Overview of Some Statistical Methods Used in Marine-Related Environmental and Toxicological Studies

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***Abstract*- The main objective of this project was to overview some statistical methods used in marine-related environmental and toxicological studies. The overview is based on 33 scientific papers on toxicology and environmental science. The papers were examined for the statistical methods that were used to yield accurate, robust, and comprehensible results. My research supported the mission of NCCOS (National Center for Coastal Ocean Science), which is to provide coastal managers with scientific information and tools needed to balance society's environmental, social, and economic goals.**

I. INTRODUCTION

A major concern of modern environmental science and toxicology is the association between pollutants and toxins and the adverse outcomes. Toxins can be defined as substances, produced by microorganisms which affect the functioning of another organism. They differ from chemical substances in they are not manmade. Pollutants on the other hand are substances introduced into the environment by man which may endanger living organisms or damage the environment. Models, Patterns/clusters, trends, monitoring, and risk assessments are all ways that statistics can be used in environmental science and toxicology. Incorrect usage of statistical methods can cause problems such as: incorrect results, problems in comprehension, inaccuracies, and wrong conclusions.

II. DISCUSSION

When the primary interest is to estimate the mean concentration of a chemical pollutant or toxin, a random or systematic sample of sites can be collected. Random sampling is selecting a sample so each item in the population has an equal chance of being selected. A random sample's value does not appear to depend on the previous sample's value, or anything else. Systematic sampling is characterized by order and planning. It follows a logical, consistent, and ordered method. A sample average then provides an unbiased estimate of the population average which means that the precision and accuracy are the same. Although the sample mean is unbiased as an estimator of the population mean it will have a large variance which means the expected value is far away from the actual value. Any contour maps used will have little accuracy in areas of high concentration.

Adaptive sampling is an alternative to the sample mean. Adaptive sampling is the method of adapting the sampling rate in response to the local characteristics of the object being rendered. Adaptive sampling involves taking a random sample of a given size and if any toxins are found in the sample analysis, return and take samples at neighboring site locations. A Disadvantage of adaptive sampling is that it can provide biased estimates. This is an estimate that may possibly posses a systematic error. There are ways to obtain an unbiased estimate. A way to obtain unbiased estimates is the Horvitz-Thompson and Hansen-Hurwitz estimators.

The Horvitz-Thompson estimator is based on the probability of the mean. The Hansen-Hurwitz estimator is the sample mean of random variables. The disadvantage of these estimators is they do not possess minimum variance. The Rao-Blackwell Theorem may then be applied. The Rao-Blackwell Theorem describes a technique that can transform a basic estimator into an estimator that is optimal. By using the Rao-Blackwell Theorem there will be variance less than equal to that of the given initial sample estimate.

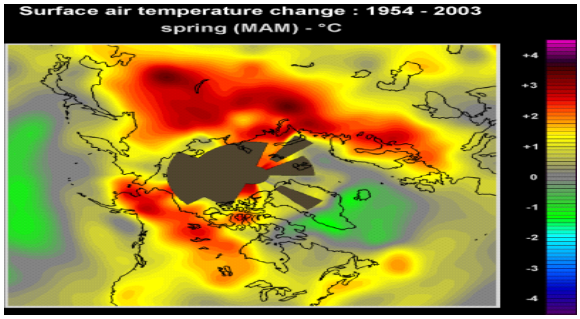

Figure 1.1 Illustration of Trend Analysis

An effect often studied in environmental science is the analysis of trend in some environmental phenomenon over time. This often leads to adjustments for spatial-temporal conditions in the data, which is an important area of environmetric trend analysis. An example when trend analysis is used is in the assessment of whether global warming is occurring in our environment. Figure 1.1 shows how trend analysis was used to generate data on surface air temperature change between 1954 and 2003.

Another important area of environmental research is that of quantitative risk assessment. Risk assessment concerns the identification of potential risks to public health from hazardous chemicals. The data often comes from bioassays. A bioassay is the method used to determine the level of toxins of chemical contaminants. A major component of such studies is statistical characterization of the stimulus/dose response of the organisms to the hazardous agent, and from this estimation of possible risks based on dose-response data.

With many environmental data sets, statistical analyses may be developed from complex models of the phenomena being studied. This is useful in cases where a time-series analysis would ignore key features of the data. An example of this fish population dynamics. The disadvantage of modeling is that it has far too many parameters which makes it difficult to comprehend. The compromise for this is to make use of both age-class components and stochastic components. Stochastic components are no more than random components.

The issue of combining environmental information is a very active area of statistical research. A method for combining results is meta analysis. This is done by reanalyzing the results and providing a quantitative analysis of the combined data. Bayesian Methods are used to combine information from multiple studies.

Statistics can also be used in clustering. Studies using Clustering to identify potential Environmental hazards are difficult to do because of the availability of the data, difficulties of measuring in small populations, and migration. In monitoring the effects of very widely spread pollutants, Such as ozone, cluster detection are not appropriate.

III. METHODOLOGY

The research called for the reading of research papers and books on environmental statistics. After comprehending the basics to environmental statistics, 33 research papers were briefly read. Special attention was paid to the statistical methods used. The papers were taken from journals found in the Noaa Library. After reading the papers, the information was put in a spreadsheet. The title, author, keyword, methods, and references in the were put in the columns of the spreadsheet. This aided in distinguishing which research effort used which method.

IV. CONCLUSION

Due to time allotted for the research and the availability of resources, definite resources were not found. From the research papers read, it is obvious that each scientist and project utilized different statistical methods which can lead to lack of comprehension and accuracy. Statistical methods have the power to give organized research efforts better conclusions and accuracy if used correctly. Due to this fact, more research needs to be conducted on the different statistical methods used in scientific marine studies.

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