidae	0	1	0	3 B2,C2,F2	1 F2	0	1 F2	1 B2	4 B2,F2
Colletteidae	0	0	0	4 Z1,B2	1 B2	0	0	0	5 Z1,B2,E2
Cryptocopidae	1	0	0	5 B2	0	0	0	0	5 B2
Leptochelidae	1	0	0	4 B2,F2	0	0	1 F2	0	5 B2,F2
Leptognathiidae	0	0	0	5	0	0	0	0	5 B2,E2,G2,H2
Neotanaidae	2 U1,C2	0	0	2	3 B2,C2,G2	0	0	0	4 B2,G2
Pseudotanaidae	0	1	0	4	1	0	0	0	1 4
Sphyrapodidae	1	1	0	2	3	0	0	2	3
Typhlotanaidae	0	1	0	4 U1,B2,F2	1	0	0	0	5 B2,E2,F2
Leptognathioides	1	0	0	4	1	0	0	0	1 4
Portatratrum	1	0	0	5	0	0	0	0	0 5
Singula	0	0	0	4	1	0	0	0	1 4
Bodotriidae	0	0	0	3 U1,Y1,A2	1 A2	1 Y1,A2	0	0	5 Y1
Diastylidae	0	0	0	3 U1,Y1		1 A2	0	0	5
Lampropidae	0	0	0	3 A2		1 A2	0	0	5 A2
Leuconidae	0	0	0	3 U1		1	1	0	5
Nannastacidae	5 U1	0	0	3 U1		1	1	0	5
Pseudocumatidae	0	0	0	3 A2,B		1 A2	0	0	5 A2
Gynodiastylidae	0	0	0	3	2	0	0	0	5
Ceratocumatidae	0	0	0	3	2	1	1	0	5
Mysida	1 B	0	0	1 B	2 B	2 B	0	5 B	0

Taxon	Motility				Bioturbation/sediment transport potential			
	Parasite/direct commensal	Fast swimmer	Slow swimmer/crawler	Crawler/limited swimmer	Crawler (no swim)	Burrower	Limited	
Paranthuridae	0	0	0	0 ^{2} ^{A2}	0	3	3	0
Thambematidae		0	0	0	0 ^{2} ^{P1}	3	3	0
Agathotanaidae		0	0	0	1	0	4	0
Akanthophoreidae		0	0	0 ^{1} ^{B2}	1	0	4	0
Anarthruridae		0	0	0 ^{1} ^{B2}		0 ^{4} ^{B2}	4	0
Apseudidae		0	0	0	1	0 ^{4} ^{A2}		0
Colletteidae		0	0	0 ^{1} ^{B2}		0 ^{4} ^{Z1,B2}		0
Cryptocopidae		0	0	0 ^{1} ^{B2}		0 ^{4} ^{B2}		0
Leptochelidae		0	0	0 ^{1} ^{B2}		0 ^{4} ^{B2}		0
Leptognathiidae		0	0	0 ^{1} ^{B2}		0 ^{4} ^{B2}		0
Neotanaidae		0	0	0	0 ^{4} ^{C2}	^{1} ^{C2}		4
Pseudotanaidae		0	2	1	0	0	2	1
Sphyrapodidae		0	0	1	0	0	4	0
Typhlotanaidae		0	0 ^{1} ^{B2}		0 ^{4} ^{B2}			0
Leptognathioides		0	0	1	0	0	4	0
Portaratrum		0	0	1	0	0	4	0
Singula		0	0	1	0	0	4	0
Bodotriidae		0 ^{1} ^{Y1,A2,B}	0	2	0 ^{2} ^{Y1,A2,B}			0
Diastylidae		0 ^{1} ^{Y1,B}	0	2	0 ^{2} ^{Y1,B}			0
Lampropidae		0 ^{1} ^{Y1,A2}	0 ^{2} ^{Y1,B}		0 ^{2} ^{Y1,A2}			0
Leuconidae	1	0	0	2	0	2		0
Nannastacidae	1	0	0	2	0	2		0
Pseudocumatidae		0 ^{1} ^{A2,B}	0	2	0 ^{2} ^{A2,B}			0
Gynodiastylidae	0	0	1	1	1	2		0
Ceratocumatidae	1	0	0	2	0	2		0
Mysida	2 ^{B}	0 ^{2} ^{B}		0	0	0 ^{2} ^{B}		4

Taxon	Low-level incidental diffusive mixing	Active significant sediment transport	Sociability: Solitary	Sociability: Gregarious	Sociability: Swarming	Parental care: Limited	Parental care: Extended
Paranthuridae	2	3	4	1	0	5	0
Thambematidae	2	3	5	0	0	4	1
Agathotanaidae	2	3	4	1	0	3	2
Akanthophoreidae	3	2	5	0	0	3	2
Anarthruridae	4	1	5	0	0	3	2
Apseudidae	3[C2]	4	4	1	0	4	1
Colletteidae	1[Z1]	5	5	0	0	2[Z1]	3[Z1]
Cryptocopidae	4	5	5	0	0	4[B2]	1[B2]
Leptochelliidae	4	1	4	1	0	3[B2]	2[B2]
Leptognathiidae	4	1	5	0	0	4[B2]	1[B2]
Neotanaidae	1	0	5	0	0	3[C2]	2[C2]
Pseudotanaidae	4	0	4	1	0	4	1
Sphyrapodidae	4	1	4	1	0	3	2
Typhlotanaidae	4	1	4	1	0	2[B2]	3[B2,D2]
Leptognathioides	3	2	5	0	0	3	2
Portaratrum	4	1	5	0	0	4	1
Simgula	3	2	5	0	0	3	2
Bodotriidae	0 5[Y1]	1[Y1,A2,B]		1	3[Y1,A2]	5	0
Diastylidae	0	5 2[B]		1	2	5	0
Lampropidae	0	5	2	1	2	5	0
Leuconidae	0	5	2	1	2	5	0
Nannastacidae	0	5 2[A2]		1	2[A2]	5	0
Pseudocumatidae	0	5 2[A2,B]		1	2[A2]	5	0
Gynodiastylidae	0	5	1	1	3	5	0
Ceratocumatidae	0	5	3	1	1	5	0
Mysida	1	0	0	4[B]	1	5	0

Appendix 5

Source literature for supertree

Source	Figure number(s)
Araujo-Silva and Larsen, (2010)	1
Best and Stachowicz, (2013)	1, 2a, 2b
Bird and Larsen, (2009)	1
Blazewicz-Paszkowycz et al. (2015)	9
Boyko et al. (2013)	1, 2
Brandt and Poore, (2003)	6b, 6d
Browne et al. (2007)	S1, S2, S3, S4, S5
Brusca and Wilson, (1991)	14
Bybee et al. (2011)	2
Corrigan et al. (2014)	1, 2, 4
Dreyer and Wagele, (2001)	5, 8, 9
Dreyer and Wagele, (2002)	6, 8
Drumm, (2010)	1a, 1b, 2a, 2b, 3
Englisch et al. (2003)	1, 3, 4, 5, 6
Guerrero Kommritz and Brandt, (2005)	2
Havermans et al. (2010)	1a, 1b
Haye et al. (2004)	1, 3b
Held, (2000)	6
Hou and Sket, (2016)	1, 2
Hurt et al. (2013)	2a, 2b
Ito et al. (2008)	2a, 2b, 2c
Jenner et al. (2009)	1, 2a, 2b, 2c, 2d, 5, 6a, 6b, 7a, 7b
Kakui et al. (2011)	2, 3, 4, 5
Kakui et al. (2012)	7a, 7b
Kavanagh and Wilson, (2007)	3b
Ki et al. (2011)	1b
Kilpert et al. (2012)	2
Kim and Kim, (1993)	5
Koenemann et al. (2010)	1, A4, A7
Krapp-Schickel and Koenemann, (2006)	4, 5, 7, 9
Larsen and Wilson, (2002)	1
Larsen and Shimomura, (2008)	12
Larsen et al. (2014)	1a, 1b, S1, S2
Larsen and Araujo-Silva, (2014)	1
Lins et al. (2012)	S1, S2, S3
Lorz and Held, (2004)	1, 2, 3, 4, 5
Lowry and Myers, (2013)	10
Meland and Willassen, (2007)	2
Myers and Lowry, (2003)	12
Poore, (2001)	4a
Raupach et al. (2004)	1
Raupach et al. (2009)	1, 2, S1
Raupach et al. (2015)	2, 4b
Rehm, (2007)	1
Riehl et al. (2014)	26
Ritchie et al. (2015)	1
Serejo, (2004)	1
Shen et al. (2015)	3
Souza-Filho and Serejo, (2014)	7
Spears et al. (2005)	2b, 3b, 4b

Source	Figure number(s)
Takeuchi, (1993)	1
Verheye et al. (2015)	2, 3, 3b
Wagele et al. (2003)	2, 3
Wetzer, (2002)	1, 2, 5, 6, 7
Wetzer et al. (2013)	3
White and Reimer, (2012)	1
Wilson, (1994)	3a, 3b
Wilson, (2009)	2, 3, 5
Wirkner and Richter, (2010)	2

