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Author(s): James R. Barnes and Thomas W. Toole

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## MACROINVERTEBRATE AND ZOOPLANKTON COMMUNITIES OF UTAH LAKE: A REVIEW OF THE LITERATURE

James R. Barnes<sup>1</sup> and Thomas W. Toole<sup>1,2</sup>

**ABSTRACT.**—Early studies on the macroinvertebrates and zooplankton of Utah Lake were taxonomic in nature. Since the late 1960s, macroinvertebrate studies have concentrated on the Goshen Bay area of Utah Lake. The rocky shore macroinvertebrate community along the eastern shore of Goshen Bay is the most diverse and productive in Utah Lake (Toole 1973). The dominant organisms are the amphipod *Hyalella azteca* and the chironomid *Dicrotendipes fumidus*. Also present along the eastern shore is an extensive zone of the sponge *Meyenia fluviatilis* (Smith 1972). Two taxa, Chironomidae and Oligochaeta, dominate the silty-ooze community in the southern portion of Utah Lake (Barnes et al. 1974). The life histories and the microdistributional patterns of the two dominant chironomids found in the silt-ooze area of Goshen Bay, *Tanypus stellatus* and *Chironomus frommeri*, have been extensively studied by Shiozawa and Barnes 1975. The distribution and abundance of the zooplankton in Utah Lake has been studied for one summer (Hanson et al. 1974). Little is known about the dynamics of the zooplankton community in Utah Lake.

The first studies on the macroinvertebrate and zooplankton communities of Utah Lake were basically faunal lists of the protozoans, zooplankton, and Mollusca found in Utah Lake (Chamberlin and Jones 1929, Hunt 1940, Tanner 1930, 1931). The identifications of the species reported in the above papers have not been reexamined. Between 1940 and 1968 the macroinvertebrates received little, if any, attention. Brown (1968) conducted the first extensive study on the littoral macroinvertebrates of the Lincoln Beach area. Most studies since then have concentrated on the Goshen Bay region. This area, consisting of approximately one-third of the lake's total surface area, will be removed from the lake proper if the proposed Goshen Bay Dike (part of the Bureau of Reclamation's Central Utah Project) is built.

This paper reviews the literature of the macroinvertebrate and zooplankton communities of Utah Lake.

### I. LITTORAL ZONE

For a general discussion of the biological, chemical, and physical characteristics of lake littoral zones, see Wetzel (1975). Littoral zone studies in Utah Lake have concentrated on the rocky area along the eastern shore of

Goshen Bay. In Utah Lake this rocky zone is the most extensive littoral area and supports a productive and diverse macroinvertebrate community (Toole 1974). In this area there are two main substrate types: compacted calcareous tufa (lacustrine) and rubble (Bissel 1942). Along the western shore of Goshen Bay, a similar rocky zone is found, although not as extensive. The eastern shoreline has numerous saline springs that are high in free carbon dioxide, bicarbonate alkalinity, and sulfate (Toole 1974).

Brown (1968) studied the fall and winter macroinvertebrate populations of Lincoln Beach. Samples were taken with a circular sampler at six stations along a 300 m stretch of rubble beach at a water depth of 0.5 m. The amphipod crustacean, *Hyalella azteca*, was the dominant macroinvertebrate in numbers, with the highest standing crop in September (mean number = 1,208/m<sup>2</sup>). The next most dominant was the chironomid *Tanytarsus* sp. The highest density of this midge was in November (mean number = 320/m<sup>2</sup>). Identification of this chironomid as *Tanytarsus* sp. is incorrect; it is probably *Dicrotendipes fumidus* (Toole 1974). The leech, *Helobdella stagnalis*, was next in abundance (150/m<sup>2</sup>). Other organisms collected were a snail, *Physella utahensis*; a trichopter-

<sup>1</sup>Department of Zoology, Brigham Young University, Provo, Utah 84602.

<sup>2</sup>Present address: Tennessee Valley Authority, Florence, Alabama, 35630.

ran, *Polycentropus* sp.; and a water mite, *Lebertia* sp.

