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Biogeography of the Lord Howe Rise region, Tasman Sea

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ABSTRACT

The two principal aims of this study were to synthesise physical and biological information to characterise the Lord Howe Rise (LHR) region and to use recent survey collections of benthic invertebrates (mostly large benthic epifauna) to describe its biogeography at regional and sub-regional scales. The LHR region is large (1.95 million km^2), spans tropical and cool temperate latitudes (18.4 to 40.3°S), and is influenced by several ocean currents, notably the East Australian Current and the Tasman Front. Our analyses revealed that biological patterns were related to two groups of geomorphic morphotypes found in this topographically complex region: subdued bathymetric features (expansive soft sediment basins and plateaus) and raised bathymetric features (scattered seamounts, guyots, knolls, and pinnacles). Raised bathymetric features in the LHR region were more likely to support richer and more abundant epifaunal assemblages dominated by suspension feeding invertebrates on hard substrata compared to subdued features which were dominated by infauna and detritivores in soft sediments. However, this trend does not apply to all raised bathymetric features (e.g., Gifford Guyot), with variations in depth, elevation, latitude, and particularly substrata affected the composition of biological assemblages. In addition, some demersal fishes, ophiuroids, and other benthic invertebrates showed distinct north-south delineations that coincide with the influence of the Tasman Front and thermal gradients. While the lack of spatially- and temporally- replicated data in the region limits our interpretation of survey data, paleo-environmental processes and examples from other regions provide some indication of how dispersal influences migration, speciation, and endemism in the LHR region. Although our current knowledge is limited, it is hoped that this review will help inform future studies in the area, as equitable examination of biological, geological, and oceanographic characteristics will facilitate future assessments of LHR biogeography and permit the inclusion of this region in biogeographic studies with a national or global context.

1. Introduction

Biogeography is the study of the geographic distribution of organisms and can be applied at global (Vierros et al., 2009), regional (Poore et al., 1994), and local (Martin and Nellen, 2004) scales. A regional scale investigation of biogeographic patterns incorporates habitat information from geological, oceanographic, and biological sources that exist at multiple spatial scales. For example, understanding differences in benthic assemblages between raised and subdued bathymetric features relies on knowledge of broad-scale depth-related variables and fine-scale seafloor substrata as well as on simple classifications of geomorphic features (Levin et al., 2001; Williams et al., 2006; Wilson and Kaufmann, 1987). Studies of biodiversity may focus on a particular feature, with seamounts recently receiving much attention (Clark et al., 2010; Froese and Sampang, 2004; Pusch et al., 2004; Schlacher et al., 2003), while comparisons between seamounts and adjacent features are less commonly addressed. This is the case to some extent in the Lord Howe Rise region, making a comprehensive synthesis of biogeography at a regional scale challenging.

The Lord Howe Rise (LHR) runs along the eastern margin of Australia, extending approximately 2800 km from the central Coral Sea in the tropical north (18.4° S) to the Challenger Plateau in the temperate south (40.3°S) (Standard, 1961; Van der Linden, 1970) (Fig. 1). Adjacent bathymetric features include Bellona Plateau, Kenn Plateau, Middleton Basin and Monowai Sea Valley lying to the west of the LHR, and New Caledonia Basin and Fairway Basin lying to the east of LHR. In addition, the Lord Howe seamount chain forms a series of volcanic edifices that sit on the LHR and extend

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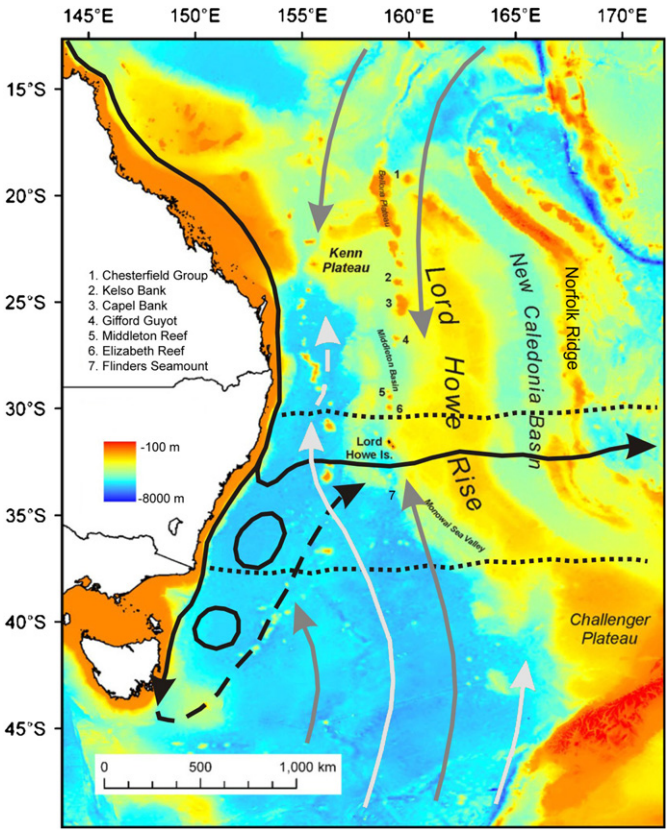

Fig. 1. The Lord Howe Rise with adjacent major bathymetric features and ocean circulation. Solid black lines represent circulation of surface waters (principally the East Australian Current); dark grey lines represent circulation of intermediate waters, and light grey lines represent circulation of deep waters in the study area. Dotted lines indicate the northern and southern limits of the seasonally migrating Tasman Front.

