Observation of the Disturbances Occurring in a Discontinuity Layer of Lake Biwa-Ko*

Kuniaki OKUDA**

Abstract: Short-period temperature fluctuations were observed in the uppermost region of the seasonal thermocline in Lake Biwa-Ko, under the existence of the strong wind-stirring. In the observation period, the temperature profile had a sharp discontinuity at the bottom of the surface mixed layer, and a large gradient in the discontinuity layer of about 2-m thickness. The most dominant disturbances occurred in the discontinuity layer had the period of 2 to 3 minutes and the amplitude of about 1 m. They occurred intermittently with 5- to 15-minute intervals, and the growth and decay cycles were repeated locally. On the basis of these results, it is suggested that they were caused by the shear instability, and that such disturbances may control the erosion process of the seasonal thermocline.

1. Introduction

It is well known that, when the strong wind continues to blow, the surface mixed layer becomes to be apparently bounded from below, by the thin layer, so called discontinuity layer, in which density changes abruptly. This means that the vertical transfer of heat and momentum into the inner region of the ocean is substantially due to the entrainment of underlying water into the surface mixed layer, and resultant deepening of the discontinuity layer. The entrainment process thus seems to be essential to constructing a realistic heat and momentum transport model.

The study of the entrainment process across a density jump has been made experimentally by ROUSE and DODU (1955), TURNER (1968), KATO and PHILLIPS (1969), and others, and some empirical relations on the entrainment rate have been derived. But in spite of their efforts, our understanding of its physical process does not seem to have much increased. For example, we cannot say anything certain about the scale of turbulent eddies in the discontinuity layer, and the manner of their breaking out. The lack of the field observations seems to have prevented further detailed studies on the problem.

The purpose of this paper is to describe the result of an observation of the temperature fluctuations in the discontinuity layer, and to show the characteristics of turbulent eddies.
which may control the entrainment process. It is not possible, however, to study this problem quantitatively from the present result since our observation was far from completeness. We must thus confine the present article to qualitative discussion on the characteristics of the large scale disturbances. But it seems to be possible to speculate on the manner of breaking out of turbulence in the discontinuity layer.

2. Observation

The observation was carried out about 200 m west of Take-Shima Island, near the center of Lake Biwa-Ko, as shown in Figure 1, from 10 to 12 June, 1971. The water depth was 20 m at the shore of Take-Shima Island, and gradually increased to 50 m at the station.

In Figure 2 is shown the instrumentation used in the observation. The temperature was measured by six thermistors, which were arranged to locate in the discontinuity layer at the beginning of the observation. The response time of the probes was about 1 second, and the temperature was recorded continuously at Take-Shima Island.

As soon as the observation was begun, the thermocline displaced upward presumably by the internal seiches in Lake Biwa-Ko, and the probes were located, during most of the observation period, in the layer in which the temperature was nearly uniform. It was fortunate, however, that the probe at 12 m continuously stayed in the discontinuity layer for 3 hours from 0:00 to 3:00, June 12, after about 30 hours from the beginning of the observation, and recorded the short-period disturbances which occurred in it. This enables us to speculate on the characteristics of the disturbances occurring in the discontinuity layer without much confusion by the existence of the irregularities of mean temperature profile.

Through the observation period the easterly wind of about 10 m/sec continued to blow, and the water surface was too rough for our small

![Fig. 2. Arrangements of the instruments at the station.](image)

![Fig. 3. Temperature profile of the upper region of the thermocline inferred from the part of the temperature series shown in Fig. 4b. The depth is taken from the interface. It was made by the step-by-step calculations of temperature gradients at 40 cm interval, on the assumption that the thickness of the discontinuity layer was not much changed in this time.](image)