Toole (1974), using concrete artificial substrate samplers, studied the standing crop (numbers and biomass) and the annual population trends of the dominant macroinvertebrates found in the rubble and lacustrine habitat along the eastern shore of Goshen Bay. The period of study was from March 1972 through May 1973. Throughout this study period the samplers were retrieved from an average water depth of 0.8 m. In the rubble area the amphipod *Hyalella azteca* and the chironomid *Dicrotendipes fumidus* were the dominant organisms on the samplers. Other organisms collected were *Polycentropus cinerinus*, a trichopteran; *Helobdella stagnalis*, *Dina parva*, and *Erpobdella punctata*, leeches; *Ambrysus mormon*, a naucorid hemipteran; and the gastropod *Physella utahensis*. At the lacustrine sampling site the same species were collected, plus a planarian worm, *Dugesia dorotocephala*. Standing crop estimates were always higher from the rubble area than the lacustrine. In the rubble area the standing crop values depended on whether or not a set of samplers was within the influence of a saline spring. Those samplers within this influence always had a greater "algal mat" growing on them and the highest numbers of associated *Hyalella azteca*. The high concentration of free carbon dioxide and bicarbonate alkalinity in the spring water may be the reason for the higher algal standing crop. It is known that *H. azteca* feed on filamentous green and blue green algae and have the ability to select sediments that contain viable microflora (Cooper 1965, Hargrave 1970).

The number of *Hyalella azteca* reported by Toole from the rubble area is the highest found in the literature. The maximum estimate was  $37,898/m^2$  for August 1972. The highest biomass value (wet weight) was  $66.5 \text{ gms}/m^2$  for April 1973. Assuming an 85 percent water content, the dry weight estimate would be  $9.9 \text{ gms}/m^2$ . These high standing crop estimates of *H. azteca* can probably be attributed to three factors: (1) an excellent substrate for epibenthic algae provided by the rubble and pieces of lacustrine substrate, (2) the eutrophic condition of Utah Lake and additional nutrients provided by saline

springs, and (3) the combined effect of a shallow water depth over most of the littoral area and high water temperatures.

In March, April, and May, 1972, the *H. azteca* population consisted entirely of first- and second-year adults—the first-year adults making up 75 percent of the population. Immatures appeared in the population in June and dominated, in numbers, through October, thus making up 50–60 percent of the population. During this same time period, the numbers of second-year adults oscillated between 10–15 percent of the total population. In November, when the first year adults became dominant, there was a dramatic decrease in the percentage of immatures. The population overwintered as immatures and first- and second-year adults. In April 1973 (the first sample taken after the ice came off the lake) the population showed the same composition as found in November 1972. In May 1973 only first- and second-year adults were present in the population.

The chironomid *Dicrotendipes fumidus* overwinters as second, third, and fourth instar larvae, with the fourth being the most abundant. A major emergence occurred in March 1972 about three weeks after the ice broke up. Adults were found in the sampling area throughout the summer, which indicates a long emergence period. However, the emergences that took place throughout the summer were much smaller than the initial emergence. The highest larval density estimate was  $21,421/m^2$  in July 1972. At this time, the population consisted of second, third, and fourth instar larvae, with the third being dominant. The sieve used in this study restrained only the second, third, and fourth instar larvae. The high wet weight biomass estimate was  $9.5 \text{ gms}/m^2$  or  $1.4 \text{ gms}/m^2$  dry weight in September 1972. In that month third and fourth instar larvae dominated the population.

These high estimates are from artificial substrate samplers that had been located within the influence of spring water. The numbers of *Hyalella azteca* found on samplers located outside the influence of spring water exceeds other estimates found in the literature (Cooper 1965, Anderson and Hooper 1956, Buscemi 1961, Gerking 1962).

The littoral zone along the eastern shore of Goshen Bay supports the most productive and diverse macroinvertebrate community in Utah Lake (Toole 1974). When converted to dry weights (assuming a water content of 85 percent) and on the basis of only two species (*Hyalella azteca* and *Dicrotendipes fumidus*), the standing crop biomass values for this area ranks Utah Lake as one of the top 10 lakes found in the United States in terms of benthic standing crop (Cole and Underhill 1965). This comparison does not take into account the other species present in this area or the extensive zone of the sponge *Meyenia fluvialis* (Smith 1972).

The trichopteran *Polycentropus cinereus* is rare in comparison to *Hyalella azteca* and *Dicrotendipes fumidus*. Emergence takes place in April along the Goshen Bay littoral area. The highest densities were 1,937/m<sup>2</sup>, November 1972 (Toole 1974).

