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THE USE OF LARGE DAPHNIA AS INDICES OF FISHING QUALITY FOR RAINBOW TROUT IN SMALL LAKES [1]

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ABSTRACT

Twenty-seven lakes (3 to 128 hectares), currently being managed for rainbow trout (Salmo gairdneri), were subjectively classified by the district fisheries supervisor as having "good" or "poor" fishing quality. During the summers of 1966 to 1968 plankton was collected periodically from these northern Michigan lakes with a small Wisconsin-type plankton net. Daphnia larger than 1.34 mm were counted and their volumes were determined. An analysis of the collection of large Daphnia revealed that a combination of two parameters--average number of large daphnids and a volumetric index--gave accurate assessments of the trout lakes categorized as "good" or "poor." The study shows (1) that plankton should be sampled once per month for two different summer months, (2) that a trout lake is poor if the average number of large daphnids is less than 100 per haul and if their volumetric index is less than 0.65, and (3) that if the number of large daphnids is more than 150 per haul and their volumetric index is greater than 0.80, the lake is good for trout.

Introduction

Management of small cold-water lakes for rainbow trout (Salmo gairdneri) sport fishing is a common practice in the United States. In Michigan there are two major types of rainbow trout lakes, trout-only and combination lakes. Trout-only lakes are lakes which are managed solely for trout and have been treated with a toxicant first to eliminate all other fishes. Combination lakes are lakes managed for both trout and other game fishes. Trout-only lakes are usually stocked with rainbow trout 5-15 cm whereas combination lakes are stocked with larger fish, 15-20 cm.

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There is no natural reproduction in either type of lake. The typical trout lake produces unusually good fishing for the first few years, followed by an abrupt decline in trout survival, and hence fishing quality, despite continued stocking. The duration of high quality fishing varies between lakes but generally ranges from 3 to 8 years. Fishing quality in combination lakes generally deteriorates sooner than in trout-only lakes.

Because these trout lakes can deteriorate so rapidly, frequent assessment is essential for wise management. Current methods used by fish managers are very time consuming and costly. There are a large number of rainbow trout lakes in Michigan and an easier and quicker method of assessment would help to accomplish a more rapid evaluation of them.

Johnson and Hasler (1954) in a study of three trout-only lakes in Wisconsin found that rainbow trout were eating *Daphnia* almost exclusively, and that growth of the trout was related to the amount of zooplankton. In a later study (Galbraith, 1967) I found that rainbow trout not only fed heavily on daphnids but selected mostly those over 1.3 mm in size. The data also suggested that the abundance of large *Daphnia* was related to both the survival of trout and the quality of fishing. The object of the present study was to determine if the abundance of large *Daphnia* is, in fact, related to quality of fishing in many other Michigan trout lakes.

Methods

Questionnaires were sent to the four fisheries managers in the Upper Peninsula and to four fisheries managers in the northern Lower Peninsula of Michigan requesting the names of rainbow trout lakes which they judged as having either "good" or "poor" fishing quality. Their judgment was based on previous fish collections, fishermen reports, and their own experiences. For the most part their judgment was, unfortunately, purely subjective.