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Appendix 6

Details of sequences downloaded from GenBank

Parent taxon	Species	COI	Accession	18S	Accession	16S	Accession	28S	Accession	Histone H3	Accession
Ampeliscidae	*Ampelisca brevicornis*	Y	KJ183007	Y	KJ182983.1	N	na	N	na	N	na
	Ampelisca diadema	Y	KT209574.1	N	na	N	na	N	na	N	na
	Ampelisca eschrichtii	Y	FJ581489.1	Y	AY826963.1	N	na	N	na	N	na
	Ampelisca ledoyeri	Y	JQ633144.1	N	na	N	na	N	na	N	na
	Ampelisca sarsi	Y	KF808157.1	N	na	N	na	N	na	N	na
	Ampelisca spinipes	Y	KT209489.1	N	na	N	na	N	na	N	na
	Ampelisca tenuicornis	Y	KT208487.1	N	na	N	na	N	na	N	na
	Ampelisca typica	Y	JX100838.1	N	na	N	na	N	na	N	na
	Byblis gaimardi	Y	DQ889084.1	Y	AY826964.1	N	na	N	na	N	na
	Haploops tubicola	N	na	Y	AY826960.1	N	na	N	na	N	na
Amphilochidae	*Amphilochus manudens*	Y	KT208996	N	na	N	na	N	na	N	na
	Gitana sarsi	Y	KT209155.1	N	na	N	na	N	na	N	na
Aoridae	*Aora gracilis*	Y	KT209553	Y	DQ378019.1	N	na	N	na	N	na
	Aoroides columbiae	Y	JX545451.1	Y	JX545349.1	Y	JX545421.1	N	na	N	na
	Globosolembos ovatus	Y	KC706701.1	N	na	N	na	N	na	N	na
	Microdeutopus chelifer	Y	KF369152.1	N	na	N	na	N	na	N	na
	Paraoroides sp.	Y	EF989711.1	N	na	N	na	N	na	N	na
Caliopidae	*Apherusa bispinosa*	Y	KT209512.1	Y	DQ378009.1	N	na	N	na	N	na
	Apherusa glacialis	Y	GU145035.1	Y	JF266612.1	N	na	N	na	N	na
	Apherusa jurinei	Y	KT209484.1	Y	DQ378010	N	na	N	na	N	na
	Calliopius laeviusculus	Y	KT209158.1	Y	DQ378008.1	N	na	N	na	N	na
	Halirages fulvocinctus	Y	FJ581692.1	N	na	N	na	N	na	N	na
	Oligochinus lighti	N	na	Y	JX545373	N	na	N	na	N	na
	Weyprechtia pinguis	Y	DQ889174.1	N	na	N	na	N	na	N	na
Caprellidae	*Aeginina longicornis*	Y	DQ889075.1	N	na	N	na	N	na	N	na
	Caprella andreae	Y	KC146175.1	N	na	N	na	N	na	N	na
	Caprella acanthifera	N	na	Y	KJ182989.1	N	na	N	na	N	na
	Caprella acanthogaster	Y	DQ466520.1	N	na	N	na	N	na	N	na
	Caprella californica	Y	JX545460.1	Y	KF743482.1	Y	JX545431.1	N	na	N	na
	Caprella danilevskii	N	na	Y	AB295398.1	N	na	N	na	N	na
	Caprella aliatata	Y	KC146202.1	Y	KC146310	N	na	N	na	N	na
	Caprella geometrica	N	na	Y	AY781423.1	N	na	N	na	N	na
	Caprella linearis	Y	FJ581575.1	Y	DQ378039.1	N	na	N	na	N	na
	Caprella mutica	Y	FJ581579.1	Y	KJ193734.1	Y	JX545433.1	N	na	N	na
	Caprella penantis	Y	KC146307.1	Y	KC146344.1	N	na	N	na	N	na
	Caprella scaura	Y	KF743385.1	Y	KF743471.1	N	na	N	na	N	na
	Caprella scauroides	Y	KF743392.1	Y	KF743472.1	N	na	N	na	N	na
	Caprella septentrionalis	Y	FJ581591.1	N	na	N	na	N	na	Y	KJ530684.1
	Caprella simia	Y	KF743447	Y	KF743487.1	N	na	N	na	N	na
	Caprella unica	Y	DQ889141.1	Y	AY692347.1	N	na	N	na	N	na
	Paracaprella pusilla	Y	KF743535.1	N	na	N	na	N	na	N	na
	Paracaprella tenuis	Y	KF743539.1	N	na	N	na	N	na	N	na
	Perotripus sp.	N	na	Y	AB295401.1	N	na	N	na	N	na
	Phtisica marina	Y	KT209123.1	Y	DQ378040.1	N	na	N	na	N	na
	Protella gracilis	N	na	Y	AB295396.1	N	na	N	na	N	na
	Protogeton sp.	N	na	Y	AB295400.1	N	na	N	na	N	na
	Protomima imitatrix	N	na	Y	AB295399.1	N	na	N	na	N	na
	Pseudoprotella phasma	Y	KF430255.1	Y	DQ378041.1	Y	KF430284.1	Y	KF430314.1	Y	KF484713
	Pseudoprotella sp.	N	na	Y	AB295397.1	N	na	N	na	N	na
Corophiidae	*Chelicorophium curvispinum*	Y	KM009064.1	N	na	N	na	N	na	N	na
	Chelicorophium robustum	Y	KM009063.1	Y	HG322470.1	N	na	N	na	N	na
	Corophium volutator	Y	KT209362.1	Y	DQ378027.1	N	na	N	na	N	na
	Monocorophium acherusicum	Y	KP255339.1	Y	KJ193825.1	N	na	N	na	N	na
	Monocorophium insidiosum	Y	KT209419.1	Y	KJ193732.1	N	na	N	na	N	na
	Monocorophium sextonae	Y	KT209012.1	Y	KJ193746.1	N	na	N	na	N	na
	Paracorophium brisbanensis	Y	HQ857946.1	N	na	N	na	N	na	N	na
	Paracorophium excavatum	Y	HQ858008.1	N	na	N	na	N	na	N	na
	Paracorophium lucasi	Y	HQ857966.1	N	na	N	na	N	na	N	na
Cressidae	*Cressa dubia*	Y	KT209069	N	na	N	na	N	na	N	na
Dexaminidae	*Dexamine thea*	Y	KT209114.1	N	na	N	na	N	na	N	na
	Dexamine spinosa	Y	KJ183011	Y	KJ182990.1	N	na	N	na	N	na
Dulichiidae	*Dulichia falcata*	Y	KT209201.1	N	na	N	na	N	na	N	na
	Dulichia sp.	N	na	Y	AB295394.1	N	na	N	na	N	na
	Dyopedos bispinis	N	na	N	na	N	na	N	na	Y	KF986565.1
	Dyopedos porrectus	N	na	Y	DQ378020.1	N	na	N	na	Y	KF986568.1
Podoceridae	*Podocerus inconspicuus*	N	na	Y	AB295409.1	N	na	N	na	N	na
	Podocerus septemcarinatus	N	na	Y	DQ378021.1	N	na	N	na	N	na
	Podocerus variegatus	N	na	Y	DQ378022.1	N	na	Y	KF430321.1	Y	KF484721.1
Epimeriidae	*Epimeria annabellae*	Y	FMS55293.1	N	na	N	na	N	na	N	na
	Epimeria bruuni	Y	FMS55298.1	N	na	N	na	N	na	N	na
	Epimeria cornigera	Y	KT208490.1	Y	KJ193824.1	N	na	N	na	N	na
	Epimeria georgiana	Y	FMS55305.1	Y	AF356546.1	N	na	N	na	N	na
	Epimeria grandirostris	Y	FMS55307.1	Y	DQ378007.1	Y	KF430283.1	Y	KF430313.1	Y	KF484712.1
	Epimeria horsti	Y	FMS55296.1	N	na	N	na	N	na	N	na
	Epimeria inermis	Y	JF271116.1	N	na	N	na	N	na	N	na
	Epimeria macrodonta	Y	AF451343.1	N	na	N	na	N	na	N	na
	Epimeria macronyx	Y	FMS55309	N	na	N	na	N	na	N	na
	Epimeria puncticulata	Y	FMS55301.1	N	na	N	na	N	na	N	na
	Epimeria reoproi	Y	AF451342.1	N	na	N	na	N	na	N	na
	Epimeria rimicarinata	Y	FMS55303	N	na	N	na	N	na	N	na
	Epimeria robusta	Y	AF451344.1	N	na	N	na	N	na	N	na
	Epimeria rubrieques	Y	AF451345	N	na	N	na	N	na	N	na
	Epimeria schiaparelli	Y	AM176768	N	na	N	na	N	na	N	na
	Epimeria similis	Y	AF451346.1	Y	DQ378006.1	N	na	N	na	N	na
	Epimeria walkeri	Y	FMS55308.1	N	na	N	na	N	na	N	na

Parent taxon	Species	COI	Accession	18S	Accession	16S	Accession	28S	Accession	Histone H3	Accession
	Paramphithoe hystrix	Y	FJ581852	N	na	N	na	Y	AYZ71830.1	N	na
Eusiridae	*Eusirus cuspidatus*	Y	FJ581636	N	na	N	na	N	na	N	na
	Eusirus giganteus	Y	JN001764.1	N	na	N	na	N	na	N	na
	Eusirus holmi	Y	FJ602463.1	N	na	N	na	N	na	N	na
	Eusirus microps	N	na	Y	DQ378011.1	N	na	N	na	N	na
	Eusirus perdentatus	Y	JN001784.1	Y	DQ378012.1	N	na	N	na	N	na
	Rhachotropis aculeata	Y	FJ581879.1	N	na	N	na	N	na	N	na
	Rhachotropis chathamensis	Y	GU804298.1	N	na	N	na	N	na	N	na
	Rhachotropis helleri	Y	JQ412477.1	N	na	N	na	N	na	N	na
	Rhachotropis inflata	Y	JQ412495.1	N	na	N	na	N	na	N	na
	Rhachotropis rossi	Y	JF498593.1	N	na	N	na	N	na	N	na
	Rhachotropis sp.	Y	EF989704.1	N	na	N	na	N	na	N	na
Hyperiidea	*Cyllopus lucasii*	Y	EF989691.1	Y	KC428887.1	N	na	Y	KC428836.1	Y	KC428938.1
	Cystisoma gershwinae	Y	EF989675.1	Y	KC428889	N	na	Y	KC428838.1	Y	KC428940
	Cystisoma pellucida	Y	EF989676.1	Y	KC428890	N	na	Y	KC428839.1	Y	KC428941.1
	Glossocephalus milneedwardsi	Y	EF989654.1	Y	KC428891.1	N	na	Y	KC428840.1	Y	KC428942.1
	Lanceola loveni	Y	EF989693.1	Y	KC428900.1	N	na	Y	KC428849	Y	KC428951.1
	Lycaea nasuta	Y	EF989647.1	Y	KC428905.1	N	na	Y	KC428854.1	Y	KC428956
	Microphasma agassizi	Y	EF989692.1	Y	KC428906.1	N	na	Y	KC428855	Y	KC428957.1
	Mimonectes loveni	Y	EF989698.1	Y	KC428907.1	N	na	Y	KC428856	Y	KC428958.1
	Phronima bucephala	Y	EF989680.1	Y	KC428911.1	N	na	Y	KC428860.1	Y	KC428962.1
	Scina borealis	Y	HM053504	Y	KC428919.1	N	na	Y	KC428868.1	Y	KC428970.1
	Themisto gaudichaudii	Y	HM053514.1	Y	AY743940.1	N	na	Y	EU375506.1	N	na
	Vibilia antarctica	Y	KC754385.1	Y	DQ378044.1	N	na	Y	KC428877.1	Y	KC428979
Ischyroceridae	*Cerapus sp.*	Y	EF998852.1	N	na	N	na	N	na	N	na
	Ericthonius pugnax	N	na	Y	AB295407.1	N	na	N	na	N	na
	Ericthonius punctatus	Y	JX545462.1	Y	DQ378016	Y	JX545434.1	N	na	N	na
	Ischyrocerus anguipes	Y	JX545466.1	Y	JX545366.1	Y	JX545438.1	N	na	N	na
	Ischyrocerus latipes	Y	DQ889106.1	N	na	N	na	N	na	N	na
	Jassa slatteryi	Y	EF989682.1	Y	AB295408.1	N	na	N	na	N	na
Leucothoidae	*Leucothoe akuma*	Y	KP896390.1	Y	JX145111.1	N	na	N	na	N	na
	Leucothoe ashleyae	Y	EF053411.1	Y	JF506071.1	N	na	N	na	N	na
	Leucothoe spinicarpa	N	na	Y	DQ378025	N	na	N	na	N	na
	Leucothoe vulgaris	Y	KP896391	Y	JX145112	N	na	N	na	N	na
Lysianassoidea	*Abyssorchomene abyssorum*	Y	KF430239.1	Y	KF430224.1	Y	KF430266.1	Y	KF430296.1	Y	KF484695.1
	Abyssorchomene chevreuxi	Y	GU109229.1	Y	KP347454.1	Y	KF430265.1	Y	GU109197.1	Y	KF484694.1
	Abyssorchomene nodimanus	Y	GU109260.1	N	na	N	na	Y	GU109183.1	N	na
	Anonyx sarsi	Y	FJ581508.1	N	na	N	na	N	na	N	na
	Bathycallisoma schellenbergi	Y	AY830441.1	Y	KP347453.1	Y	AY256969.1	N	na	N	na
	Centromedon zoe	Y	KF430236.1	Y	KF430221.1	Y	KF430263.1	Y	KF430293.1	Y	KF484692.1
	Cyclocaris sp.	Y	KF430245.1	Y	KF430230.1	Y	KF430272.1	Y	KF430302.1	Y	KF484701.1
	Eurythenes gryllus	Y	U92660.1	Y	AY826967.1	Y	U40437.1	Y	KF430303.1	Y	KF484702.1
	Falklandia reducta	Y	GU109256.1	N	na	N	na	Y	GU109193.1	N	na
	Hirondellea dubia	Y	AY183359.1	Y	KP347459.1	Y	KP456065.1	N	na	N	na
	Hirondellea namarensis	Y	KF430248.1	Y	KF430233.1	Y	KF430275.1	Y	KF430305.1	Y	KF484704.1
	Lepidepecreum umbo	N	na	Y	AY826968.1	N	na	N	na	N	na
	Onesimoides sp.	Y	JQ246436.1	Y	JQ246437.1	N	na	N	na	N	na
	Orchomene oxystoma	Y	KF430242.1	Y	KF430227.1	Y	KF430269.1	Y	KF430299.1	Y	KF484698.1
	Orchomene pectinatus	Y	KF430241.1	Y	KF430226.1	Y	KF430268.1	Y	KF430298.1	Y	KF484697.1
	Orchomenella franklini	Y	GU109226.1	N	na	N	na	Y	GU109203.1	N	na
	Orchomenella gerulicorbis	Y	KF430240.1	Y	KP347455.1	Y	KF430267.1	Y	KF430297.1	Y	KF484696.1
	Orchomenyx macronyx	Y	GU109231.1	N	na	N	na	Y	GU109200.1	N	na
	Pseudorchomene coatsi	Y	GU109245.1	N	na	N	na	Y	GU109185.1	N	na
	Stephonyx biscayensis	Y	KF430237.1	Y	KF430222.1	Y	KF430264.1	Y	KF430294.1	Y	KF484693.1
	Tmetonyx sp.	Y	KF430247.1	Y	KF430232.1	Y	KF430274.1	Y	KF430304.1	Y	KF484703.1
	Uristes murrayi	Y	GU109268.1	Y	AY826965.1	N	na	N	na	N	na
	Uristes sp.	Y	KP713947.1	Y	KP347458.1	Y	KP456063.1	N	na	N	na
Maeridae	*Elasmopus rapax*	Y	KF369125.1	N	na	N	na	N	na	N	na
	Maera danae	N	na	N	na	Y	AB432976.1	Y	AB432977.1	N	na
	Maera sp.	N	na	N	na	Y	AB432978.1	Y	AB432979.1	N	na
	Paraceradocus gibber	N	na	Y	AF419232.1	N	na	N	na	N	na
	Quadrimaera inaequipes	Y	KF369148.1	Y	AF419229.1	N	na	N	na	N	na
	Quadrimaera pacifica	N	na	N	na	Y	AB432980.1	Y	AB432981.1	N	na
Melitidae	*Exitomelita sigynae*	Y	JN831764.1	N	na	N	na	N	na	N	na
	Megamoera subtener	Y	AY926678.1	Y	AY926855.1	N	na	N	na	N	na
	Melita dentata	Y	FJ581757.1	Y	DQ378014.1	N	na	N	na	N	na
	Melita formosa	Y	FJ581759.1	N	na	N	na	N	na	N	na
	Melita matilda	Y	KC517350.1	N	na	N	na	N	na	N	na
	Melita nitida	Y	AY926679.1	Y	AY926795.1	Y	AY926733.1	N	na	N	na
	Melita palmata	Y	KT208397.1	N	na	N	na	N	na	N	na
	Norcapensis mandibulis	Y	JQ608487.1	N	na	N	na	N	na	N	na
Melphidippidae	*Melphidippa antarctica*	N	na	Y	DQ377998.1	Y	KF430289.1	Y	KF430319.1	Y	KF484719.1
Oedicerotidae	*Arrhis phyllonyx*	N	na	Y	AF419235.1	N	na	N	na	N	na
	Bathymedon obtusifrons	N	na	Y	AF419236.1	N	na	N	na	N	na
	Deflexilodes intermedius	Y	FJ581764.1	N	na	N	na	N	na	N	na
	Monoculodes antarcticus	Y	AF451356.1	N	na	N	na	N	na	N	na
	Monoculodes carinatus	N	na	Y	AF419230.1	N	na	N	na	N	na
	Monoculodes packardi	N	na	Y	DQ378015.1	N	na	N	na	N	na
	Oediceros saginatus	Y	FJ581790.1	N	na	N	na	N	na	N	na
	Paroediceros propinquus	N	na	N	na	N	na	N	na	N	na
	Rostrozuloides borealis	Y	EF432738.1	N	na	N	na	N	na	N	na
Photidae	*Gammaropsis melanops*	N	na	Y	DQ378028.1	N	na	N	na	N	na
	Gammaropsis nitida	Y	KT208645.1	N	na	N	na	N	na	N	na
	Gammaropsis utinomii	N	na	Y	AB295406.1	N	na	N	na	N	na
	Megamphopus cornutus	Y	KT208434.1	N	na	N	na	N	na	N	na