General population trends and emergence patterns of the dominant macroinvertebrates in the lacustrine area follow those found in the rubble area. The standing crop of the lacustrine area was smaller than reported for the rubble area. Brown's (1968) standing crop estimates of *Hyalella azteca* from the lacustrine area are difficult to compare with those obtained by Toole (1974) because Brown's sampling was limited to a water depth of 0.5 m or less. Toole's maximum estimate from the lacustrine area was 15,121/m<sup>2</sup>, August 1972, which is 10 times greater than Brown's maximum estimate. Artificial substrate samplers retrieved from the lacustrine area always had less algae and more silt than samplers from the rubble area.

Tillman and Barnes (1973) studied the reproductive biology of the leech *Helobdella stagnalis* in the same rubble area studied by Toole (1974). The annual reproductive cycle of *Helobdella stagnalis* in Utah Lake is considerably different from the cycle found in Whiteknights Lake, Reading, Berkshire, England (Mann 1957). Mann reported that overwintering adult leeches produced a brood of young in May and then died in June. Over 50 percent of the new brood matured and reproduced in July and August and died after reproduction. The next year's overwintering leeches were composed of June leeches that did not mature and July-to-August leeches

produced by the mature June brood leeches. Tillman and Barnes found in Utah Lake that overwintering adult leeches have a first brood of young in May that release from the adults in mid-June. Then the same adults bear a second brood of young in late June and early July. The adults disappear from the population after the second brood of young. Very few first and second brood leeches mature and reproduce that same summer. The leeches from the first and second brood then become the next overwintering population.

## II. CLAY-SILT AREA

For a description of the substratum composition, see Bingham (1974). Barnes et al. (1974) sampled the clay-silt area of the southern part of Utah Lake monthly from September 1971 to September 1972, except when the lake was iced over. Two transects (1 and 2) were located in the area of Goshen Bay to be diked off and the other two (3 and 4) were located in front of the proposed dike (the area to be retained as part of the lake). Only two dominant taxa were found: Chironomidae and Oligochaeta.

Oligochaetes collected in this study were not classified. Preliminary examinations indicate that there are three dominant oligochaete species. During the period of study, the mean number of oligochaetes collected ranged from 8643/m<sup>2</sup> to 26,192/m<sup>2</sup>. In general the oligochaetes showed a decrease in numbers during the spring and then an increase during late summer and early fall.

There are at least three species of chironomids present in the silty clay area: *Chironomus frommeri*, *Tanytarsus stellatus*, and *Procladius freemani*. They were not separated to species when sorted to taxa and only total numbers were reported. The mean number of chironomids ranged from 237/m<sup>2</sup> to 7167/m<sup>2</sup>. Like the oligochaetes, the chironomids showed a decrease in numbers during spring and then an increase during late summer and fall. Because of the screen size used in sieving, the numbers of chironomids are represented by only second, third, and fourth instars of the larger species and third and fourth instars of the smaller species.

Analysis of variance (ANOVAR) was used to compare the mean number of chironomids and oligochaetes in the following contrasts:

Transects 1 and 2 versus 3 and 4, transect 1 versus 2, and transect 3 versus 4. At the 0.05 level there was a significant difference between the oligochaete means of transects 1,2 (area to remain in the lake) and transects 3,4 (area to be diked off). There were no significant differences between the oligochaete means in 1 versus 2 and 3 versus 4. The chironomid means showed no significant differences in any contrasts at the 0.05 level.

The numbers of oligochaetes per square meter in Utah Lake are consistent with numbers reported from other eutrophic waters. In Toronto Harbor, Lake Ontario, which is grossly polluted, the oligochaete population averaged 96,000/m<sup>2</sup> (Brinkhurst 1972) with one worker reporting densities of well over a million/m<sup>2</sup> (Aston 1973). The low number of oligochaete species present in the clay-silt of Utah Lake is consistent with other shallow lakes that also show little diversity in benthic habitat. Heuschele (1969) studied the benthic community of a shallow floodplain lake and found only three species of oligochaetes present. Utah Lake, like the flood plain lake, has little to no rooted aquatic vegetation present and a majority of the lake substratum is quite uniform with respect to chemical factors, temperature, depth, and light. Greater numbers of oligochaete species are found in deeper lakes with more diverse habitats. Thirty-three species have been reported from Lake Maggiore (Brinkhurst 1963) and 22 from Esrom Lake (Berg 1938). In comparison with deeper, oligotrophic lakes (Thut 1969), Utah Lake has a low number of chironomid species. The density of chironomids found in the Goshen Bay area is consistent with that found in shallow lakes (Heuschele 1969).

