An investigation of the relationship between seabed type and benthic and bentho-pelagic biota using acoustic techniques

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Abstract

A growing recognition of the need for effective marine environmental management as a result of the increasing exploitation of marine biological resources has highlighted the need for high speed ecological seabed mapping. The practice of resource mapping making extensive use of satellite remote sensing and airborne platforms is well established for terrestrial management. Marine biological resource mapping however is not readily available except in part from that derived for surface waters from satellite based ocean colour mapping. Perhaps the most fundamental reason is that of sampling difficulty, which involves broad areas of seabed coverage, irregularities of seabed surface and depth. Conventional grab sampling techniques are widely accepted as a standard seabed mapping methodology that has been in use long before the advent of acoustic techniques and continue to be employed. However, they are both slow and labour intensive, factors which severely limit the spatial coverage available from practical grab sampling programs. While acoustic techniques have been used for some time in pelagic biomass assessment, only recently have acoustic techniques been applied to marine biological resource mapping of benthic communities. Two commercial bottom classifiers available in the market that use normal incidence echosounders are the RoxAnn and QTC View systems. Users and practitioners should be cautious however when using black box implementations of the two commercial systems without a proper quality control over raw acoustic data since some researchers in their studies have indicated problems with these two bottom classifiers such as, among others, a depth dependence.

In this thesis, an alternative approach was adopted to the use of echosounder returns for bottom classification. The approach used in this study is similar to that used in the commercial RoxAnn system. In grouping bottom types however, multivariate analysis (Principal Component Analysis and Cluster Analysis) was adopted instead of the allocation system normally used in the RoxAnn system, called RoxAnn squares. In addition, the adopted approach allowed for quality control over acoustic data before further analysis was undertaken. As a working hypothesis, it was assumed that on average $dE1/dR0=0$ and $dE2/dR0=0$ where E1 and E2 are the roughness and hardness indices, respectively, and R0 is the depth. For roughness index (E1), this was achieved by introducing a constant angular integration interval to the tail of the first bottom returns whereas for hardness index (E2), this was achieved by introducing a constant depth integration interval. Since three different frequencies, i.e. 12, 38 and 120 kHz, were operated, Principal Component Analysis was used here to reduce the dimensionality of roughness and hardness indices, formed from the three operated frequencies, separately. The k-means technique was applied to the first principal component of roughness index and the first principal component of hardness index to produce separable seabed types. This produced four separable seabed types, namely soft-smooth, soft-rough, hard-smooth and hard-rough seabeds. Principal Component Analysis was also used to reduce the dimensionality of the area backscattering coefficient sA, a relative measure of biomass of benthic mobile biota.

The bottom classification results reported here appear to be robust in that, where independent ground truthing was available, acoustic classification was generally congruent with ground truth results. When investigating the relationship between derived bottom type and acoustically assessed total biomass of benthic mobile biota, no trend linking the two parameters, however, appears. Nevertheless, using the hierarchical agglomerative technique applied to a set of variables containing the average first principal component of the area backscattering coefficient sA, the average first principal component of roughness and hardness indices, the centroids of the first principal component of roughness and hardness indices associated with the four seabed types and species composition of fish group of the common species in trawl stations available, two main groups of quasi acoustic population are observed in the North West Shelf (NWS) study area and

three groups are observed in the South East Fisheries (SEF) study area. The two main groups of quasi acoustic population in the NWS study area and the three main groups of quasi acoustic population in the SEF study area are associated with the derived seabed types and fish groups of the common species.