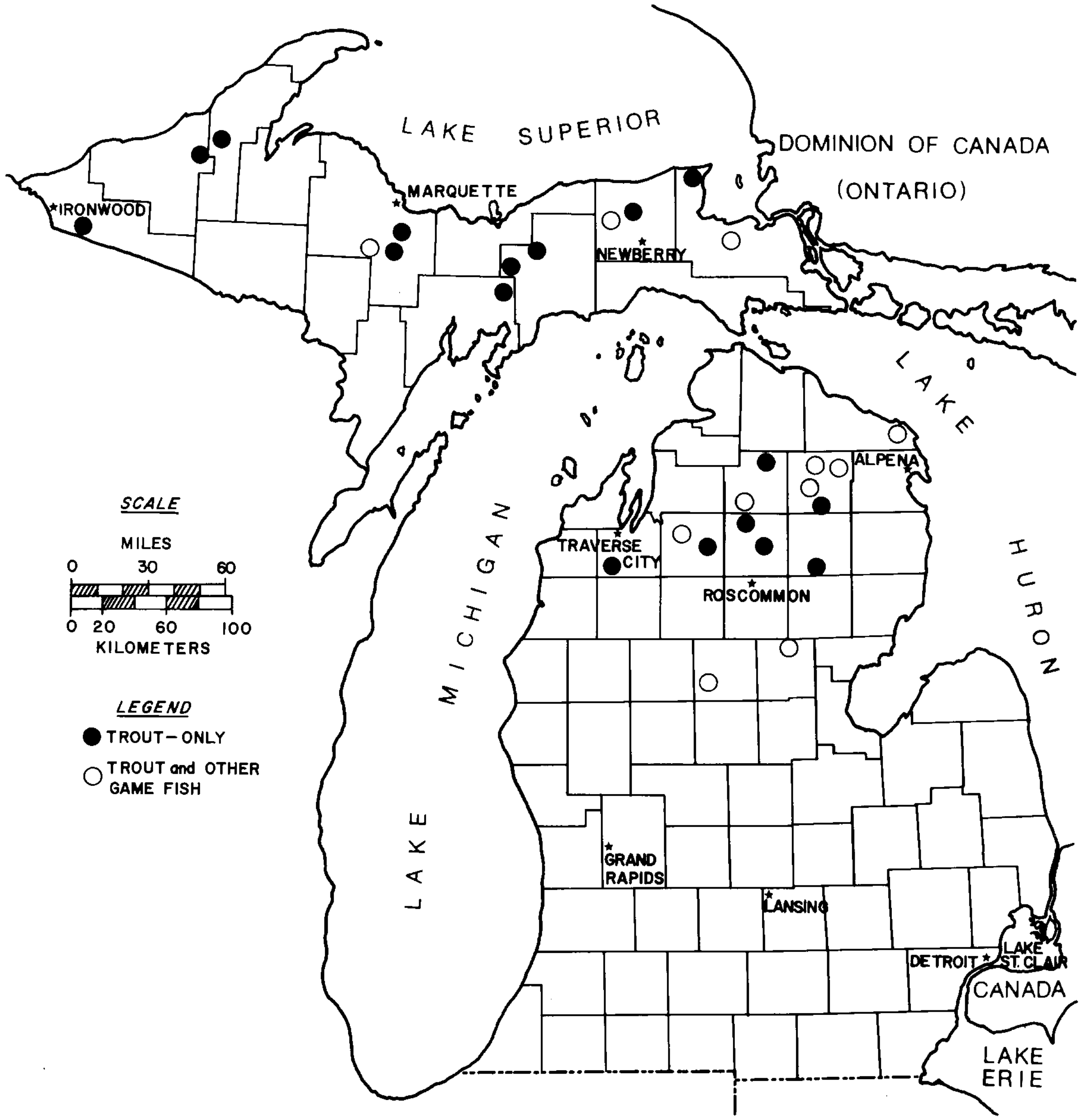


Figure 1.--Distribution of study lakes in Michigan, 1966-1968.

Twenty-eight lakes ranging in size between 2 and 128 ha were selected for study (Fig. 1). Seventeen of these lakes were trout-only lakes and 11 lakes were combination trout lakes. All but 2 were smaller than 59 ha--a size comparable to most Michigan trout lakes.

In order to get a quantitative measurement of the potential fishing quality, 38-m experimental gill nets were used to collect trout. However, nets were set in only 11 trout-only lakes and 8 combination lakes. The number of fish per overnight net set was the index of fishing quality.

Plankton was collected with a Wisconsin-type plankton net having a mouth diameter of 12 cm and a mesh size of 160μ. This Nytex net has a filtration ratio of 8.9 to 1. I made vertical plankton hauls from many depths and locations throughout one of the study lakes in order to determine variability of large daphnids between sampling locations and depths. The results showed that the mean number of large daphnids collected from 4 1/2 m and 7 1/2 m near the center of the lake was not significantly different ($t_{df_3} = 2.20 + 1.07$, respectively, $P < 0.5$) from the number of large daphnids collected in close to shore at those same depths. There also was no difference between the mean number of large daphnids collected from either the 10 1/2- or 13-m depths. Therefore vertical plankton hauls were made in single-basin lakes at four different locations--two shallow and two deep. The shallow stations were at the 6-m depth contour--one at each end of the lake--usually on a line parallel to the long axis of the lake. The deep-water stations were located perpendicular to the long axis and near the center of the lake. The oxygen content in deep water of each lake was first determined to insure that plankton hauls commenced in that zone containing little or no oxygen. In most lakes the vertical column of water sampled in deep water ranged between 10 and 15 m in depth.