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	Photis longicaudata	Y	KT208497.1	N	na	N	na	N	na	N	na
Phoxocephalidae	*Fuegiphoxus abjectus*	N	na	Y	AY826972.1	N	na	Y	EU693290.1	N	na
	Harpinia antennaria	Y	KT209377.1	N	na	N	na	N	na	N	na
Pleustidae	*Pleustes panoplus*	Y	FJ581859.1	Y	DQ378034.1	N	na	N	na	N	na
Pontogeneiidae	*Paramoera erimoensis*	N	na	N	na	N	na	Y	AB778500.1	N	na
	Paramoera koysama	N	na	N	na	N	na	Y	AB778499.1	N	na
	Pontogeneia rostrata	Y	JX545474.1	Y	JX545416.1	Y	JX545447.1	N	na	N	na
	Stermomoera japonica	N	na	N	na	N	na	Y	AB778491.1	N	na
	Stermomoera morinoi	N	na	N	na	N	na	Y	AB778479.1	N	na
	Stermomoera rhyaca	N	na	N	na	N	na	Y	AB778498.1	N	na
	Stermomoera yezoensis	N	na	N	na	N	na	Y	AB778481.1	N	na
Stegocephalidae	*Andaniexis lupus*	N	na	Y	AY826969.1	N	na	N	na	N	na
	Andaniopsis nordlandica	N	na	Y	AY826971.1	N	na	N	na	N	na
	Stegocephalus inflatus	N	na	Y	AY826970.1	N	na	N	na	N	na
Stenothoidae	*Antatelson walkeri*	N	na	Y	AY826961.1	N	na	N	na	N	na
	Metopa alderi	Y	KT209338.1	N	na	N	na	N	na	N	na
	Stenothoe brevicornis	N	na	Y	AY826962.1	N	na	N	na	N	na
	Stenothoe marina	Y	KT208537.1	N	na	N	na	N	na	N	na
	Stenothoe monoculoides	Y	KT208446.1	N	na	N	na	N	na	N	na
	Stenula rubrovittata	Y	KT208695.1	N	na	N	na	N	na	N	na
Synopiidae	*Synopia sp.*	Y	EF989701.1	N	na	N	na	N	na	N	na
	Syrrhoe psychrophila	Y	KF430259.1	Y	DQ378030.1	N	na	Y	KF430318.1	Y	KF484718.1
Unciolidae	*Neohela monstrosa*	N	na	Y	DQ378018.1	N	na	N	na	N	na
Urothoidae	*Urothoe brevicornis*	N	na	Y	AY826973.1	N	na	Y	EU693331.1	N	na
	Urothoe elegans	Y	KT208637.1	N	na	N	na	N	na	N	na
	Urothoe poseidonis	Y	KT208414.1	N	na	N	na	N	na	N	na
	Urothoe pulchella	Y	KJ183013.1	Y	KJ182995.1	N	na	N	na	N	na
Anthuroidea	*Apanthura sp.*	Y	AF255789.1	N	na	Y	AF259545.1	N	na	N	na
	Caenanthura sp.	Y	KP225160.1	N	na	N	na	N	na	N	na
	Colanthura pigmentata	Y	KR095339.1	N	na	N	na	N	na	N	na
	Cyathura carinata	N	na	Y	AF332146.1	Y	AJ388072.1	N	na	N	na
	Cyathura sp.	N	na	Y	KC428886.1	N	na	Y	KC428835.1	Y	KC428937.1
	Paranthura japonica	N	na	Y	GQ302713.1	Y	GQ302694.1	N	na	N	na
	Paranthura nigropunctata	N	na	Y	AF279598.1	N	na	N	na	N	na
Antarcturidae	*Antarcturus spinacoronatus*	N	na	Y	AF279604.1	Y	AF268206.1	N	na	N	na
Arcturidae	*Arcturus baffini*	Y	DQ889078.1	N	na	N	na	N	na	N	na
	Astacilla intermedia	Y	KT208555.1	N	na	N	na	N	na	N	na
	Astacilla longicornis	Y	KT208682.1	N	na	N	na	N	na	N	na
Cirolanidae	*Antrolana lira*	Y	EF670465.1	N	na	Y	EF460861.1	N	na	N	na
	Bathynomus doederleinii	Y	AB851912.1	N	na	Y	AF501683.1	N	na	N	na
	Bathynomus giganteus	Y	AY566523.1	N	na	Y	AF501684.1	N	na	N	na
	Cirolana harfordi	Y	AF260838.1	N	na	Y	AF259543.1	N	na	N	na
	Cirolana kokoru	N	na	Y	JF699513.1	N	na	N	na	N	na
	Cirolana rugicauda	Y	AF260840.1	N	na	Y	AF259544.1	N	na	N	na
	Cirolanides texensis	Y	AY566471.1	N	na	Y	AY570106	N	na	N	na
	Eurydice pulchra	Y	KT208410.1	Y	AF255690.1	N	na	N	na	N	na
	Excirolana braziliensis	Y	KP172594.1	N	na	N	na	N	na	N	na
	Excirolana chiltoni	Y	KJ592751.1	N	na	Y	AF260849.1	N	na	N	na
	Excirolana hirsuticauda	Y	FJ532099.1	N	na	N	na	N	na	N	na
	Excirolana mayana	Y	KP172617.1	N	na	Y	AF260851.1	N	na	N	na
	Marocolana delamarei	Y	EF526114.1	N	na	Y	DQ194363.1	N	na	N	na
	Natatolana borealis	Y	KT208809.1	N	na	N	na	N	na	N	na
	Natatolana gallica	Y	KT208657.1	N	na	N	na	N	na	N	na
	Natatolana meridionalis	N	na	Y	AF255691.1	N	na	N	na	N	na
	Natatolana rossi	Y	GQ302696.1	Y	GQ302712.1	Y	GQ302693.1	N	na	N	na
	Speocirolana hardeni	Y	AY566524.1	N	na	Y	AY570141.1	N	na	N	na
	Speocirolana thermydronis	Y	AY566526.1	N	na	Y	AY570144.1	N	na	N	na
	Sphaeroiana affinis	Y	AY566518.1	N	na	Y	AY570109.1	N	na	N	na
	Sphaeromides virei	Y	AY998016.1	N	na	Y	DQ194360.1	N	na	N	na
	Typhlocirolana haouzensis	Y	EF526113.1	Y	AF453249.1	Y	AF356848.2	N	na	N	na
	Typhlocirolana moraguesi	N	na	Y	AF255692.1	Y	AF356849.1	N	na	N	na
Dendrotionidae	*Acanthomunna spinipes*	N	na	Y	EU414421.1	N	na	Y	EU414346.1	N	na
	Dendromunna sp.	N	na	Y	EU414422.1	N	na	Y	EU414348.1	N	na
	Dendrotion sp.	N	na	Y	EU414423.1	N	na	Y	EU414349.1	N	na
Desmosomatidae	*Chelator aequabilis*	Y	KJ578689.1	Y	KJ578681.1	Y	KJ578662.1	N	na	N	na
	Chelator insignis	Y	KJ578692.1	Y	KJ630818.1	Y	KJ630811.1	N	na	N	na
	Chelator rugosus	Y	KJ578683.1	Y	KJ578677.1	Y	KJ578668.1	N	na	N	na
	Chelator sp.	N	na	N	na	N	na	Y	EU414350.1	N	na
	Chelator vulgaris	N	na	Y	KJ630816.1	Y	KJ630813.1	N	na	N	na
	Disparella sp.	N	na	N	na	N	na	Y	EU414351.1	N	na
	Eugerda sp.	N	na	Y	AY461463.1	N	na	N	na	N	na
	Eugerdella huberti	Y	HQ214677.1	Y	KJ578682.1	Y	HQ214679.1	N	na	N	na
	Eugerdella natator	N	na	Y	AY461462.1	N	na	N	na	N	na
	Eugerdella theodori	Y	KJ578699.1	Y	KJ578679.1	Y	KJ578673.1	N	na	N	na
	Mirabilicaxa sp.	N	na	Y	AY461461.1	N	na	Y	EU414353.1	N	na
	Parvochelus russus	Y	KJ578695.1	Y	KJ578674.1	Y	KJ578672.1	N	na	N	na
	Prochelator sp.	Y	KJ736043.1	N	na	N	na	N	na	N	na
	Whoia sp.	Y	KJ736051.1	N	na	N	na	N	na	N	na
Gnathiidae	*Elaphognathia rangifer*	Y	AB713955.1	N	na	N	na	N	na	N	na
	Gnathia limicola	Y	AB713956.1	N	na	N	na	N	na	N	na
	Gnathia maculosa	Y	AB713960.1	N	na	N	na	N	na	N	na
	Gnathia trimaculata	Y	AB713957.1	N	na	N	na	N	na	N	na
Haplomunnidae	*Thylakogaster sp.*	N	na	Y	EU414425.1	N	na	Y	EU414354.1	N	na
Haploniscidae	*Antennuloniscus armatus*	N	na	Y	AY461468.1	N	na	Y	EU414356.1	N	na
	Antennuloniscus sp.	N	na	Y	EU414426.1	N	na	Y	EU414357.1	N	na

