INTERNAL REPORT 71

A PROGRESS REPORT ON INSECT EMERGENCE AT FINDLEY LAKE DURING 1972

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ABSTRACT

The preliminary results of a study of the insect emergence at Findley Lake in the Cascade Mountains of Washington during 1972 are presented. Bottom samples were taken from different regions of the lake to compare the insect emergence at the surface, the physical conditions of the bottom, and the biological communities within the bottom sediments. Those insects that have both an aquatic larval stage and an adult flying stage in their life cycles were collected when they emerged from the lake by ten floating- and ten shore-emergence traps.

The insects were identified to family, then counted, dried, weighed, and the total biomass that emerged was determined. Graphs were constructed showing the biomass that emerged per day for those orders and families that contributed more than one percent of the total biomass. The dominant insects were Trichoptera (Limnephilidae), Diptera (Tendipedidae and the culicid genus *Chaoborus*), and Ephemeroptera (Baetidae). There were two main periods of emergence, one consisting mainly of Diptera a few days after the ice melted off the lake in early July, and another consisting mainly of Trichoptera in late August and early September. The greatest insect emergence was near the inlet streams that provided undecomposed plant material to the lake.

INTRODUCTION

The purpose of this project is to study the production of adult flying insects from a mountain lake and to relate the biomass that is produced and the species that emerge to the physical and biological conditions within the lake. Many species of insects spend part of their life cycles as aquatic larvae feeding upon plant material that is produced within the lake, decomposing plant material that enters the lake from the surrounding land, or upon other animals within the lake. They then undergo metamorphosis and emerge at the surface or at the shore of the lake as flying adults.

Those insects that emerge represent a transfer of nutrients across the boundary separating the aquatic environment from the surrounding terrestrial environment. Many of these insects return nutrients to the lake by laying eggs within the lake, being captured by aquatic predators, or dying and returning to the lake by other means. Other insects contribute their nutrients to the surrounding terrestrial environment by being prevented from returning to the lake by weather conditions, being unsuccessful in reaching other bodies of water, or by being captured by terrestrial predators. This progress report concentrates on the work that was done during 1972 to quantify the insect emergence from the aquatic environment.

PHYSICAL AND BIOLOGICAL CHARACTERISTICS OF FINDLEY LAKE

Meteorological Conditions

Findley Lake is located in the Cedar River watershed on the west side of the Cascade Mountains of Washington at an altitude of 1128 meters and a latitude of 47° 19' north. This area has a heavy precipitation with most of it occurring during the winter as snow. An average of 10.67 meters of snow falls each year at the Snoqualmie Pass weather station, 16 kilometers northeast of Findley Lake at an altitude of 920.5 meters (George Hendrey, personal communication). During the winter of 1971-1972, a new world's record snowfall of 28.77 meters was recorded at Paradise ranger station, 55 kilometers south of Findley Lake at an elevation of 1677 meters.

During November, a thin layer of ice forms on the surface of the lake. This ice is then rapidly covered by a thick layer of snow. As more snow accumulates on the top, the ice gradually melts from the bottom of this frozen mass until the lake is covered by a two- to three-meter thick layer of frozen snow. This does not thaw until June or July. The two ponds near Findley Lake (Figure 1) thaw at about the same time as the lake, but the shallow pond occasionally freezes temporarily as early as October.

Watershed

The 117,356-square meter lake and two smaller ponds (Figure 1) are located at the bottom of a cirque that was carved in volcanic rock by an alpine glacier about 15,000 years ago. A ridge rises 160 to 300 meters above the lake on all sides except to the north where Findley Creek drains the cirque. Cliffs with loose talus rocks below them and steep forested slopes of Pacific silver fir (*Abies amabilis*) and mountain hemlock (*Tsuga mertensiana*) surround the lake. Other common plants are huckleberry (*Vaccinium* spp.) and bear grass (*Xerophyllum tenax*). There are several wet meadows at the shore of the lake and the shallow pond.

Most of the water enters the lake from eight streams supplied by melting snow from the approximately 100-hectare watershed. These streams, which are being studied by Greg Rau, carry a considerable amount of undecomposed and partially decomposed conifer needles, bark, and sticks into the lake. Their contribution probably varies considerably from year to year depending upon the amount of snowfall and the avalanche conditions. It appears that avalanches in the past have carried entire trees into the lake.

Lake Water

The water of Findley Lake is extremely clear. During the plankton bloom after the ice melted off the lake, a 20-cm secchi disc was visible at a depth of 12.0 meters. The water then became clearer until the secchi disc was visible at 20.5 meters on 12 September 1972. The clarity is an indication of the low photosynthetic productivity of the water and the lack of suspended particulate matter. Not only is the water clear, but the ice-free growing season is short.

The water of the two ponds is also clear. A secchi disc was visible on the deepest part (4.0 meters) of the bottom of the lower pond during the entire summer and early fall of 1973. Small objects were distinctly seen on the deepest part (1.5 meters) of the bottom of the shallow pond during the entire summer of 1972.

Bottom Types

There are two deep basins in the lake (Figure 1) with maximum depths of 30 and 17 meters. The composition of the bottom sediments of these basins is uniform, consisting of a soft brown ooze with a few rust colored sand grains. There are many large red Tendipedid (= Chironomid) larvae.

A midlake ridge 3 to 12 meters below the surface separates the two deep basins. Some rocks can be seen extending above the surrounding sediments which consist of a thin layer of light brown mud over a layer of light gray clay over sand. This sand is similar to that of the shallow parts of Findley Lake and the lower pond. The midlake ridge is below the level to which the lake freezes in the winter and does not receive material directly from streams and avalanches. Most of the finer organic material that settles on the ridge probably gradually slides off it and into the two basins.

There is a greater diversity of bottom types where the water is less than 6 meters deep. The bottom sediments are influenced by various factors: input from the cliffs, waves, ice and snow pressure, large mammals, and the surrounding forest.

Most of the shallow bottom on the north and east sides of the lake consists of a thin layer of brown organic material over sand that is apparently derived from the talus rocks. A layer of light gray clay is found between the organic material and the sand in some areas. Occasional rocks protrude above the surrounding sediments. The areas near the outlet of the lake and the meadow inlet on the east side of the lake thaw several weeks before the rest of the lake.

The bottom near the cliffs and talus slopes of the west side of the lake has a steep slope and many talus rocks showing above the surrounding sediments. There are several streams feeding into the south side of the lake from the avalanche-disturbed forested slopes. Bottom samples from this area consist of brown organic mud, undecomposed and partially decomposed conifer needles, pieces of bark, and sticks.

The shallow bay on the south side of the lake is partially separated from the rest of Findley Lake by large logs and tree trunks. There are small submersed reeds, some of which reach the surface late in the summer. Bottom samples from the level bottom consist of hard-packed organic material. This is the first part of the lake to freeze in the fall and the last part to thaw in the spring. It freezes to the bottom during the winter. During the summer, the temperature of the water in the bay fluctuates more with variations in the air temperature than the water of the rest of the lake. Elk and bear wade here. In many ways, the shallow bay resembles the shallow pond more than it resembles the rest of Findley Lake.

Although Figure 1 shows the bottom of the lake divided into several parts, there is a gradual transition from one type of bottom to another. There are also small areas of certain bottom types mixed in with larger areas of other types. The divisions of Figure 1 show the relative areas of the different bottom types.

Aquatic Plants

Rooted aquatic plants are present in about three percent of the lake, mainly in the shallow bay, and about 25 percent of the shallow pond. Even at these locations, the vegetation is sparse. It consists of small submersed and emergent reeds. The shallow pond also has horsetails (*Equisetum*). There is not much rooted or floating aquatic vegetation for herbivorous aquatic insect larvae to eat compared to the amount of undecomposed vegetation that enters these bodies of water from the surrounding terrestrial environment. Moss (*Fontinalis* and *Sphagnum*) grows along parts of the shore.

Animals

Findley Lake has no fish. Although the aquatic insect larvae could possibly support a population of trout, no fish have successfully migrated past the waterfall barriers and colonized the lake since the lake was formed by an alpine glacier.

Several amphibian predators are present. Rough-skinned newts (*Taricha granulosa*) are found throughout Findley Lake and the two ponds. Many of them were seen on the midlake ridge at a depth of eight meters and near the outlet of the lower pond. Cascades frogs (*Rana cascadae*) and western toads (*Bufo boreas*) are common along the shores of all three bodies of water and in the wet meadows. Toads are frequently seen as far from the water as the top of the ridge 300 meters above the lake. There are a few northwestern salamanders (*Ambystoma gracile*) and Pacific tree frogs (*Hyla regilla*).

The insect predators that are aquatic both as larvae and adults include backswimmers (Notonectidae), water striders (Gerridae), whirlgig beetles (Gyrinidae), and predaceous diving beetles (Dytisiidae). There is a greater population density of them in the two ponds and in the shallow areas of the lake than in the deeper areas of the lake.

Black bears (*Ursus americanus*) have eaten amphibians, rodents, the larvae of bees and wasps (Hymenoptera), and vegetation. Their wading in the shallow water near the meadows of the lake and the shallow pond has disturbed the bottom sediments. An unidentified carnivore, possibly a raccoon (*Procyon lotor*) has fed upon the amphibians of the shallow pond.

There are no ducks, loons, herons, or other large aquatic birds that live at the lake during the summer, although ducks occasionally visit the lake. This might be because of the lack of fish or low densities of other food. Dippers (*Cinclus mexicanus*) feed in the stream that flows between Findley Lake and the lower pond. They are occasionally seen feeding upon insect larvae near the inlets to the lake.

The elk (*Cervus canadensis*) and mule deer (*Odocoileus hemionus*) are herbivores, but they have had a considerable influence upon the meadows and shallow areas of Findley Lake and the shallow pond. Not only do they feed upon the vegetation of the meadows, but their hooves compress the meadow plants and disturb the banks and shallow water sediments.

METHODS

Bottom Samples

Samples of the bottom material were obtained with a 15.2 cm x 15.2 cm x 15.2 cm Ekman dredge. The dredge was lowered to the bottom on a calibrated line. The jaws of the dredge were closed, the depth of the bottom was recorded, and the trap was hauled back to the surface. In areas with many large rocks or pieces of wood, the dredge was lowered to within one meter of the bottom, and then lowered the rest of the way only if there was no obstacle under it that would prevent the jaws from closing. Samples were examined only if the jaws had successfully closed. In shallow areas where the bottom was too firm for normal operation of the dredge, the dredge was pushed into the substrate by hand. This was done to three different depths in the packed bottom material of the shallow bay to determine how deep in the sediments the organisms were located.

The thickness of the layers of the sediments in the dredge was observed. The contents were then poured into a bucket, mixed with water, and allowed to settle for five minutes in glass jars in order to observe the relative proportions and densities of the bottom materials and the organisms present. These samples were then discarded.

On eight dates from 25 July 1972 to 29 September 1972, bottom samples were obtained from six sites at Findley Lake that were marked by buoys. These sites were adjacent to some of the insect emergence traps, but far enough from them so that the substrate under the emergence traps was not disturbed. The samples were poured through a sieve with 0.5 cm openings to remove the larger rocks, sticks, and pieces of bark. They were then put into closed containers until they were processed in the laboratory that evening or the following morning.

The method used for separating the organisms from the bottom material was based upon the work done by Klaassen (1967). The samples were washed through a sieve with .42 millimeter openings to separate the organisms and some of the larger debris from the finer sediments. The organisms were then floated on a sucrose solution with a specific gravity that was gradually increased from 1.1 to 1.2 by pouring additional sucrose into the container. The larger organisms were picked off the surface with forceps and the smaller ones were collected with an eye dropper. The remaining debris was examined against a white background in order to recover any organisms, such as fingernail clams (Sphaeriidae) or worms (Oligochaeta), that might not have floated. The organisms were washed, preserved in 80% isopropyl alcohol, identified to the family level and counted.