Plankton samples were collected during the summers of 1966 through 1968. The lakes were sampled twice each year during August and September of 1966, and June and August of 1967 and 1968.

All large daphnids greater than 1.34 mm from each station were measured and counted. Lengths were measured from the top of the head to the base of the spine. Volumes of large daphnids were determined by centrifugation. The number of large daphnids in the figures are mean number per unit surface area sampled (0.011 m^2).

Results

The number of large daphnids and the volumetric index, per net haul, were the parameters used to evaluate the results. The volumetric index is used to indicate the mean size of the large daphnids in a sample; it is the ratio of the mean volume of large daphnids in milliliters to the mean number of large daphnids times 1,000. A comparison of the length-frequency distribution of the large daphnids from some of the lakes with their volumetric index indicated that a value between 0.30 and 0.60 means the majority of large daphnids are not much larger than 1.34 mm.

A three-way analysis of variance test was used to detect differences between the numbers and the volumetric indices of the large daphnids between good and poor lakes, between types of lake, and between depths (Tables 1 and 2). Because the sampling error includes the variances due to differences between months, between and within lakes, and to variation in sampling techniques, the confidence limits are considered conservative.

In both trout-only and combination trout lakes the large daphnids are significantly more abundant and larger in good lakes than in poor lakes. In good trout lakes the mean number and mean size of the large daphnids in deep water are also much larger than in shallow water. This difference in abundance between depths is not due merely to differences in volume of water sampled, for if it were, the difference would have been only about twice rather than four-fold. In contrast to the good lakes, there is no difference in the abundance and size of the large daphnids between deep or shallow water of poor lakes. This probably reflects the severity of size-selective predation by rainbow trout which normally feed in the deep

Table 1.--Mean number of large Daphnia per net haul, with 95% confidence limits, in relation to quality, type, and depth of collection, 1966-1968

	Deep water	Shallow water
Good lakes		
Trout only	278 ± 17	68 ± 17
Combination	386 ± 26	92 ± 26
Poor lakes		
Trout only	45 ± 17	22 ± 17
Combination	66 ± 23	24 ± 23

Table 2.--Mean volumetric index of large Daphnia per net lift, with 95% confidence limits in relation to quality, type, and depth of collection, 1966-1968

	Deep water	Shallow water
Good lakes		
Trout only	0.93 ± 0.04	0.67 ± 0.04
Combination	1.06 ± 0.03	0.66 ± 0.03
Poor lakes		
Trout only	0.53 ± 0.04	0.50 ± 0.04
Combination	0.47 ± 0.03	0.49 ± 0.03

water at this time of year. The fact that the daphnids in deep water of good lakes were much larger than those in the deep water of poor lakes is further evidence of the severity of size selectivity by trout predation in deep water.

The potential quality of fishing as expressed by trout collected per net set was compared with the number of large daphnids and their volumetric indices in trout-only and combination lakes netted (Figs. 2 and 3). There was no correlation between abundance or volumetric index of the large daphnids and the number of trout netted in good or poor lakes; but the poor lakes are grouped together and are quite distinctly separate from the good lakes of both trout-only and combination type lakes. The average number of trout caught per net set in the poor lakes was five or less.