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	Chaulidoniscus sp.	N	na	Y	EU414427.1	N	na	N	na	N	na
	Haploniscus cassilatus	N	na	Y	DQ435679.1	N	na	Y	EU414359.1	N	na
	Haploniscus cucullus	N	na	N	na	N	na	Y	EU414360.1	N	na
	Haploniscus nondescriptus	N	na	Y	EU414428.1	N	na	Y	EU414361.1	N	na
	Haploniscus nudifrons	N	na	Y	DQ435680.1	N	na	Y	EU414362.1	N	na
	Haploniscus rostratus	Y	JF283460.1	Y	EU414429.1	N	na	Y	EU414363.1	N	na
	Haploniscus sp.	N	na	Y	AY461465.1	Y	AY693403.1	Y	EU414365.1	N	na
	Haploniscus spinifer	N	na	Y	EU414430.1	N	na	N	na	N	na
	Haploniscus weddellensis	N	na	Y	DQ435681.1	N	na	Y	EU414364.1	N	na
	Hydroniscus sp.	N	na	Y	EU414433.1	N	na	N	na	N	na
	Mastigoniscus polygomphios	N	na	Y	EU414434.1	N	na	N	na	N	na
	Mastigoniscus sp.	N	na	Y	AY461469.1	Y	AY693399.1	Y	EU414367.1	N	na
Ischnomesidae	*Graciliimesus insignis*	N	na	Y	AY461473.1	N	na	N	na	N	na
	Haplomesus sp.	N	na	Y	AY461474.1	N	na	N	na	N	na
	Ischnomesus sp.	N	na	Y	EU414435.1	N	na	N	na	N	na
	Stylomesus sp.	N	na	Y	EU414436.1	N	na	Y	EU414371.1	N	na
Janirellidae	*Janirella sp.*	N	na	Y	AY461475.1	N	na	N	na	N	na
Janiridae	*Carpias nereus*	N	na	Y	AF496657.1	N	na	N	na	N	na
	Iais pubescens	N	na	Y	EU414437.1	N	na	N	na	N	na
	Ianiropsis epilittoralis	Y	EF682303.1	Y	EF682260.1	Y	AF260859.1	Y	EF682305.1	N	na
	Iathrippa sarsi	N	na	Y	EU414438.1	N	na	Y	EU414373.1	N	na
	Iathrippa trilobatus	N	na	Y	AF279606.1	N	na	N	na	N	na
	Jaera albifrons	Y	FJ581736.1	Y	AF279609.1	Y	AJ388078.1	N	na	N	na
	Jaera nordmanni	N	na	Y	AF279610.1	N	na	N	na	N	na
	Janira maculosa	Y	KT208628.1	Y	AF255700.1	N	na	N	na	N	na
	Neojaera antarctica	N	na	Y	AY461454.1	N	na	Y	EU414374.1	N	na
	Neojaera sp.	N	na	Y	EU414439.1	N	na	Y	EU414375.1	N	na
Macrostylidae	*Macrostylis roaldi*	Y	JX260254.1	Y	JX260351.1	Y	JX260348.1	N	na	N	na
	Macrostylis sp.	N	na	Y	EU414442.1	N	na	Y	EU414379.1	N	na
Munnidae	*Munnidae sp.*	Y	KJ736157.1	N	na	N	na	N	na	N	na
Munnopsidae	*Acanthamunnopsis longicornis*	Y	EF682265.1	Y	EF682220.1	N	na	Y	EF682310.1	N	na
	Acanthamunnopsis milleri	Y	EF682261.1	Y	EF682219.1	N	na	Y	EF682308.1	N	na
	Acanthocope galatheae	Y	EF682285.1	Y	AF496656.1	N	na	Y	EU414382.1	N	na
	Acanthocope sp.	Y	EF682286.1	Y	EF682240.1	N	na	Y	EF682336.1	N	na
	Betamorpha africana	Y	EF682292.1	Y	EF682248.1	N	na	Y	EU414384.1	N	na
	Betamorpha fusiformis	Y	EF682291.1	Y	EF116546.1	Y	EF116494.1	Y	EU414386.1	N	na
	Coperonus sp.	N	na	Y	EU414448.1	N	na	Y	EU414388.1	N	na
	Disconectes antarcticus	Y	EF682293.1	Y	EF682250.1	N	na	Y	EU414389.1	N	na
	Dubinectes acutitelson	Y	EF682294.1	Y	EU414452.1	N	na	Y	EF682330.1	N	na
	Dubinectes nodosus	N	na	Y	EU414453.1	N	na	Y	EU414394.1	N	na
	Echinozone sp.	N	na	Y	EF116549.1	Y	EF116491.1	N	na	N	na
	Eurycope complanata	Y	EF682281.1	Y	EF682256.1	N	na	Y	EU414395.1	N	na
	Eurycope eltaniae		na	Y	KJ716804.1	Y	KJ716802.1	N	na	N	na
	Eurycope glabra	Y	EF682280.1	Y	EF682255.1	N	na	Y	EU414396.1	N	na
	Eurycope sarsi	N	na	Y	AY461479.1	N	na	Y	EU414397.1	N	na
	Ilyarachna antarctica	Y	EF682299.1	Y	AY461481.1	N	na	Y	EU414400.1	N	na
	Ilyarachna triangulata	N	na	Y	EF682244.1	N	na	Y	EU414401.1	N	na
	Mimocopelates sp.		na	Y	EU414460.1	N	na	Y	EU414404.1	N	na
	Munneurycope murrayi	Y	EF682275.1	Y	EF682232.1	N	na	Y	EF682319.1	N	na
	Munneurycope sp.	Y	EF682278.1	Y	EF682236.1	N	na	Y	EF682322.1	N	na
	Munnopsis abyssalis	Y	EF682273.1	Y	EF682222.1	N	na	Y	EF682314.1	N	na
	Munnopsis sp.	N	na	Y	EF682225.1	N	na	Y	EF682313.1	N	na
	Munnopsoides sp.	Y	EF682271.1	Y	EF682224.1	N	na	Y	EF682312.1	N	na
	Munnopsurus sp.	Y	EF682288.1	Y	EF682238.1	N	na	Y	EF682341.1	N	na
	Notopais magnifica	N	na	Y	EU414454.1	N	na	Y	EU414393.1	N	na
	Paramunnopsis sp.	Y	EF682266.1	Y	EF682230.1	N	na	Y	EF682315.1	N	na
	Paropsurus giganteus	Y	EF682287.1	Y	EF682253.1	N	na	Y	EF682339.1	N	na
	Storthyngura kussakini	N	na	Y	EU414465.1	N	na	Y	EU414408.1	N	na
	Storthyngurella menziesi	N	na	Y	EU414464.1	N	na	Y	EU414407.1	N	na
	Syneurycope heezeni	Y	EF682295.1	Y	EU414466.1	N	na	Y	EF682334.1	N	na
	Syneurycope sp.	Y	EF682296.2	Y	EF682243.1	N	na	Y	EF682335.1	N	na
	Tytthocope sp.	Y	EF682290.1	Y	EF682252.1	N	na	Y	EF682342.1	N	na
	Vanhoeffenura sp.	Y	EF682284.1	Y	EF682239.1	N	na	Y	EF682338.1	N	na
Nannoniscidae	*Austroniscus sp.*	N	na	Y	EU414469.1	N	na	Y	EU414411.1	N	na
	Nannoniscus sp.	N	na	Y	EU414470.1	N	na	Y	EU414412.1	N	na
Thambematidae	*Thambema sp.*	Y	KJ736122.1	N	na	N	na	N	na	N	na
Agathotanaidae	*Agathotanais ingolfi*	Y	KJ934609.1	N	na	N	na	N	na	N	na
	Paranarthrura sp.	N	na	Y	AB618196.1	N	na	N	na	N	na
Apseudidae	*Apseudes talpa*	Y	JF927715.1	Y	KJ182985.1	N	na	Y	JF927717.1	Y	JF927716.1
	Apseudopsis latreillii	N	na	Y	KJ182984.1	Y	AJ388110.1	N	na	N	na
	Atlantapseudes sp.	N	na	Y	AB618176.1	N	na	N	na	N	na
	Carpoapseudes varindex	N	na	Y	AB618177.1	N	na	N	na	N	na
	Fageapseudes brachyomos	N	na	Y	AB618174.1	N	na	N	na	N	na
	Leviapseudes sp.	N	na	Y	AB618178.1	N	na	N	na	N	na
	Paradoxapseudes (Apseudes) bermudeus	N	na	Y	GQ175865.1	N	na	Y	HM016191.1	Y	HM016178.1
	Paradoxapseudes littoralis	N	na	Y	AB618175.1	N	na	N	na	N	na
Leptocheliidae	*Leptochelia rapax*	Y	KP254749.1	N	na	N	na	Y	HM016198.1	Y	HM016183.1
	Leptochelia dubia	Y	HM016215.1	N	na	N	na	Y	HM016199.1	Y	HM016187.1
	Leptochelia forresti	Y	KP254788.1	N	na	N	na	N	na	N	na
	Leptochelia itoi	N	na	Y	AB618197.1	N	na	N	na	N	na
	Leptochelia sp.	N	na	Y	AF496660.1	N	na	N	na	N	na
	Pseudoleptochelia sp.	Y	HM016202.1	N	na	N	na	N	na	Y	HM016173.1
Neotanaidae	*Neotanais sp.*	N	na	Y	AB618189.1	N	na	N	na	N	na
	Venusticrus thor	Y	KT592232.1	N	na	N	na	Y	KT592231.1	N	na
Nototanaidae	*Nesotanais ryukyuensis*	N	na	Y	AB618198.1	N	na	N	na	N	na

