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# Sportfish Harvest Predicted by Summer Chlorophyll-*a* Concentration in Midwestern Lakes and Reservoirs[1]

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## Abstract

An index based on the relationship between angler harvest and mean summer phytoplankton standing crop (chlorophyll *a*) is a basis for estimating the annual yield of sportfishes in midwestern lakes and reservoirs. The relationship is stronger than that between fish yield and total phosphorus, alkalinity, or the morphoedaphic index.

In this paper an index based on the relationship between angler harvest and mean summer phytoplankton standing crop (chlorophyll *a*) is presented as a basis for estimating the annual yield of sportfishes from midwestern lakes and reservoirs.

A basic need of fisheries management is the ability to predict the potential yield of sportfish from a lake or reservoir. A reliable estimate of the capacity of a given water body to produce fish would provide fishery managers with a quantitative basis for resource planning. Such an estimate would help establish management objectives, evaluate past management efforts, and allocate resources.

For this purpose, quantitative relationships involving physical, chemical, and biological indices to predict fish production or harvest have been proposed (Rawson 1952, 1960; Carlander 1955; Moyle 1956; Northcote and Larkin 1956; Jenkins and Morais 1971). Of these, the morphoedaphic index (MEI: total dissolved solids or conductivity divided by mean depth) has been used to successfully predict fish yields from Canadian lakes (Ryder 1965), large temperate reservoirs (Jenkins 1967), and African lakes (Regier et al. 1971, as cited by Ryder et al. 1974). However, the index is not universally applicable for management purposes because the criteria for its use exclude certain types of lakes (Ryder et al. 1974). Oglesby (1977) found that log-normal transformations of either summer chlorophyll *a* or annual primary production were better predictors of fish yield from lakes on several continents than was the MEI.

## Methods

Sportfish harvest data were obtained from expandable creel census programs conducted between 1970 and 1980 by the Missouri Department of Conservation and the Iowa Conservation Commission (Table 1). The surveys were based on a 12–16-hour fishing day (0600–0800 hours to 2000–2200 hours); a stratified random sampling design that separates weekends and holidays from weekdays; and, depending on the lake, a 3- to 7-month sampling period between April and October. For the analyses, data from all lakes were expanded to a 7-month period and arithmetic averages were used for those lakes with data from more than 1 year. Limnological data were taken from Jones and Bachmann (1976, 1978) or unpublished sources (Table 1).

## Results and Discussion

We found a strong linear correlation ($r = 0.91$; $N = 25$; $P \leq 0.01$) between fish yield and the summer chlorophyll-*a* values for lakes and reservoirs in Missouri and Iowa (Fig. 1, Table 1). This relationship is surprisingly good when it is considered that both natural and artificial lakes are included; that creel and chlorophyll data were not from the same years for all lakes; that lakes differ in morphology, hydrology, trophic status, and fish communities; and that precision of harvest estimates varies among lakes. The single outlier to this relationship (Beeds Lake, Iowa, Table 1) was not included in the regression. This lake had a large population of common carp *Cyprinus carpio,* which

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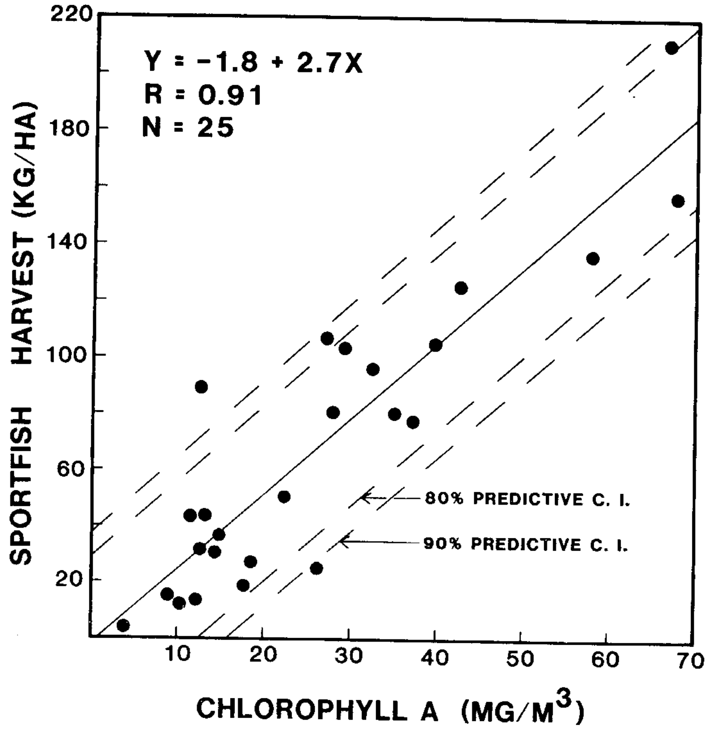

FIGURE 1.—*Angler sportfish harvest (Y, kg/hectare) as a function of mean summer chlorophyll-*a *concentrations (X, mg/ m³) for water bodies in Missouri and Iowa (C. I. = confidence interval).*

was poisoned the year before the creel data were collected. The sportfish harvest from this lake was two orders of magnitude lower than predicted.