Another comparison was made of the density and volumetric index of large daphnids in good and poor trout-only and combination lakes over the 3-year period (Figs. 4 and 5). I arbitrarily drew a line on these figures which I think divides the good from the poor trout lakes. With few exceptions, the average number of large daphnids in good lakes of both types exceeded 100 individuals per net haul, and their volumetric indices were greater than 0.65. Those good lakes which were the exception had only recently been treated with rotenone. By comparison, the number of large daphnids collected in the poor trout-only and combination lakes was less than 100 per haul, and their volumetric index was less than 0.65. Although the density of large daphnids in two of these lakes was much higher, an inspection of their size revealed that they were relatively small, having a volumetric index of 0.52 or less. The dominant daphnids in both these lakes were either *Daphnia retrocurva* or *Daphnia galeata mendotae*, both helmeted morphs. Brooks (1965) is of the opinion that helmeted morphs are seen less easily than those of the same length without helmets. Perhaps the exceptionally large number of helmeted daphnids encountered in these two lakes are those which were not apparent to the trout and therefore were not consumed.

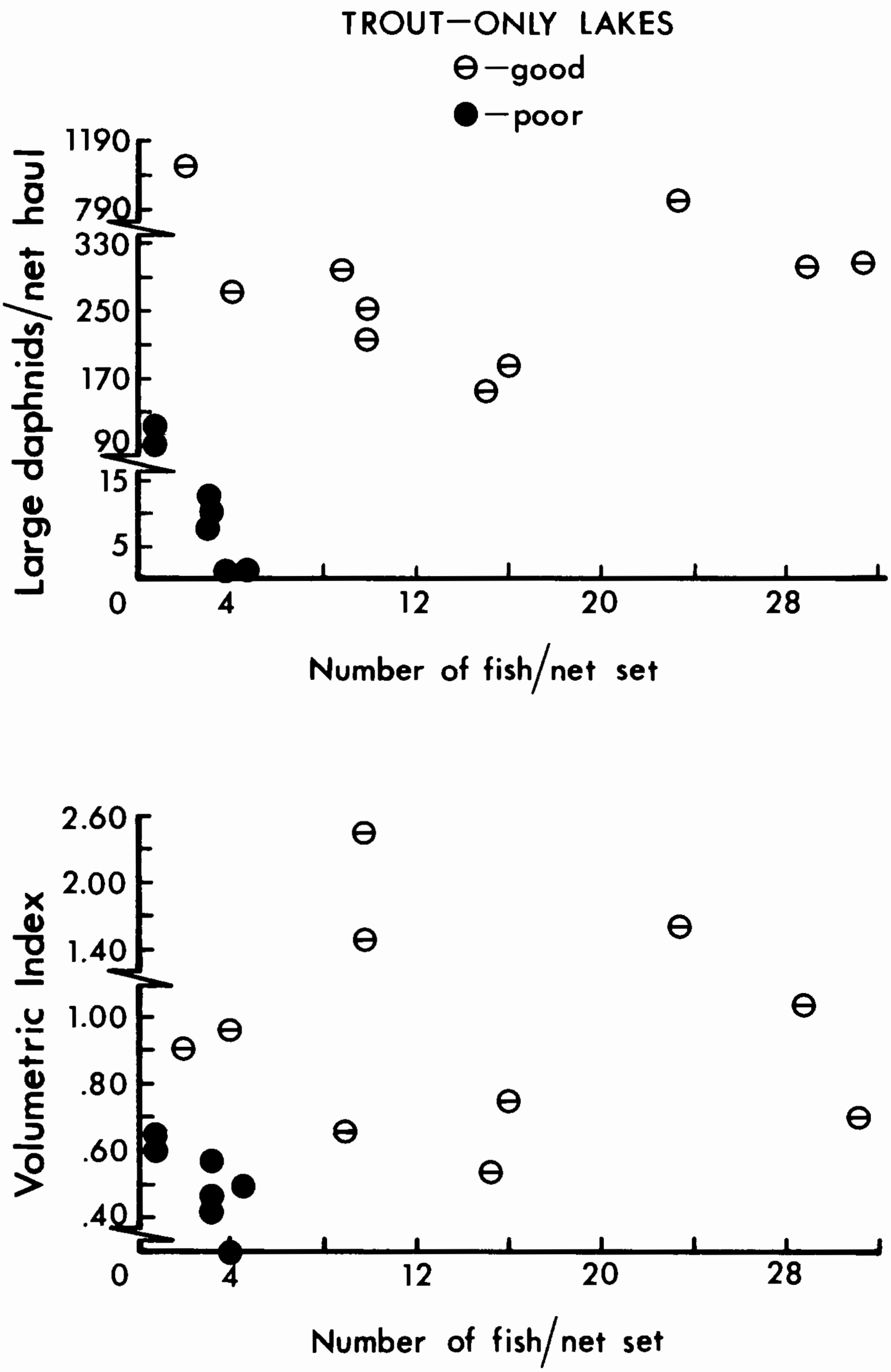


Figure 2.--The relationship between density (upper) and volumetric index (lower) of large daphnids and the density of trout in good and poor trout-only lakes, 1966-1967.

