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Spatial Analysis of Sea Outfall Discharges

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Outfalls are designed to promote the natural assimilative capacity of the oceans to dispose of wastewaters with minimal environmental impact. This is accomplished through the vigorous initial mixing that is followed by oceanic dispersion within spatially and temporally varying currents. Usually, those mixing processes, in conjunction to bacterial mortality, result in rapid reductions in the concentrations of contaminants and organisms present in the wastewater to near background levels. However, coastal physical, chemical and biological processes, very dynamic and complex, and intimately coupled to the concentration and content of wastewater, are in most instances, poorly understood. Much effort has been devoted recently to improve means to monitor and characterize effluent plumes under a variety of oceanographic conditions, on relevant temporal and spatial scales. However, effluent plumes dispersion is still a difficult problem to study in situ. Autonomous Underwater Vehicles (AUVs) already demonstrated to be very appropriate for high-resolution surveys of small features such as outfall plumes. Some of the advantages of these platforms include: easier field logistics, low cost per deployment, good spatial coverage and capability of feature-based or adaptive sampling. In this paper we use geostatistics in the spatial analysis of environmental data gathered with an autonomous underwater vehicle (AUV) in a monitoring campaign to a sea outfall, aiming: (i) to distinguish the effluent plume from the receiving water; (ii) to estimate the salinity value at unknown locations and map its distribution by kriging interpolation, motivated by environmental impact assessment for decision-making and (iii) to validate predictions of plume dispersion models. In a first step the spatial structure of the observations was inspected thought a descriptive statistical analysis. Then, the degree of spatial correlation among data in the study area as function of the distance and direction was expressed in terms of the semivariogram. Finally, ordinary kriging was used to estimate salinity at unknown locations, and a map of this parameter distribution in the field was generated. Cross-validation indicators and additional model parameters helped to choose the most appropriate models. Kriged maps show clearly the spatial variation of salinity in the studied area. From these maps it is possible to identify unambiguously the effluent plume and its dispersion downstream in the north-south direction. Our study demonstrates that geostatistical analysis can provide estimates of effluents dispersion valuable for environmental impact assessment and management of sea outfalls.

Keywords: geostatistics, sea outfalls, environmental impact, autonomous underwater vehicles