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Modelling hydrography and currents in Finnish coastal archipelagos

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We used a 3D hydrodynamic model COHERENS to model temperature, salinity and currents in the Archipelago Sea, located in the northern part of the semi-enclosed and brackish water Baltic Sea. This coastal archipelago is one of the most complex coastal areas with over 40 000 small islands and islets. It is also very vulnerable area, heavily stressed with eutrophication. A high-resolution grid with c. 460 m resolution was build based on best available bathymetric data. Boundary conditions for this limited area were provided from coarser resolution, 2 nmi, Baltic Sea grid.

The capability of the modelling system to simulate the hydrography of the Archipelago Sea was evaluated with comparing a 3 years model run against available measurements in the area (Tuomi et al., 2018). The model was able to simulate well the temperature and salinity and the seasonal variability in these parameters. However, the density gradients were not as pronounced in the model as in the measurements. There was large year-to-year variability in the surface current fields. The bottom currents showed a more constant pattern.

The effect of year-to-year differences in the circulation patterns to the transport of substances in and through the area was studied by introducing passive tracers in the model through river discharge and as point sources. The prevailing wind conditions lead to more transport from the Bothnian Sea to the Baltic Proper, than vice versa. However, in certain years, a larger amount of transport could also be from the Baltic Proper towards the Bothnian Sea. Analysis of the tracer concentrations simulating discharge of nutrients from the largest river, the River Aurajoki, in the domain showed that the tracer concentration was highest in the shallow and narrow river estuary. When the tracers reached the deeper areas of the inner archipelago and spread further to the outer archipelago, the concentrations became very small, negligible compared to the background values of e.g. total phosphorus or nitrogen. This indicates that the measures to reduce the amount of nutrients in the watershed would mainly affect the inner archipelago areas closest to the mainland.

The capability of the model system to function as a part of a coastal water quality system was further evaluated with a longer 10-years model simulation, which was compared against measurements including also current measurements at few locations in the Archipelago Sea. We present how the model was able to simulate the currents in the narrow channels of the inner archipelago as well as the general features in the outer archipelago. We also re-evaluate the transport patterns in the Archipelago Sea area based on the longer, 10-year simulation.

Tuomi, L., Miettunen, E., Alenius P., Myrberg, K., 2018. Evaluating hydrography, circulation and transport in a coastal archipelago using a high-resolution 3D hydrodynamic model, Journal of Marine Systems, 180:24-36, https://doi.org/10.1016/j.jmarsys.2017.12.006.