Organisms from bottom samples at ten sites at the lower pond were collected in 1973. The average number of individuals per square meter of bottom material of the most common groups of animals, including the Nematoda, Oligochaeta, and Sphaeriidae was determined (Table 4). This table is accurate only for those groups that lived within the bottom sediments. The method used did not capture or retain all of the organisms that lived upon the surface of the bottom sediments such as caddisflies (Trichoptera) or mayflies (Ephemeroptera).

Insect Emergence Traps

Floating traps (Figure 2) were constructed to collect the insects as they emerged from the water. The frames of the traps were made of wood. The horizontal pieces of the frames measured 2.7 cm x 2.7 cm x 86.0 cm, and the vertical pieces measured 2.7 cm x 2.7 cm x 46.0 cm. Hinged doors were placed on two of the sides and the sides and top were covered by screening. Four 9.6 cm x 9.6 cm x 101.0 cm styrofoam blocks were attached to the sides. If half of the emerging insects that hit the styrofoam blocks on their way to the surface emerged inside the trap, then the trap collected from an area of one square meter of water. Each trap was anchored by a line tied to a rock.

Ten floating traps (white squares on Figure 3) were placed on Findley Lake and five traps on the shallow pond in 1972. Ten floating traps (Figure 4) were placed in the same positions on Findley Lake in 1973 and an additional three traps were used as controls. Six floating traps were placed on the lower pond in 1973.

Table 1 lists the depth, the direct sunlight exposure on 7 August 1972, the distance from the nearest shore, the area of the lake represented, and the percent of the lake represented by the ten floating traps that were used both in 1972 and 1973.

It was thought that the high ridge would cause a considerable difference in the daily duration of direct sunlight at each trap, and that this might have an influence upon the insect emergence. The difference was less than expected, with Trap 9 on the midlake ridge receiving nine hours and fifty six minutes of sun, only one hour and six minutes more than what Trap 4 near the west cliffs received. This difference is probably greater during other seasons when the sun is at a lower angle.

Because of the diversity of bottom types increasing with decreasing depth from the uniform deep basins to the highly varied shoreline, more traps were used over the shallow water than over the deep water. Each individual trap at a deep site represented a larger area and percent of the lake than a trap at a shallow site. Two traps were placed over the deepest basin of the lake. Bottom samples indicated that the two deep basins were similar. There were two traps over the midlake ridge at different depths and six traps over the shallow bottom. Descriptions of the floating trap sites are given in Table 2.

Because of the possibility that the traps themselves could act as a substrate upon which insect larvae that would eventually emerge in the traps could grow, the traps were periodically cleaned. The number of Trichoptera egg masses that were removed from the styrofoam floats was recorded. The larger larvae that were removed during 1973 were identified to the family level and counted. The traps were cleaned often enough so that there was not time for any Trichoptera larvae that crawled up the anchor line to the floating traps to pupate and emerge.

As an additional control to determine if any of the emergence in the traps was due to insect larvae crawling up the anchor line, three floating traps were positioned in a group in the shallow bay for part of the 1973 emergence season. Two of them were anchored by a rope to similar talus rock anchors. A third trap was similar to these two except that it was kept in position by a rope that ran through the air at least half a meter above the water.

Although there were only 1350 meters of shoreline, ten shore emergence traps (black squares on Figure 3) collected from the varied shore of the lake. Three of these were damaged by bears so that only the data from the surviving seven traps were analyzed. The sites of the shore traps at Findley Lake in 1972 are described in Table 3. Five additional shore traps were used at the shallow pond in 1972. Figure 4 shows the location of the shore traps in use in 1973.

The shore traps collected those insects such as the dragonflies (Odonata) that can emerge only on a solid support such as the shore or emergent vegetation. The shore trap design was a modification of the floating trap design (Figure 2). There were no styrofoam floats. The trap rested on the shore of the lake with one end in the water and one end on land. The land side had a door and the bottom was sealed to prevent insects from crawling or flying out or in. The lake side of the trap rested on the bottom. Instead of a second door, a screen extended down to a level slightly below the surface of the water. There was a gap between the bottom of the screen and the lake bottom so that insect larvae could crawl along the bottom, enter the trap underwater, and then emerge upon the enclosed section of shore. As the water level changed, the screen or the trap itself was repositioned. The water level probably varied less than 0.3 meters at Findley Lake and 0.5 meters at the shallow pond during 1972. The water level of all three bodies of water was accurately measured during 1973.

The insects were collected from each trap at one- to five-day intervals. The collections were usually done every other day during the summer and every three or four days during October when it was cooler and fewer insects were emerging. Collecting began on 20 July 1972, about two weeks after the ice had melted off the lake, and continued until 24 October. Insects that emerged during the period between the thaw and the installment of traps were not sampled. In 1973 each trap was put in position as soon as the ice had melted at that particular site.

The smaller insects were captured by opening a door of the trap and holding a vial of 80% isopropyl alcohol under each one. The insect then fell or was nudged into the alcohol. The larger insects were picked up by hand. If any escaped, a note was made and added to the vial.

The insects were identified to the level of family, divided into species categories which were assigned numbers because most of the identification to species level has not yet been done, and counted. Average dry weights were determined for each species category (Table 5). Males and females were weighed separately when they were of different sizes.

The following information was placed on computer cards for the insects in each vial: year, month, and day of collection; number of days since the previous collection; trap number; sex (male, female, or not determined); number of individuals of a given sex and species category; order, family, and identification number assigned to a given species category within the family: and biomass in milligrams of dry weight per individual. Insects are not discussed in this report if only one individual of a species category was collected in the emergence traps during 1972, or if they were terrestrial species.

The biomass of each family that emerged from the open water of the lake (Table 8) was determined by multiplying the total biomass of each family that emerged in each trap by the area of the lake that each trap represented, and then adding the totals from each area. The average emergence per square meter of lake was obtained by dividing the total for the open water of the lake by the area of the lake. The biomass of each family of insects that emerged from the shore of Findley Lake during 1972 (Table 9) was expressed as emergence from the entire shore of the lake and as emergence per meter of shore. The totals for the lake (Table 10) were obtained by adding the totals from the open water (Table 8) to the totals from the shore (Table 9). The emergence per square meter of lake was determined by dividing these totals by the area of the lake.

Graphs were made of the biomass of insects that emerged per day from the open water of Findley Lake during 1972. These graphs (Figures 5-10) show the seasonal cycle of the total insect emergence and those orders and families that contributed more than one percent of the total biomass from the open water. These graphs were constructed by multiplying the total biomass of a family that was collected in a trap on a collection date by the area of the lake represented by that trap, adding the products from all ten floating traps, and dividing by the number of days since the last collection to give the emergence from the lake per day. The graphs were drawn with a running average of five days by averaging the emergence on each day with the emergence from the two preceding days and the two following days. A running average was made because it was not possible to collect from all thirty traps in the Findley Lake area once per day at the exact same time each day, although this was attempted because it would have been better for showing short-term variations in the emergence. These data on a daily basis are available from us for the 1972 collections from Findley Lake and the shallow pond.

Graphs were made of the biomass of insects that emerged per day from the shore of Findley Lake during 1972 (Figures 11-19). They show the seasonal cycle of the total insect emergence and those orders and families that contributed more than one percent of the biomass from the shore. The left ordinates are expressed in grams of dry weight that emerged from the shore of the lake per day. The right ordinates are expressed in milligrams of dry weight that emerged per meter of shoreline per day. These graphs were constructed by averaging the total biomass of a family that was collected from the shore traps on a particular date, dividing by the number of days since the last collection to give the emergence from the lake per day, and taking a running average of five days.

Predators

Amphibians were collected in 1972 and 1973. The stomach contents of those collected in 1972 have been analyzed to compare their diet to the insect emergence. Counts of the number of individuals of each species in the vicinity of each trap were made in 1973. Amphibian migration at the lake and shallow pond was studied in 1972. Fecal pellets containing the undigested hard parts of prey have been collected from freshly caught dragonfly larvae from the three bodies of water during 1973. Population counts of Gerridae and Gyrinidae were made at all three bodies of water in 1973.

RESULTS

Bottom Samples

Almost all of the organisms found in bottom samples obtained from the area of Floating Trap 3 in the deepest basin of the lake were large red Tendipedid larvae (Table 4). This was true also for other samples taken from other places in both deep basins. Not only were there more Tendipedid larvae at the deep basin sites than at the other sites, but they were of a larger size. The total biomass of these larvae per square meter of deep basin bottom was greater than the total biomass of all other groups of organisms that live within the bottom sediments found at the other sites. It did not seem as if enough Tendipedid adults were collected from the emergence traps during 1972 to equal the number of larvae in the bottom sediments. There are several possible explanations for this. One is that these larvae in the cold deep basins have a very slow rate of growth and take several years to mature, so that only a small fraction of them emerge each year. Another explanation is that they are synchronized in their development, taking several years to mature, and that all or most of them emerge in one year and none or few of them emerge in other years. They also might emerge within a short period of a few days duration immediately after the ice thaws from the lake. The data collected during 1973 tends to support the last possibility, although all explanations may be correct to some degree. Species identification of the dominant species of larvae in the deep basin ooze and the dominant species of adult midges that emerge a few days after the ice melts is needed.

Fewer Diptera larvae per square meter were found in the sediments of the lower pond basin than in the sediments of the lake basin. The number of Diptera larvae per square meter appeared to increase gradually during the summer of 1972 in the sediments from the shallow areas of the lake. This might be an indication that many of these larvae, if they survive the winter, emerge within a few days after the ice thaws.

Insect Emergence

Table 5 is a taxonomic list of the insect orders and families that emerged at Findley Lake during 1972. An additional species of Odonata, the damselfly *Enallagma boreale* (coenagrionidae), emerged at the shallow pond, but not at Findley Lake. A Trichopteran larva larger than any of those observed at Findley Lake was seen at the outlet of the shallow pond during the spring thaw. Three individuals of an adult Trichopteran, larger than any of those that emerged at Findley Lake, emerged in the shore traps of the lower pond in 1973 within 50 meters of the outlet. The heaviest adult insects (Table 5), female *Aeshna palmata* (Odonata), weighed 3223 times as much as the lightest insects, tiny males of an unidentified midge (Tendipedidae).

The biomass of insects that emerged from the lake during 1972, except for about the first two weeks emergence that were missed, was 68.4 kg (Table 10). This is approximately equivalent to having one full-grown 160.5 kg wet weight bear (bears are about 57% water, slightly less watery than insects) emerge from the lake per year. It is also equivalent to having 583 mg dry weight of insects per square meter per year (Table 10) crossing the interface from the lake to the surrounding terrestrial environment. These figures will be increased when the early Diptera emergence is added from the 1973 data. Those insect nutrients that do not return to the lake in the form of eggs or dead insects can act as fertilizer to the surrounding forest.

The dominant families produced were Limnephilidae (418 mg per square meter), Tendipedidae (111 mg per square meter), Culicidae (27 mg per square meter), Baetidae (21 mg per square meter), and Empididae (3 mg per square meter) (Table 10), although the Tendipedidae might equal the Limnephilidae in 1973 because of the more complete collections.

The emergence of Tendipedidae and Culicidae was less than the approximately 404 mg of Tendipedidae and 33 mg of Culicidae that emerged per square meter of Fern Lake, a 96,500-square-meter, 8-meter-deep lake located at an elevation of 66 meters on the Kitsap Peninsula of Washington (Klaassen 1967). Further comparisons between the Findley Lake emergence and the emergence from other lakes will be made after the 1973 data have been analyzed.

Emergence from the open water

Of the total biomass of 68.4 kg that emerged from the lake in 1972, 67.1 kg came from the open water (Table 8). The dominant insect families from the entire lake (Table 10) were the same as the dominant ones from the open water because of the relative extent of the open water.

The most productive areas, as measured by the biomass of insects that emerged, were the shallow areas that were supplied with undecomposed vegetation by the inlet streams. The undecomposed plant material that is carried into the lake by streams and avalanches might be more important for supplying nutrients for the insect larvae of Findley Lake than in other lakes where the water itself has a higher productivity. The greatest total biomass, 1782 mg per meter of shore, that was collected from any trap was from Shore Trap 24 on the shore of the delta meadow, and the second greatest biomass, 1264 mg per square meter, was from Floating Trap 5 next to the delta meadow (Table 7). Trap 24 collected the most Trichoptera of any of the shore traps, and Trap 5 collected the most Trichoptera of any of the floating traps. Thr greatest dance fly (Empididae) emergence was from the delta meadow shore (Table 6). The areas near the inlets of the ponds also produced many insects.

