

THE MACROBENTHIC ECOLOGY OF THE STRAITS OF MAGELLAN AND THE BEAGLE CHANNEL

ECOLOGÍA MACROBENTÓNICA DEL ESTRECHO DE MAGALLANES Y CANAL BEAGLE

Sven Thatje¹ & Alastair Brown

ABSTRACT

The macrobenthic community of the Straits of Magellan and the Beagle Channel was investigated using a Reineck box corer at 22 stations during the Chilean “Cimar Fiordo 3” expedition in 1997. A total of 173 taxa represented by 2188 individuals were identified and are reported for the investigated area. Clear exponential relationships with depth were revealed by analysis of abundance, biomass, species richness, and evenness. These patterns coincide with posited theories of pelagic-benthic coupling and the source-sink hypothesis of colonisation-extinction dynamics. Polychaeta dominated macrobenthic community abundance and biomass, 67% and 38% respectively, therefore consideration of biogeographic affinities concentrated on this taxon. 13 species of polychaetes observed in the study area co-occur in Antarctica suggesting biogeographic or evolutionary affinities between these adjacent regions.

Key words: biogeography, diversity, polychaete, Antarctica, Subantarctic

RESUMEN

En octubre 1997 se investigaron los ensamblajes macrozoobentónicos del estrecho de Magallanes y el canal Beagle con un “Reineck Box corer” en 22 estaciones durante la campaña chilena “Cimar Fiordo 3”. Se identificó un total de 173 taxones representados por 2188 especímenes en el área de investigación. Se detectó una relación exponencial de profundidad dada por el análisis de abundancia, riqueza de especies y uniformidad. Estos patrones coinciden con teorías establecidas de flujos bento-pelágicos y las hipótesis de “*source-sink*”. Los poliquetos dominan los ensamblajes macrobentónicos en abundancia y biomasa en 67% y 38% respectivamente, y por tanto el análisis biogeográfico presentado se basa en ellos. Trece de las especies de poliquetos identificados en el área investigada se conocen también por estar distribuidos en Antártica. Proponemos entonces afinidades biogeográficas y evolutivas entre ambas regiones.

Palabras clave: biogeografía, diversidad, poliqueto, Antártica, Subantártica

¹ National Oceanography Centre, Southampton, School of Ocean and Earth Science, University of Southampton, European Way, Southampton, SO14 3ZH, United Kingdom. svth@noc.soton.ac.uk

INTRODUCTION

The Magellan region is geologically young. Although glaciation in the biogeographic Magellan region (*sensu* Camus 2001) did not reach the extent experienced by Antarctica, an extensive ice cap from 35 to 55°S did exist during the Late Glacial Maximum (LGM), approximately 21 ky ago (Benn & Clapperton 2000). The processes of gradual warming following the LGM explain much of the modern biogeographic pattern in the Magellan region (Arntz *et al.* 2005). During the glacial period sea level was between *ca.* 125 and 135m lower than it is today (Fairbanks 1989, Yokoyama *et al.* 2000). The earliest incursions of seawater into the Straits of Magellan occurred by the end of deglaciation around 8 ky ago. It has been proposed that the Straits did not fully open until approximately 7 ky ago (McCulloch & Davies 2001). All present species in Magellan waters therefore recolonised this region from adjacent Atlantic and Pacific areas (Montiel *et al.* 2005a). The area is a meeting place for water bodies from the Atlantic and Pacific, and is also partially influenced by the Southern Ocean (Panella *et al.* 1991).

The modern hydrologic regime in the Straits of Magellan and the Beagle Channel reflects the complex geomorphology and topography, and is highly variable (Brambati *et al.* 1991, Dávila *et al.* 2002). The regime is characterised by strong freshwater input from the runoff of high precipitation, sufficient to establish a strong and shallow pycnocline, mean temperature of 7-9°C and salinity of 30 (Artegianni & Pachini 1991, Dávila *et al.* 2002). High sediment loads are associated with these inputs in regions of glacial action (Brambati *et al.* 1991). The regime varies significantly between narrows and basins, *e.g.* currents of 1 m s⁻¹ on the Atlantic side of the Straits decrease to 0.2 m s⁻¹ in the Paso Ancho (Michelato *et al.* 1991). This results in characterisation of these zones by coarse and fine sediments respectively (Brambati *et al.* 1991). Additionally, a wide depth range exists with depths reaching 1200 m at the western gateway to the Straits (Antezana *et al.* 1992). These factors have been identified as significant in structuring Magellan invertebrate communities (Montiel *et al.* 2005b, Moreno *et al.* 2008).