Shiozawa and Barnes (1977) studied the microdistributional patterns and life histories of larval *Tanypus stellatus* and *Chironomus frommeri* in Goshen Bay from July 1973 to August 1974. Vertical distribution data showed that over 90 percent of the larvae were located in the top 7.5 cm of the substratum. Depth of penetration into the substratum increased with the later instars. The *C. frommeri* larvae penetrated deeper than those of *T. stellatus*. Biomass was distributed bimodally. The mode at the 0–2.5 cm depth was due to high numbers of early instar larvae. The second mode, at the 17.5–20.0 cm

depth, was due to the presence of fourth instar *C. frommeri* larvae. The *T. stellatus* showed a contagious distribution in the early instars with a trend toward randomization within the later instar stages. The *C. frommeri* larvae rarely showed contagious distributions. This was likely related to their low abundance in the samples, making detection of a contagious distribution difficult.

Larvae of *T. stellatus* overwintered in the first and second instar. This overwintering generation emerged in early July and gave rise to a second summer generation emerging in August. *Chironomus frommeri* overwinter mainly as third and fourth instar larvae. Emergence occurred throughout the summer, although two strong emergence pulses were seen; one occurred in May and the second in July–August.

### III. ZOOPLANKTON

Hanson et al. (1974) sampled the zooplankton in Utah Lake during a three-month period from June to August 1974. Transects were chosen to represent three subenvironments within the lake. The northern or Geneva transect ran west from the settling pond spillway of United States Steel's Geneva Works. Five sites were sampled. The middle or Boat Harbor transect also had five stations running west from a point just south of the mouth of the Provo River and north of Provo Bay. The southern or Goshen Bay transect, being shortest with only four sampling sites, ran west from Ludlow's sheep barns near Lincoln Beach. Samples were collected every nine days between 4 June and 15 August 1974.

A complete list of the zooplankton identified in this study is given below (those marked by an asterisk have not previously been reported):

#### Copepoda

*Diaptomus* spp. (two species)

*Cyclops* spp. (two species)

#### Cladocera

*Daphnia retrocurva*

*Pseudosida bidentata*

*Leptodora kindtii*

\**Bosmina longirostris*

*Chydorus sphaericus*

*Ceriodaphnia* sp.

## Rotifera

- Keratella cochlearis*
- Keratella quadrata f. valga*
- Keratella quadrata f. frenzeli*
- Brachionus caudatus*
- Brachionus calyciflorus*
- Brachionus budapestensis*
- Filinia terminalis*
- Polyarthra* sp. (*minor* or *remata*)
- Synchaeta* sp.
- Notommata* sp.
- Asplanchna* sp.
- Colurella* sp.
- Cephalodella* sp.

Most zooplankton species were present at all stations, though their frequencies varied rather widely. Areas influenced by the inflow from the Provo River showed more diversity, less dominance by few species, and larger standing crops. Using the variance to mean ratio (Elliott 1971), zooplankton distribution in total numbers was determined to be aggregated. Populations in large clumps make it very difficult to determine accurate standing crop estimates. For instance, two samples taken on the Boat Harbor transect at Station A on two consecutive days, 21 June, and 22 June, illustrate this. The 21 June sample contained 398,000 zooplankton/m<sup>3</sup>; the sample collected the following day contained only 50,000 zooplankton/m<sup>3</sup>. Relative densities of individual species in the two samples were also very different.

Some zooplankton population trends were observed. In the northern two transects, the total zooplankton numbers peaked in late June and early July, then dropped off in August. No pattern was as obvious in Goshen Bay, although highest numbers were observed in early August. Trends in some populations are reported. In early samples the calanoid copepods dominated, with their dominance decreasing steadily throughout the summer; by August *Daphnia retrocurva* and *Pseudosida bidentata* were found in slightly higher numbers than the calanoids. *Pseudosida* populations were stable, although *Daphnia* populations seemed to show a slight inverse proportionality to calanoid populations. This tendency was more evident in Goshen Bay than in the other parts of the lake. A more obvious trend was the increase

through the summer in numbers of predatory cyclopoid copepods and *Leptodora kindtii*. No correlations between phytoplankton and zooplankton populations were made.

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