Tendipedidae emerged everywhere (Table 6), but the greatest biomass of them emerged in the traps over the deep basin ooze where the greatest biomass and number of their larvae was found (Table 4). The smallest Trichoptera emergence occurred there.

Trap 6 in the shallow bay collected only 350 mg per square meter during 1972, less than any of the other traps at Findley Lake (Table 7). Fewer Trichoptera emerged there than in any of the other floating traps except those over the deep basin. Similar results were obtained from the three traps in this bay in 1973 (Figure 4). The emergence from the shallow bay will be compared to that from the shallow pond in a future report.

Emergence from the shore

Many families of insects emerged from the shore (Table 9) that did not emerge from the open water of the lake (Table 8). The Odonata, stoneflies (Plecoptera), craneflies (Tipulidae), and two of the less common Trichoptera families emerged only in the shore traps. The alderflies (Sialidae) were found in all of the shore traps plus the floating trap in the shallow bay (Table 6). More Ephemeroptera and Empididae, and fewer Tendipedidae, emerged per meter of shore than per square meter of open water. The least Diptera emergence, 50 mg per meter, was from the aquatic moss *Fontinalis* and rocks under Shore Trap 28 (Table 7).

Although only 1.3 kg of insects (Table 9) emerged from the shore, the 953 mg that emerged per meter of shore (Table 9) was greater than the 572 mg that emerged per square meter of open water (Table 8). This was partially because of insects like the Odonata that fed in many parts of the lake but emerged only upon the shore.

The actual biomass that emerged per meter of shore was probably higher than Table 7 indicates because of loss by predation. Although no loss from predators, except for occasional spiders, was detected in the floating traps, there were many predators along the shore. *Rana cascadae* and *Bufo boreas* were occasionally found inside the shore traps. Gerridae, which were found only near the shore, were observed catching insects such as *Chaoborus* and other Diptera as they emerged inside the shore traps. Harvestmen (Phalangida) were often found inside of Trap 24, the trap that had the greatest biomass of insect emergence.

Seasonal Cycles of Emergence

Total emergence

There were two distinct peaks of emergence from the open water of Findley Lake during 1972 (Figure 5). The first consisted almost entirely of Diptera, and the second consisted almost entirely of Trichoptera. The insects that emerged between the thawing of the lake and the placing of the floating traps were missed. There was no noticeable emergence between the date of the last collection in October and the date that the traps were removed from the freezing lake in November.

The insects that were collected in 1973 have not been counted yet, but it appears as if the emergence was similar except that the lake thawed about one month earlier than in 1972. There was no emergence for several days after the ice melted, but within a few more days, the Diptera emergence reached a peak that was probably as great as, or possibly greater than the 1972 peak emergence of Trichoptera. The total emergence declined, possibly to a lower level than in 1972. The Trichoptera peak of emergence started about the same time in 1973 as in 1972, reached about the same level, and ended at about the same time. A preliminary conclusion is that about half of the emergence occurs within a predictable period of time after the ice thaws, and that the other half occurs at the same time each year. The term "emergence" in the following discussions refers to emergence per square meter from the open water and emergence per meter on the shore.

The open water emergence from the shallow pond in 1972 was less than that from Findley Lake. Most of this emergence occurred during a one-month period between 24 July and 24 August at about the same time as the first peak of emergence from Findley Lake. Very few insects emerged from the shallow pond during the period of time that the lake had its second peak of emergence. During late August and early September, the water level dropped about half a meter in the shallow pond. The surface of the shallow pond froze temporarily in October.

The open water emergence from the lower pond in 1973 was less than that from Findley Lake. There was very little Diptera emergence during the period that the lake had its early peak of Diptera emergence. Most of the emergence from the lower pond occurred at the same time as the Trichoptera peak of emergence from Findley Lake and consisted of the same species.

The first peak of shore emergence from Findley Lake (Figure 11) was greater than the first peak of emergence from the open water (Figure 5). In addition to the Diptera, there were several species of Trichoptera that emerged from the shore soon after the ice melted off the lake. Some of these did not emerge from the open water. There were also other species of insects that had larvae that lived in many areas of the lake but only emerged upon the shore. Some insects emerged directly from the shallow water that was enclosed within the shore traps.

The 6 September 1972 peak of emergence from the shore (Figure 11) was smaller than the second peak from the open water (Figure 5). Fewer individuals of the dominant species of Trichoptera from the open water emerged per meter of shore than per square meter of open water.
The emergence from the shore after 20 Deptember 1972 was greater than the emergence from the open water. This late emergence was dominated by Ephemeroptera.

Megaloptera

All of the Megaloptera that were collected from Findley Lake during 1972 emerged in the shore traps except for one female that was collected from Trap 6 in the shallow bay. The larvae are aquatic predators; pupation occurs on shore (Pennak 1953). The emergence from the lake occurred in August (Figure 12).

Ephemeroptera

About three percent of the biomass that emerged from the open water consisted of Ephemeroptera (Table 8). They emerged during the entire period that the traps were sampled in 1972 with a greater emergence in September and early October than in July and August (Figure 6). The results in 1973 were similar. The open water emergence from the lower pond in 1973 might have been equal to, or slightly greater than the emergence from Findley Lake. More Ephemeroptera emerged from the shore (Figure 13) than from the open water (Figure 6). Most of the biomass that emerged in the shore traps after 20 September 1972 consisted of Ephemeroptera.

The adults gathered in large mating swarms that were usually located at only a few places near the shore of the lake. The position of these swarms seemed to depend upon wind direction and temperature. An observer near a swarm would probably be convinced that the Ephemeroptera were the dominant insects at Findley Lake. Similar swarms were seen at the lower pond in 1973. The larvae of these insects are herbivores. They may come to the surface or crawl out of the water on a solid support to emerge (Pennak 1953).

Odonata

The Odonata emerged only from the shore (Figure 14). Although there were two peaks of emergence in the traps, the actual emergence of both species from the entire shore was probably continuous from late July to early September with an emergence peak in early August. Because of the Odonata data representing a small number of large individuals, a greater sampling error was possible than in the data representing many small individuals.

The influence of the Odonata upon the shallow pond was probably considerably greater than their influence upon Findley Lake. The Odonata emergence from the shore from the shallow pond was more than that from the lake. It represented a larger fraction of the total shallow pond shore insect emergence and the shore represented a greater proportion of the entire body of water.

Odonata larvae are predators that might have had a significant effect upon the population size of the other insect species and upon the zooplankton species, especially in the shallow pond. *Aeshna palimata* larvae in the laboratory visually hunted all of the Findley Lake zooplankton and active insect larvae that were presented to them. Each individual larva had a preferred size range for its food with the preferred size increasing with the increasing size of the larva. There was also a preference for continuous prey movement, but the larger *Aeshna* larvae did eat as many as five last instar *Chaoborus* larvae per day in the laboratory. The other Findley Lake Odonata species, *Somatochlora albicincta* is a tactile predator that feeds upon animals that brush against its sensory hairs. A third species, the damselfly *Enallagina boreale*, found only at the shallow pond, is a visual predator.

Trichoptera

Most of the insect emergence from the open water of Findley Lake during 1972 (Figure 5), except for the first part of the summer, consisted of

Trichoptera (Figure 7). Most of these were of the family Limnephilidae, and the emergence peak from 30 August to 24 September seemed to consist almost entirely of a single species. This species emerged at the same time in 1973 at Findley Lake and the lower pond. The second emergence peak of Trichoptera from the shore of the lake consisted primarily of the most common species that emerged from the open water of the lake (Figure 15). Considering the dominance of this species and other Limnephilids, identification of the species of this family is needed to determine what role their larvae play in the lake and why they are so abundant.

These large insects (Table 5) were the dominant insects in the traps, but they were rarely seen flying in the air or perched on land. The reason for this is that they are nocturnal and cryptically colored. The dominant species had a wing pattern that appeared to blend with the pattern of dead conifer needles on the forest floor. Other species had wings that matched dead leaves, reeds, and grasses along the shore and bark. One species even blended with the weathered pine frame of the emergence traps. By releasing a known number of Findley Lake Limnephilidae of various species within an enclosed area of shore or forest floor, and hunting for them until they were all recaptured, it became obvious why they were so rarely seen by people and how they escaped bird predation during the day.

Because of the importance of these insects at Findley Lake and because it was thought at first that all Trichoptera could not emerge from the open water, but had to crawl along the bottom to emerge on a solid support, an "air suspended" trap and two anchored traps were placed in the shallow bay during 1973 to see if the Trichoptera emergence from the open water was due to the larvae crawling up the anchor rope to pupate on the trap and then emerge. A day after the "air suspended" trap was put in position, Trichoptera had emerged within it. According to Pennak (1953), pupation lasts about two weeks and the pupae of some species can swim to the surface to emerge. They usually emerge during the late afternoon or night, which explains why none of them were seen emerging. Although the adults that were on land were well camouflaged, the few large Trichoptera that were seen during the day heading towards shore would have been good targets for predators. Although the 1973 data have not been analyzed yet, it seems as if no more Trichoptera emerged inside of the traps that were anchored to the bottom than emerged inside the trap that was "air suspended."

Diptera

It was obvious that many Diptera had emerged during the two-week period between the thaw and the installation of the emergence traps (Figures 8 and 16). This early emergence was collected in 1973 and was probably equal to or possibly greater than the Trichoptera peak of emergence. The early Diptera emergence from the lower pond in 1973 was much less than that from the Findley Lake open water and was less than the late peak of Trichoptera emergence from the lower pond. Most of the early Diptera emergence from the shallow pond in 1972 was collected. It was less than that from Findley Lake and less than the Trichoptera emergence from the shallow pond. Most of the Diptera that emerged from the open water of the shallow pond in 1972 were Tendipedidae.

All Culicidae that were collected from the floating and shore traps of all three bodies of water in 1972 and 1973 belonged to the genus *Chaoborus* (phantom midge). The emergence was greatest a few days after the ice melted, and then decreased (Figures 9 and 17). The emergence of *Chaoborus* from the shallow pond was much less than that from Findley Lake in 1972. Although the larvae of the other insects that emerged from Findley Lake either lived within the bottom sediments or upon the surface of the lake bottom, *Chaoborus* was planktonic and fed upon the red copepods and other zooplankton of the water of the lake.

The transparency and behavior of *Chaoborus* probably helped them avoid being captured by larger predators. Experiments in the laboratory with the predators from Findley Lake showed that the swimming behavior of the *Chaoborus* larvae, with brief swimming movements followed by longer quiet intervals, did not attract the attention of *Aeshna* larvae as much as the constant motion of the other zooplankton species.

The midge emergence from Findley Lake in 1972 and 1973 was probably greatest during the two-week period after the ice melted from the lake, and then gradually decreased (Figures 10 and 18). Their larvae were the dominant insects in the ooze of the deep basins of the lake.

The emergence from the open water of the lower pond was less than that from Findley Lake. Although the bottom of about half of the shallow area of the lower pond resembled that of the bottom near the delta meadow of the lake, bottom sediments of the lower pond basin were distinctly different from those of the deep basins of Findley Lake. The biomass of Tendipedid larvae per square meter was less in the lower pond basin than in the lake basins. Gas was constantly bubbling to the surface from the lower pond basin sediments during most of the summer of 1973.

Two-thirds of the Empidid biomass that emerged from Findley Lake during 1972 emerged from the shore. The greatest emergence was from the delta meadow area. There were several peaks during August (Figure 19).

