Field Observations and Numerical Simulation of Currents and Water Quality in the Harbor of Osaka Bay

Masayasu Irie, Shuzo Nishida, and Keiji Nakatsuji
Department of Civil Engineering Graduate School of Engineering, Osaka University
Suita City, Osaka, Japan

ABSTRACT

The coastal area at the head of Osaka Bay, which is highly urbanized, has been developed into an enclosed area with complicated artificial islands and breakwaters. In order to clarify the processes of anoxic water in this enclosed area, field surveys were done to measure currents inside the ports of Amagasaki-Nishinomiya-Ashiya and Kobe. Numerical computations to simulate currents and water quality in summertime were also carried out using the Princeton Ocean Model (POM) and a water quality model.

KEY WORDS: Hypoxia; anoxic water; harbor; Osaka Bay; three dimensional numerical simulation; water quality; current.

INTRODUCTION

Hypoxia, which is often defined by the low concentration of dissolved oxygen, is one of the main subjects of environmental research in the estuaries of Japan. Hypoxia compromises the survival of marine life and biodiversity, and the volume of the hypoxia never decreases in contrast with the reduction of the polluting load from land areas in recent decades. Osaka Bay is surrounded by industrially developed and highly urbanized areas. The number of people in the river basins that flow into the bay is 17 million. Most of the coast line is developed with ports which create large sections of calm water and closed harbor spaces.

Hypoxia in Osaka Bay occurs in early summer, spreads to the head of the bay and decreases in October. In the harbor of the bay, it occurs earlier and remains in November. It spreads from the ports to outside of the ports. Obviously, improvement in the water quality in the harbor is a start to the improvement of the whole bay.

In the present paper, field surveys have been conducted to clarify the dynamics of water mass with the low concentration of DO. One of the main surveys is to measure currents in two ports in the northern part of the bay. The simulation of currents and water quality using the three-dimensional flow and water quality model were also carried out.

SETTING OF FIELD SURVEYS AND NUMERICAL SIMULATION

Outline of Survey Area

The survey area for the present paper is located in the northern part of the head of Osaka Bay and includes the port of Amagasaki-Nishinomiya-Ashiya (ANA port; for short) and the port of Kobe as shown in Fig. 1. The length of the area from east to west is 17.7 km with the width 8.3 km from north to south. The survey area is largely surrounded by reclaimed land used for industrial factories and residential buildings. Harbor facilities are set along the quays of Rokko Island in the central section of the area and Port Island in the western section of the area. Port Island divides the port of Kobe into the western and eastern parts. Lots of narrow channels have been formed between the artificial, reclaimed islands and the original land. Only small areas of the original coastline remain. The studied area is highly enclosed with only five narrow open channels into and out of it. Two open channels on the south end of the western port of Kobe are each 250 m wide. Another with the width of 0.5 km is on the south end of the eastern port of Kobe, and another is a 1.6 km wide fairway between the Nishinomiya Breakwater and the No.7 Breakwater on the south end and the other is 1.4km wide on the east end of the ANA port. The narrowest channel with the width of 180m connects between the western and eastern port of Kobe, and two channels with the width of 0.4 and 0.7 km connect the western port of Kobe and the ANA port. The water depth at the ANA port is 9–14 meters, decreasing as you go northward. The depth at the eastern and western port of Kobe is 9–13m and 8–13m respectively.

There are some small rivers flowing directly into the harbor area, but the influence of freshwater from them can be ignored. However, the mouth of the Yodo River which is largest river flowing into Osaka Bay is 3 km east from the east end of the studied area. During periods when it discharges large amounts of freshwater, it mixes with the seawater at the east end of the port and flows into the study area.

The port of Kobe has water surface area of 9,200 ha, and 44,000 vessels enter the port carrying, 96 million tons of cargo volume and trade worth 9200 billion yen. This operated cargo volume is 17% of the...