Zooplankton Recolonization of a Lake Cove Treated with Rotenone[1]

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Rotenone
plankton
Invertebrate
Population Density

ABSTRACT

The application of rotenone to a 4.5-hectare cove of South Branch Lake, Maine, greatly reduced the abundances of most zooplankton species. The recolonization of the cove by limnetic zooplankters was rapid, and species abundances there approached those of open waters and of the control cove within one week.

Rotenone has been widely used as a fish toxicant for the past 35 years (Smith 1940), although its detrimental effects on nontarget organisms has only more recently been criticized (Hubbs 1963). Studies concerned with the immediate and long-term effects of rotenone on benthic invertebrates (Cushing and Olive 1957; Almquist 1959; Cook and Moore 1969) and zooplankton (Kiser, Donaldson, and Olson 1963; Anderson 1970) indicate that the recovery of benthic communities is quite rapid, whereas zooplankton resurgence is much slower.

Previous investigations on zooplankton recovery were associated with the complete poisoning of a lake to remove undesirable fish species. With the increasing use of spot poisoning to reduce stunted populations, to remove spawning aggregations of undesirable species, and to estimate standing crop, the time necessary for invertebrate recovery assumes greater importance. The present study was undertaken in conjunction with a fish competition project to determine the time required for zooplankton to recolonize a lake cove treated with rotenone.

STUDY AREA

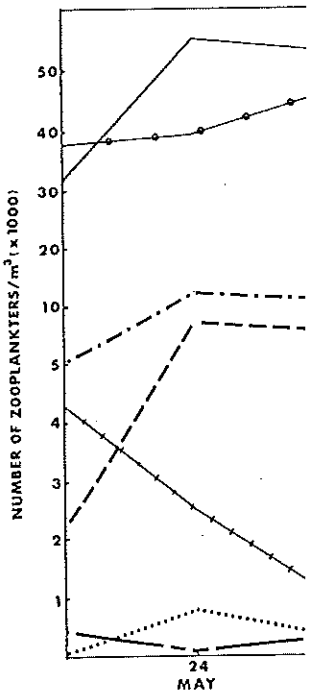
South Branch Lake is a shallow warmwater lake located in Penobscot County, north-central Maine. It has a surface area of 824 hectares with an average depth of less than 6 m. The lake has a typical warmwater fish fauna (Bryant 1972) with only two species of major interest to anglers: white perch (*Morone americana*) and smallmouth bass (*Micropterus dolomieui*).

The cove under study is located on the west side of the lake and has an area of 4.52 hectares and a mean depth of 1.6 m. Vegetation was sparse on the mud bottom during the poisoning and recovery period, although floating leaf plants (*Nymphaea* and *Brasenia*) appeared by mid-June. Water chemistry data taken in the cove prior to rotenone treatment were as follows: dissolved oxygen 9.1 ppm, alkalinity 8 ppm, pH 6.5, temperature 16.0 C.

MATERIALS AND METHODS

The entrance to the cove was closed off, prior to poisoning, with blocking nets of 4.8 mm mesh extending from shore to a small island between the cove and the lake proper. Noxfish® (5% rotenone) was applied from a boat to attain a concentration of approximately 0.6 ppm during the afternoon of June 2. Water temperature during June was monitored with a maximum-minimum thermometer.

Zooplankton samples were collected during the afternoon of each sampling date, using a No. 20 conical plankton net (0.5 m mouth, 76 μm mesh). Two floats were placed 100 m apart in the cove to standardize the distance and location of sampling. The mean water depth between floats was 2.0 m. Each surface tow co-



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[1]Contribution of the Maine Cooperative Fishery Unit: United States Bureau of Sport Fisheries and Wildlife; Department of Zoology, University of Maine at Orono; and the Maine Department of Inland Fisheries and Game, cooperating.

