IMPLICATIONS FOR FAUNAL HABITAT RELATED TO ALTERED MACROPHYTE STRUCTURE IN REGULATED LAKES IN NORTHERN MINNESOTA

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Abstract: Water-level regulation has altered the plant species composition and thus the structure of nearshore aquatic macrophyte communities in two regulated lakes in northern Minnesota as compared with a nearby unregulated lake. Results of previous faunal studies in the regulated lakes were used as a basis for assessing the effects of vegetation changes on faunal communities. The unregulated lake with mean annual water-level fluctuations of 1.6 m supported structurally diverse plant communities and varied faunal habitat at all depths studied. Mean annual fluctuations on one regulated lake were reduced to 1.1 m, and dense beds of four erect aquatic macrophytes dominated the 1.75-m depth that was never dewatered. We suggest that this lack of plant diversity and structural complexity resulted in diminished habitat for invertebrates, reduced availability of invertebrates as food for waterbirds and fish, reduced winter food supplies for muskrats, and reduced feeding efficiency for adult northern pike, yellow perch, and muskellunge. Mean annual fluctuations in the other regulated lake were increased to 2.7 m, and rosette and mat-forming species dominated the 1.25-m depth that was affected by winter drawdowns. We suggest that the lack of larger canopy plants resulted in poor habitat for invertebrates, reduced availability of invertebrates as food for waterbirds and fish, and poor nursery and adult feeding habitat for many species of fish. In addition, the timing and extent of winter drawdowns reduced access to macrophytes as food for muskrats and as spawning habitat for northern pike and yellow perch. In regulated lakes throughout the world, indirect effects on aquatic fauna resulting from alteration of wetland and aquatic macrophyte communities should be considered when water-level management plans are developed.

Key Words: Aquatic macrophytes, structural diversity, faunal habitat, water-level regulation, reservoirs.

INTRODUCTION

Wetland and aquatic macrophytes provide structural habitat for aquatic fauna in freshwater lakes, and they also affect other aspects of the environment in which the fauna live. Macrophytes are colonized by epiphytes, which provide food for invertebrate grazers. Invertebrates also find refuge from predation and sites for oviposition in macrophyte areas. Dead macrophytes and their associated bacteria are a food source for detritivores. Living macrophytes are a direct food source for aquatic herbivores, including invertebrates, fish, waterfowl, and muskrat, and they also provide shelter for many of these organisms (Carpenter and Lodge 1986). Different macrophyte communities provide habitats with different structure, cover, and food for aquatic fauna, with much of the difference in quality dependent on species diversity, density, and structural aspects of the plants (Engel 1985). The relations between macrophyte community structure and the various individual components of the faunal community are well documented (e.g., Bellrose 1950, Weller and Spatchler 1965, Crowder and Cooper 1982, Brown et al. 1988). However, the relations among altered hydrology, altered plant communities, resultant altered faunal habitat, and the differences in observed fauna have generally not been explored.

Wilcox and Meeker (1991) investigated the effects of two water-level regulation schemes on littoral mac-
macrophyte communities in two large lakes (Rainy and Namakan) in Voyageurs National Park, Minnesota by making comparisons with an unregulated lake (Lac La Croix). Changes in both species composition and structure of the macrophyte communities resulted from alteration of water-level regimes in the regulated lakes. The effects of water-level regulation on faunal communities in the regulated lakes were studied independently by others; however, these studies of invertebrates (Kraft 1988), aquatic birds (Reiser 1988), muskrats (Thurber et al. 1991), and fish (Kallemeyn 1987a, 1987b) did not interpret differences in faunal communities between lakes on the basis of differences in habitat provided by macrophytes.

In this paper, we assess the data from the macrophyte study to explore differences in the physical structure of the plant communities at different depths in the lakes and interpret how the structural changes might influence the faunal habitat provided. We review the literature on use of macrophyte habitat by different faunal groups to reinterpret the results of the faunal studies with respect to our findings on habitat differences.

