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EXECUTIVE SUMMARY

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1) NIWA's SEAMOUNT database was enhanced in order to improve its utility for fisheries managers addressing issues around the effects of bottom trawling on "seamounts".

2) Forty-one additional data fields were erected and populated to create a second version of the database (now with a total of 72 data fields).

3) Access to the updated database is restricted at present to NIWA and MFish. Broader public access is planned by 2010.

4) Development of the database has been possible through collaboration between this MFish project and NIWA's FRST-funded Seamounts Programme.

5) The potential uses of the various types of data included in the new version of the database are discussed in relation to their use as indicators or measures to assess the ecological risk to seamount biota from bottom trawling.

6) Indicators/measures of risk which can be derived from data that could be added to the database in the future are proposed.

7) Four types of methods available for the task of ecological risk assessment are reviewed, and their particular advantages and disadvantages discussed.

8) It is recommended that the preliminary evaluation of these and other ecological risk assessment methods is continued through a workshop forum.

9) Recommendations for continued development of the SEAMOUNT database are made.

1. INTRODUCTION

1.1 Overview

The New Zealand region, because of its geological setting and history, has a complex seafloor relief. Tectonism and volcanism since 300 million years ago, and crucially within the last 80–100 million years, have formed a seafloor bathymetry in which isolated submarine rises feature prominently (CANZ 1997). The major physiographic features were known by the early 1970s (Brodie 1964, Wanoa & Lewis 1972, Thompson 1991), but with the advent of GPS satellite navigation, use of multibeam swath-mapping, and declassification of satellite altimetry data (Sandwell & Smith 1997), the last 10 years has seen a significant increase in knowledge of the distribution of "seamounts"[1] around New Zealand (Ramillion & Wright 2000). Such data have produced detailed bathymetry of seamounts in some areas (Lewis et al. 1997, Wright et al. 2006), but most have not been mapped in detail.

Biological research published in the primary literature on seamounts of the New Zealand region is limited, and is largely directed at the fishery or fishing impact issues (Probert et al. 1997, Clark 1999, Clark & O'Driscoll 2003, Tracey et al. 2004). Only since 1999 has research been focused on assessing the diversity and ecology of seamount benthic macroinvertebrate fauna (Clark et al. 1999). Determining the identities of species sampled from such previously unexplored habitats is very time-consuming and the results of such research effort have only recently begun to be published in preliminary/interim reports (Clark & O'Shea 2001, Rowden et al. 2002, 2003, 2004, Rowden & Clark in press).

As part of the FRST-funded research programme "Seamounts: their importance to fisheries and marine ecosystems" NIWA undertook to identify and map seamount distribution and bathymetric structure for previously "unmapped" areas of the New Zealand region, as well as determine the size, origin, geological structure, and composition of these seamounts. This information has been stored in the database "SEAMOUNT". A preliminary synopsis of the physical characteristics of seamounts within the New Zealand region (taken as the area bounded by 24° S, 167° W, 57° S, and 157° E) was initially presented by Wright (1999), and a more extensive characterisation (of over 800 seamounts) and classification of a subset (over 400) of New Zealand's seamounts has been produced (Rowden et al. 2005). The latter procedure was conducted because, in the absence of extensive and consistent biological data, biologically focused classification of physical variables will advance understanding of seamount biodiversity patterns and improve the effectiveness of seamount conservation/management strategies (Stocks et al. 2004). Rowden et al. (2005) demonstrated the potential management utility of the SEAMOUNT database by identifying groups of seamounts with potentially different benthic biota, from which individual seamounts could be selected for representative protection.

Nonetheless, the utility of the SEAMOUNT database for fisheries management can be improved, and this is underway as part of NIWA's FRST-funded Sustainable Production Systems (SPS) research project "Effective management strategies for seamount fisheries and ecosystems" (hereafter this project and the previous FRST-funded project are referred to collectively as NIWA's Seamount Programme). For example, data for fish species occurrence at (or near) seamount features are available for inclusion/linkage from the Ministry of Fisheries (MFish) database "TRAWL", as are

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[1] The term "seamount" as used in this report is synonymous with the term "underwater topographic feature" and refers to all underwater features with a vertical elevation greater than 100 m. See Rowden et al. (2005) for further discussion on what is considered a seamount in the New Zealand context.

data for macroinvertebrates (at relatively coarse levels of taxonomic identification) from various databases maintained at NIWA. In addition, the inclusion of (or links to) oceanographic data that relate to the ecology of seamounts is desirable, and to specifically improve the fishery management capability of the database, data or indices that relate to fishing effort can be added. Such an improved version of the SEAMOUNT database, with a suitable interactive interface, would then have greater usefulness for the development and preliminary implementation of a method to assess the effects of trawling on seamounts. Risk assessment methods can be used to assist in devising appropriate management strategies to avoid, remedy, or mitigate the adverse effects of fishing on seamounts.