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	Nototanais sp.	N	na	N	na	N	na	Y	HM016196.1	Y	HM016188.1
Sphyrapodidae	*Pseudosphyrapus serratus*	N	na	Y	AB618187.1	N	na	N	na	N	na
	Pseudosphyrapus quintolongus	N	na	Y	AB618185.1	N	na	N	na	N	na
Pseudotanaidae	*Pseudotanais sp.*	N	na	N	na	N	na	N	na	Y	HM016172.1
Bodotriidae	*Bodotria scorpioides*	Y	KT208398.1	N	na	N	na	N	na	N	na
	Cumopsis goodsir	Y	AF137518.1	N	na	N	na	N	na	N	na
	Cyclaspis alba	Y	AF137517.1	N	na	N	na	N	na	N	na
	Cyclaspis caprella	Y	DQ889092.1	N	na	N	na	Y	AF169712.1	N	na
	Eocuma longicorne	Y	AF520445.1	N	na	N	na	N	na	N	na
	Heterocuma sp.	Y	AF520443.1	N	na	N	na	N	na	N	na
	Iphinoe trispinosa	Y	AF137519.1	Y	KJ182988	N	na	N	na	N	na
	Iphinoe truncata	Y	DQ070286.1	N	na	N	na	N	na	N	na
	Leptocuma sp.	Y	AF520444.1	N	na	N	na	N	na	N	na
	Mancocuma stellifera	Y	AF137520.2	N	na	N	na	N	na	N	na
	Pomacuma australiae	Y	AF352302.2	N	na	N	na	N	na	N	na
	Spilocuma salomani	N	na	Y	AY781432.1	N	na	N	na	N	na
	Vaunthompsonia cristata	Y	AF352301.2	N	na	N	na	N	na	N	na
Diastylidae	*Colurostylis longicaudata*	Y	AF520446.1	N	na	N	na	N	na	N	na
	Diastylis bispinosa	Y	AF137511.1	N	na	N	na	N	na	N	na
	Diastylis crenellata	Y	AF352298.1	N	na	N	na	N	na	N	na
	Diastylis rathkei	Y	AF069764.1	N	na	Y	HQ450555.1	N	na	N	na
	Diastylis rugosa	Y	KT209009.1	N	na	N	na	N	na	N	na
	Diastylis sculpta	Y	AF137510.1	Y	AY781431.1	Y	U81512.1	N	na	N	na
	Diastylopsis thileniusi	Y	AF520442.1	N	na	N	na	N	na	N	na
	Oxyurostylis lecroyae	Y	AF137513.1	N	na	N	na	N	na	N	na
	Oxyurostylis smithi	Y	AF137512.1	N	na	N	na	N	na	N	na
Lampropidae	*Hemilamprops californicus*	Y	AF061781.2	N	na	N	na	N	na	N	na
	Hemilamprops sp.	Y	AF520448.1	N	na	N	na	N	na	N	na
	Lamprops quadriplicata	Y	AF352297.2	N	na	N	na	N	na	N	na
	Lamprops sp.	N	na	Y	JN800572.1	Y	JN800544.1	Y	JN800639.1	Y	JN800701.1
Leuconidae	*Eudorella pusilla*	Y	AF137516.1	N	na	Y	U81513.1	N	na	N	na
	Eudorella truncatula	N	na	Y	KJ193737.1	N	na	N	na	N	na
Nannastacidae	*Campylaspis sp.*	Y	AF520450.1	N	na	N	na	N	na	N	na
	Cumella sp.	Y	AF520449.1	N	na	N	na	N	na	N	na
Pseudocumatidae	*Monopseudocuma gilsoni*	Y	KT208619.1	Y	KJ193843.1	N	na	N	na	N	na
	Pseudocuma simile	Y	AF137514.2	Y	KJ193845.1	N	na	N	na	N	na
Mysida	*Boreomysis arctica*	Y	FJ581526.1	Y	AM422481.1	N	na	N	na	N	na
	Gastrosaccus psammodytes	N	na	Y	AJ566087.1	N	na	N	na	N	na
	Hansenomysis fyllae	N	na	Y	AM422480.1	N	na	N	na	N	na
	Hemimysis anomala	Y	EU029162.1	Y	AJ566104.1	N	na	Y	EU233527.1	N	na
	Heteromysis formosa	Y	KP255226.1	Y	AY781419.1	Y	JN800542.1	Y	JN800637.1	Y	JN800699.1
	Michthyops parvus	N	na	Y	AM422490.1	N	na	N	na	N	na
	Mysis oculata	Y	EF609268.1	Y	AM422510.1	Y	DQ189194.1	N	na	N	na
	Neomysis americana	Y	FJ581783.1	Y	HM179998.1	Y	HM179997.1	Y	HM179999.1	N	na
	Praunus flexuosus	Y	KT208416.1	Y	AM422512.1	Y	JN800554.1	Y	JN800644.1	Y	JN800712.1
	Pseudomma affine	Y	AY624266.1	Y	AY624283.2	N	na	N	na	N	na
	Rhopalophthalmus sp.	N	na	Y	AM422488.1	N	na	N	na	N	na
	Siriella armata	Y	KT208432.1	Y	AJ566105.1	N	na	N	na	N	na
Bochusacea	*Thetispelecaris remex*	N	na	Y	AY781421.1	N	na	N	na	N	na
Lophogastrida	*Eucopia sculpticauda*	N	na	Y	AM422473.1	N	na	N	na	N	na
	Gnathophausia ingens	Y	DQ889115.1	Y	AY781416.1	N	na	Y	AF244095.1	N	na
	Gnathophausia zoea	Y	EF015490.1	Y	AM422474.1	N	na	N	na	N	na
	Lophogaster typicus	N	na	Y	AM422476.1	N	na	N	na	N	na
Spelaeogriphacea	*Spelaeogriphus lepidops*	N	na	Y	AY781414.1	N	na	N	na	N	na
Stygiomysida	*Stygiomysis aemete*	N	na	Y	AM422477.1	N	na	N	na	N	na
	Stygiomysis cokei	N	na	Y	AM422478.1	N	na	N	na	N	na
	Stygiomysis holthuisi	N	na	Y	AM422479.1	N	na	N	na	N	na
Thermosbaenacea	*Tethysbaena argentarii*	N	na	Y	AY781415.1	Y	DQ470612.1	Y	DQ470634.1	N	na
Stomatopoda	*Gonodactylellus viridis*	N	na	Y	AY743947.1	N	na	Y	AY739190.1	N	na
	Gonodactylus chiragra	Y	AF205250.1	Y	HM138870.1	Y	AF107614.1	Y	HM180014.1	N	na
	Gonodactylus smithii	Y	AF205233.1	Y	HM138873.1	Y	AF107615.1	Y	HM180017.1	N	na
	Harpiosquilla harpax	Y	FJ229770.1	N	na	Y	FJ871137.1	Y	FJ871143.1	N	na
	Lysiosquillina maculata	Y	HM138793.1	Y	HM138878.1	Y	AF107618.1	Y	EU920998.1	Y	JN800704.1
	Oratosquilla oratoria	Y	HM180743.1	N	na	Y	FJ224276.1	N	na	N	na
	Squilla empusa	Y	HM138809.1	Y	L81946.1	Y	JN800539.1	Y	HM180041.1	Y	JN800718.1
Leptostraca	*Nebalia sp.*	Y	FJ170237.1	Y	L81945.1	N	na	Y	AF169699.1	Y	AF110869.1
	Paranebalia longipes	N	na	Y	EF189630.1	Y	AY744909.1	Y	EF189655.1	Y	AY744905.1
Euphausiacea	*Euphausia pacifica*	Y	AF177184.1	Y	AY141010.1	Y	AF177176.1	Y	EF595675.1	N	na
	Meganyctiphanes norvegica	Y	AF177191.1	Y	DQ900731.1	Y	AY744910.1	Y	AY744900.1	Y	AY744906.1
	Nyctiphanes simplex	Y	AY601092.1	Y	DQ900732.1	Y	AY574928.1	N	na	N	na
Anaspidacea	*Anaspides tasmaniae*	Y	DQ889076.1	Y	L81948.1	Y	AF133683.1	Y	AF169703.1	N	na
Bathynellacea	*Iberobathynella magna*	Y	HQ659856.1	N	na	Y	AF508569.1	N	na	N	na
Anomura	*Albunea catherinae*	N	na	Y	KF182445.1	Y	JN800534.1	Y	KF182607.1	Y	JN800689.1
	Dardanus fucosus	N	na	Y	JN800563.1	Y	JN800537.1	Y	KF182654.1	N	na
	Emerita talpoida	Y	L43105.1	Y	AY743949.1	Y	KF182557.1	Y	KF182587.1	Y	KF182702.1
	Eumunida picta	Y	EU243556.1	Y	KF182464.1	Y	KF182518.1	Y	KF182620.1	Y	KF182690.1
	Oedignathus inermis	Y	EU329164.1	Y	Z14062.1	N	na	Y	AF425353.1	N	na
	Paguristes cadenati	N	na	Y	KF182493.1	Y	KF182540.1	Y	KF182637.1	Y	JN800707.1
	Pagurus policaris	Y	AF483160.1	Y	KF182458.1	Y	FJ869152.1	Y	KF182589.1	Y	KF182737.1
Upogebiidae	*Upogebia major*	Y	JX502989.1	N	na	Y	KF910454.1	N	na	N	na
	Upogebia pusilla	Y	KP136655.1	N	na	N	na	N	na	N	na
Brachyura	*Austinograea alayseae*	Y	KC603865.1	N	na	Y	JQ407449.1	Y	JQ407434.1	N	na
	Austinograea rodriguezensis	Y	AB813071.1	N	na	Y	JQ407452.1	Y	JQ407437.1	Y	JQ407464.1
	Bathynectes longispina	Y	JN800677.1	Y	JN800594.1	Y	JN800535.1	Y	JN800629.1	Y	JN800691.1
	Callinectes sapidus	Y	AY682072.1	Y	AY743951.1	Y	JX123476.1	Y	AY739194.1	Y	FM208798.1

Parent taxon	Species	COI	Accession	18S	Accession	16S	Accession	28S	Accession	Histone H3	Accession
	Carcinus maenas	Y	FJ581592.1	Y	AY383974.1	Y	AY383901.1	Y	DQ079798.1	Y	DQ079669.1
	Eriocheir sinensis	Y	AF105247.1	Y	GU362670.1	Y	AF105243.1	N	na	N	na
	Geothelphusa dehaani	Y	KC545613.1	N	na	Y	AB290630.1	N	na	Y	AB290667.1
	Hemigrapsus sanguineus	Y	EU169901.1	N	na	Y	AJ493053.1	N	na	N	na
	Pseudocarcinus gigas	Y	HM638058.1	Y	HM638021.1	Y	HM637969.1	N	na	Y	HM596631.1
	Scylla paramamosain	Y	HQ687226.1	Y	KC902763.1	Y	FJ774905.1	Y	KC902762.1	Y	KJ133188.1
	Xenograpsus testudinatus	Y	AB933569.1	N	na	Y	FM863827.1	N	na	Y	FN434066.1
Polychelida	*Polycheles typhlops*	Y	JQ306297.1	Y	FJ174921.1	Y	FJ174890.1	Y	EU921004.1	Y	FJ174856.1
Astacidea	*Astacus astacus*	Y	DQ320049.1	Y	U33181.1	Y	GU727618.1	Y	DQ079773.1	Y	DQ079660.1
	Cherax destructor	Y	FJ965956.1	Y	FJ965974.1	Y	AY191767.1	Y	FJ966009.1	N	na
	Enoplometopus occidentalis	Y	KF828008.1	Y	AY383966.1	Y	AY383892.1	Y	AY383984.1	Y	KF828077.1
	Homarus americanus	Y	FJ581693.1	Y	AF235971.1	Y	EU882875.1	Y	DQ079788.1	Y	FJ174854.1
	Nexius glyptocercus	N	na	Y	EU874994.1	Y	EU874944.1	N	na	N	na
	Nephrops norvegicus	Y	JQ306231.1	Y	Y14812.1	Y	EU882880.1	Y	DQ079803.1	Y	DQ079692.1
	Nihonotrypaea japonica	Y	JX502970.1	N	na	Y	EU882953.1	N	na	N	na
	Procambarus clarkii	Y	AY701195.1	Y	AF436001.1	Y	KJ645835.1	Y	EU920970.1	Y	EU921067.1
Caridea	*Alvinocaris longirostris*	Y	AB222050.2	Y	KP215300.1	Y	KP215285.1	Y	KP215315.1	Y	KP215342.1
	Atyoida bisulcata	Y	DQ681257.1	Y	DQ079738.1	Y	EF489995.1	Y	DQ079774.1	Y	DQ079661.1
	Exopalaemon carinicauda	Y	HM180579.1	Y	HQ172894.1	Y	JF767296.1	N	na	Y	JN674393.1
	Hippolyte pleuracanthus	N	na	Y	AY743956.1	N	na	N	na	N	na
	Macrobrachium lanchesteri	Y	KP759427.1	Y	KP725754.1	Y	JF775468.1	Y	KP725930.1	Y	FM958106.1
	Palaemonetes vulgaris	Y	FJ581830.1	Y	AY743941.1	Y	JQ042300.1	Y	AY739184.1	Y	JN674372.1
Achelata	*Panulirus argus*	Y	GU476034.1	Y	U19182.1	Y	AF502947.1	Y	AY210833.1	N	na
	Panulirus ornatus	Y	JN391362.1	Y	JQ229942.1	Y	KF489896.1	Y	FJ966369.1	Y	KF828097.1
	Sagmariasus (Jasus) verreauxi	Y	FJ174952.1	Y	KF828103.1	Y	AF192874.1	Y	KF828236.1	Y	FJ174870.1
	Scyllarides latus	Y	JQ623990.1	Y	AF498669.1	Y	DQ377974.1	Y	FJ036959.1	Y	FJ174862.1
Stenopodidea	*Stenopus hispidus*	Y	KJ690260.1	Y	FJ943443.1	Y	FJ943437.1	Y	DQ079812.1	Y	FJ943457.1
Dendrobranchiata	*Penaeus chinensis*	Y	EU366231.1	Y	JQ936018.1	Y	AF245113.1	N	na	N	na
	Penaeus semisulcatus	Y	KF192814.1	Y	DQ079766.1	Y	GU573957.1	Y	DQ079809.1	Y	KM486611.1
	Orconectes virilis	Y	AF474365.1	Y	AF235965.1	Y	JN800549.1	Y	DQ079804.1	Y	JN800706.1
	Porcellana sayana	Y	JN800685.1	Y	JN800619.1	Y	JN800553.1	N	na	Y	KF182715.1
Amphipoda misc.	*Acanthogammarus victorii*	Y	FJ756298.1	Y	AY926817.1	Y	AY926695.1	N	na	N	na
	Brandtia latissima	Y	AY926654.1	Y	AY926758.1	Y	AY926698.1	N	na	N	na
	Cyphocaris sp.	Y	KP713952.1	N	na	Y	KP456133.1	N	na	N	na
	Diplacanthus brevispinus	Y	AY926651.1	Y	AY926754.1	Y	AY926694.1	N	na	N	na
	Echinogammarus ischnus	Y	FJ581620.1	N	na	N	na	Y	AY529070.1	N	na
	Echinogammarus trichiatus	Y	KM024679.1	N	na	N	na	Y	AY529072.1	N	na
	Echinogammarus marinus	Y	GQ341698.1	Y	KF478638.1	N	na	Y	KF478494.1	N	na
	Eulimnogammarus cyaneus	Y	FJ756324.1	Y	FJ756228.1	Y	FJ756275.1	N	na	N	na
	Eulimnogammarus cruentus	Y	AY926661.1	Y	AY926769.1	Y	AY926709.1	N	na	N	na
	Eulimnogammarus viridis	Y	AY926664.1	Y	AY926774.1	Y	AY926714.1	N	na	N	na
	Eulimnogammarus maacki	Y	AY926663.1	Y	AY926771.1	Y	AY926711.1	N	na	N	na
	Eulimnogammarus vittatus	Y	FJ756326.1	Y	AY926838.1	Y	AY926716.1	N	na	N	na
	Gammarus daiberi	Y	DQ300252.1	N	na	N	na	N	na	N	na
	Gammarus tigrinus	Y	FJ581678.1	Y	EF582932.1	N	na	Y	EF582994.1	N	na
	Gammarus aequicauda	Y	AY926667.1	Y	JF966119.1	Y	AY926718.1	Y	JF965637.1	N	na
	Gammarus lacustris	Y	GU066811.1	Y	EF582915.1	Y	AY926724.1	Y	AY529073.1	N	na
	Gammarus locusta	Y	GQ341768.1	Y	AF419222.1	Y	AY926726.1	Y	EF582967.1	N	na
	Gibberosus longimerus	N	na	Y	DQ378035.1	N	na	N	na	N	na
	Hakonboeckia strauchii	Y	AY926676.1	Y	AY926853.1	Y	AY926731.1	N	na	N	na
	Macrohectopus branickii	Y	FJ756332.1	Y	AY926854.1	Y	AY926732.1	N	na	N	na
	Monoporeia affinis	Y	KM068102.1	Y	AY926861.1	Y	AY926738.1	N	na	N	na
	Odontogammarus calcaratus	Y	FJ756341.1	Y	AY926862.1	Y	AY926739.1	N	na	N	na
	Onychogammarus pictoides	Y	AY926690.1	Y	AY926870.1	Y	AY926747.1	N	na	N	na
	Oxyacanthus flavus	Y	JN393847.1	N	na	N	na	N	na	N	na
	Pallasea cancellus	Y	AY926687.1	Y	AY926865.1	Y	FJ756295.1	N	na	N	na
	Plesiogammarus brevis	Y	AY926689.1	Y	AY926869.1	Y	AY926746.1	N	na	N	na