ACKNOWLEDGMENTS

We would like to thank the people who helped us on this project. Sue Hills spent many days and nights at Findley Lake collecting from the emergence traps during the summer of 1972. Charles Turner made collections during the fall of 1972. Janet Kime identified and counted the insects that were collected that year. Elisabeth Schaublin and Greg Rau prepared the data for computer analysis. The graphs and tables were prepared on the Hewlett-Packard 9810, a calculator that was provided by John Palka. Sally Woodin and Greg Rau assisted with the collection of the early Diptera emergence in 1973. Ursula and Randolph Bear provided entertainment and modified the experimental procedure during both summers.

We would especially like to thank Paul Olson for providing transportation, shelter, and equipment. The logistics of these studies at a roadless mountain lake were difficult, but Mr. Olson always had what was needed. The field work and this report would not have been possible without his support.

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Table 1. Depth, sunlight, distance from shore, and area represented by floating trap sites at Findley Lake during 1972.

Trap number	Depth (m)	Direct sunlight 7 Aug. 1972 sunrise	sunset	Distance from nearest shore (m)	Area of lake represented (m^2)	% of lake represented
1	5.2	0740	1645	15	5,634	4.8
2	8.4	0740	1652	35	27,872	23.75
3	17.1	0800	1705	65	27,872	23.75
4	5.6	0740	1630	20	1,760	1.5
5	1.8	0800	1705	10	5,868	5.0
6	0.5	0907	1808	10	3,521	3.0
7	1.5	0905	1835	15	12,909	11.0
8	7.6	0830	1817	115	9,506	8.1
9	11.7	0804	1800	130	9,506	8.1
10	2.7	0807	1800	25	12,909	11.0

Table 2. Description of the floating trap sites at Findley Lake during 1972. These traps are also being used in 1973.

Trap 1 is on the west side of the lake near the large talus slope below the cliff. There is evidence of former snow avalanches and rock avalanches in this area. Falling rocks are heard occasionally. The anchor is on sloping bottom at the transition from where the underwater talus rocks can be seen to where they are covered by the surrounding sediments. Bottom samples from this area consist of a thin layer of soft brown mud over sand that is derived from the talus rocks. More Sphariidae (fingernail clams), Nematodes, Heleidae larvae and Empididae larvae were found here than at any other Findley Lake floating trap site where bottom samples were taken.

Trap 2 is on the west side of the lake near the large talus slope below the cliff, but farther from shore than trap 1. The anchor is on sloping ooze of the deepest basin of the lake. Bottom samples from this area consist of soft brown mud with occasional rock fragments that may have been carried by the ice. There are many large red Tendipedidae (Chironomidae) larvae.

Trap 3 is on the west side of the lake near the large talus slope below the cliff, but farther from shore than traps 1 and 2. The anchor is in the ooze of the deepest basin of the lake. Bottom samples from this area consist of soft brown mud with a few rust colored sand grains. The biomass per square meter of large red Tendipedidae larvae is greater than the biomass per square meter of all endobenthic organisms found at the other floating trap sites.

Trap 4 is next to the forested former talus slope on the southwest corner of the lake. There is evidence of former snow avalanches in this area. The anchor is on sloping bottom that is covered with logs, branches, and tree trunks. Bottom samples from this area, which were difficult to obtain because of these obstructions, consisted of a layer of soft brown mud over talus sand.

Trap 5 is next to one of the inlet streams of the delta meadow on the south side of the lake. These inlet streams drain a part of the cirque where there is considerable snow avalanche disturbance, and carry a load of undecomposed tree fragments during the spring thaw. One of the streams ran throughout the summer of 1972 after the record snowfall of the winter of 1971-1972, but all of the streams ceased to run during the dry summer of 1973. The sloping bottom consists of brown organic mud with many undecomposed sticks, pieces of bark, and conifer needles.

Trap 6 is in the shallow bay on the south side of the lake. This bay is partially separated from the rest of the lake by large logs and tree trunks, some of which support their own picturesque islands of tiny conifers, wildflowers, and blueberry bushes. The shore is a wet meadow. There are small rooted aquatic plants, some of which reach the surface late in the summer. Bottom samples from the level bottom consist of hard packed organic material. This was the first site to freeze in the fall of 1972 and the last site to thaw in 1973.

The freezing extended to the bottom. During the summer, the temperature of the water in this bay seemed to fluctuate more with the variations in air temperature than the water of the rest of the lake did. Elk and bear waded here. In many ways, the shallow bay resembled the shallow pond more than Findley Lake.

Trap 7 is next to the meadow on the east side of the lake. There is an inlet meltwater stream that drains an avalanche disturbed area. The gently sloping bottom consists of packed brown mud over sand. This site froze completely from the surface to the bottom during the winter of 1972-1973.

Trap 8 is located on the midlake ridge that separates the two deep basins of the lake. Some rocks can be seen extending above the surrounding sediments. Bottom samples consist of a thin layer of light brown mud over a layer of light grey clay that covers sand. There are some large red Tendipedidae larvae, but not as many as at sites 2 and 3. Many newts (*Taricha granulosa*) were seen on the bottom here during the summer of 1973.

Trap 9 is located approximately in the center of the lake on the midlake ridge. Some rocks can be seen extending above the surrounding sediments. Bottom samples consist of a layer of light brown mud over light grey clay over sand. Most of the sand is of the same composition as that found at the other midlake ridge and shallow sites, but there are a few grains of the type of rust colored sand found at site 3.

Trap 10 is on the north side of the lake. The bottom is smooth with a few rocks and is intermediate between that of the midlake ridge and that of site 7. Bottom samples consist of light brown mud over light grey clay over talus sand.

Table 3. Description of the shore trap sites at Findley Lake during 1972.

Trap 21 was on the west side of the lake 15 meters north of the big rock near the outlet. The trap had conifers rising above it and was on a moss and grass shore. The bottom consisted of rocks and mud.

Trap 22 was on the west side of the lake at the base of the large talus slope. Rocks covered almost all of the bottom.

Trap 23 was on the rocky shore at the base of the steep, brush covered former talus slope on the west side of the lake.

Trap 24 was at the grassy edge of the delta meadow at the south side of the lake. The sandy bottom had a few small rocks. This trap is also being used in 1973.

Trap 25 was at the shady end of the shallow bay with a moss shore and a sand bottom. This trap was damaged by the bear cubs and repaired several times. After it was finally carried out into the bay, turned upside down, ripped apart, and squashed, it was decided not to use the data from trap 25 in this report.

Trap 26 was on the shaded rock and grass south shore of the lake with conifers above it and a muddy bottom below it. It was destroyed by the bears and the data from this trap was not used in this report.

Trap 27 was at the edge of the meadow on the east side of the lake near an inlet stream. The bottom consisted of algae, rocks, mud, and aquatic plants. There were many amphibians here. The bear cubs played on this meadow but fortunately missed this trap which is also in use in 1973.

Trap 28 was under tall conifers on the east side of the lake. The bottom consisted of large rocks and *Fontinalis* moss.

Trap 29 was on the north side of the lake where rocks and logs protected the grass, moss, and rock shore. Because of bear damage, the data from this trap was not used in this report.

Trap 30 was on the rocky point near the outlet. There was heather and moss on the shore.

Table 4. Average number of individuals per square meter in bottom samples taken near the floating trap sites. This table does not include Trichoptera and Ephemeroptera.

Floating trap number	Bottom sample site number	Number of samples taken	Mega-loptera	Total Diptera	Tendi-pedidae	Empid-idae	Helei-dae	Nema-toda	Oligo-chaeta	Sphar-iidae	Other Arthropoda found at site
1	45	6		1658	1472	26	160	56	2856	238	Dytiscidae
3	46	6		6449	6449				692		Ostracoda
5	47	7	26	5713	5583		130		390	14	
6	48	10	17	4251	4112		139		2986	108	Odonata
7	49	7		1757	1688		69	13	1861	25	
8 + 9	50	4		4469	4458	11			346	113	

Table 5. Taxonomic list of the insect families that emerged at Findley Lake during 1972.

Order	Family	Code for species within family	Dry weight of an individual (mg) Male	Female	Sex?
1 Megaloptera	1 Sialidae	1	2.553	5.970	
2 Ephemeroptera	1 Baetidae	1	1.201	1.823	
		3	0.926	1.835	
3 Odonata	2 Aeshnidae	2	89.5	99.4	
	3 Corduliidae	3	30.7	47.1	
4 Trichoptera	1 Rhyacophilidae	1			0.945
	2 Limnephilidae	2	10.407	12.428	
		4	5.993	11.855	
		8	9.157	9.250	
		9	9.340	12.537	
	3 Psychomyiidae	5			0.830
	4 Philopotamidae	10			0.945
	5 Goeridae	6			3.0
	6 Hydroptilidae	7			3.0
5 Plecoptera	1 Perlodidae	1			0.760
6 Diptera	1 Culicidae	1	0.457	0.833	
		25			0.234
	2 Tendipedidae	11	0.026	0.044	
	= Chironomidae	15	0.166	0.227	
		20	0.126	0.168	
		35	0.198	0.222	
		36		0.449	
		37	0.091	0.118	
		38	0.207	0.288	
		39	0.350	0.617	
		40	0.845	1.288	
		44		1.290	
	3 Empididae	23			0.295
		42	0.189	0.100	
		43	0.349	0.360	
		44	0.448	0.580	
		45	0.580		
		46	0.646		
	4 Heleidae	19			0.060
	=Ceratopogonidae	24	0.126	0.211	
	5 Tipulidae	21	1.353	2.580	

Table 6. Sites at which various families of insects emerged at Findley Lake. X = site of greatest emergence of a family, (X) = sites that tied for greatest emergence of a family, x = site where a family emerged.

Order	Family	Floating trap number 1	2	3	4	5	6	7	8	9	10	Shore trap number 21	22	23	24	27	28	30
Megaloptera	Sialidae						x					x	x	X	x	x	x	x
Ephemeroptera	Baetidae	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x	x
Odonata	Aeshnidae												x		x	X		
	Corduliidae														x	X		
Trichoptera	Rhyacophilidae	x						x		X				x				x
	Limnephilidae	x	x	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x
	Psychomyiidae			x		x		x			x	x	x	X	x		x	
	Philopotamidae			x		(X)						x	x	x	x	x	(X)	
	Goeridae																X	
	Hydroptilidae													X				
Plecoptera	Perlodidae											x			X			x
Diptera	Culicidae	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x		x
	Tendipedidae	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Empididae	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x
	Heleidae	x	x	x	X	x	x	x			x	x	x	x	x	x	x	x
	Tipulidae											x				X		

Table 7. Biomass of insect emergence at each trap during 1972 in milligrams of dry weight.

Floating trap number	Insecta per meter^2	Trichoptera per meter^2	Diptera per meter^2
1	852.1	707.1	115.9
2	244.8	106.3	122.8
3	405.0	211.0	183.6
4	735.0	606.8	77.7
5	1264.0	1059.2	164.2
6	349.7	215.8	107.6
7	884.3	705.2	168.1
8	858.7	702.5	133.3
9	609.7	505.8	87.3
10	686.5	561.0	104.3
Shore trap number	**Insecta per meter of shore**	**Trichoptera per meter of shore**	**Diptera per meter of shore**
21	666.6	367.9	61.6
22	770.9	353.5	187.8
23	1190.4	395.5	221.9
24	1782.2	664.8	828.1
27	1185.3	293.0	328.9
28	625.5	155.2	49.8
30	442.3	149.2	128.4

Table 8. Biomass of insect emergence from the floating traps at Findley Lake during 1972 in milligrams of dry weight.

Order	Dry weight from open water of lake (mg)	Dry weight per m^2 (mg)	Family	Dry weight from open water of lake (mg)	Dry weight per m^2 (mg)
Megaloptera	21,020	.18	Sialidae	21,020	.18
Ephemeroptera	2,082,027	17.74	Baetidae	2,082,027	17.74
Trichoptera	48,703,689	415.01	Rhyacophilidae	56,671	.48
			Limnephilidae	48,549,067	413.69
			Psychomyiidae	49,431	.42
			Philopotamidae	48,520	.41
Diptera	16,283,032	138.75	Culicidae	3,098,835	26.41
			Tendipedidae	12,959,160	110.43
			Empididae	127,025	1.08
			Heleidae	98,021	.84
Total Insecta	67,089,768	571.68			

Table 9. Biomass of insect emergence from the shore traps at Findley Lake during 1972 in milligrams of dry weight.