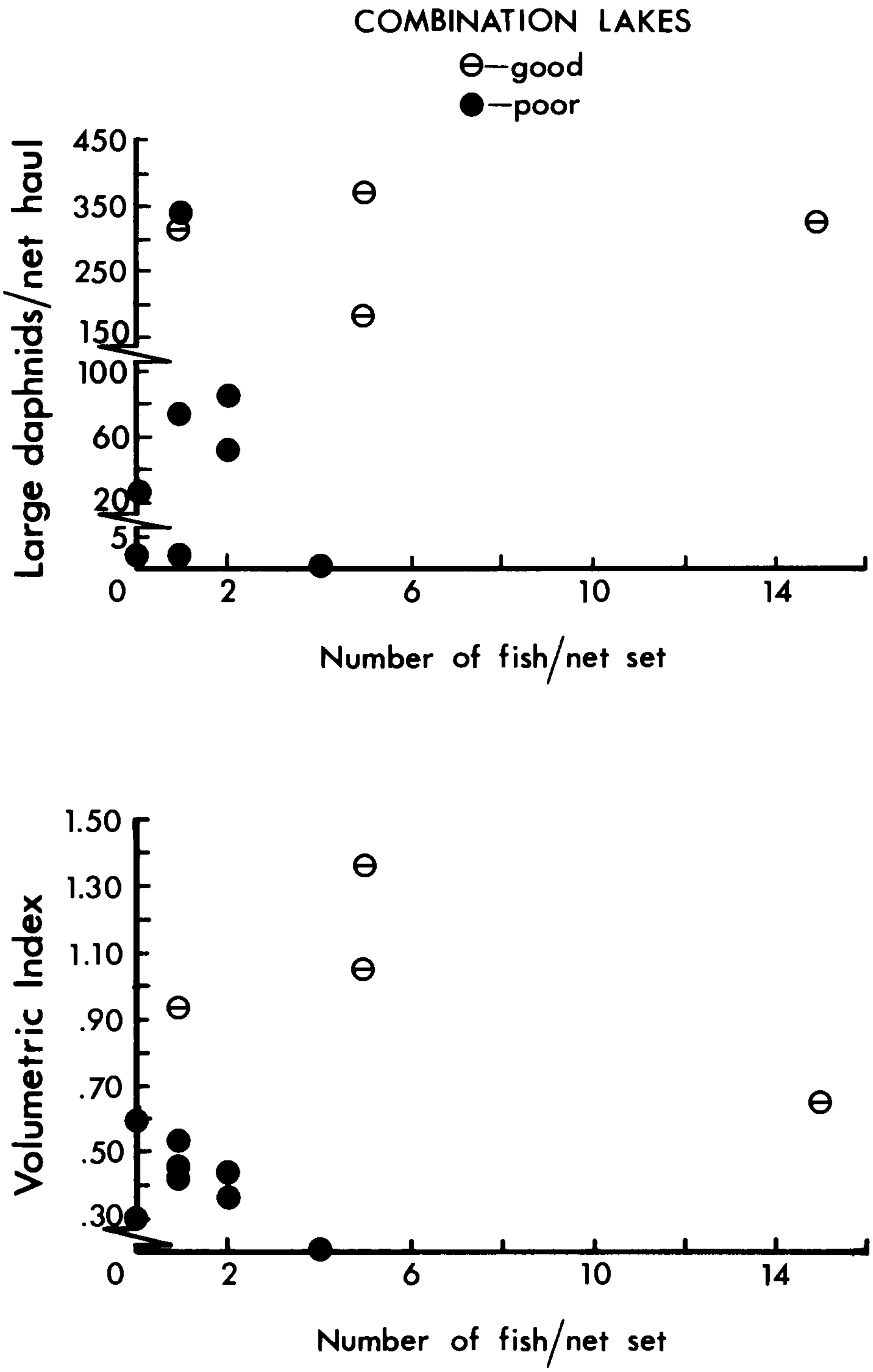
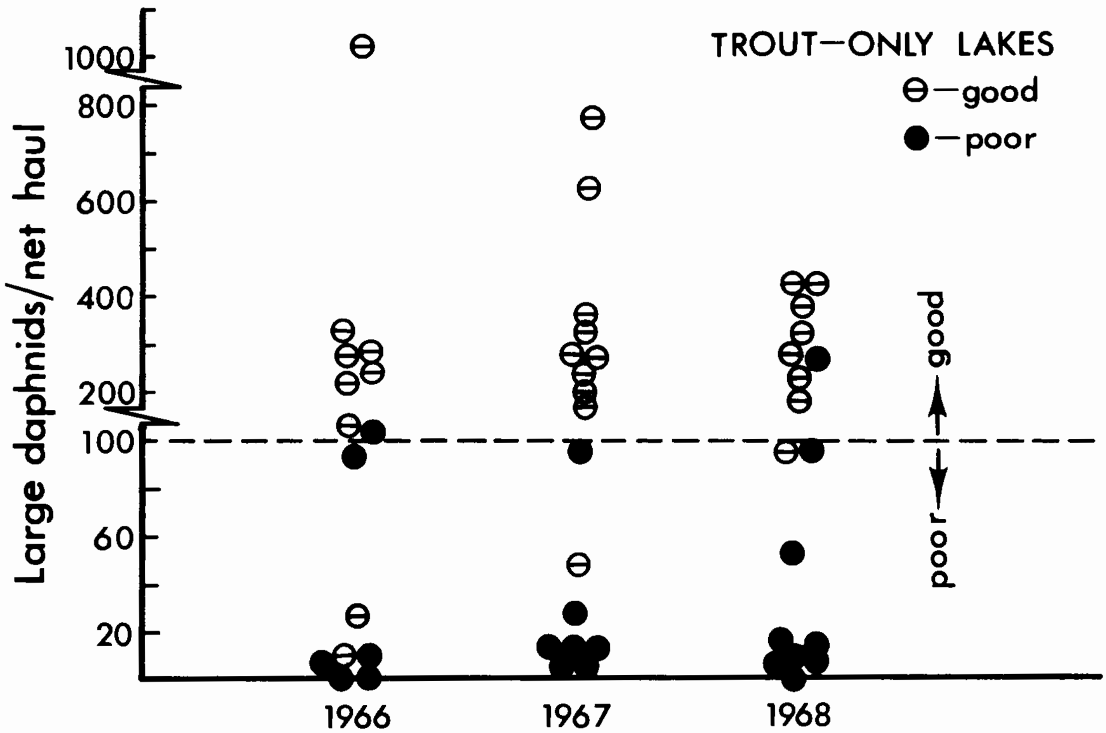