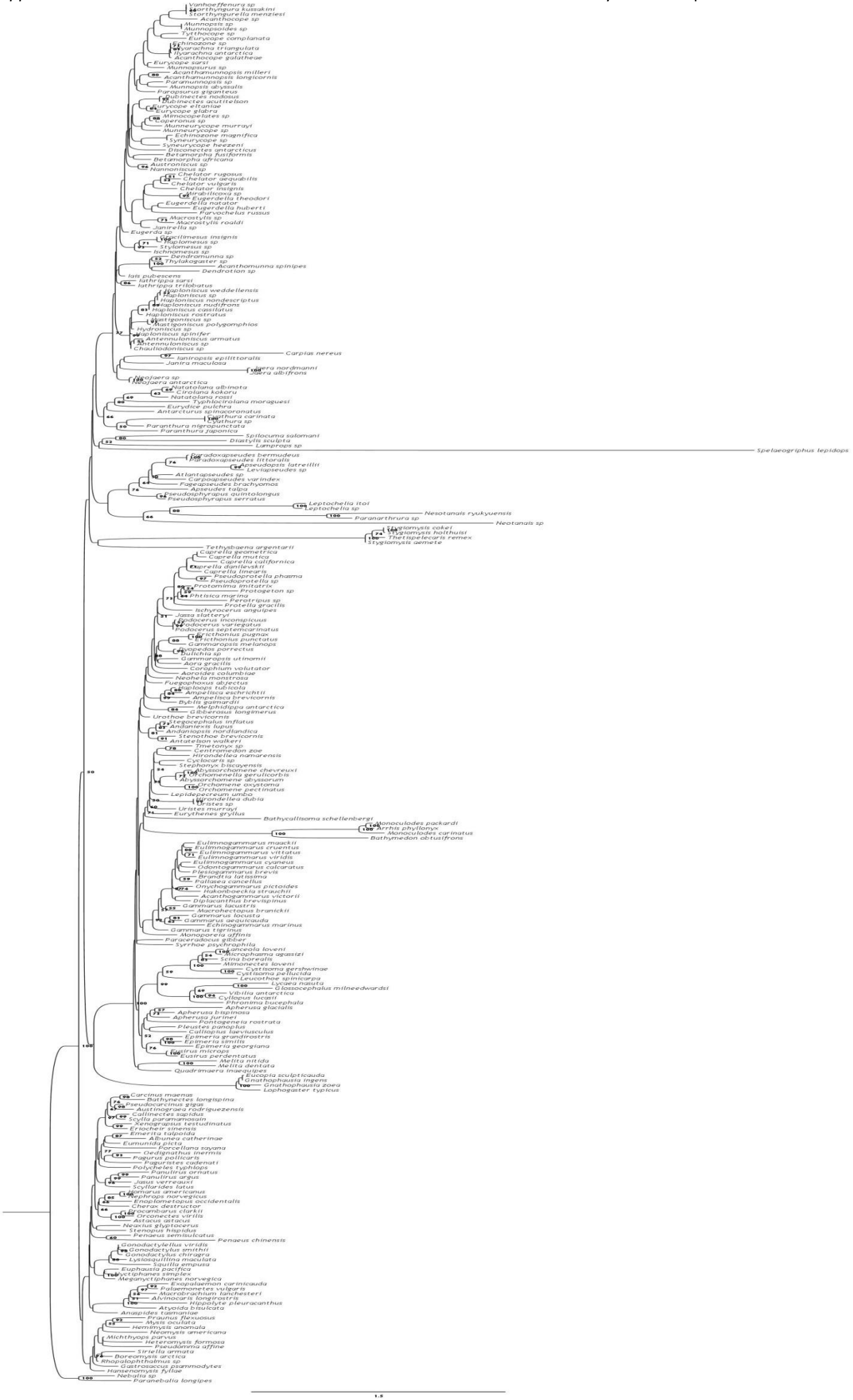
Appendix 7

Bayesian and Maximum Likelihood phylogenies

Figure A7.1: (Over). Bayesian phylogeny (50% majority rule consensus) depicting relationships between 285 malacostracan taxa, estimated using MrBayes v3.2.6 (Ronquist et al., 2012). Concatenated dataset of 18S SSU rDNA, 16S rDNA, cytochrome c oxidase 1 (COI) and Histone H3 sequence data (2536 base pairs) obtained from GenBank and analysed under the General Time Reversible Model (Tavaré, 1986) + invariable site proportion + gamma-distributed rate variation among sites (GTR+I+G) applied across two partitions: 1) 16S, COI, and 3rd codon position of H3, and 2) 18S and 1st and 2nd codon positions of H3. Posterior probabilities are illustrated at branch nodes.


Caprella linearis
Caprella danilevskii
Caprella geometrica
Caprella californica
Caprella mutica
Pseudoprotella phasma
Pseudoprotella sp
Protomima imitatrix
Prototeon sp
Phtisica marina
Perotripus sp
Protella gracilis
Ischyrocerus anguipes
Syrrhoe variegata
Podocerus inconspicuus
Podocerus septemcarinatus
Jassa slatteryi
Aora gracilis
Aoroides columbiae
Corophium volutator
Erichthonius punctatus
Erichthonius pugnax
Gammaropsis melanops
Dyopedos porrectus
Dulichia sp
Gammaropsis utinomii
Neohela monstrosa
Ampelisca eschrichtii
Haploops tubicola
Ampelisca brevicornis
Bybilis gaimardii
Stegocephalus inflatus
Andaniexis lupus
Andaniopsis nordlandica
Anonyx sp. wolkeri
Stenothoe brevicornis
Urothoe brevicornis
Melphidippa antarctica
Gibberosus longimerus
Paracerados gibber
Fuegiphoxus abjectus
Monoporeia affinis
Abyssorchomene chevreuxi
Orchomenella gerulicorbis
Abyssorchomene abyssorum
Orchomene pectinatus
Orchomene oxystoma
Stephonyx biscayensis
Cyclocaris sp
Centromedon zoe
Tmetonyx sp
Hirondellea namarensis
Lepidepecreum umbo
Iphimedia sp
Hirondellea dubia
Uristes murrayi
Eurythenes gryllus
Bathycallisoma schellenbergi
Arrhis phyllonyx
Monoculodes packardi
Monoculodes carinatus
Bathymedon obtusifrons
Eulimnogammarus vittatus
Eulimnogammarus viridis
Eulimnogammarus cruentus
Eulimnogammarus maackii
Pontogammarus brevis
Eulimnogammarus cyaneus
Odontogammarus calcaratus
Brandtia latissima
Pallasea cancellus
Diplacanthus brevispinus
Hakonboeckia strauchii
Onychogammarus pictoides
Acanthogammarus victorii
Gammarus locusta
Gammarus aequicauda
Echinogammarus marinus
Gammarus lacustris
Macrohectopus branickii
Gammarus tigrinus
Syrrhoe psychrophila
Lanceola loveni
Microphasma agassizi
Scina borealis
Mimonectes loveni
Cystisoma gershwinae
Cystisoma pellucida
Leucothoe spinicarpa
Vibilia antarctica
Cyllopus lucasii
Glossocephalus milneedwardsi
Lycaea nasuta
Phronima bucephala
Apherusa bispinosa
Apherusa glacialis
Apherusa jurinei
Pontogeneia rostrata
Pleustes panoplus
Calliopius laeviusculus
Epimeria grandirostris
Epimeria similis
Epimeria georgiana
Eusirus perdentatus
Eusirus microps
Melita dentata
Melita nitida
Quadrimaera inaequipes
Spelaeogriphus lepidops
Gnathophausia zoea
Gnathophausia sculpticauda
Gnathophausia ingens
Lophogaster typicus
Eurycope eltaniae
Eurycope glabra
Pubinectes acuttelson
Pubinectes nodosus
Coperonus sp
Mimocopelates sp
Munneurycope murrayi
Munneurycope sp
Vanhoeffenura sp
Ethythyngura kussakini
Storthythyngurella menziesi
Acanthocope sp
Munnopsoides sp
Eophinozone sp
Paragnathia triangulata
Paragnathia antarctica
Acanthocope galatheae
Paramunnopsis sp
Munnopsis abyssalis
Munnopsis sp
Syneurycope sp
Echinozone magnifica
Syneurycope heezeni
Acanthamunnopsis milleri
Acanthamunnopsis longicornis
Tytthocope sp
Eurycope complanata
Discopinectes antarcticus
Paropsurus giganteus
Munnopsurus sp
Eurycope sarsi
Austroniscus sp
Nannoniscus sp
Betamorpha fusiformis
Betamorpha africana
Phelator rugosus
Chelator aequabilis
Chelator vulgaris
Chelator insignis
Eugerdella huberti
Eugerdella natator
Parvochelus russus
Eugerdella theodori
Mirabilitoxa sp
Macrostylis sp
Macrostylis roaldi
Janirella sp
Eugerda sp
Haplonesus sp
Gracilinesus insignis
Stylonesus sp
Ischnonesus sp
Dendromunna sp
Thylakogaster sp
Acanthomunna spinipes
Dendrotion sp
Iais pubescens
Iathrippa sarsi
Iathrippa trilobatus
Haploniscus sp
Haploniscus weddellensis
Haploniscus nondescriptus
Haploniscus nudifrons
Haploniscus cassilatus
Haploniscus rostratus
Mastigoniscus sp
Mastigoniscus polygomphios
Hydroniscus sp
Antennuloniscus sp
Antennuloniscus armatus
Chauliodoniscus sp
Haploniscus spinifer
Ianiropsis epilittoralis
Carpias nereus
Jaera albifrons
Jaera nordmanni
Janira maculosa
Neojaera antarctica
Neojaera sp
Natatolana albinota
Cirolana kokoru
Natatolana rossi
Typhlocirolana moraguesi
Eurydice pulchra
Cyathura carinata
Cyathura sp
Paranthura nigropunctata
Paranthura japonica
Antarcturus spinacoronatus
Diastylis sculpta
Splocuma salomani
Lamprops sp
Paradoxapseudes bermudeus
Paradoxapseudes littoralis
Apseudopsis latreillii
Leviapseudes sp
Atlantapseudes sp
Carpoapseudes varindex
Apseudes talpa
Fageapseudes brachyomos
Pseudosphyrapus quintofongus
Pseudosphyrapus serratus
Leptochella sp
Leptochella itoi
Paranarthrura sp
Nesotanais ryukyuensis
Neotanais sp
Styloniysis holthuisi
Styloniysis cokei
Thetispelecaris remex
Styloniysis aemete
Tethysbaena argentarii
Emerita talpoida
Albunea catherinae
Eumunida picta
Porcellana sayana
Pagurus politicaris
Oedignathus inermis
Paguristes cadenati
Polycheles typhlops
Pseudocarcinus gigas
Austinograea rodriguezensis
Carcinus maenas
Bathynectes longispina
Callinectes sapidus
Scylla parramosain
Etrocher sinensis
Xenograpsus testudinatus
Panulirus ornatus
Panulirus argus
Jasus verreauxi
Scyllarides latus
Homarus americanus
Nephrops norvegicus
Enoplometopus occidentalis
Cherax destructor
Orconectes virilis
Procambarus clarkii
Astacus astacus
Stenopus hispidus
Negaxis glyptocerus
Acanthodactylus smithii
Lithodactylelius viridis
Lithodactylus chirgara
Squilla empusa
Lysiosquillina maculata
Meganyctiphanes norvegica
Euphausia pacifica
Nyctiphanes simplex
Palaemonetes vulgaris
Exopalaemon carinicauda
Macrobrachium lanchesteri
Alvinocaris longirostris
Hippolyte pleuracanthus
Atyoida bisulcata
Penaeus semisulcatus
Penaeus chinensis
Anaspides tasmaniae
Praunus flexuosus
Mysis oculata
Hemimysis anomala
Neomysis americana
Heteromysis formosa
Pseudomma affine
Michthyops parvus
Siriella armata
Boreomysis arctica
Hyperophthalmus sp
Gastrosaccus psammodytes
Hansenomysis fyliae
Paranebalia longipes
Nebalia sp
1.3

Figure A7.2: (Over). Maximum likelihood phylogeny depicting the relationships between 285 malacostracan taxa, estimated using RAxML v8.2.8 (Stamatakis, 2014). Concatenated dataset of 18S SSU rDNA, 16S rDNA, cytochrome c oxidase 1 (COI) and Histone H3 sequence data (2536 base pairs) obtained from GenBank and analysed under the General Time Reversible Model (Tavaré, 1986) + invariable site proportion + gamma-distributed rate variation among sites (GTR+I+G) applied across two partitions: 1) 16S, COI, and 3rd codon position of H3, and 2) 18S and 1st and 2nd codon positions of H3. Bootstrap support values (360 rapid bootstraps halted under autoMRE criterion) greater than 50 are illustrated at branch nodes.