The aim of this study was to develop the existing characterisation of the macrobenthic ecology

Table 1. Data for sample stations in the Straits of Magellan and the Beagle Channel from the Chilean "Cimar Fiordo 3" expedition in October 1997. For station map see Thatje & Mutschke (1999a).

Station	Date	Latitude (S)	Longitude (W)	Depth (m)	Location
2	22/10	52.32	69.20	40	E. Magallanes (Posesión)
5	22/10	53.06	70.55	51	E. Magallanes (Paso Ancho)
6	22/10	53.28	70.69	195	E. Magallanes (Paso Ancho)
8	14/10	53.86	71.53	270	E. Magallanes (Bahía Snug)
12	12/10	52.98	73.81	571	E. Magallanes (C. Tamar)
13	11/10	52.78	74.20	192	E. Magallanes (Islas Parker)
15	11/10	52.74	74.93	91	E. Magallanes (B. Occidental)
16	11/10	53.14	73.08	411	G. Xaultegua
24	13/10	53.36	71.79	130	E. Silva Palma
29	14/10	54.46	70.43	162.5	Seno Agostini
30	14/10	54.41	71.03	102	Canal Magdalena
41	16/10	54.90	67.57	35	Canal Beagle (Puerto Williams)
42	17/10	55.19	66.77	45	Paso Richmond (Isla Lennox)
49	18/10	55.10	68.25	246	Bahía Nassau (S. Ponsonby)
50	18/10	55.12	68.82	65	Seno Ponsonby
51	20/10	54.58	69.33	173	Bahía Parry
52	20/10	54.41	69.19	112	Seno Almirantazgo
53	20/10	54.21	69.86	290	Seno Almirantazgo
54	20/10	53.88	70.26	290	Canal Whiteside
55	20/10	53.61	70.27	272	Bahía Inútil
56	20/10	53.54	69.91	62	Bahía Inútil
67	16/10	53.46	69.51	45	Bahía Inútil

of the Magellan region by examining a high-level taxonomic abundance and biomass data for over the entire region, following a diversity approach. Due to the low number of replicates at each sampling station community analysis was considered inappropriate. Biogeographic affinities of the polychaetes, found as the dominant taxon in the Magellan region, with the Antarctic are discussed.

MATERIAL AND METHODS

Data collection

Sampling was undertaken on the Chilean "Cimar Fiordo 3" expedition in 1997, from AGOR Vidal Gormaz (Thatje & Mutschke 1999a). A total of 22 stations were sampled: 18 stations located within the Strait of Magellan, adjacent channels and fjords, and 4 stations located within the eastern part of the Beagle Channel, adjacent channels and fjords (Table 1). Depths of sample stations ranged between 35 and 571m. Sampling was performed using a Reineck box corer (core area 0.017 m²), and 2 or 3 cores were taken at each location. Samples were sieved through 0.5mm mesh and preserved in 4% hexamethylenetetramine-buffered formalin prior to sorting. Animals with calcareous shells were transferred to 70% ethanol following fixation.

Univariate analysis

Species-level identification was conducted by specialists and abundance (ind. m⁻²) was determined from pooled cores per station. Colonial hydrozoan and bryozoan were only considered as present (1 ind.

m⁻²) or absent for calculation of abundance values. Abundance data for station 5 were not preserved. Other univariate analyses were calculated from all remaining species-level abundance data using Margalef's *d* for species richness, Pielou's *J* for evenness and the Shannon-Wiener *H'* (based on log_e) index for diversity. Analysis was implemented using the DIVERSE routine in PRIMER v6 (Plymouth Routines in Multivariate Ecological Research; Clarke and Gorley 2006).

RESULTS

A total of 173 species/morphotypes were identified across all taxa (Table 2). Low-level taxonomic analysis indicated that Polychaeta dominated abundance (67%), followed by Arthropoda (17%), Mollusca (5%) and Echinodermata (4%) (Fig. 1a). Polychaeta also dominated biomass (38%), followed by Echinodermata (23%), Arthropoda (21%) and Mollusca (10%) (Fig. 1b). Average abundance of the Magellan region was 2179 ind. m⁻² (range 313 - 10168 ind. m⁻²), and average biomass was 36.8 g ww m⁻² (range 2.4 - 142.3 g ww m⁻²). Polychaete abundance was dominated by the families Cirratulidae (271 ind. m⁻²), Ampharetidae (262 ind. m⁻²), Spionidae (227 ind. m⁻²) and Paraonidae (157 ind. m⁻²) with the most speciose families the Spionidae (6), Lumbrineridae (5), Nereididae (4) and Orbiniidae (4).