Figure 3.--The relationship between density (upper) and volumetric index (lower) of large daphnids and the density of trout in good and poor combination trout lakes, 1966-1967.



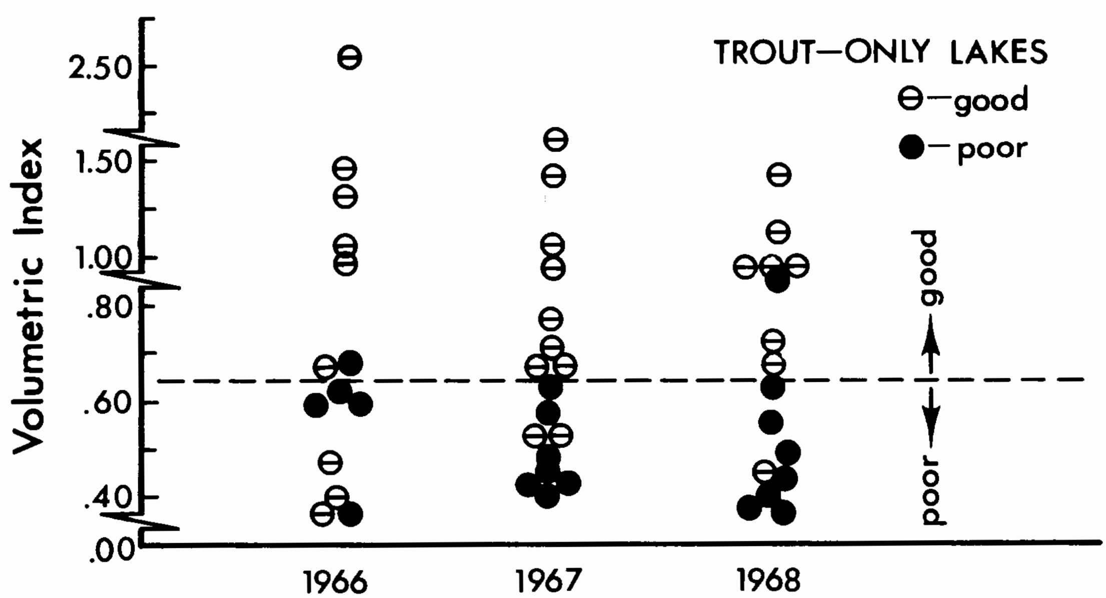


Figure 4.--Comparison of density (upper) and volumetric index (lower) of large daphnids in good and poor trout-only lakes over a 3-year period, 1966-1968.