Vanhoeffenura sp
Storthyngura kussakini
Storthyngurella menziesi
Acanthocope sp
Munnopsis sp
Munnopsoides sp
Tytthocope sp
Eurycope complanata
Echinozone sp
Hyarachna triangulata
Hyarachna antarctica
Acanthocope galatheae
Eurycope sarsi
Munnopsurus sp
Acanthamunnopsis milleri
Acanthamunnopsis longicornis
Paramunnopsis sp
Munnopsis abyssalis
Paropsurus giganteus
Dubinectes nodosus
Dubinectes acutitelson
Eurycope eltaniae
Eurycope glabra
Mimacopelates sp
Coperonus sp
Munneurycope murrayi
Munneurycope sp
Echinozone magnifica
Syneurycope sp
Syneurycope heezeni
Disconectes antarcticus
Betamorpha fusiformis
Betamorpha africana
Austronicus sp
Nannonicus sp
Chelator rugosus
Chelator aequabilis
Chelator vulgaris
Chelator insignis
Mirabilicoxa sp
Eugerdella theodori
Eugerdella natator
Eugerdella huberti
Parvochelus russus
Macrostylis sp
Macrostylis roaldi
Janirella sp
Eugerda sp
Paracallimesus insignis
Haplomesus sp
Stylomesus sp
Ischnomesus sp
Dendromunna sp
Thylakogaster sp
Acanthomunna spinipes
Dendrotion sp
Iais pubescens
Iathrippa sarsi
Iathrippa trilobatus
Haploniscus weddellensis
Haploniscus sp
Haploniscus nondescriptus
Haploniscus nudifrons
Haploniscus cassilatus
Haploniscus rostratus
Austrogonicus sp
Mastigoniscus polygomphios
Hydroniscus sp
Haploniscus spinifer
Antennuloniscus armatus
Antennuloniscus sp
Chauliodoniscus sp
Carpias nereus
Ianiropsis epilittoralis
Janira maculosa
Joera nordmanni
Joera albifrons
Mesojaera sp
Mesojaera antarctica
Natatolana albinata
Cirolana kokoru
Natatolana rossi
Typhlocirolana moraguesi
Eurydice pulchra
Antarcturus spinacornatus
Paranthura carinata
Paranthura sp
Paranthura nigropunctata
Paranthura japonica
Spilocuma salomani
Diastylis sculpta
Lamprops sp
Spelaeogriphus lepidops
Carradoxapseudes bermudeus
Paradoxapseudes littoralis
Apseudopsis latreillii
Leviapseudes sp
Atlantapseudes sp
Carpoapseudes varindex
Fageapseudes brachyomos
Apseudes talpa
Pseudosphyrapus quintolongus
Pseudosphyrapus serratus
Leptochelia itoi
Leptochelia sp
Nesotanais ryukyuensis
Paranarthrura sp
Neotanais sp
Stygiomysis cokei
Stygiomysis holthuisi
Metispelecaris remex
Stygiomysis semele
Tethysbaena argentarii
Caprella geometrica
Caprella mutica
Caprella californica
Caprella danilevskii
Caprella linearis
Pseudoprotella phasma
Pseudoprotella sp
Protomima imitatrix
Protogeton sp
Phtisica marina
Peratripus sp
Protella gracilis
Ischyrocerus anguipes
Jassa slatteryi
Podoceridae inconspicuus
Podocerus variegatus
Podocerus septemcarinatus
Erichthonius pugnax
Erichthonius punctatus
Gammaropsis melanops
Dulichia porrecta
Dulichia sp
Gammaropsis utinomii
Aora gracilis
Coraphium volutator
Aoroides columbiae
Neohela monstrosa
Fuegophoxus abjectus
Haploops tubicola
Ampelisca eschrichtii
Ampelisca brevicornis
Byblis gaimardii
Melphidippa antarctica
Gibberosus longimerus
Urothoe brevicornis
Stegocephalus inflatus
Andaniexis lupus
Andaniopsis nordlandica
Stenothoe brevicornis
Antatelson walkeri
Timetonyx sp
Centromedon zoe
Hirondellea namarensis
Cyclocaris sp
Stephonyx biscayensis
Abyssorchomene chevreuxi
Orchomenella gerulicorbis
Abyssorchomene abyssorum
Orchomene oxystoma
Orchomene pectinatus
Lepidepecreum umbo
Hirondellea dubia
Uristes sp
Uristes murrayi
Eurythenes gryllus
Bathycallisoma schellenbergi
Monoculodes packardi
Arrhis phyllonyx
Monoculodes carinatus
Bathymedon obtusifrons
Eulimnogammarus maackii
Eulimnogammarus cruentus
Eulimnogammarus vittatus
Eulimnogammarus viridis
Eulimnogammarus cyaneus
Odontogammarus calcaratus
Plesiogammarus brevis
Brandtia latissima
Pallasea cancellus
Onychogammarus pictoides
Hakarobaeckia strauchi
Acanthogammarus victorii
Digitocuspis brevispinus
Gammarus lacustris
Macrohectopus branickii
Gammarus locusta
Gammarus aequicauda
Echinogammarus marinus
Gammarus tigrinus
Monoporeia affinis
Paraceradocus gibber
Syrrhoe psychrophila
Lanceola loveni
Microphasma agassizi
Scina borealis
Mimonectes loveni
Cystisoma gershwinae
Cystisoma pellucida
Leucothoe spinicarpa
Lycaea nauta
Glossocephalus milneedwardsi
Vibilia antarctica
Cyllopus lucasii
Phronima bucephala
Apherusa glacialis
Apherusa bispinosa
Apherusa jurinei
Pontogeneia rostrata
Pleustes panoplus
Calliopius laeviusculus
Epimeria grandirostris
Epimeria similis
Epimeria georgiana
Eusirus microps
Eusirus perdentatus
Melita nitida
Melita dentata
Quadrimaera inaequipes
Eucopia sculpticauda
Gnathophausia ingens
Gnathophausia zoea
Lophogaster typicus
Carcinus maenas
Bathynectes longispina
Pseudocarcinus gigas
Austinograea rodriguezensis
Callinectes sapidus
Scylla paramamosain
Xenograpsus testudinatus
Eriocheir sinensis
Emerita talpoida
Albunea catherinae
Eumunida picta
Porcellana sayana
Oedignathus inermis
Pagurus pollicaris
Paguristes cadenati
Polycheles typhlops
Panulirus ornatus
Panulirus argus
Jasus verreauxi
Scyllarides latus
Homarus americanus
Nephrops norvegicus
Enoplometopus occidentalis
Cherax destructor
Procambarus clarkii
Oronectes virilis
Astacus astacus
Nexuus glyptocerus
Stenopus hispidus
Penaeus semisulcatus
Penaeus chinensis
Gonodactylellus viridis
Gonodactylus smithii
Gonodactylus chiragra
Lysiosquillina maculata
Squilla empusa
Euphausia pacifica
Nyctiphanes simplex
Meganyctiphanes norvegica
Exopalaemon carinicauda
Palaemonetes vulgaris
Macrobrachium lanchesteri
Alvinocaris longirostris
Hippolyte pleuracanthus
Atyoida bisulcata
Anaspides tasmaniae
Praunus flexuosus
Mysis oculata
Hemimysis anomala
Neomysis americana
Michthyops parvus
Heteromysis formosa
Pseudomma affine
Sirella armata
Boreomysis arctica
Rhopalophthalmus sp
Gastrosaccus psammodytes
Hansenomysis fyliae
Nebalia sp
Paranebalia longipes
1.5

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STAMATAKIS, A. 2014. RAxML version 8: a tool for phylogenetic analysis and post-analysis of large phylogenies. *Bioinformatics*.

TAVARÉ, S. 1986. Some probabilistic and statistical problems in the analysis of DNA sequences. *Lectures on mathematics in the life sciences,* 17**,** 57-86.

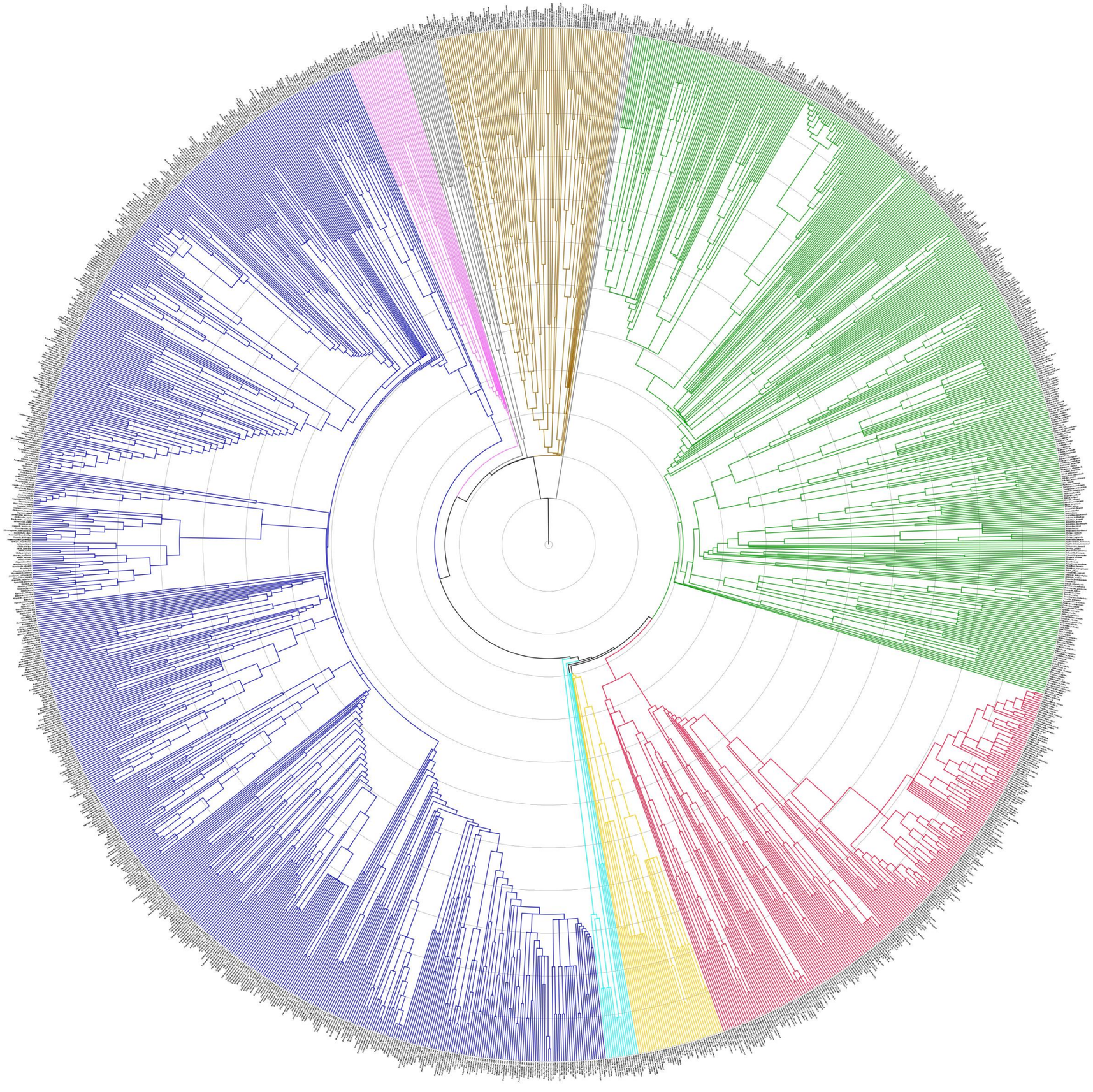
Appendix 8

Supertree of Peracarida

Figure A8.1: (Over). Supertree chronogram of Peracarida, including other malacostracan taxa as outgroups. 1487 terminal taxa. Produced from 129 source trees, including *de novo* maximum likelihood and Bayesian phylogenies, using MultiLevelSupertree 1.0 (Berry et al., 2013) run on Oxford's Advanced Research Computing facility. Root at 600 Ma, concentric circles representing 50 Ma steps to present (tips). Colours denote same taxonomic groups as in Figure 2.2.