Abundance, biomass and species richness all decreased exponentially with depth (Fig. 2a, b and c). Linear regression analysis of natural log transformed abundance and biomass data over log transformed depth indicated that both measures co-varied significantly with natural log transformed

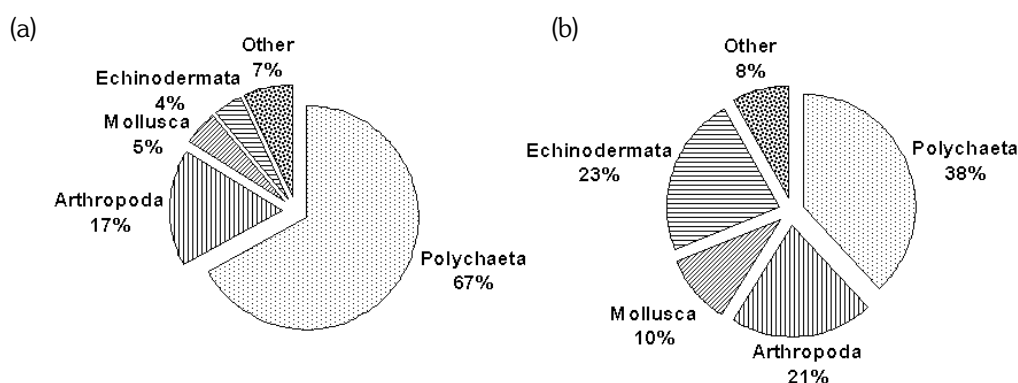


Fig. 1. Relative proportions of taxa **a** in macrobenthic abundance and **b** in macrobenthic biomass in samples from the Straits of Magellan and the Beagle Channel taken during the Chilean "Cimar Fiordo 3" expedition in 1997.

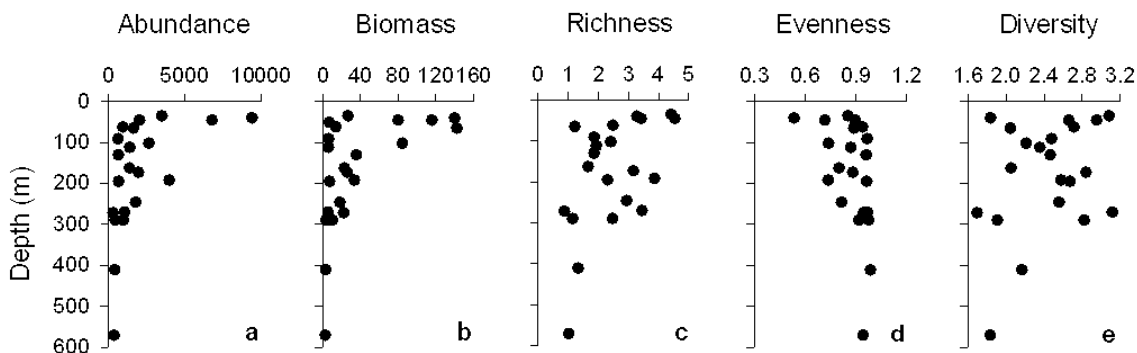


Fig. 2. Univariate analysis of **a** abundance, **b** biomass, **c** species richness (Margalef's d), **d** evenness (Pielou's J) and **e** diversity (Shannon Wiener H' based on \log_e) for samples from the Straits of Magellan and the Beagle Channel taken during the Chilean "Cimar Fiordo III" expedition in 1997).

depth ($F_{1,19} = 17.69$, $P < 0.05$, and $F_{1,20} = 14.37$ $P < 0.05$, respectively). Linear regression analysis of species richness data over natural log transformed depth indicated that species richness co-varied significantly with depth ($F_{1,19} = 7.92$, $P < 0.05$). These analyses yielded r^2 values that indicated that the natural log depth model explained 48.2% of the variation in abundance and 41.8% of the variation in biomass and that the natural log depth model explained 29.4% of the variation in richness. Evenness increased exponentially with depth (Fig. 2d), and linear regression analysis of evenness data over natural log transformed depth indicated significant co-variation ($F_{1,19} = 6.13$, $P < 0.05$) with the natural log depth model explaining 24.4% of the variation in evenness. No trend was observed in diversity with depth (Fig. 2e) and linear regression analysis of diversity data over natural log transformed depth indicated that there was no significant co-variation ($F_{1,19} = 1.55$, $P > 0.05$). Visual inspection of the residuals for all linear regressions showed approximately homogenous variances and minimal deviation from normality, confirming validity of the test.