The work presented here incorporates data obtained through FRST projects (C01808, C01X0028, C01X0224, C01X0508) as well as other MFish projects (ZBD2000/04, ZBD2001/10, ZBD2004/01, ENV2005/16), and has involved a collaborative approach by researchers from a wide range of disciplines.

1.2 OBJECTIVES

1.2.1 Overall objective

To provide an analytical tool to assist in the assessment, research, and management of the risks to benthic organisms and their habitats, from bottom trawling on underwater topographical features (UTFs; see footnote on previous page).

1.2.2 Specific objectives

1. To provide an atlas with an interactive database that identifies all known seamounts in the New Zealand region, encompassing the area from 24°00' – 60°00' S, 155°00' E – 165°00' W. The atlas will catalogue relevant data (e.g., physical, biological, location, fishing effort) for individual UTFs. The purpose of the database is to facilitate data analysis in relation to management options regarding the effects of bottom trawling on UTFs.

2. To develop a preliminary risk assessment model from data stored in the database to predict the effects of bottom trawling on the benthic environments of UTFs of New Zealand's EEZ, and to identify management options for these ecosystems.

It was determined early in the work programme that an atlas as such was not going to be a particularly useful product. Efforts under Specific Objective 1 were therefore focused on developing and enhancing the database, from which any combination of variables could be extracted and mapped according to the user's requirements.

The development of a risk assessment model was not possible given the data currently available, and the uncertainty about key management priorities that would help formulate the model. Thus Specific Objective 2 was directed towards exploring potential ecological risk assessment methodologies, and indicators for use in such models.

2. THE SEAMOUNT DATABASE (VERSION 1)

The type, source, and reasoning for data stored in the SEAMOUNT (v1) database has already been largely detailed by Rowden et al. (2005); however, it is repeated and augmented here for the sake of completeness and specifically to provide a context for those data added as part of this project. The names of the 31 data fields are italicised in the text below and are also listed in Figure 1 and Appendix I.

2.1 Physical data

Physical data on seamounts have been collated from existing sources used in the updating of regional bathymetry in 1997 (CANZ 1997), including data held by NIWA, the New Zealand Hydrographic Office, Royal New Zealand Navy, National Geophysical Data Centre (U.S.A), South Pacific Applied Geoscience Commission (Fiji), published scientific papers, and recent multibeam surveys funded by Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER, France). This information was supplemented by detailed data on smaller features from University of Kiel (Germany), Seabed Mapping New Zealand Ltd., and research surveys carried out over the last 20 years by NIWA and MFish (including multibeam surveys in the last 5 years).

Latitude and *longitude* of a seamount were based on the location of the summit, which was determined from actual bathymetric data wherever possible, or from the central point of the *minimum depth contour* derived from NIWA's regional bathymetric dataset. *Depth at peak* is the shallowest depth record known from the seamount. The *depth at base* of the seamount was generally taken from the deepest most complete depth contour (*maximum depth contour*) that encircled the entire seamount. In some cases, there was an appreciable difference between sectors of a seamount, where one side is, for example, up-slope of a broader feature like a rise. In these cases the mid-point between the shallow and deep basal depth was taken. *Elevation* was computed as the difference between depth at peak and depth at base. *Area* and *perimeter* were estimated from the polygon of the basal depth contour. Slope was calculated in two ways. First, echo-sounding data from ship tracks over seamounts were analysed and *maximum slope*, *minimum slope* (usually zero at the peak), and *mean slope* (and *standard deviation of the slope*) computed. For many seamounts, however, data are inadequate for this method, and hence slope was calculated from the seamount trigonometry using elevation and base radius to derive average slope. This method tends to underestimate the true slope on the flanks of seamounts, since most seamounts have broadly domed peak regions (i.e., the method tends to average the low gradients near the peak and higher gradients on the flanks).

