



Figure 2 (left) and figure 3 (above). Home to coastal sand dunes, bluffs, forests, lakes, and streams, the park began a comprehensive aquatic resource inventory and monitoring program in 1990. Survey sites include Deer, Bass, and Otter Lakes (left), and middle Otter Creek (above).

MAINTAINING A WATER QUALITY MONITORING PROGRAM AT SLEEPING BEAR DUNES

By LAUREL L. LAST AND RICHARD L. WHITMAN

SLLEEPING BEAR DUNES NATIONAL Lakeshore is located on the northwest shore of the Michigan lower peninsula (fig. 1). The park is a diverse landscape of coastal sand dunes, bluffs, forests, lakes, and streams (figs. 2 and 3). Its topography and geology have been influenced by glaciation, erosion, and sedimentation. Although extensive lumbering begun in the late 1800s had depleted the area's forest resources by 1910, much of the cleared land has been reforested since the 1920s. Presently, much of the national lakeshore is covered by pine, aspen, and northern hardwoods. Over the years, tourism has become the number one industry for the local economy. Concern for protection of area natural resources led to park creation in 1970. The lakeshore now provides thousands of visitors each year with a variety of recreational opportunities, from enjoying the outdoors (through hiking, canoeing, fishing, beachcombing, and other activities) to exploring the fascinating history.

PROGRAM BEGINNINGS

In accordance with the lakeshore general management plan (NPS 1979), the park initiated a project in 1990 to provide a comprehensive aquatic natural resource inventory and a program for long-term aquatic resource monitoring. During the first 3 years of the program, 1990-92, the NPS Water Resources Division performed a thorough, well-funded aquatic resource inventory. The result was both a report and a manual to guide future lakeshore monitoring efforts (Boyle and Hoefs 1993b and 1993a).

Following the initial 3-year project period, the monitoring program became the responsibility of the park. In 1993, a bachelor-level biologist without specific aquatic training and unfamiliar with the project continued the monitoring program. She collected the data and samples, with help from various other park employees and volunteers, and the samples were analyzed by an outside lab and expert macroinvertebrate specialist. The park received only the data sheets and lab results, with no interpretation or analysis.



Figure 1 (map). Sleeping Bear Dunes National Lakeshore, Michigan.

In 1994, the first author, working for the NBS Lake Michigan Ecological Station, sampled and collected field data (with help from the second author and two park interns); she also analyzed and interpreted macroinvertebrate and water

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quality data. An aquatic ecologist working on her master's degree conducted the monitoring after she received 3 weeks of training at the ecological station. She completed the macroinvertebrate analysis that fall and winter while attending the university. The station performed the water quality analysis using methodology outlined in Whitman et al. (1992) and provided the park with a report (Whitman et al. 1994).

years of the program, analyzes problems in maintaining program consistency, and suggests solutions to these problems.

macroinvertebrate samples were collected at each stream site using a square-foot (1.0 mm mesh) Surber sampler.



Figure 5. The first author performed Secchi disc visibility depth determinations on Big Glen Lake in the 1994 studies.

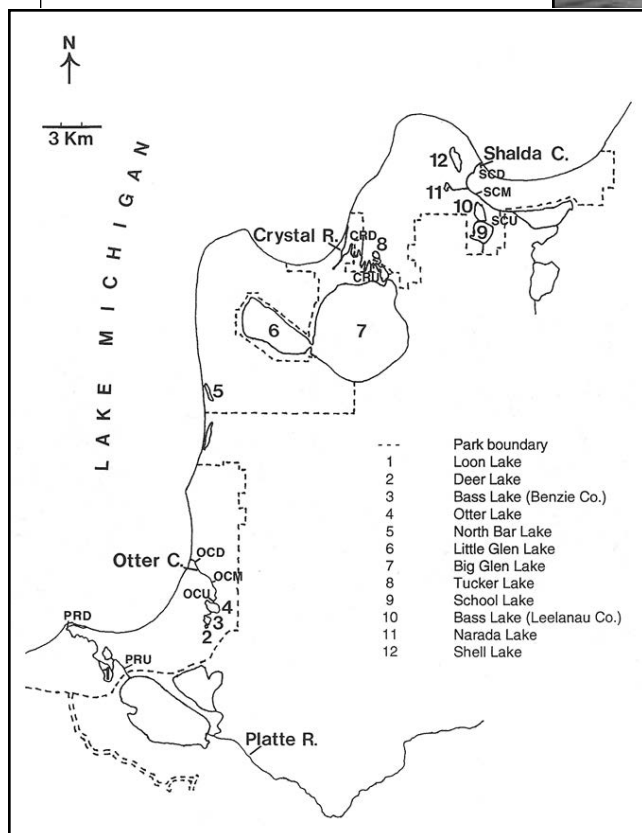


Figure 4. Map of Sleeping Bear Dunes National Lakeshore, Michigan, and the 12 lakes and 10 stream sites under study in 1994 and 1995. (North and South Manitou Islands not shown).

In 1995, we returned with a fisheries biologist and five volunteers and finished the sampling in only 2 days, versus several weeks of effort in 1994. The National Biological Service again analyzed water quality, but had inadequate human resources for the macroinvertebrate analysis.