~1400 km from the Chesterfield Group in the north to Flinders Seamount in the south (Fig. 1). All references to the LHR region in this review include the LHR and bathymetric features mentioned above unless otherwise noted, spanning a 1.95 million km^2 area. Water depths across the LHR region range from 1000 m on the crest of Lord Howe Rise to 3500 m in the New Caledonia Basin. Larger seamounts along this chain rise to within 200-400 m of sea level (e.g., Gifford Guyot, Chesterfield Group), while others form islands, reefs and banks at or near sea level (e.g., Middleton Reef, Elizabeth Reef, Kelso Bank, Capel Bank).

The LHR region is dominated by subdued bathymetric features such as plateaus and basins but has high regional habitat complexity due to the occurrence of raised bathymetric features such as volcanic cones and seamounts. Seamounts are considered biologically important in relation to adjacent basins and plains despite covering approximately only 1% of the entire LHR region according to the geological definition adapted in Heap and Harris (2008) (Fig. 1). Despite the LHR's potential ecological importance, value for commercial fishing, and prospectivity for oil and gas extraction (Heap et al., 2009; Morato and Pauly, 2004), there have been few efforts to obtain biological samples from most areas of the Lord Howe Rise, likely due to its remote location (exceptions are accessible shallow sites such as Lord Howe Island, Middleton and Elizabeth reefs). As a result, the biogeography of the LHR is little studied compared to other parts of Australia and New Zealand (e.g., Glasby and Alvarez, 1999; Poore et al., 1994).

As a supporting review to a collection of research papers focused on the Lord Howe Rise, this study aims to synthesise physical and biological information to characterise the Lord Howe Rise (LHR) region and to analyse recent survey data and describe the LHR biogeography at regional and sub-regional scales.

With the exception of shallow reefs and seamount crests, much of our information comes from two recent surveys: The NORFANZ survey primarily collected samples of large invertebrate epifauna and fishes from seamounts, slopes and plateaus in both the LHR region and the Norfolk Ridge (Clark and Roberts, 2003, Williams et al., 2006). These data are empirically examined elsewhere in this volume (Williams et al., 2011; Zintzen et al., 2011). The Geoscience Australia TAN0713 survey focused on part of the western flank of northern Lord Howe Rise and the Gifford Guyot and resulted in detailed bathymetry and backscatter as well as underwater video and physical and biological samples (Heap et al., 2009), some of which is examined elsewhere in this volume (Anderson et al., 2011; Nichol et al., 2011; Radke et al., 2011).

2. Geology & oceanography of the LHR region

2.1. Geology & sediments

The LHR region has a range of hard and soft substrates (Nichol et al., 2011) but is dominated by soft sediments. The TAN0713 survey mapped approximately 25,500 km^2 of the western flank of the LHR and 1365 km^2 across the Gifford Guyot (~ 1% of the total area of the LHR region). Approximately 0.1% of the LHR seafloor is classed as hard substrata based on the combined area of ~31 km^2 for 16 volcanic peaks. Similarly, the Gifford Guyot has continuous sediment deposits on its summit but variable cover on its steep flanks. Underwater images from the same survey revealed that on the flank of the LHR ridges, valleys, plains and holes, as defined by Heap and Harris (2008), all have continuous unconsolidated sediment cover, with expansive flat areas of soft-sediments occurring in 84% of video characterisations and hard substrata limited to isolated areas of volcanic outcrop (12%) and rarer occurrences of mixed habitats characterised by gravels or boulders (4%). Raised bathymetric features, including Gifford Guyot, smaller peaks and steeper ridges were generally characterised by discontinuous sediment punctuated by rocky outcrops, boulders, and cobbles (Heap et al., 2009; Nichol et al., 2011), in contrast to raised features with hard substrata elsewhere in the LHR (Williams et al., 2006) and in nearby regions (Rowden et al., 2004). However, no clear relationship was detected between sediment texture and geomorphic features across the survey area (Nichol et al., 2011).

Seafloor sediments in the deeper waters of LHR and adjacent areas are poorly documented, with most collected from the part of the rise that falls within the EEZ of Australia (Keene et al., 2008). Their composition shows a range from carbonate sandy mud to mud, with mud content higher (~70%) in water depths greater than 2000 m. The TAN0713 samples showed the western flank of the LHR (~1200–2700 m) are mostly sandy mud (n=25), while sediment from the summit (~300 m) and flank (~2100 m) of Gifford Guyot generally has high percentages of sand and gravel (n=10) (Heap et al., 2009). Similarly, sediments on other seamounts in the Lord Howe chain range from carbonate sands and gravels on their summit to ooze on the flanks (Quilty, 1993). Where seamounts rise close to sea level (e.g., Lord Howe Island, Elizabeth Reef and Middleton Reef) shelf sediments are dominated by calcareous sand to gravelly sand (Kennedy et al., 2002; Kennedy and Woodroffe, 2004). Outside the Australian EEZ, descriptions of sediments across the LHR and New Caledonia basin typically report pelagic carbonate mud and foraminiferal ooze (Hayward et al., 2003).