PhD Thesis B: **Three-dimensional numerical simulation of the hydrodynamic circulation in the Gulf of Patras with emphasis on the currents in the coastal zone of the Port of Patras**

In this Doctoral Thesis, the hydrodynamic circulation in the Gulf of Patras, in western Greece, is studied using three-dimensional numerical simulations. The Gulf of Patras is a shallow basin (depth ‹ 135 m) opening into the Ionian Sea on the west, and through the straits of Rio-Antirio into the Gulf of Corinth, on the east. The basin is bracketed between two sills, one on the west at the opening with the Ionian Sea and the other on the east at the straits of Rio-Antirio. The simulations are performed using the three-dimensional modeling system MIKE 3 FM (HD). The model is based on the numerical solution of the three-dimensional RANS equations, invoking the Boussinesq assumption and the hypothesis of hydrostatic pressure in the vertical. The turbulence closure is affected using the Smagorinsky in the horizontal and the standard k-ε model in the vertical direction. The code is first tested in the solution of two fairly well understood problems relevant to the analysis of coastal ciruculation, namely, wind-induced flow in an elongated rectangular basin and unsteady turbulent open-channel flow. The wind-induced circulation is then examined in the natural basin of the Gulf of Patras, in which batotropic flow develops, according to field measurements, during the winter months. The simulations show that the wind-induced flow creates strong currents near the coasts, which determine the sense of rotation of the gyres that develop in the Gulf. Strong currents are also created at the Rio-Antirio straits. The wind-induced, barotropic currents do not seem to contribute to the renewal of bottom waters, which recirculate between the two sills. Depending on the speed of the wind, which is forcing the flow, the residence time of the waters in the Gulf of Patras is estimated to range from one month to one week. Then, the tide induced circulation is examined. The flow forcing is provided by the synthesis of eight principle tidal constituents, used to compute the tidal elevations at the boundaries of the computational doamain. The results indicate that strong, tidal currents develop at the straits of Rio-Antirrio and in the main body of the Gulf, with cyclonic and anticyclonic eddies developing at the northern and southern coasts, respectively. When there is also wind blowing, nearshore gyres develop, the sense of rotation of which is by the wind direction, while in the central part of the Gulf the flow pattern is dictated by the tidal action. Further, the baroclinic wind and tide induced circulation are studied to investigate the effect of stratification on the structure of the flow. Numerical simulations show that at the summer period the wind-induced flow and the wind generated turbulence driven by winds of medium strong are restricted to the upper layer of the epilimnion, while the strong winds cause tilt and erosion of the thermocline in the central part of the Gulf and generation of internal waves at the straits of Rio-Antirio. Salient features of the summer circulation are the strong upwellings and the central cyclonic gyre which are predicted using numerical simulations. Specifically, upwellings occur along the northwesterly portion of the Nafpaktos bay coasts at the westerly part of the Gulf of Corinth, under southwesterly wind, and to the south of Rio cape at the front of the city of Patras, under northeasterly wind. Concerning with the central cyclonic eddy, according to numerical simulations it develops exclusively during the flood tide under the simultaneous action of northeasterly winds. The numerical predictions were validated against satellite images of the surface temperature field determined by NOAA-6 and NOAA-7 which closely confirm the simulation results. Finally, the simulated barotropic and baroclinic flow fields are applied to the calculation of the currents near the port of Patras and to the advection and diffusion of the treated sewage effluents disposed of near the southeasterly coast of the Gulf, near the city of Patras. The numerical model predictions for the concentration of both conservative and non-conservative pollutants were found to be under the admissible level near the swimming zone, in all cases examined.