This article presents an overview of the 1990-95 studies of the Sleeping Bear Dunes monitoring program. It compares logistical approaches used in different

(an indicator of ion content) and ammonia-nitrogen. Except for 1993, 10 sites on four streams—Platte River, Otter Creek, Crystal River, and Shalda Creek—were monitored every year (see figure 4 for site locations). Stream data collected included temperature, dissolved oxygen concentration, pH, and benthic macroinvertebrate community composition all years, plus specific conductance in 1994-95. Five benthic

CONSISTENCY ISSUES

Data collection methods were generally similar between years (Boyle and Hoefs 1993a and 1993b, Whitman et al. 1994). Staff monitored 21 lakes in 1990. Although 12 lakes were monitored each year thereafter, only 10 remained in common between 1991-92 and 1993-95. The lakes sampled in 1994-95 are shown in figure 4. Lake data collected all years included temperature and dissolved oxygen vertical profiles; Secchi disk transparency (fig. 5); and surface (or "shallow") pH, chlorophyll *a*, nitrate-nitrogen, and total phosphorus. Additional characteristics monitored in 1994-95 included specific conductance

Besides the designed reduction in collected data after the initial 3-year inventory, other differences in methods resulted from personnel, time, and budget decreases and loss of corporate memory. Fewer stream sites were sampled in 1993, and some of the 1994-95 sites were not the same ones sampled during the inventory. The lake samples were analyzed for ammonia-nitrogen in 1994-95, rather than Kjeldahl as in 1990-92, and no nitrogen species were analyzed in 1993. Nutrients and chlorophyll *a* analyses were done for shallow and deep samples from most lakes during the 1990-92 inventory. In 1993, samples were taken as depth composites as outlined by Boyle and Hoefs (1993a). Although depth-composited samples were taken initially in 1994, time constraints soon forced surface grab sampling instead.

One very important difference between years was the length of the data collection period. Although stream macroinvertebrate communities do not usually vary much over the short-term, some lake water parameters can change dramatically from day to day, depending on ambient events, changes in biological systems, and other limnological occurrences. Accurate comparisons of chlorophyll *a* or nutrient concentrations between lakes can therefore only be made if the observations occur within a 1- or 2-day period of comparable

weather. Lake sampling occurred over a 12-, a 4-, and a 5-day period in 1990, 1991, and 1992, respectively. Lake sampling in 1993 occurred over a 51-day period. Although the rest of the lake sampling took 15 days in 1994, samples for (surface) nutrient and chlorophyll *a* analyses were taken within an 8- and a 24-hour period, respectively. In 1995, all of the lakes were sampled in 1 day (12 hours).

Inconsistency in sampling methods restricts an investigator's ability to determine if data changes reflect actual water quality trends, thereby limiting the utility of a monitoring program. However, if methods are carefully recorded, one can determine how comparable the resulting data are. In this monitoring program, some data collection methods (such as exact sampling locations) were not well documented, making replication difficult. However, most methods were well documented. We know, for example, at what depths chlorophyll *a* samples were taken in each lake in each year, and, although the resulting concentrations may not correspond directly, we can still make general comparisons. Although methods consistency is very important, methods documentation is critical.

LESSONS LEARNED

The water quality monitoring program has provided us with valuable insight into the problems, issues, and compromises inherent in the creation and operation of such a program in a world of finite resources. From both our personal experiences in 1994-95 and a study of the project from its initiation, we have learned some lessons that we believe will be useful to those involved with monitoring programs in other parks.

Although mission commitment by the host park and regional office remained impressively strong, many of the problems encountered were related to lack of continuity of personnel and support and the learning curve to be expected for any complex field project. Consistent, reliable commitment and support are imperative not only for program continuity, but also for data integrity and ultimate program survival. Due to fiscal

constraints, program scale may be compromised for the sake of program survival, but consistency and continuity of salient programmatic elements must be maintained on some routine basis. Lack of adequate programmatic resources translates to increased turnover in program personnel and experience, resulting in decreased performance, efficiency, analytical accuracy, and consistency, and—most importantly—loss of corporate memory.

There are many programmatic compromises and issues involved in the development and operation of any water quality monitoring program, such as fineness or coarseness of sampling intensity, replication, quality assurance, and spatial-temporal representation. While the

former issues are quite important, consistency and program intensity remain the foundation of a quality monitoring program. Nonetheless, modifications to improve accuracy, efficiency, representation, and techniques should be continually considered. While it is possible to maintain program size by decreasing monitoring frequency (e.g., sampling in alternate years), loss of experienced personnel between sampling years remains a critical disadvantage. Also, gaps in information grow with decreased monitoring activity, and the advantages and disadvantages should be weighed in each situation.

Sleeping Bear Dunes and the former NPS Midwest Regional Office management remain deeply committed to a water quality program, as demonstrated by dedicated lab space, acquisition of modern analytical equipment, cooperation and assistance by all management branches of the park, and energy spent to find a source of continued funding. In the end, it is not the money that defines the program, but the dedication of the

support personnel. Nonetheless, people drive the monitoring train, and without fuel, neither can go very far.



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