DISCUSSION

Grab sampling has been shown to underestimate epibenthic species that are large, highly motile or rare (Dahm 1996). For example, although large decapod species such as *Peltarion spinosulum* or motile species such as *Munida subrugosa* are known to occur in large numbers in the Magellan region (Gorny 1999, Gutt *et al.* 1999) they were not found in the present

study. A variety of grab cores using the same mechanical principles constitute the dominant benthic sampling method reported for this and comparable regions (Gerdes *et al.* 1992, Brey & Gerdes 1999, Gerdes & Montiel 1999, Thatje & Mutschke 1999b, Piepenburg *et al.* 2002) and are therefore the most appropriate method to facilitate contribution to, and comparison with, the existing literature.

This study aimed to assess the macrobenthic ecology through analysis of a large-scale high-level taxonomic abundance and biomass data set. Community analysis was not envisaged for this study with limited sampling undertaken due to time and weather constraints. Despite the low number of stations sampled for the overall area under investigation, clear patterns were established by the diversity analysis. Both the range of abundance and biomass and the means calculated for these parameters strongly resemble other values reported for the Straits of Magellan and the Beagle Channel, and for Antarctica (see Table 2 in Arntz *et al.* 2005). This is consistent with observations on the absence of latitudinal trends in this region (Brey & Gerdes 1999, Gerdes & Montiel 1999, Piepenburg *et al.* 2002). Similarly, the observed decrease in abundance and biomass with depth is a common pattern and has been reported from numerous other regions, *e.g.* for the high Antarctic Weddell and Lazarev Seas (Brey & Gerdes 1998). Pelagic-benthic coupling has been suggested as the dominant factor causing these patterns (Cattaneo-Vietti *et al.* 1999), with the flux of organic matter from the pelagic to the benthic being the major factor structuring these communities.

Decreasing species richness and increasing evenness with depth have also been reported from numerous regions, e.g. for the Gulf of Mexico (Pérez-Mendoza *et al.* 2003). Analysis of these patterns in the polychaetes of the Pacific coast of South America suggests that a source-sink hypothesis of colonisation-extinction dynamics, where shallower “sources” maintain deeper “sinks”, provides a conceptual and methodological framework that explains patterns of diversity (Moreno 2008). The absence of any correlating pattern in diversity in the study region is consistent with other studies (Gutt *et al.* 1999) and may result from variation in hydrologic regime and sedimentation processes between stations and/or the low number of replicates.

Moreno *et al.* (2006) identified a pattern of decreasing endemism in benthic polychaete species of the Magellan region with increasing latitude. Although species endemic to the Straits of Magellan and the Beagle Channel are therefore less likely to have been observed, the absence of available biogeographic information in the literature prevented an assessment of endemism within the study region. Interestingly, a total of 13 of the 78 polychaete species/morphotypes identified in the samples from this study are known from the Antarctic shelf (e.g. *Phylofelix*, *Leanira quatrefagesi*, *Nereis eugeniae*, *Glycinde armata*, *Idanthyrsus armatus*). Clear distribution patterns have been identified between polychaete communities of the Magellan region and Weddell Sea shelves (Montiel *et al.* 2005b). Polychaete reproductive strategy commonly involves a meroplanktonic larval stage (Giangrande 1997) and Montiel *et al.* (2005a) suggest that the dispersal of Antarctic species through larval transport in easterly circumpolar currents plays an important part determining in the existing distribution patterns of the fauna around the Magellan region (for discussion see also Thatje & Fuentes 2003). This is supported by a greater proportion of species with high Antarctic affinities to the Pacific coast compared to the relatively small proportion of species with affinities to the Atlantic side (Montiel *et al.* 2005a). The durations of larval stages of polychaete species can be extremely short but at lower temperatures have been reported at several months (Bhaud 1998). Reduced densities of larvae observed in the Antarctic and the less obvious seasonality of these larvae may be attributable to further protracted larval development resulting

from low temperatures (Stanwell-Smith *et al.* 1997). However, the key criteria for establishment of a successful population in a new habitat are recruitment conditions and the substrate choice of settling larvae (Raguá-Gil *et al.* 2004), and therefore the spreading potential of polychaete larvae does not necessarily predict species' adult distribution (Bhaud 1998). Ultimately, given the glacial history of the region, the presence of common species on both sides of the Drake Passage strongly suggests that dispersion is an important process for faunal exchange between the Magellan region and Antarctica, and therefore that for many species the polar front does not necessarily function as a strict barrier (Thatje & Fuentes 2003, Montiel *et al.* 2005a).

The macrobenthic ecology identified in this study provides evidence of patterns in the Magellan region that have been reported for numerous other regions, additionally indicating exchange processes by which this region may have been recolonised following glaciation and which may still occur. This is a first study of high taxonomic level analysis providing information that may be of use in future biogeographic studies. Further high resolution sampling is required to develop community analysis of the region and elucidate Magellan-Antarctic connections.

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