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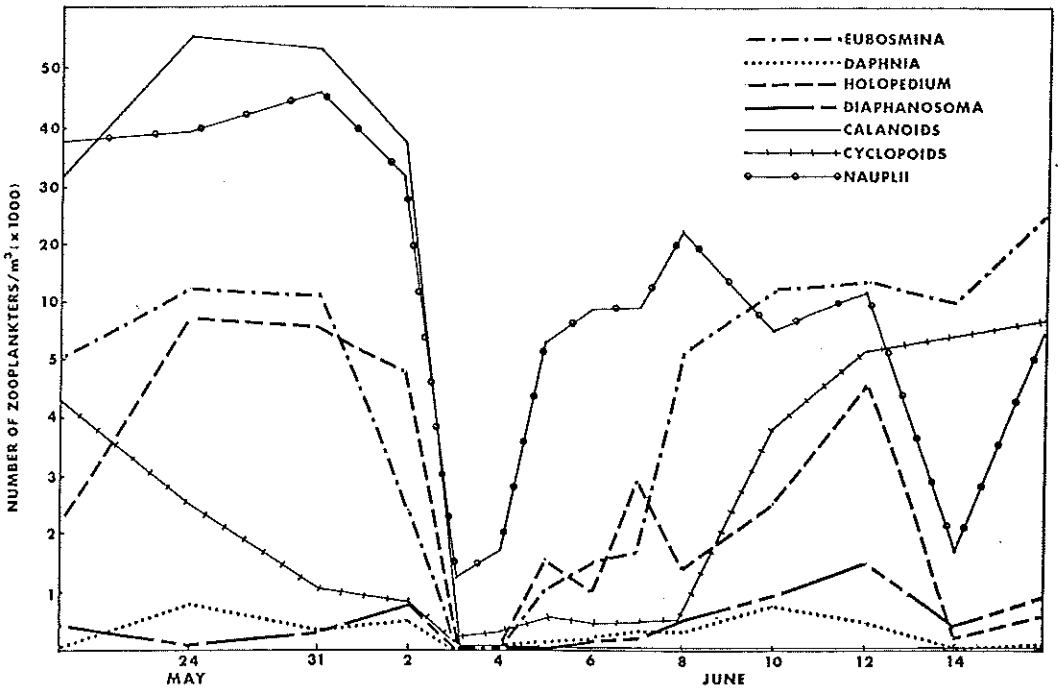

FIGURE 1.—Abundance of major constituents of the zooplankton per cubic meter in the cove prior to and after application of rotenone on June 2.

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vered 100 m at a speed of approximately 2.4 km/h. To determine normal fluctuations of open water and cove zooplankton populations, two additional 100 m stations were established: one outside the study cove to monitor the source of recolonization, and the other in an adjacent cove. The mean water depths at these stations were 4.0 m and 1.8 m, respectively. Samples were collected daily at all three sites during the first week and every other day thereafter.

The filtration coefficient (f) of the net was determined before and after the sampling period, using flowmeters attached inside and outside of the net. The slight decrease in f was used to correct the volume of water filtered for each sampling date, assuming a gradual decline in filtration efficiency. Samples were preserved in 5% formalin and allowed to settle for 24 hours in either an Imhoff cone or a graduated cylinder for a quantitative assessment.

For zooplankton counts, each sample was diluted to a workable density (100–200 macroplankters/ml). Five 1-ml subsamples were taken with a large-bore pipette and generic counts made, using a Sedgewick-Rafter cell under a binocular microscope (40×). Identifications were made, using Pennak (1953), Brooks (1957), and Edmondson (1959). The mean number per cell and the percent composition for each date was calculated from the subsamples and converted to a standard volume of 1 liter. Zooplankton abundance is expressed as number/m^3 of water filtered.

RESULTS

Within 24 hours after rotenone application, net plankton volume dropped to 3% of pre-rotenone levels. Copepod and cladoceran populations were nearly exterminated after two days of toxic conditions (Fig. 1). Rotifer populations also declined, although *Keratella* and *Conochilus* were not greatly affected. These genera produced minor blooms in the study cove during the recovery period and peaked in abundance on June 9. Mean water temper-

