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Spatial and Temporal Patterns of Minke Whale Distributions off the east coast of Korea

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Introduction

The minke whale (*Balaenoptera acutorostrata*) is found in all the oceans of the world, and is a major whale species off the east coast of Korea. To estimate its abundance, the National Fisheries Research and Development Institute (NFRDI) of Korea performed ship surveys in June of 1999 and May of 2000. During these surveys, scientists found two interesting facts, i.e. most whales were sighted close to shore, and whales appeared to move north from May to June. The following questions arose: is the observed spatial pattern significant? Did whales actually migrate north from May to June? If so, then which environmental factors affected their distributions? These questions were answered in this project.

Materials and methods ▪

Data: Two groups of explanatory variables - bathymetry and water temperature - were used to explain whale distributions as a function of physical environmental factors.

For the bathymetry data, we digitized a bathymetry chart into a line coverage, and then created grids of the distance from the shore, the distance from the shelf break, the slope, and the depth. For the water temperature data, we got serial oceanographic observation data (point) from NFRDI, and made grids of water temperatures (0, 10, 20, 30, 50m deep) by interpolation.

Sampling was performed by converting the paths of the survey ship into grids, and using them to sample the values for the dependent (whale occurrence) and the independent variables. The values for the equal number of random points were also sampled for the null model data.

Analyses : Ripley s *K(d)* function was employed to assess the spatial structures of whale distributions; we compared the distribution of whale-to-whale distances to a distribution of hypothesized points.

Simple and partial Mantel s tests were used to define the relationships variables in terms of classifying whale sightings from random points in both months.

From the results of the logistic regression, it was proved that the distance from the shore had a negative association with the probability of whale occurrence while the water temperature had a positive association in May. In June, the distance from the shore also had a negative association with the probability, but contrary to May, the water temperature had a negative association with probability.

When we tried to predict the probability of whale occurrence in June using the logistic regression model for May, we had a high commission error: 94% of whale sightings were located in areas with probabilities over 50%, but 71% of random points were also located in that area.

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between space, whale distributions, and physical environmental factors. The specific question for the simple Mantel s test is, Do samples that are similar in terms of physical environmental factors or space also tend to be similar in terms of whale occurrence? , while the specific question for the partial Mantel s test is, Do samples that are similar in terms of physical environmental factors or space also tend to be similar in terms of whale occurrence, given the spatial autocorrelation and inter-correlations among explanatory variables? . The partial Mantel s test also served as a variable selection device for logistic regression.

Logistic regression enabled us to calculate the probability of whale occurrence by fitting a logistic equation to binary (whale presence or absence) data. CART analysis made trees depicting the conditions of environmental envelopes, which can discriminate whale sightings from random points. As CART analysis selects important variables automatically, we did not use any variable selection device.

The results from logistic regression are probabilities (0~1) while the results from CART are binary (potential habitat or not habitat). For comparison, areas with probability over 50% in logistic regression were considered as potential habitats and areas with probability under 50% were considered as not habitat (Legendre 1998).

Results

Whale distributions had clumping patterns in both months. However, the degree of clumping became stronger from May to June.

All physical environmental factors and whale distributions had spatial autocorrelations in both months, though the spatial structures became stronger from May to June. In May, after accounting for the spatial auto-correlations, the distance from the shore, the slope, and the depth had significant relationships with whale distributions. After accounting for the spatial autocorrelations and the inter-correlations, water temperature at 20 m deep was also significant. In June, after accounting for the spatial auto-correlations, the distance from the shore, the depth, and all water temperatures had significant relationships. After accounting for the spatial autocorrelation and the inter-correlations, only the distance from the shore and the water temperature at 10m deep remained significant.

The results from the CART analysis showed that the distance from the shore and the surface water temperatures were the two most important