Literature cited

BERRY, V., BININDA-EMONDS, O. R. P. & SEMPLE, C. 2013. Amalgamating source trees with different taxonomic levels. *Systematic Biology,* 62**,** 231-249.



Appendix 9

R code and Akaike Information Criterion (AIC) values for final Generalised Additive Models analysed in Chapter 3 and Chapter 4

Code written as appropriate for the function *gam* in the package 'mgcv 1.7-26' (Wood, 2013).

Chapter 3

Abundance: gam(Abundance ~ s(Current_short, fx = FALSE, k = -1) + s(Current_max, fx = FALSE, k = -1) + s(Chloro_surface, fx = FALSE, k = -1) + s(POC_surface, fx = FALSE, k = -1) + Total_carbon + s(Sand_percent, fx = FALSE, k = -1) + s(Sediment_psd, fx = FALSE, k = -1) + factor(Geology_simple) + s(Log_trawl_3km, fx = FALSE, k = -1) + s(BPI_125, fx = FALSE, k = -1) + factor(Collection_year), family=negbin(c(1,25), link = "log"), data = NEREIDA_diversity)
AIC = 2925.65.

Biomass: gam(Biomass ~ s(Temperature_short, fx = FALSE, k = -1) + s(Temperature_long, fx = FALSE, k = -1) + Chloro_surface + s(POC_surface, fx = FALSE, k = -1) + s(POC_depth, fx = FALSE, k = -1) + s(Total_carbon, fx = FALSE, k = -1) + s(Organic_carbon, fx = FALSE, k = -1) + s(Sediment_psd, fx = FALSE, k = -1) + s(BPI_125, fx = FALSE, k = -1) + s(Roughness_3, fx = FALSE, k = -1) + factor(Collection_year) + factor(Collection_month), family = Gamma (link = inverse), data = NEREIDA_diversity)
AIC = -1423.25

Richness: gam(Genera_richness ~ s(Current_short, fx = FALSE, k = -1) + s(Current_max, fx = FALSE, k = -1) + POC_surface + Total_carbon + s(Sand_percent, fx = FALSE, k = -1) + s(BPI_125, fx = FALSE, k = -1) + s(Roughness_3, fx = FALSE, k = -1) + factor(Collection_year), family = quasipoisson (link = identity), data = NEREIDA_diversity)
QAIC = 743.31

Rao Quadratic Entropy: gam(Quadratic_Entropy ~ s(Temperature_long, fx = FALSE, k = -1) + s(Current_max, fx = FALSE, k = -1) + s(Chloro_surface, fx = FALSE, k = -1) + POC_depth + s(Organic_carbon, fx = FALSE, k = -1) + s(Sand_percent, fx = FALSE, k = -1) + s(Log_trawl_3km, fx = FALSE, k = -1) + s(Rugosity_25, fx = FALSE, k = -1) + s(Roughness_3, fx = FALSE, k = -1) + factor(Collection_year) + factor(Collection_month) + factor(Crew), family = gaussian (link = identity), data = NEREIDA_diversity)

AIC = -334.75

Shannon Diversity: gam(Shannon_index ~ s(Temperature_long, fx = FALSE, k = -1) + Current_short + s(Current_max, fx = FALSE, k = -1) + Chloro_surface + POC_surface + POC_depth + s(Total_carbon, fx = FALSE, k = -1) + s(Organic_carbon, fx = FALSE, k = -1) + s(Sand_percent, fx = FALSE, k = -1) + s(Log_trawl_3km, fx = FALSE, k = -1) + s(Rugosity_25, fx = FALSE, k = -1) + factor(Collection_month) + factor(Crew), family = gaussian (link = identity), data = NEREIDA_diversity)

AIC = 476.38

'Phylogenetic Species Variability': gam(PSV ~ Temperature_short + s(Temperature_long, fx = FALSE, k = -1) + Current_max + s(Chloro_surface, fx = FALSE, k = -1) + s(Organic_carbon, fx = FALSE, k = -1) + s(Sand_percent, fx = FALSE, k = -1) + Sediment_psd + factor(Collection_year) + factor(Collection_month) + factor(Crew), family = gaussian (link = identity), data = NEREIDA_diversity)

AIC = -1014.22

'Functional Species Variability': gam(FSV ~ s(POC_depth, fx = FALSE, k = -1) + s(Total_carbon, fx = FALSE, k = -1) + Sand_percent + Log_trawl_3km + BPI_125 + s(Roughness_3, fx = FALSE, k = -1) + factor(Collection_month) + factor(Crew), family = Gamma (link = identity), data = NEREIDA_diversity)

AIC = -1041.90

'Phylogenetic Species Richness': gam(PSR ~ s(Temperature_long, fx = FALSE, k = -1) + s(Current_short, fx = FALSE, k = -1) + s(Current_max, fx = FALSE, k = -1) + s(POC_surface, fx = FALSE, k = -1) + Total_carbon + s(Sand_percent, fx = FALSE, k = -1) + factor(Geology_simple) + s(Rugosity_25, fx = FALSE, k = -1) + factor(Collection_year) + factor(Crew), family = Gamma (link = identity), data = NEREIDA_diversity)

AIC = 1862.77

'Functional Species Richness': gam(FSR ~ s(Current_short, fx = FALSE, k = -1) + s(Current_max, fx = FALSE, k = -1) + POC_surface + s(POC_depth, fx = FALSE, k = -1) + s(Total_carbon, fx = FALSE, k = -1) + s(Organic_carbon, fx = FALSE, k = -1) + s(Sand_percent, fx = FALSE, k = -1) + s(Rugosity_25, fx = FALSE, k = -1) + factor(Collection_year) + factor(Crew), family = Gamma (link = identity), data = NEREIDA_diversity)

AIC = 1665.05

'Phylogenetic Species Evenness': gam(PSE ~ s(Chloro_surface, fx = FALSE, k = -1) + POC_depth + Total_carbon + s(Organic_carbon, fx = FALSE, k = -1) + s(Sand_percent, fx = FALSE, k = -1) + s(Log_trawl_3km, fx = FALSE, k = -1) + s(Rugosity_25, fx = FALSE, k = -1) + s(Roughness_3, fx = FALSE, k = -1) + factor(Collection_year) + factor(Collection_month) + factor(Crew), family = gaussian (link = identity), data = NEREIDA_diversity)

AIC = -372.04

'Functional Species Evenness': gam(FSE ~ Chloro_surface + s(POC_surface, fx = FALSE, k = -1) + s(POC_depth, fx = FALSE, k = -1) + s(Total_carbon, fx = FALSE, k = -1) + s(Organic_carbon, fx = FALSE, k = -1) + s(Sand_percent, fx = FALSE, k = -1) + s(Log_trawl_3km, fx = FALSE, k = -1) + s(BPI_125, fx = FALSE, k = -1) + s(Rugosity_25, fx = FALSE, k = -1) + s(Roughness_3, fx = FALSE, k = -1) + factor(Collection_year) + factor(Collection_month) + factor(Crew), family = gaussian (link = identity), data = NEREIDA_diversity)

AIC = -417.55

Chapter 4

Abundance: gam(Abundance ~ s(Downie_sponge, fx = FALSE, k = -1) + sqrt_Kenchington_sponge + s(sqrt_Kenchington_sea_pen, fx = FALSE, k = -1) + s(sqrt_Kenchington_large_gorgonian, fx = FALSE, k = -1) + factor(spicules) + factor(closed_area) + s(latitude, fx = FALSE, k = -1), family=negbin(c(1,100), link = "log"), data = Biogenic_variables)

AIC = 2919.37

Biomass: gam(Biomass ~ s(Downie_sponge, fx = FALSE, k = -1) + s(Downie_sea_pen, fx = FALSE, k = -1) + sqrt_Kenchington_sponge + s(sqrt_Kenchington_sea_pen, fx = FALSE, k = -1) + factor(cruise_crew) + factor(spicules) + factor(closed_area) + s(latitude, fx = FALSE, k = -1), family= Gamma (link = inverse), data = Biogenic_variables)

AIC = -1384.94

Richness: gam(Genera_richness ~ s(Downie_sponge, fx = FALSE, k = -1) + sqrt_Kenchington_sponge + s(sqrt_Kenchington_sea_pen, fx = FALSE, k = -1) + factor(spicules) + s(latitude, fx = FALSE, k = -1), family= quasipoisson (link = identity), data = Biogenic_Variables)

QAIC = 733.58

Rao Quadratic Entropy: gam(Quadratic_Entropy ~ s(Downie_sponge, fx = FALSE, k = -1) + s(sqrt_Kenchington_sponge, fx = FALSE, k = -1) + sqrt_Kenchington_sea_pen + factor(spicules) + factor(closed_area), family= gaussian (link = identity), data = Biogenic_Variables)

AIC = -290.65

Shannon Diversity: gam(Shannon_index ~ s(Downie_sponge, fx = FALSE, k = -1) + s(sqrt_Kenchington_sponge, fx = FALSE, k = -1) + factor(spicules), family= gaussian (link = identity), data = Biogenic_Variables)

AIC = 495.46

'Phylogenetic Species Variability': gam(PSV ~ s(Downie_sponge, fx = FALSE, k = -1) + s(Downie_large_gorgonian, fx = FALSE, k = -1) + factor(cruise_crew) + s(latitude, fx = FALSE, k = -1), family= gaussian (link = identity), data = Biogenic_Variables)

AIC = -990.35

'Functional Species Variability': gam(FSV ~ Downie_sponge + s(Downie_sea_pen, fx = FALSE, k = -1) + sqrt_Kenchington_sea_pen + factor(cruise_crew) + factor(spicules) + s(latitude, fx = FALSE, k = -1), family= Gamma (link = identity), data = Biogenic_Variables)

AIC = -1019.71

'Phylogenetic Species Richness': gam(PSR ~ s(Downie_sponge, fx = FALSE, k = -1) + sqrt_Kenchington_sponge + s(sqrt_Kenchington_sea_pen, fx = FALSE, k = -1) + factor(spicules) + s(latitude, fx = FALSE, k = -1), family= Gamma (link = log), data = Biogenic_Variables)

AIC = 1847.93

'Functional Species Richness': gam(FSR ~ s(Downie_sponge, fx = FALSE, k = -1) + sqrt_Kenchington_sponge + s(sqrt_Kenchington_sea_pen, fx = FALSE, k = -1) + factor(spicules) + s(latitude, fx = FALSE, k = -1), family= Gamma (link = log), data = Biogenic_Variables)

AIC = 1656.48

'Phylogenetic Species Evenness': gam(PSE ~ Downie_sponge + s(sqrt_Kenchington_sponge, fx = FALSE, k = -1) + factor(closed_area) + s(latitude, fx = FALSE, k = -1), family= gaussian (link = identity), data = Biogenic_Variables)

AIC = -329.92

'Functional Species Evenness': gam(FSE ~ s(Downie_sponge, fx = FALSE, k = -1) + s(sqrt_Kenchington_sponge, fx = FALSE, k = -1) + sqrt_Kenchington_sea_pen + factor(cruise_crew) + factor(closed_area) + s(latitude, fx = FALSE, k = -1), family= gaussian (link = identity), data = Biogenic_Variables)

AIC = -362.91

Literature cited

WOOD, S. N. 2013. Mixed GAM computation vehicle with GCV/AIC/REML smoothness estimation. 1.7-26 ed. CRAN repository.