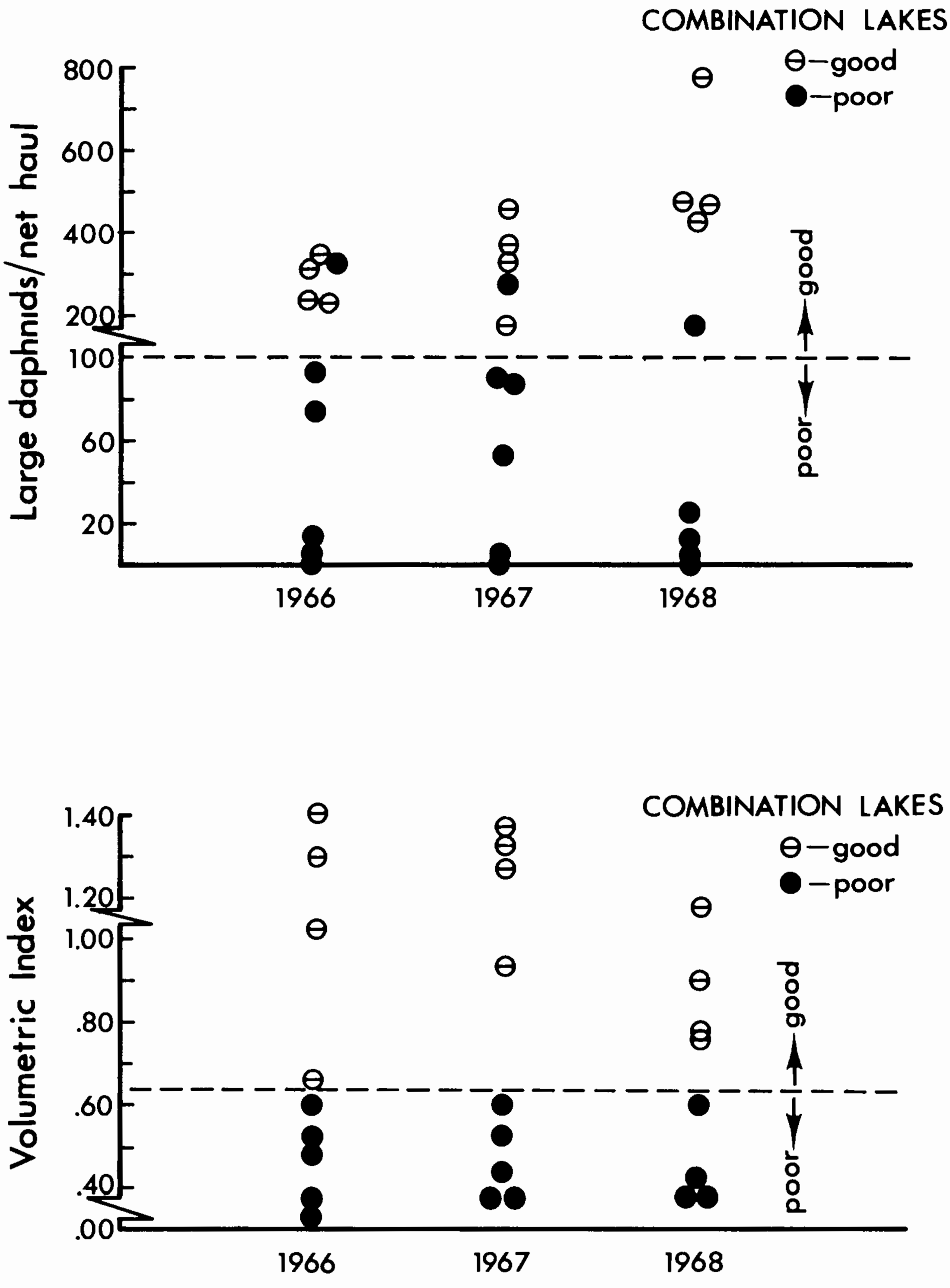


Figure 5.--Comparison of density (upper) and volumetric index (lower) of large daphnids in good and poor combination trout lakes over a 3-year period, 1966-1968.

Samples of large daphnids from each lake were examined to determine if there was any difference in good and poor lakes between the species of *Daphnia* dominating the zooplankton. *Daphnia pulex* dominated in 79% of the good trout-only and combination lakes. In comparison, most of the poor trout lakes were dominated by *D. galeata mendotae* or *D. retrocurva*; only 33% of these lakes were dominated by *D. pulex*. It appears that in upper Michigan, as most trout lakes deteriorate, there is a change in the daphnid population from one dominated by *D. pulex* to one dominated by cyclomorphic species such as *D. retrocurva* or *D. galeata mendotae*.

Discussion

Fish predation on daphnids appears to play a major role in the ability of a lake to produce a good sport fishery for rainbow trout. The data presented demonstrate convincingly that the abundance and size of the daphnids can be used as indices of the quality of fishing and the survival of rainbow trout in small trout lakes. The data show that if the plankton is sampled twice during a summer, i.e., June and August or August and September, and the average number of large (> 1.34 mm) daphnids collected is less than 100 per haul, the lake is a poor trout lake. If collections average more than 150 large daphnids per haul, then the trout lake is a good one. The data also indicate that the volumetric index for these large daphnids would be less than 0.65 in poor lakes and greater than 0.80 in good lakes.