Order	Dry weight from total shore of lake (mg)	Dry weight per m of shore (mg)	Family	Dry weight from total shore of lake (mg)	Dry weight per m of shore (mg)
Megaloptera	34,066	25.23	Sialidae	34,066	25.23
Ephemeroptera	324,620	240.46	Baetidae	324,620	240.46
Odonata	117,961	87.38	Aeshnidae	72,915	54.01
			Corduliidae	45,046	33.37
Trichoptera	459,719	340.53	Rhyacophilidae	364	0.27
			Limnephilidae	449,503	332.97
			Psychomyiidae	5,927	4.39
			Philopotamidae	2,188	1.62
			Goeridae	1,158	0.86
			Hydroptilidae	579	0.43
Plecoptera	1,320	0.98	Perlodidae	1,320	0.98
Diptera	348,663	258.27	Culicidae	35,989	26.66
			Tendipedidae	45,442	33.66
			Empididae	260,789	193.18
			Heleidae	1,415	1.09
			Tipulidae	5,028	3.72
Total Insecta	1,286,349	952.85			

Table 10. Total biomass of insect emergence from Findley Lake during 1972 in milligrams of dry weight.

Order	Dry weight from total lake (mg)	Dry weight per m^2 of lake (mg)	Family	Dry weight from total lake (mg)	Dry weight per m^2 of lake (mg)
Megaloptera	55,086	0.47	Sialidae	55,086	0.47
Ephemeroptera	2,406,647	20.51	Baetidae	2,406,647	20.51
Odonata	117,961	1.01	Aeshnidae	72,915	0.62
			Corduliidae	45,046	0.38
Trichoptera	49,163,408	418.93	Rhyacophilidae	57,035	0.49
			Limnephilidae	48,998,570	417.52
			Psychomyiidae	55,358	0.47
			Philopotamidae	50,708	0.43
			Goeridae	1,158	0.01
			Hydroptilidae	579	0.005
Plecoptera	1,320	0.01	Perlodidae	1,320	0.01
Diptera	16,631,695	141.72	Culicidae	3,134,824	26.71
			Tendipedidae	13,004,602	110.81
			Empididae	387,814	3.30
			Heleidae	99,427	0.85
			Tipulidae	5,028	0.04
Total Insecta	68,376,117	582.64			

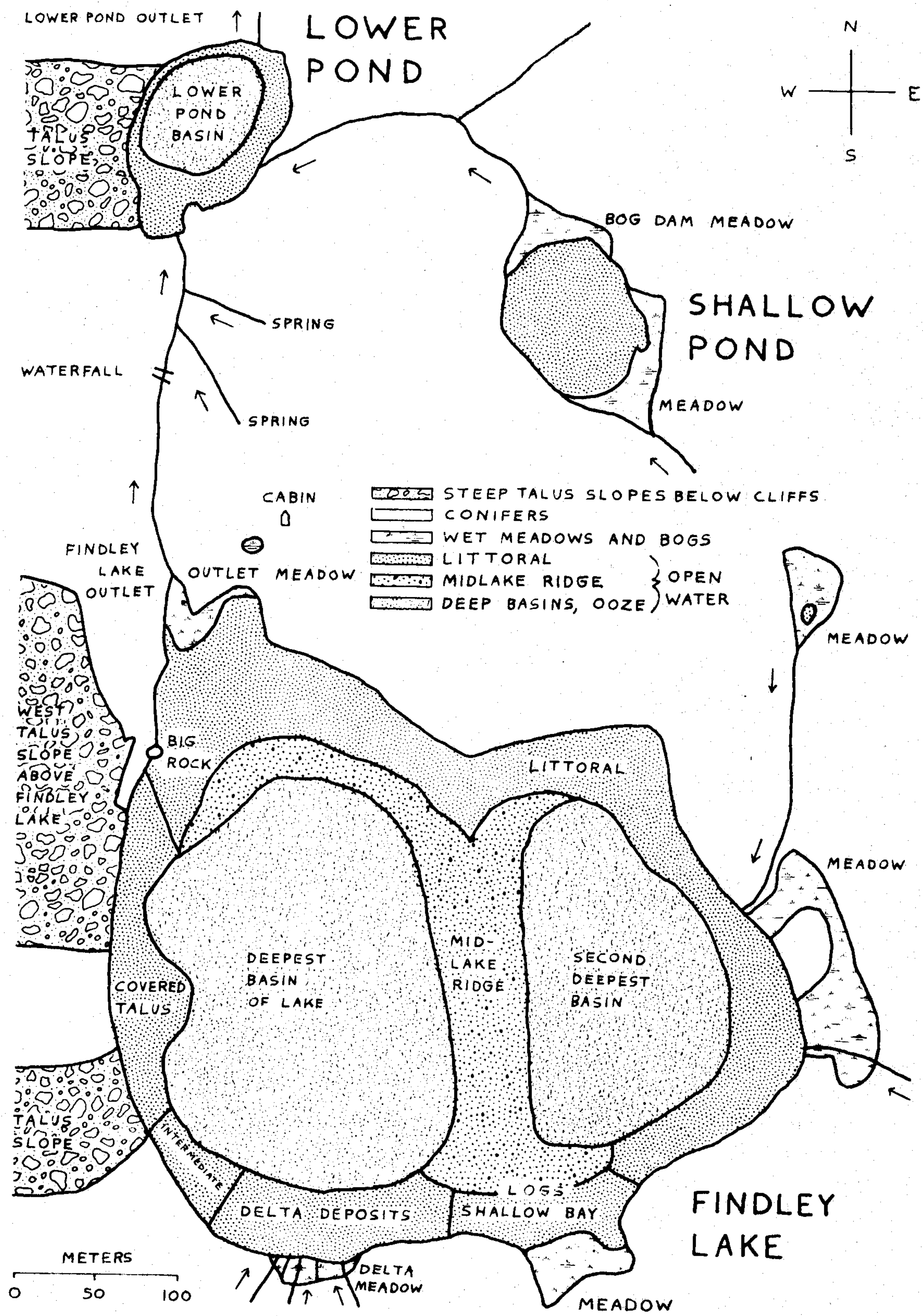

Figure 1. Topography of Findley Lake.

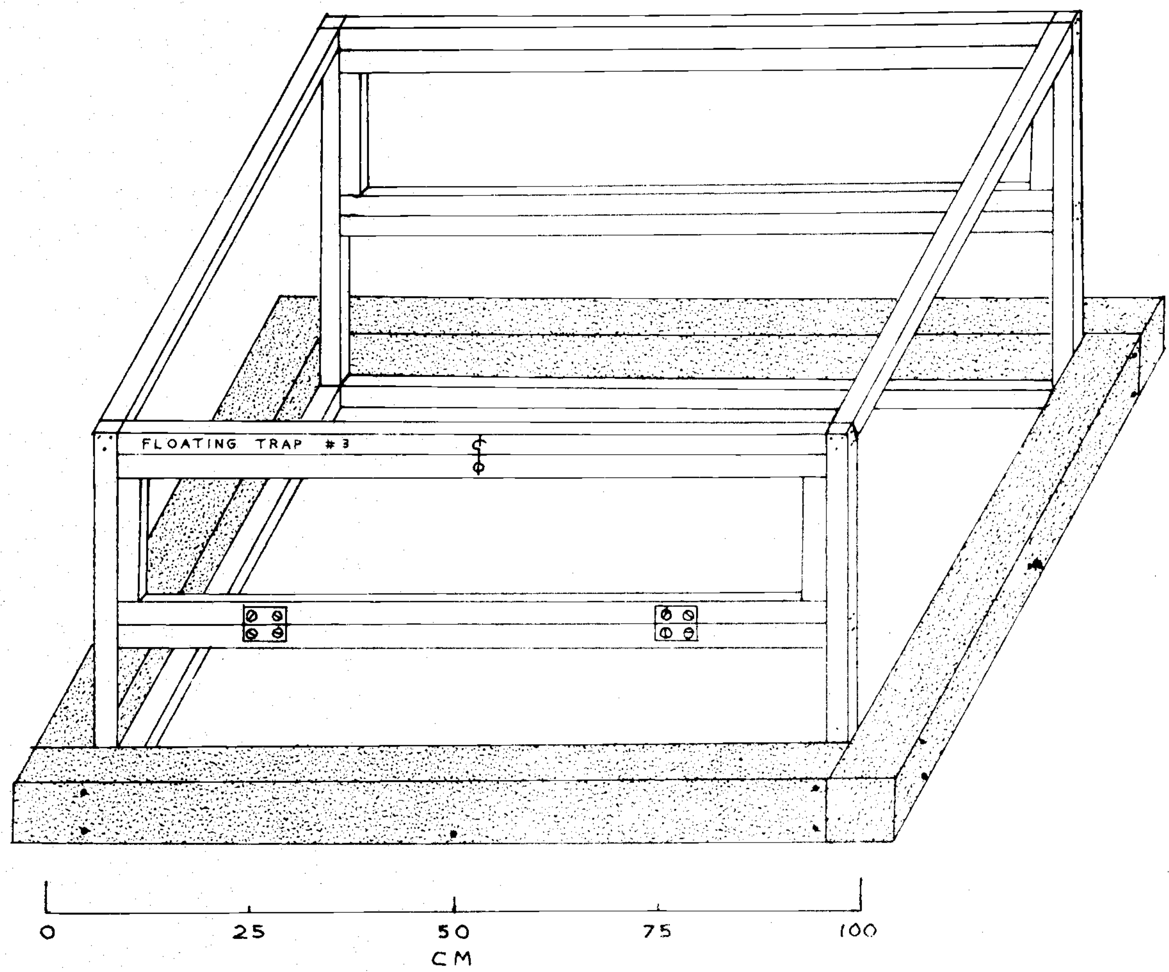

Figure 2. Floating trap design for insect emergence.

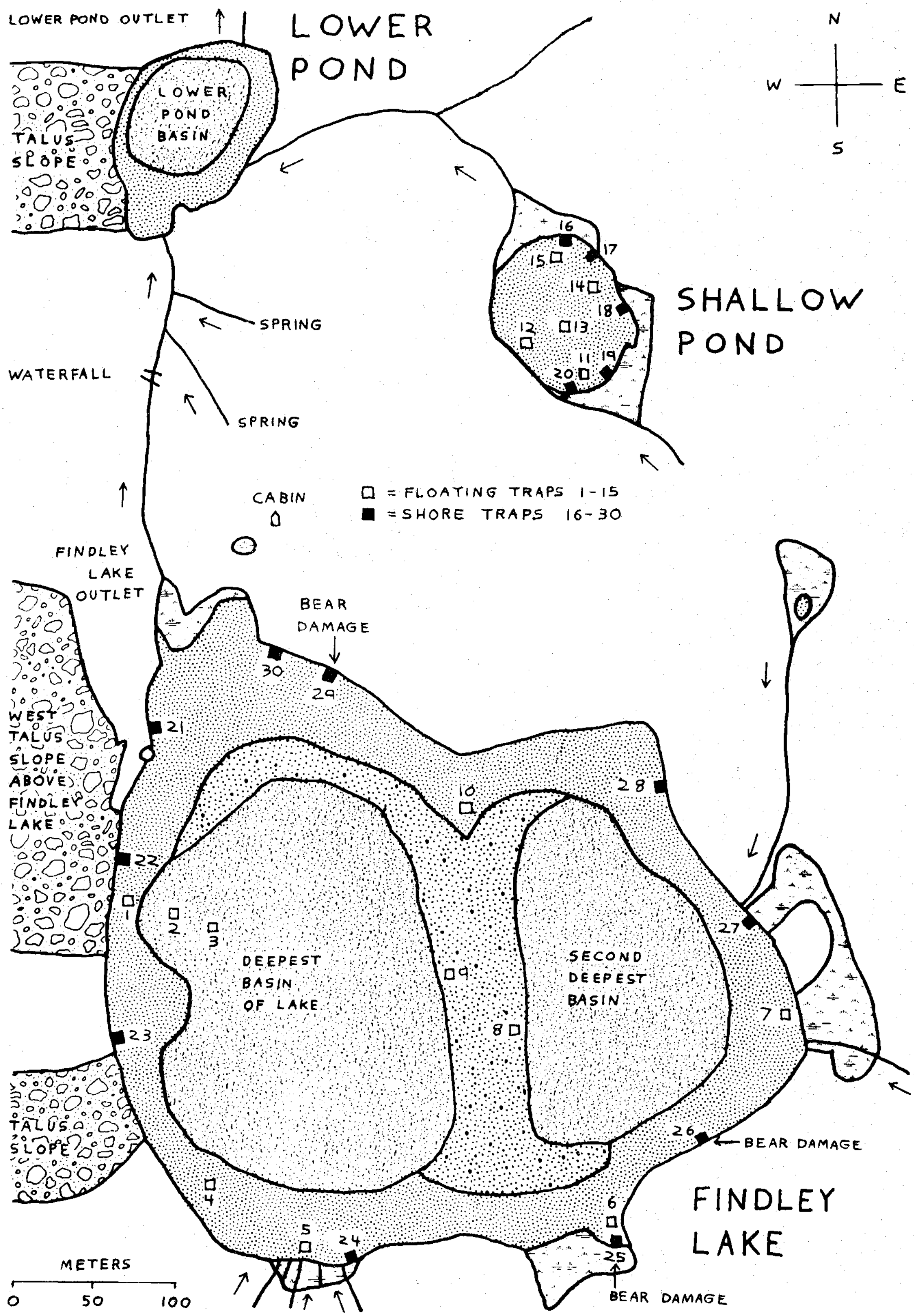

Figure 3. 1972 map of the locations of the insect emergence traps.