2.2 Geological data

The *geological association* of seamounts has been broadly categorised as being associated either with the inner New Zealand continental margin (within the enclosing continuous 2000 m isobath) or with various types of ridge and rise systems on the surrounding oceanic seafloor. Most of the known seamounts have received little or no scientific study, and their *geological origin* is not definitive, but over 500 seamounts included in the database were classified on the basis of geological composition or location, i.e.; arc/mid-plate/oceanic plate/hotspot/rifted margin volcanoes, tectonic ridge, rifted continental block, or continental rise. Fewer than 10 seamounts in the New Zealand region have any form of direct radiometric age dating (Wright 1994, unpublished data, Mortimer et al. 1998), thus most *age* determinations were based on interpretation of magnetic anomaly and plate reconstructions and a regional assessment of seafloor volcanism (Sutherland 1999).

2.3 Oceanographic data

Which *water mass* overlies each seamount was determined by reference to the characterisation produced for the New Zealand region by Carter et al. (1998). Remotely sensed data were available to directly measure sea surface temperature and derive data that give temporally and spatially continuous variables that characterise different water masses. Data for *sea surface temperature* (SST) variables 'wintertime SST', 'annual amplitude of SST', 'spatial SST gradient', and 'summertime SST anomaly' were calculated from NIWA archived SST climatology dataset. Procedures for collecting satellite radiometer data, detecting cloud and retrieving SST data were described by Uddstrom & Oien (1999), and the calculation of the specified variables for the New Zealand region (at 1 km resolution) were detailed by Snelder et al. (2006). Patterns in wintertime SST are a proxy for water mass (which is related to nutrient availability); variations in the annual amplitude of SST are due to differences in stratification and wind mixing, that together produce the mixed layer across the region; spatial SST gradient recognises fronts in oceanic water masses (and is expected to correlate with variation in primary productivity); summertime SST anomaly is expected to recognise anomalies in temperature that are due to hydrodynamic forcing, such as upwelling and vigorous mixing due to eddies (areas with high values of this variable are expected to correlate with high primary productivity). All these parameters derived from SST data possibly influence the composition of pelagic and benthic assemblages (Longhurst 1998).

2.4 Biological data

The shortest *distance a seamount is from the continental shelf* was calculated using ArcGIS where seamount distances from the 250 m depth contour (which approximates the continental shelf edge) were calculated at a resolution of ± 1 km, based on an azimuthal equidistant projection (Central Meridian 171° E, Latitude of Origin 41° S, Datum WGS84). The composition of faunal assemblages on seamounts (which are generally features of the slope or deep-sea) is expected to be in part influenced by the degree to which faunal colonisation has been possible from the shallow-water of the shelf (Leal & Bouchett 1991, Gillet & Dauvin 2000). Thus, a measure of the shortest distance from the shelf edge is expected to be a reasonable proxy for the likely extent of seamount colonisation by shallow-water species. To some extent this measure is a proxy for the general degree of biological isolation, and therefore the relative level of likely endemism of a seamount's benthic fauna. Distance from the shelf edge is also a reasonable proxy for the existence of localised, biologically meaningful, hydrodynamic processes. The intensity of the current flow field near a seamount decreases with distance from continental margins (Smith et al. 1989), which concomitantly affects the development of hydrographic features (e.g., localised upwelling, Taylor Caps) that can influence primary productivity overlying seamounts (Comeau et al. 1995).

SeaWiFS 4 km L1A daily radiances for 1998–2002 were processed using the OC4v4 algorithm (Pinkerton et al. 2005) to derive surface chlorophyll a concentrations (mg m^{-3}). The resulting daily chlorophyll products were then further processed using the Fourier decomposition and objective analysis method of Uddstrom & Oien (1999) to generate a temporal *mean chlorophyll a* (and *SD and CV estimates about the mean chlorophyll a* measure) measure for the surface water overlying each seamount. The spatial resolution of these climatologies is about 8 km. Remotely sensed chlorophyll *a* data are generally related to the relative occurrence of phytoplankton in surface waters, and given reasonable assumptions are proxies for phytoplankton biomass in the ocean above the seamount (Martin 2004). The amount of phytoplankton (or rather primary productivity) associated with seamounts is likely to influence the diversity of pelagic, and subsequently the benthic faunal, assemblages (Piepenburg & Müller 2004).