Although it appears that either one of these indices could be used alone to evaluate the condition of small rainbow trout lakes, both indices are more valuable and probably more reliable when used together. These indices are, like many biological indicators, not without their exceptions. Notable among the exceptions in my study, where one or even both indices may give conflicting results, are:

1. lakes which winterkill,
2. lakes in which the condition of the trout stocked was poor,

3. lakes where heavy predation on trout by fish or other animal predators occurs,
4. lakes with outlets through which the trout can escape,
5. lakes which had recently been chemically treated to remove fish--especially during the first year or two after treatment, and
6. lakes which contain cyclomorphic species of daphnids.

Where cyclomorphic species dominate and the daphnids have high helmets, it may be necessary to either increase the critical size of the index for the large daphnids from 1.4 mm to 1.7 mm, or to measure the daphnids from the base of the spine to just above the eye. The former method would be more rapid.

Gerking (1962), Brooks and Dodson (1965), Galbraith (1967), Green (1967), Wells (1970), Hutchinson (1971), Nilsson and Pejler (1973) and others have presented evidence to show the deleterious effect that fish predators have on the size structure of the zooplankton. However, none to my knowledge, have used this information to develop a practical tool for managing lakes for planktivorous fish. This study was an approach toward finding a technique which fish managers can use to evaluate their small rainbow trout lakes. Similar, but somewhat modified, methods of evaluation might also be used to determine the potential of lakes to produce other planktivorous fishes.

Acknowledgments

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