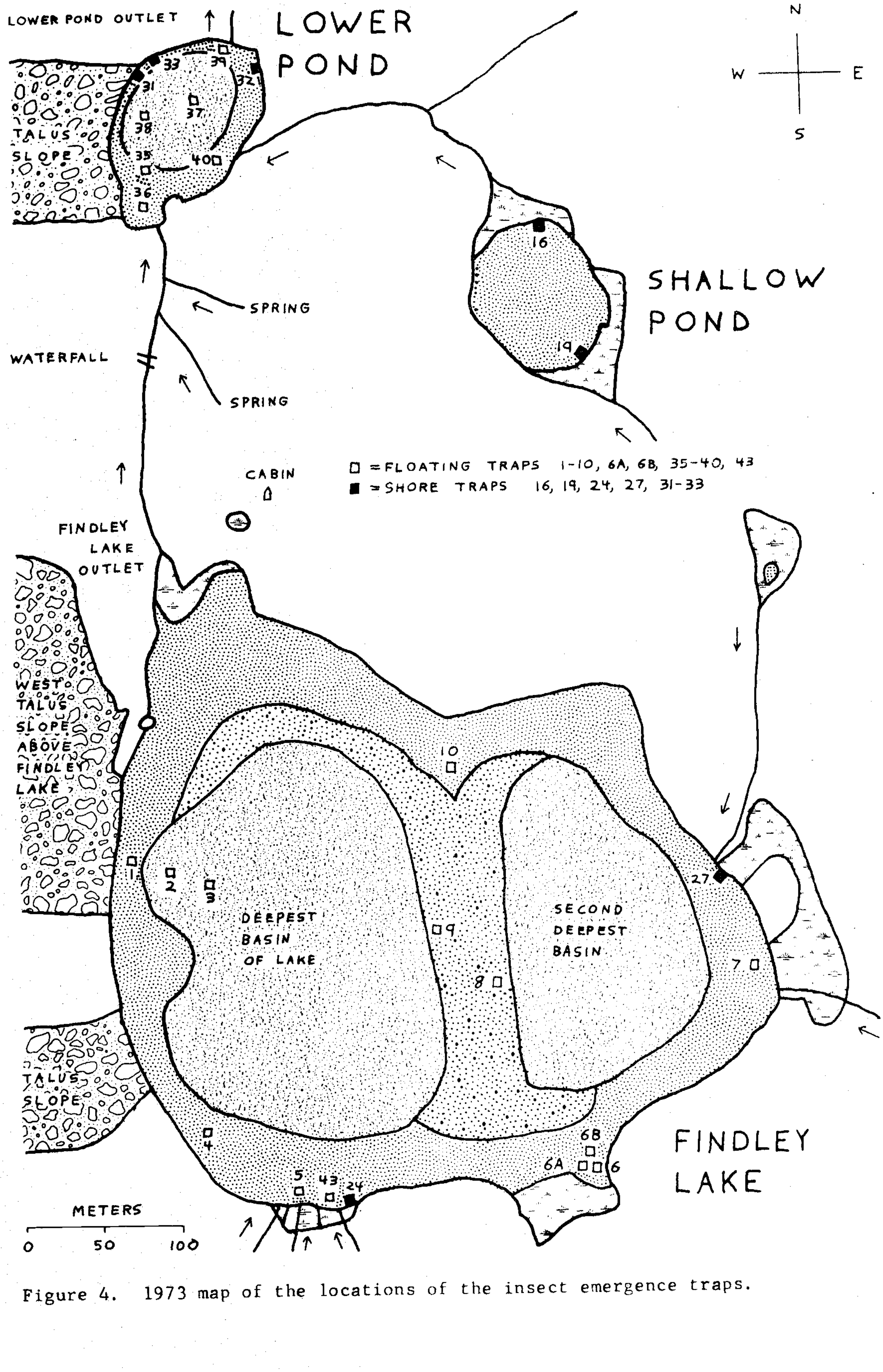

Figure 4. 1973 map of the locations of the insect emergence traps.

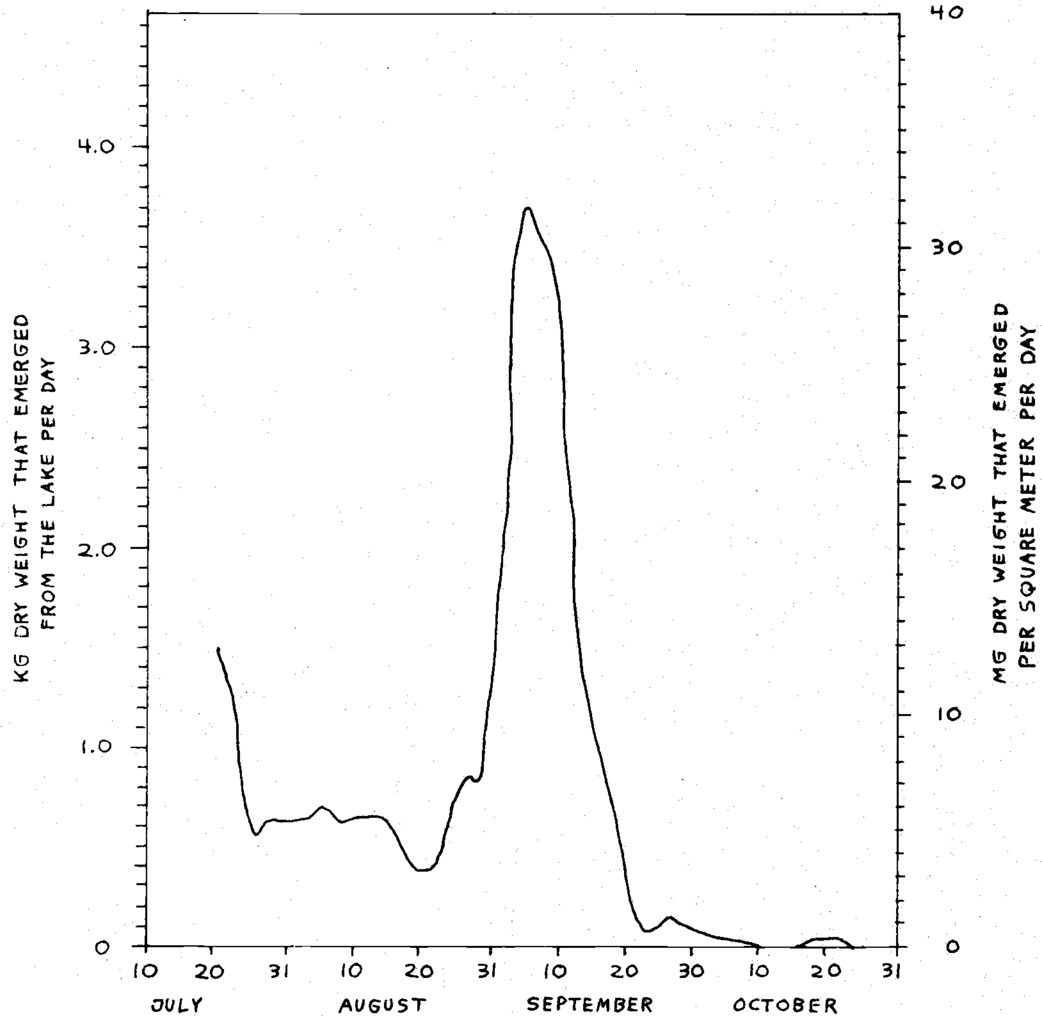

Figure 5. 1972 insect emergence from the floating traps at Findley Lake.

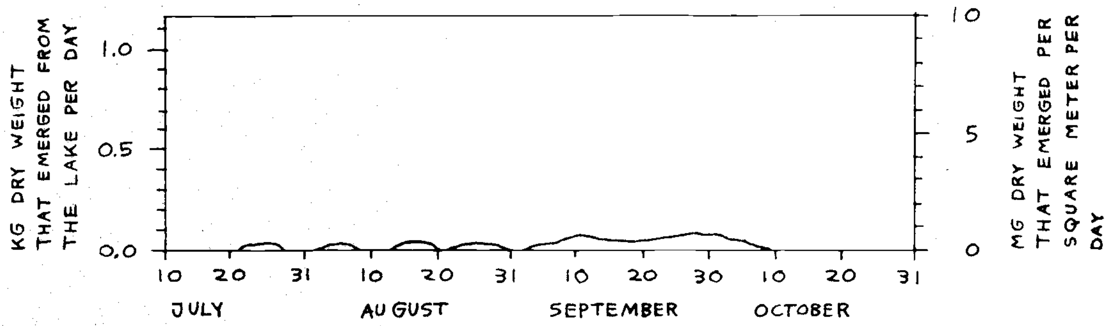

Figure 6. 1972 Ephemeroptera (mayfly) emergence from the floating traps at Findley Lake.

