Semi-persistent patterns of transport in surface layers of the Gulf of Finland

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The BONUS+ BalticWay project attempts to identify the regions that are associated with increased risk to other sea areas and to propose ways to reduce various risks by placing activities in the most suitable areas. A solution to this inverse problem is sought by means of statistical analysis of a large pool of solutions to an associated direct problem of current-driven transport of adverse impact (a generic example of which is an oil spill).

We report results of the analysis of a large ensemble of Lagrangian transport paths of water and pollution particles in the Gulf of Finland and in the northeastern Baltic Proper. The trajectories are determined with the use of TRACMASS code from three-dimensional current velocity fields calculated by the Rossby Centre Regional Ocean model with a resolution of 2×2 miles.

The ability of the method to adequately reflect the basic properties of current patterns in the Gulf of Finland is implicitly verified by means of considering the ratio of net and bulk transport for simulations of different length. The resulting estimates of the typical size of mesoscale eddies match well independent estimates of Rossby radius. The pool of trajectories covering several years is then used to evaluate the basic parameters of current-driven transport that cannot be extracted directly from the velocity data: the average net transport rate in different directions, the ratio of average net and bulk transport (equivalently, the ratio of the final displacement and the length of the trajectories), and the duration of time it takes for pollutants to hit the coasts. These parameters allow estimating whether or not the proposed approach would lead to substantial benefit in a given area.

Further analysis of average fields of net and bulk transport indicate the existence of various semi-persistent patterns of currents, including unexpectedly pronounced transport pathways across the Gulf of Finland. Their presence leads to a high variability of the transport of dangerous substances and adverse impacts from different sea areas to the vulnerable areas. This variability and accompanying heterogeneity of current-driven transport opens a principally new way towards the use of intrinsic properties of marine dynamics for reducing the environmental risks stemming from shipping, offshore, and coastal engineering activities. The key benefit is an increase of time during which an adverse impact (for example, an oil spill) reaches a vulnerable area after an accident has happened.