STUDY AREA

Voyageurs National Park is situated on the United States–Canada border in the State of Minnesota (Figure 1). Water levels in a chain of large lakes on the Rainy River are regulated by several dams. The largest of the lakes is Rainy Lake, which has a total surface area of 89,357 ha, of which about 14,600 ha are in the park. Namakan Reservoir is upriver from Rainy Lake and consists of Namakan, Kabetogama, Sand Point, Crane, and Little Vermilion lakes. Namakan, Kabetogama, and Sand Point lakes are at least partially within the park and have a within-park surface area of 18,410 ha.

Lac La Croix, in Boundary Waters Canoe Area, is a natural lake upriver from Rainy Lake and the lakes of Namakan Reservoir and is similar to those lakes in most aspects except that its water levels are not regulated. The mean annual fluctuation of water levels in Lac La Croix is about 1.6 m (Figure 2). Lake levels peak in late May or early June and then decline gradually until spring runoff begins during the following April.

Water levels in Rainy Lake and Namakan Reservoir have been regulated by the International Joint Commission since 1970 in accordance with a water management program that sets acceptable high and low limits (termed "rule curves") for water levels throughout the year (Figure 2). Modeling has shown that the mean annual fluctuations of water levels under natural conditions would be 1.9 m for Rainy Lake and 1.8 m for Namakan Lake, but regulation results in mean annual fluctuations of 1.1 m and 2.7 m, respectively (Flug 1986). The rule curves can allow annual fluctuations as low as 0.6 m on Rainy Lake and as high as 3.0 m on Namakan Reservoir. Under the management plan, the lakes are regulated to reach peak levels in late June or early July, rather than immediately following spring runoff as much as a month earlier. Levels are then held stable throughout the summer and allowed to decline gradually through autumn and winter, as opposed to a gradual decline that would begin naturally immediately after the peak.

The annual water-level regime is more variable in Lac La Croix than in the regulated lakes because regulation reduces variability in Rainy Lake and Namakan Reservoir. Although Rainy and Namakan lakes deviate from the guidelines as much as 19% of the time, the annual variation is more extreme at Lac La Croix, ranging from 0.3 m to 3.0 m. Water quality and clarity are similar in the three study lakes (Kepner and Stottlemyer 1988, Minnesota Department of Natural Resources, unpublished data).

For the macrophyte study, two sites each were selected at Rainy Lake, Namakan Lake, and Lac La Croix. Details on site selections are given in Wilcox and Meeker (1991). At Rainy Lake, the sites selected were just east of Dove Bay (R1) and at Alder Creek (R2); at Namakan Lake, they were at Sheen Point (N1) and Deep Slu (N2); at Lac La Croix, they were at the east (L1) and west (L2) sides of Lady Boot Bay (Figure 1). Some of these sites were among those used for the faunal studies: Kraft (1988) studied invertebrates at Sheen Point in Namakan Lake; Reiser (1988) studied aquatic birds at Deep Slu in Namakan Lake; Thurber et al. (1991) studied muskrats at Alder Creek in Rainy Lake; and Kallemeyn (1987a, 1987b) studied fish at stations near Dove Bay in Rainy Lake and near Sheen Point and Deep Slu in Namakan Lake.

ANALYSIS OF MACROPHYTE COMMUNITIES

Vegetation was sampled along four transects at each study site in 1987 (see Figure 2), as described in Wilcox and Meeker (1991). The transects were established nearly parallel to the shoreline at altitudes (described as depth from mean high water) that represented specific habitat types in the non-regulated control lake, Lac La Croix. By also sampling at these altitudes on the regulated lakes, the effects of altered hydrologic regimes on plant communities could be assessed. The four transects at each site were at depths of 0.0, 0.5, 1.25, and 1.75 m. Twenty 1 × 1 m sampling quadrats were randomly located on each of the four transects at each of the six sites. At each quadrat, species identifications and percent cover estimations were made. Importance Values were calculated for each taxon as the sum of relative frequency and relative mean cover.