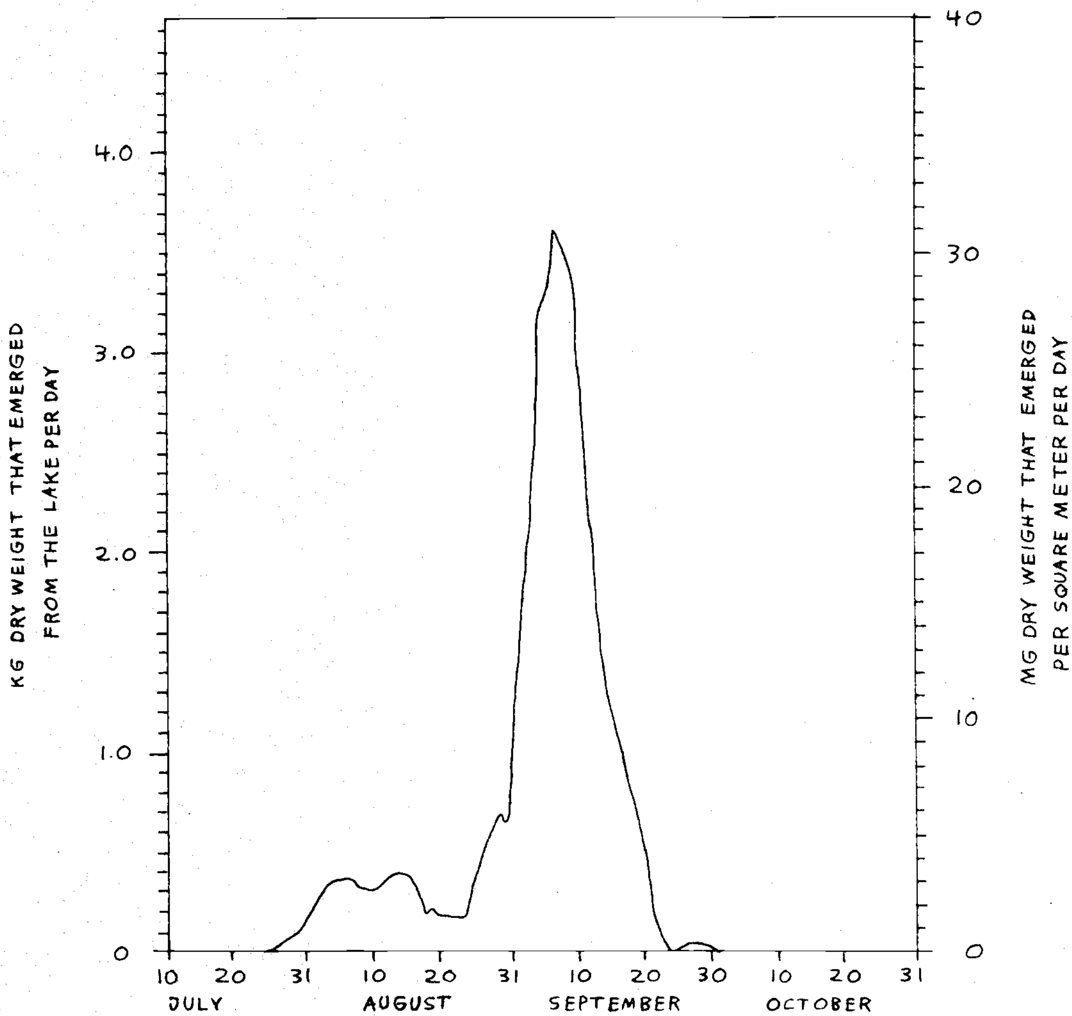

Figure 7. 1972 Trichoptera (caddis fly) emergence from the floating traps at Findley Lake.

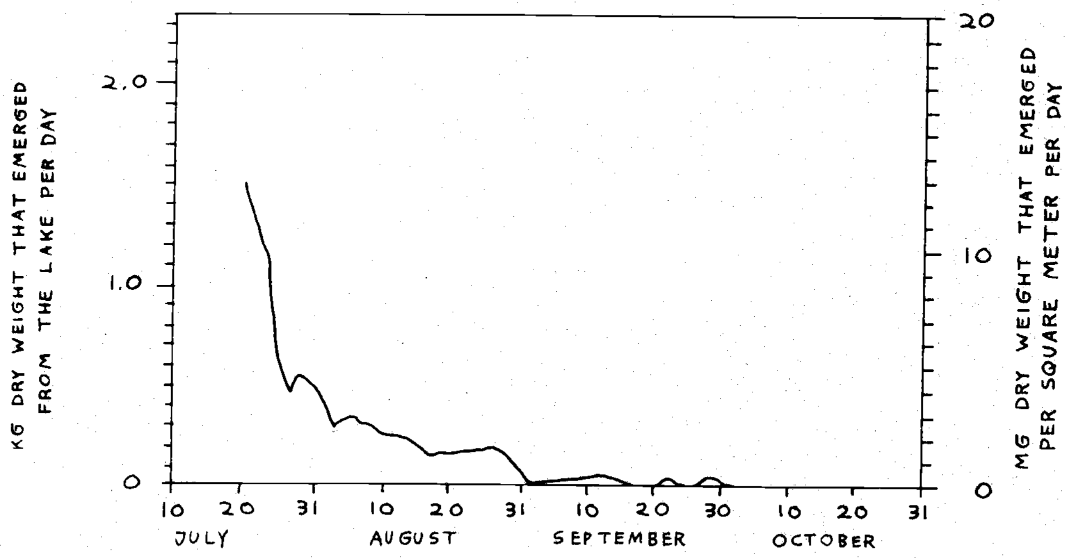

Figure 8. 1972 Diptera emergence from the floating traps at Findley Lake.

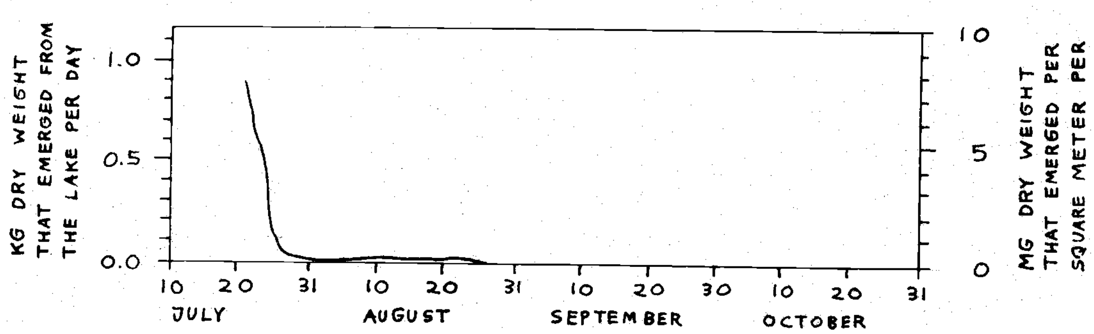

Figure 9. 1972 Culicidae (Chaoborus) emergence from the floating traps at Findley Lake.

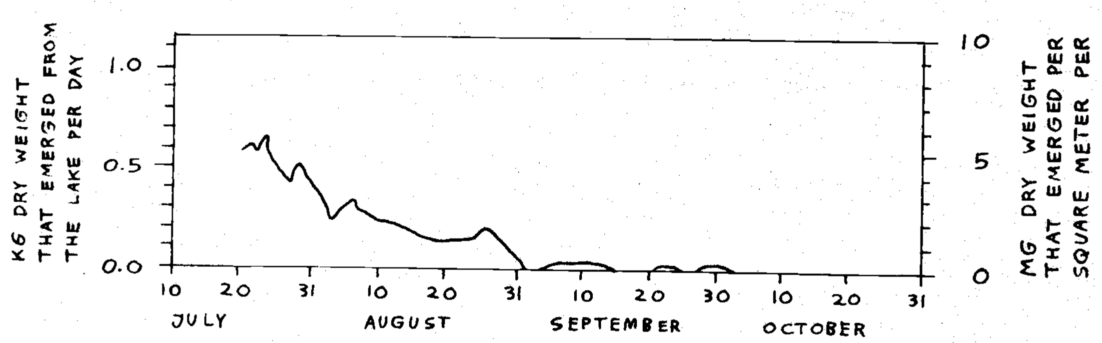

Figure 10. 1972 Tendipedidae (= Chironomidae) emergence from the floating traps at Findley Lake.

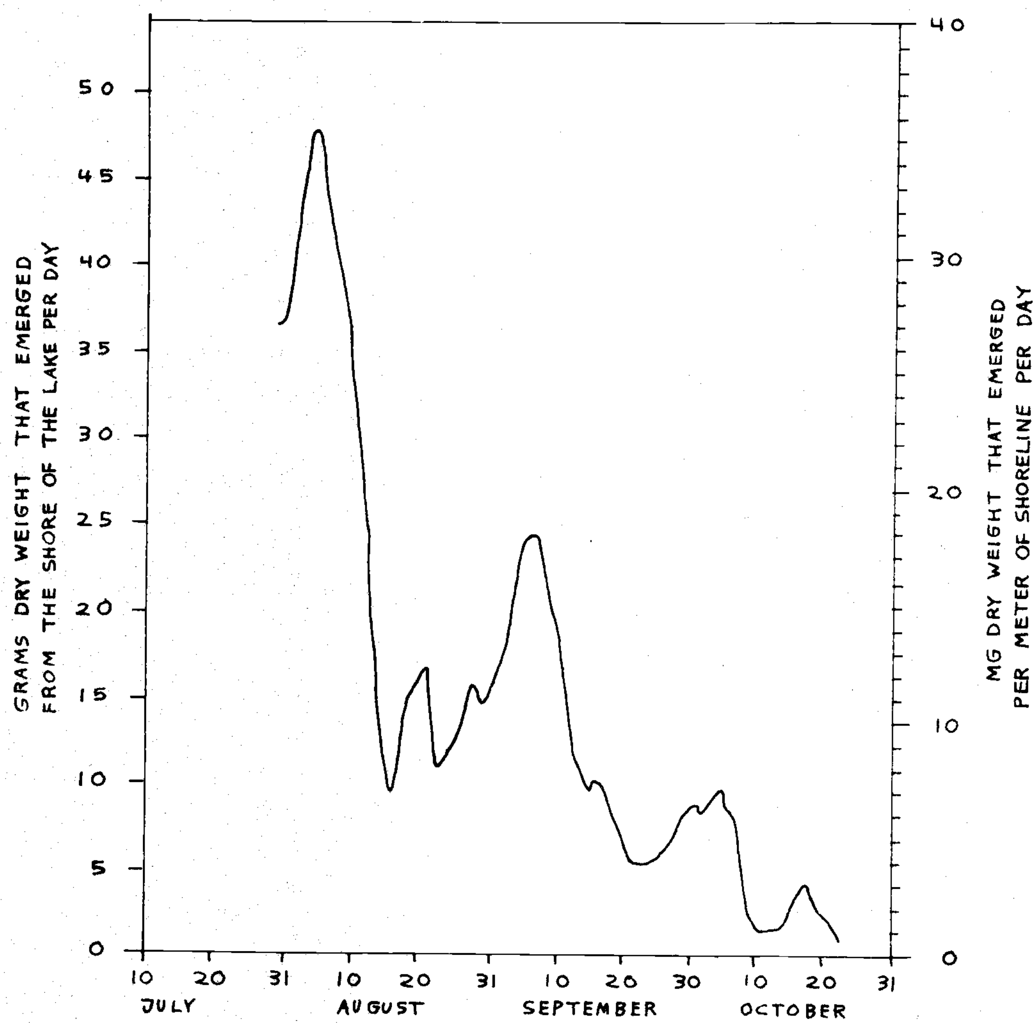

Figure 11. 1972 insect emergence from the shore traps at Findley Lake.

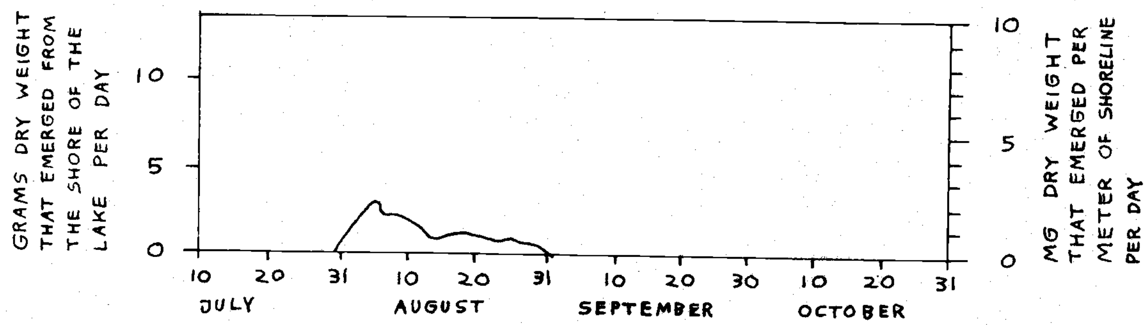

Figure 12. 1972 Megaloptera (Sialidae, alderfly) emergence from the shore traps at Findley Lake.