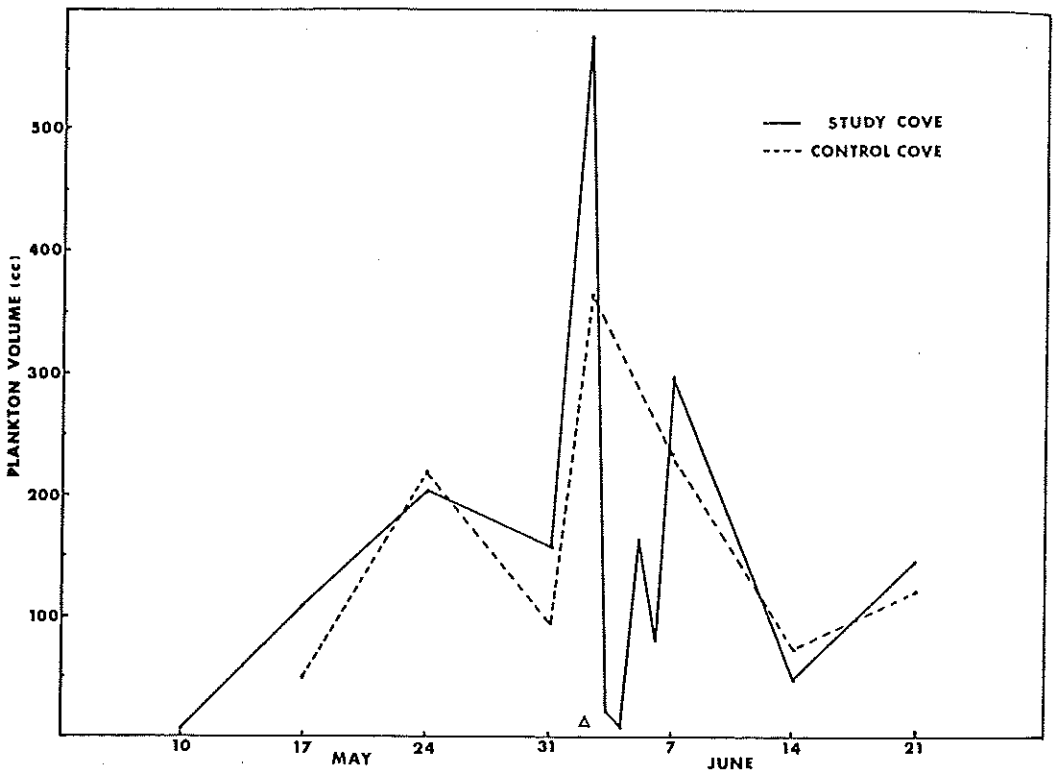

FIGURE 2.—Total plankton volume in the study cove and control cove showing recovery rate after rotenone application on June 2. Δ indicates point of application.

atures during the first and second weeks of June were 17.0 C and 19.5 C, respectively. Entomostracans present in the water column during the toxic period, although in greatly reduced numbers, included *Eubosmina* sp., *Mesocyclops edax*, *Tropocyclops prasinus*, and copepod nauplii (Fig. 1). Limnetic species completely eradicated by the rotenone included the cladocerans: *Daphnia catawba*, *Daphnia dubia*, *Diaphanosoma leuchtenbergianum*, *Holopedium gibberum*, *Leptodora kindtii*, and *Polyphemus pediculus;* and the copepods *Epischura lacustris*, *Diaptomus minutus*, and *Cyclops vernalis*. Most benthic invertebrates did not appear distressed by the treatment, although a few mayfly nymphs and biting midge larvae (Ceratopogonidae) appeared in the plankton collections of June 3 and 4.

Species composition within the study cove approached that of the outside station on June 6 and that of the control cove on June 8. A quantitative comparison of samples taken from the two coves indicated that zooplankton abundance also returned to normal in less than one week (Fig. 2).

DISCUSSION

Detoxification of the cove and recolonization by limnetic species was more rapid than was anticipated. Northeast winds on June 2 probably assisted in the dilution of the rotenone concentration within the cove.

Qualitative differences between littoral and open water entomostracans are not readily apparent in South Branch Lake during June (Neves 1973). Species compositions at the three sampling sites were therefore similar, although day to day variability was in some cases extreme. Wind direction changes and patchiness in plankton created problems with the quantitative estimates of zooplankton abundance within

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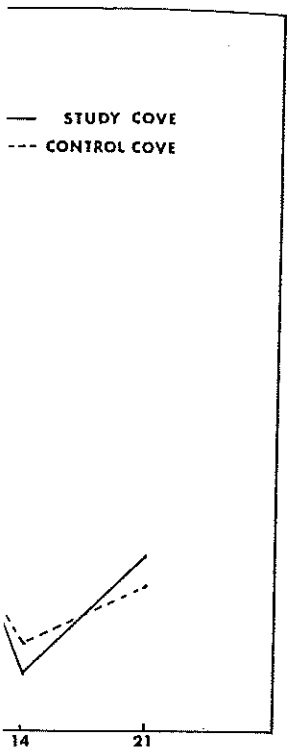

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the coves. Large settling volumes, in most cases, reflected the abundance of the larger encapsulated *Holopedium gibberum* and not the more numerous, but smaller, species. A similar quantitative bias due to this species was reported by Kiser, Donaldson, and Olson (1963).

The emigration of cladoceran species from shoreline vegetation reported in previous rotenone studies (Kiser, Donaldson, and Olson 1963; Anderson 1970) was negligible, due to the rapid immigration of limnetic zooplankters. The disappearance of calanoids in the study cove on June 3 preceded, by two days, a natural decline in abundance within the control cove. Examination of plankton tows, taken after June 5 at all three sampling sites, showed a precipitous decline of both calanoid species (*D. minutus* and *E. lacustris*). The rotifer blooms recorded during the recolonization period probably resulted from either the lack of competition or the low population levels of grazing zooplankters.

ACKNOWLEDGMENTS

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