An Empirical Method to Determine a patterns of the risk of coastal pollution in the Gulf of Finland

Bert Viikmäe, Raul Isotamm, Nicole Delpeche

Institute of Cybernetics at Tallinn University of Technology
Akadeemia tee 21, 12618 Tallinn; bert@ioc.ee

One of the aims of the BONUS+ BalticWay project is to identify areas that are at high and low risk of current-transported coastal pollution in the Baltic Sea (Soomere and Quak, 2007). We describe first steps made towards creating a technology for identifying such areas for fairway designs. The basic tool for the analysis of current-driven pollution is a Lagrangian trajectory model, TRACMASS (Döös, 1995, de Vries and Döös, 2001) with the use of three-dimensional current velocity fields calculated by the Rossby Centre global circulation model (Regional Ocean model, RCO) with a resolution of 2×2 nautical miles. Trajectories of current-driven pollution are simulated for a few weeks and the simulations for each sea point are repeated over several years. A high risk to a coastal section is assumed when pollution reaches a sea point located at a distance of two or three grid points from the coast. The average time it takes for the pollutants to reach such points is a measure of risk associated with the starting point.

While the probability of coastal pollution for open ocean coasts can be reduced by shifting the fairway offshore, a central question for narrow bays is how to minimize the joint probability of hitting of either of the coasts. The first order solution is the equiprobability line, the probability of propagation of pollution from which to either of the coasts is equal. This line/area serves as an area of low environmental risk and indicates a safe fairway. We propose two methods for numerical estimation of the location of the equiprobability line. The first method is referred to as the linear method whilst the second method is referred to as the smooth method.

The first method consists in the analysis of trajectories starting from each single cell. For each grid cell, 4 starting positions of trajectory are defined. The coastal zone is divided into a southern part and northern part.

A statistical analysis is then performed on each grid cell. First, a count is made on if at least 50% of the trajectories travelled to either of the coast. If yes, the cell is marked as being a probable source of pollution for the particular coastal section. If not, the cell is marked as a part of an undefined area, propagation of pollution from which to any of the coasts is unlikely. The separation line of cells – probable sources of pollution to different coasts – evidently can be interpreted as the estimate of the location of the equiprobability line.

The described method generally leads to quite a large level of noise and for this reason, we use another method for specification of this line that implicitly involves a smoothing process. The method consists of dividing the sea area into clusters of 3×3 grid cells and considering integral properties of pollution propagation from these clusters. By tracing nine trajectories in each cluster (one from each cell) it is established whether the majority of the trajectories end up at one of the coasts or stays in the open sea area.

Results indicate that increase in the simulation time causes an increase in the low-risk area. As the current fields in the Gulf of Finland exhibit strong seasonal variability, this feature suggests that a similar variability exists for low-risk areas. The equiprobability line was found to be substantially shifted northwards from the axis of the Gulf of Finland for both the methods. Most of the area between the coasts is the area with the larger probability of hitting the southern coast.

References

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