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Tracking Temporal Trend Breaks of Anthropogenic Change in Mussel Watch (MW) Databases

Carlos Guitart,*[,†] Adrian Hernández-del-Valle,[‡] J. Miguel Marín,[§] and José Benedicto[†]

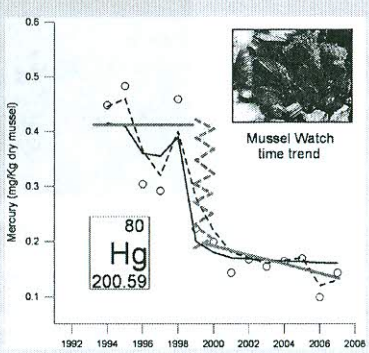
[†]Spanish Institute of Oceanography, Murcia Oceanographic Center, 30740 Murcia, Spain

[‡]Department of Economics, National Polytechnic Institute, 07738 Mexico DF, Mexico

[§]Department of Statistics, University Carlos III, 28903 Madrid, Spain

Supporting Information

ABSTRACT: The potential for structural changes in time trend concentrations of mercury (Hg), lead (Pb), cadmium (Cd), zinc (Zn), and copper (Cu) in the Mediterranean mussel, *Mytilus galloprovincialis*, was examined in Mussel Watch (MW) databases of metal pollution at eighteen coastal stations over a decadal period, from 1992 to 2007. Simultaneously, by using two statistical methods representing both the classical hypothesis-testing and the Bayesian approaches, we found single and multiple trend breaks for Hg (28% of the stations), Cd (17%), and Pb (11%) within trends in connection with anthropogenic and subtle natural environmental changes. Also called change point problems, if not accounted for, these could bias time trend investigations and interpretations. We calculated trend rate differences of 39% and switches up to 1 order of magnitude from classical linear trend assessments. We discuss sampling, analytical, and environmental (both natural and anthropogenic) sources of data set variabilities, showing that, in practice, the overall 16-year analytical performance could be as elevated as the yearly sampling reproducibility. We demonstrate that environmental time trend interpretations benefit from undertaking prior structural change analysis. After decades of MW marine chemical pollution assessments these have proven extremely useful, although the occurrence of trend breaks directly affects the long-term marine environmental monitoring strategies. Our results suggest a broader concept to design monitoring programs in agreement with rapid global anthropogenic and environmental changes.



INTRODUCTION

Marine environment assessments based on the "Mussel Watch" concept have been conducted for almost 30 years providing unique marine chemical pollution long-term databases.[1] In essence, instead of complex and expensive off-shore coastal sampling designs (including extensive use of research vessels and seawater trace chemical analysis), surveillance along coastal areas using widespread marine filter-feeding organisms as sentinels (e.g., mussels, oysters, etc.) should provide a straightforward time-integrated measure of a chemical's concentration in the surrounding coastal waters.[1,2] While the use of marine organisms as sentinels to monitor the seas and ocean's anthropogenic pollution is frequently debated,[3,4] the concept became global and has indicated upward and downward coastal pollution trends. The International Mussel Watch (IMW), the longest-running program for the monitoring of spatial distributions and temporal trends of chemical contaminant concentrations in different coastal environments, began worldwide in 1991,[5] following the pioneering U.S. Mussel Watch Program started in 1976 by E.D. Golberg and the National Status and Trends Program (NS&T) from the U.S. National Oceanographic and Atmospheric Agency (NOAA).[6] As a result, national mussel watch programs were implemented globally to cover numerous geographical areas of coastal oceans and seas as a primary component of marine monitoring programs, such as the MEDPOL Program in the Mediterranean Sea.[7] Within such programs, rigorous analytical quality assurance programs were established to ensure both sampling methods and chemical measurements of pollutants in biota tissues are made on a comparable basis worldwide. As a premise, temporal trend monitoring implies that sampling and analytical procedures do not change over the studied period and that data sets comply with a certain analytical quality threshold. To this end, analytical quality assurance and quality control (QA/QC) programs and marine certified reference materials (CRMs) were developed and supported by international organizations.[8] The World Mussel Watch Database includes coastal chemical pollution data sets from more than fifty countries worldwide[9,10] affording a huge amount of scientific research.

In environmetrics it is frequently difficult to determine significative temporal trends in time series or longitudinal data. In particular, marine environmental databases such as MW databases, are often statistically compromised with restricted sample sizes over long periods of time and are hindered by

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