important ecologically because it produces hydrogen sulfide, which is hazardous for aquatic animals (NIES, 1996).

When strong northerly to northeasterly winds continue for several days, an offshore flow is generated at the surface along the northern coast of Tokyo Bay and a compensatory shoreward flow is formed at the bottom. This flow pattern causes upwelling and vertical mixing along the northern coast of the Bay by which anoxic bottom water is transported to the surface. This is a simple description of the mechanism of a blue tide. The blue-green color of blue tides is thought to be attributable to colloidal sulfur, which is formed at the surface due to the oxidation of abundant hydrogen sulfide originally in the bottom water during the upwelling and vertical mixing process. When a blue tide occurs, vertical distribution of temperature, salinity and oxygen concentration are observed to be uniform and dependent on bottom water quality along the northern coastal area, which exhibits the consequence of the upwelling of bottom water and vertical mixing.

3.2 Computation Procedure

The grids

The geographical area covered in this simulation is shown in Fig. 3.2. The numerical resolution for the Bay and rivers is $\Delta x = \Delta y = 1$ km. The number of grids is 70 for the north-south direction and 50 for the east-west. The area is divided into 10 σ-levels vertically. Geographical data were obtained from water-depth data files provided by the Japan Oceanographic Data Center (JODC). The 5 rivers considered in the simulation are the Tsurumi, Tama, Sumida, Ara and Edo. Each river segment was modeled up to 10-km upstream from the river mouth.

Boundary conditions and initial conditions

The vertical distribution of temperature and salinity at the mouth of Tokyo Bay were provided by observations by Kanagawa Prefecture (Kaikyo-Yoho-Jigyo-Kekka-Hokokusyo, 1989, 1990). Tidal elevation at the mouth was based on harmonic constants K_2, M_2, S_2, O_1, P_1, K_1 and S_a at Jogashima and Iwaibukuro (Table of tidal harmonic constants for Japan's coast, Maritime Safety Agency, Japan).

The initial temperature and salinity conditions in Tokyo Bay were from observed data by the Environment Agency of Japan.

Input data

a) Freshwater input

Flow rates of the Tsurumi, Tama, Ara and Edo rivers were from observations by the Ministry of Construction (Fig. 3.3). Temperature changes in river waters were based on observations by the Environment Agency of Japan. Since there were no flow-rate data available for the Sumida River, we used that of the Tama River, which has almost the same size river basin. As sources of freshwater discharge, we inputted discharge data from publicly owned wastewater treatment plants (POTW), factories and power stations along the shore of Tokyo Bay, according to records (Fig. 3.4).

Meteorological information such as temperature, solar radiation, humidity, wind speed and cloud cover observed by the Meteorological Agency at the observation station in Tokyo City, was used to calculate the heat balance at the water surface (Fig. 3.5). Wind speed and direction observed at the Chiba, Kisarazu and Tokyo heliport stations of the Automated Meteorological Data Acquisition System (AMeDAS) were averaged and used to calculate the wind-shear stress at the water surface (Fig. 3.6).