ENVIRONMENTAL CHARACTERISTICS IN OLIGOTROPHIC WATERS:
DATA EVALUATION AND STATISTICAL LIMITATIONS IN WATER
QUALITY STUDIES

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Abstract. Standard statistical tests of nutrient variability in the euphotic layer of an oligotrophic system in the
S.E. Aegean Sea were performed. Practical problems resulting from data handling, such as high errors
associated with low concentrations, nonlinearity and interaction among variables were examined. The
practical problems in the analysis of environmental data, arising from statistical limitations were considered:
linear correlations between chlorophyll a and nutrients were found to be significant only for ammonia, and the
multiple regression model was found to be of limited value as a tool for a description of the system. By contrast,
principal component analysis contributed significantly to the interpretation of each variable. The difficulties
arising from the use of statistical methodology, and particularly the limited goodness-of-fit of the regression
models, are discussed in relation to the suitability of oligotrophic waters as 'control sites' in eutrophication
studies.

1. Introduction

The term 'oligotrophy' has been used to describe waters which are poor in nutrient levels
which are necessary for phytoplankton growth (Thomas 1970). Nutrient and chloro-
phyll a concentrations in oligotrophic systems can scarcely be measured with standard
analytical procedures (Strickland and Parsons 1972) because the values are near the
analytical zero of the method and gross experimental errors are therefore inevitable
(Legendre 1987). Relations detected through the application of statistical models may not
be recorded adequately and the connection between biological and environmental
variables appears to be rather weak. Since strong phytoplankton - nutrient relationships
reflect the seasonality of ecosystems unaffected by human stresses (Ignatiades et al. 1983),
it is apparent that the degree of these relationships indicates environmental quality. In
addition, the physical, chemical and biological variables involved are usually non linear.
Ordination techniques have also been used extensively in biological effects studies (Clarke
and Green 1988, Zenetos and Papathanassiou 1989). The distance between test areas and
control sites can be used as an estimate of stress response induced by human activities. The
shortcomings mentioned above affect the interpretation of the results and, therefore, an
understanding of the ecosystem.

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Oligotrophic systems are characterized by lack of man-made environmental stress and so they can be used as control sites, i.e. relatively unimpacted (reference) sites for which comparisons can be made with sites which are affected by contaminants, (Clarke and Green 1988, Gray 1989). However, possible statistical limitations encountered as a result of the problems mentioned above may pose restrictions on the use of statistical methodology if the relevant assumptions are not fulfilled. Although the role of oligotrophic waters as test sites is well established (U.N. 1984), there is limited information concerning the description and the understanding of oligotrophic systems (Raymont 1982).

In the present paper the environmental characteristics of an oligotrophic area in the S.E. Aegean Sea, Greece (Delalo 1966, Kimor and Berdugo 1967; Kimor and Wood 1975) are studied and the problems related to the statistical treatment of the data are considered. In particular, interaction between nutrient variables, the dependence of chlorophyll $\alpha$ on nutrient concentrations and the possibility of detecting seasonal trends are examined. The importance of the oligotrophic systems as control sites is discussed in relation to data handling limitations.

2. Materials and Methods

2.1. DATA COLLECTION

Water samples were collected from standard depths from five stations (Figure 1) with NIO water bottles on a seasonal basis (Siokou-Frangou and Pancucci-Papadopoulou 1988). Phosphate, nitrate and nitrite concentrations were determined according to Strickland

![Fig. 1. Location of the stations.](image-url)