Origin and Maintenance of the Benthic Nepheloid Layer

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Overview

The processes responsible for the transport, deposition, and resuspension of solids are of considerable importance in both the Great Lakes and the coastal ocean since this material can significantly affect both biological productivity and the cycling of chemical substances. In the Great Lakes the benthic nepheloid layer (bnl) may play a significant role in the transport of both suspended sediments and their associated pollutants, but the processes responsible for its origin and maintenance are poorly understood.

Project Rationale

Hawley and Lesht (1995) showed that local episodic resuspension due to storm action probably does not maintain the bnl, and suggested that it is sustained by a combination of vertical mixing and the offshore advection of material resuspended in shallow water. More recently Hawley and Murthy (1996) and Lee and Hawley (1998) have shown that the amount of material suspended in the bnl does not increase during downwelling events but that it does increase during upwelling episodes. However, in neither of these studies was there sufficient data to determine the change in the mass of suspended material other than the few times when a vertical profile was made. Lee and Hawley suggested that the increase in the amount of suspended material during upwellings may be due to the resuspension of bottom material by breaking internal waves, as described on the California continental shelf by Bogucki et al. (1997), and that this may be the major source of material to the bnl.
Although benthic nephloid layers are present during the unstratified period, they are most evident when the lakes are stratified. Recent work in the Lake Michigan Mass Balance Study shows that the bnl exhibits significant short-term variability in both its thickness and in the amount of material suspended within it. These changes appear to be related to the near-inertial current oscillations present in the lake, but the exact relationship is not clear. Since these oscillations are a ubiquitous feature of the lake’s circulation during the stratified period they may be the dominant physical mechanism responsible for maintaining the bnl either directly, or by generating breaking solitary internal waves. The effects of upwelling and downwelling events on the bnl also need to be better resolved. This study is designed to measure changes in the vertical structure of the bnl over relatively short time scales (hours) in order to determine which (if any) of these three processes are important in maintaining the bnl during the stratified period.

Although time series observations at a fixed depth provide some information on the response of the bnl to various physical forcings, they cannot provide any details on changes in the bnl thickness or in the total amount of suspended material. To obtain this information a series of vertical profiles made at relatively short time intervals (hourly) are needed for several weeks, not the once per day observations that that can usually be obtained by making profiles from a ship.

**Project Plans**

Analysis of the data collected in 2002 will continue. Analysis of the data collected in 2002 will be completed and a manuscript prepared. Another deployment will be made with the vertical profiler, particle size analyzer, adcps, and a set of transmissometers. Data from this deployment will be used to determine to what extent changes in particle size are responsible for the changes in water transparency in the benthic nepheloid layer. The deployments will be made at a greater depth than the previous ones to determine if short-period internal waves resuspend bottom material at the base of the lake slope.

Several instances of short-period internal waves have been identified in the adcp records, but these occurrences do not coincide with occurrences of higher sediment concentration. It appears that although short-period internal waves do occur, they are not responsible for initiating sediment resuspension, at least at the sites we occupied. There does however appear to be a correlation between higher sediment concentration and onshore advection. This correlation will be investigated further during the coming year and a manuscript describing the results will be prepared.

A short field program will also be done during which the particle sizer will be deployed at a site in Lake Michigan for several weeks in conjunction with the vertical profiler and measurements of current velocity and water transparency. Analysis of this new data will be directed at determining if the observed changes in transparency are due to changes in the particle size of the suspended material. The deployments will be done at the base of the lake slope (80 m) to determine if resuspension by short-period internal waves occurs there lead this effort.
Accomplishments

Previous work showed that there is a correlation between changes in the thickness of the benthic nepheloid layer and internal near-inertial waves (period of about 17 hours), but the causal mechanism could not be identified (Fig. 1). The velocities associated with the near-inertial waves appear to be too low to resuspend bottom material, so the data analysis has concentrated on determining whether or not short-period (less than a few hours) internal waves resuspend bottom material, thus increasing the amount of material in the benthic nepheloid layer. Downwellings may also be an important factor since they tend to diminish the alongshore currents, thus allowing the near-inertial waves to propagate up the lake slope and generate the shorter period waves. Wavelet analysis of both the currents and the suspended sediment concentrations suggests that short period waves may resuspend bottom material, but analysis of the cross wavelet coherence between the two parameters is just beginning.

Figure 1: Time series (hourly) measurements of water temperature, turbidity, and current speed (in cm/s) at a station located in 55m of water near Muskegon. The effects of near-inertial waves
(period of about 17 h) are readily apparent, but the current speeds appear to be too low to resuspend bottom material.

**Products**


**References**