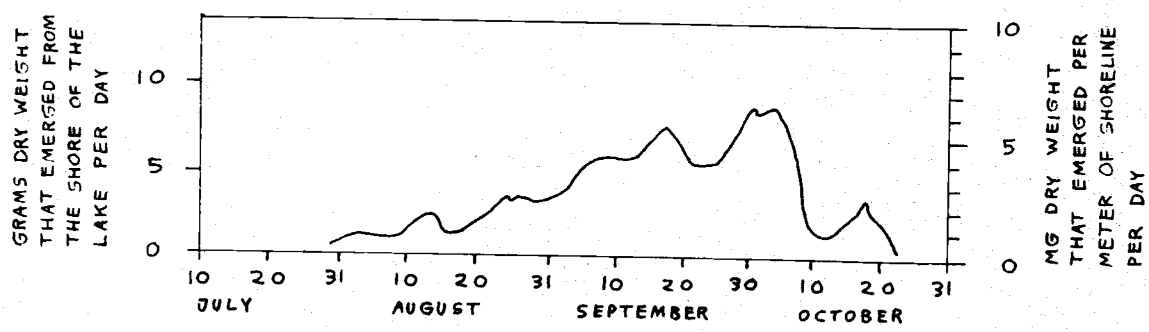

Figure 13. 1972 Ephemeroptera (mayfly) emergence from the shore traps at Findley Lake.

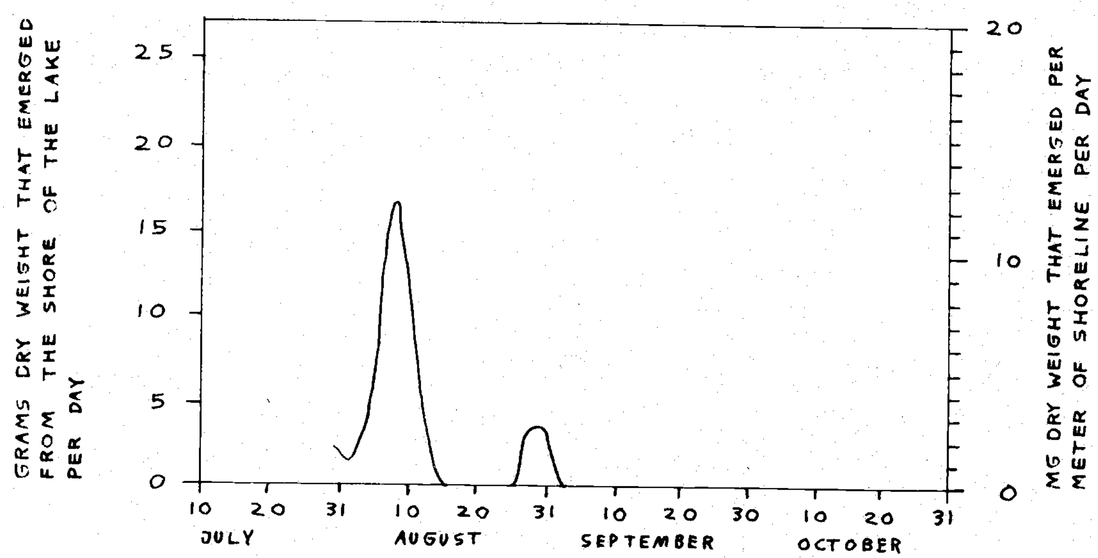

Figure 14. 1972 Odonata (dragonfly) emergence from the shore traps at Findley Lake.

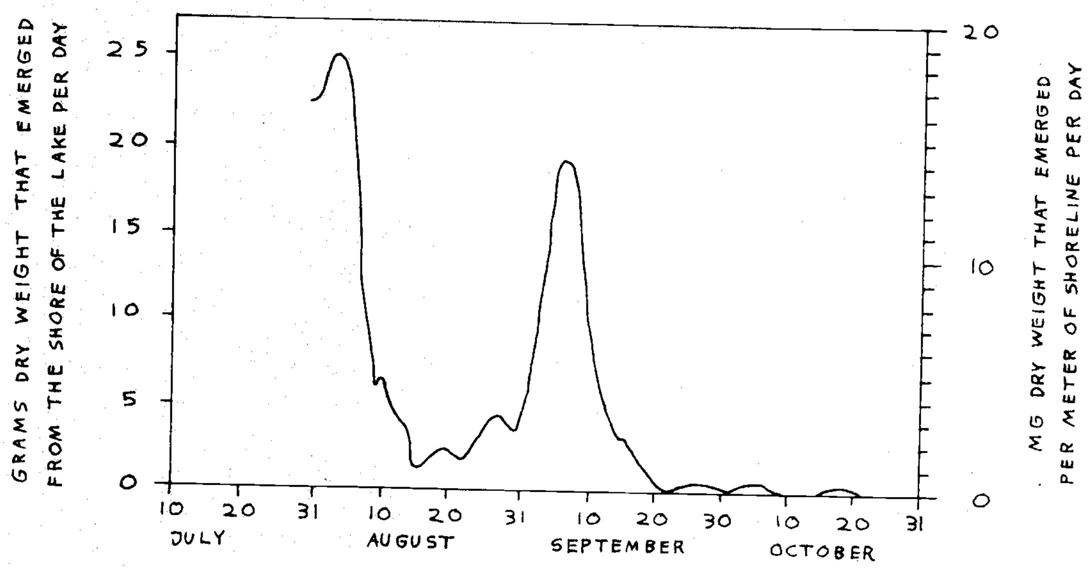

Figure 15. 1972 Trichoptera (caddis fly) emergence from the shore traps at Findley Lake.

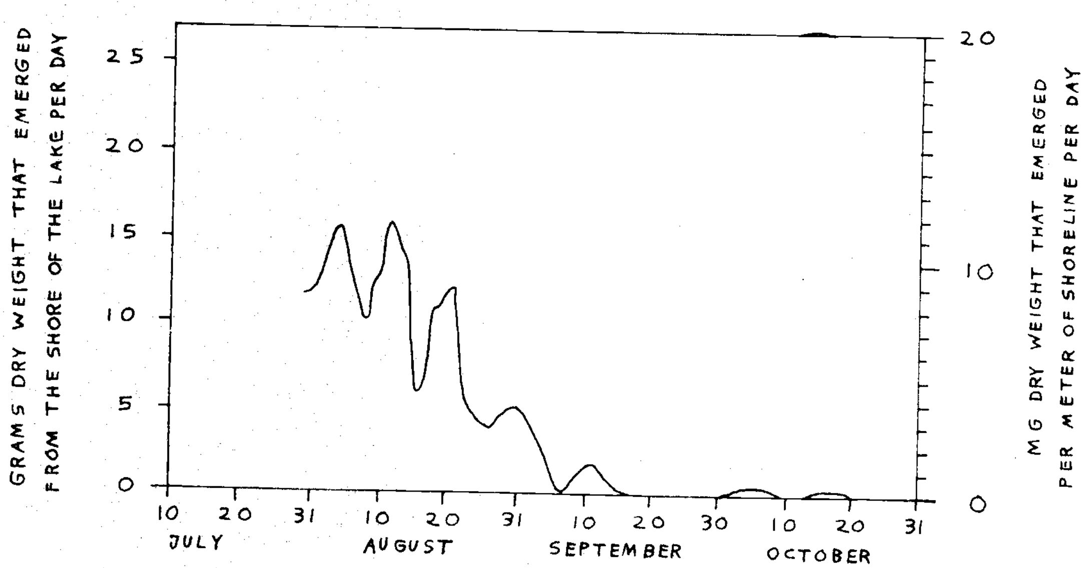

Figure 16. 1972 Diptera emergence from the shore traps at Findley Lake.

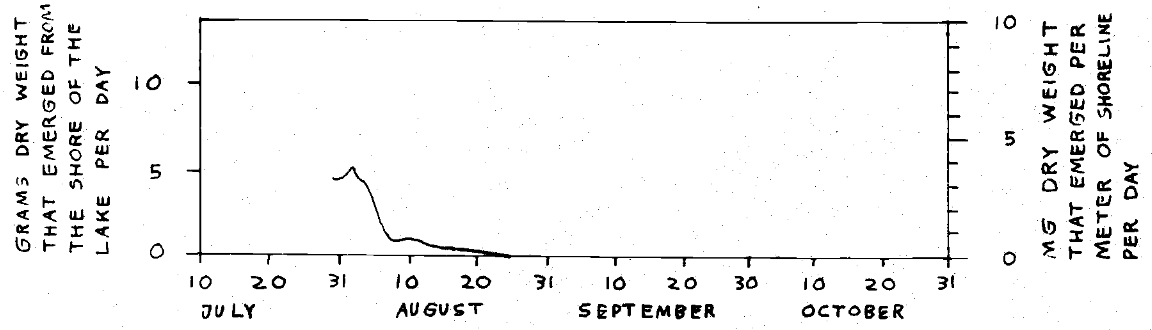

Figure 17. 1972 Culcidae (Chaoborus) emergence from the shore traps at Findley Lake.

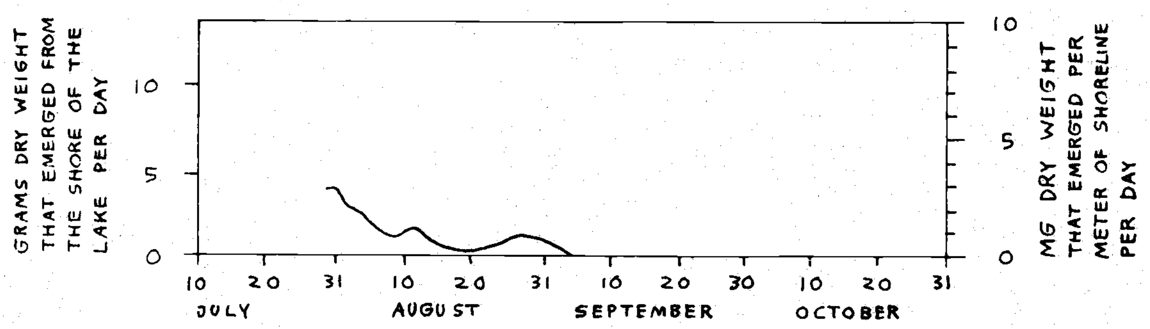

Figure 18. 1972 Tendipedidae (= Chironomidae) emergence from the shore traps at Findley Lake.

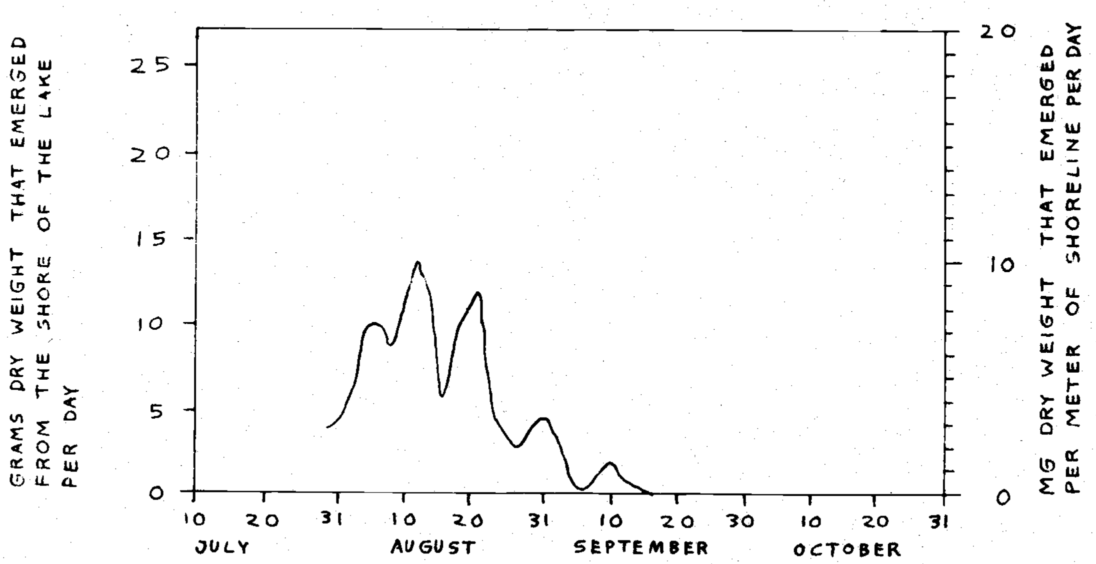

Figure 19. 1972 Empididae (dance fly) emergence from the shore traps at Findley Lake.