Correlations between fish yield and total phosphorus ($r = 0.72$; $P \leq 0.01$), alkalinity ($r = 0.23$; not significant), and the MEI calculated with conductivity values ($r = 0.40$; $P = 0.07$) were lower than that between fish yield and chlorophyll-*a* concentration. The poor correlation with the MEI is expected because our lakes are differentially affected by cultural eutrophication. Anthropogenic nutrient additions increase the productivity of lakes but may not greatly affect the total concentration of dissolved materials in lake water. Under such conditions, total dissolved solids, alkalinity, or conductivity are inappropriate indicators of lake productivity (Ryder et al. 1974). Also, our lakes have various concentrations of inorganic turbidity, a wide range of surface area, and a very small range of mean depth values (Table 1). Therefore, these lakes do not meet the criteria for use of the MEI.

The correlation between fish yield and chlorophyll *a* supports the previous study by Oglesby (1977). The regression equation proposed by Oglesby (1977), however, underestimates fish yield for our lakes by 64% (range 36 to 90%). Oglesby's data came from several sources and fish yields presumably were estimated from more than one method. This indicates such an index is best developed from homogeneous data sets and applied to lakes within a given climatic region (Ryder 1978).

The theoretical basis for predicting fish yield from chlorophyll-*a* values is that summer chlorophyll *a* is an index of lake trophic state (Carlson 1977), which has been correlated with nutrient concentration (Jones and Bachmann 1976), photosynthetic production (Smith 1979), suspended organic matter (Hoyer 1981; Fig. 2), and zooplankton biomass (Patalas 1972; McCauley and Kalff 1981). For this reason, summer chlorophyll *a* is a valid estimator of the organic base upon which fish production and yield depend. This relationship implies that lake trophic state is a major factor controlling fish production

TABLE 1.—*Morphometry, fish yield, chlorophyll* a, *and water chemistry of water bodies in Missouri and Iowa.*

| Lake (county) | Surface area, hectares | Mean depth, m | Fish yield,[a] kg/hectare | Chlorophyll *a*,[a] $\text{mg/m}^3$ | Total P,[b] $\text{mg/m}^3$ | Specific conductance,[b] μmhos/cm 25 C | Alkalinity,[b] mg/liter $CaCO_3$ |
|---|---|---|---|---|---|---|---|
| ***Missouri*** | | | | | | | |
| Binder (Cole) | 60 | 3.6 | 107 (2) | 27.2 (2) | 56 | 346 | 109 |
| Blind Pony (Saline) | 85 | 4.0 | 51 (3) | 22.3 (2) | 50 | 236 | 72 |
| Deer Ridge (Lewis) | 19 | 4.6 | 19 (3) | 17.6 (2) | 45 | 139 | 52 |
| Henry Seaver (Knox) | 64 | 4.0 | 16 (3) | 8.3 (2) | 22 | 161 | 61 |
| Hunnewell (Shelby) | 92 | 4.6 | 37 (1) | 14.7 (2) | 34 | 151 | 56 |
| Lake of the Ozarks | 24,100 | | | | | | |
| Gravois Arm (Morgan) | | | 13 (4) | 10.3 (5) | 22 | 268 | 94 |
| Niangua Arm (Camden) | | | 31 (3) | 14.3 (5) | 31 | 268 | 103 |
| Little Dixie (Callaway) | 83 | 4.6 | 44 (5) | 13.1 (3) | 31 | 140 | 53 |
| Little Prairie (Phelps) | 40 | 4.0 | 91 (1) | 12.5 (2) | 25 | 103 | 37 |
| Paho (Mercer) | 110 | 4.4 | 44 (1) | 11.5 (1) | 52 | 164 | 64 |
| Pony Express (De Kalb) | 97 | 5.8 | 104 (4) | 29.2 (1) | 67 | 157 | 66 |
| Table Rock (Stone) | 16,800 | | | | | | |
| James River Arm | | | 25 (3) | 26.1 (1) | 55 | 211 | 79 |
| Long Creek Arm | | | 4 (3) | 3.9 (1) | 15 | 211 | 87 |
| Thomas Hill (Macon) | 1,818 | 4.2 | 14 (1) | 12.0 (3) | 46 | 364 | 65 |
| ***Iowa*** | | | | | | | |
| Anita (Cass) | 65 | 4.2 | 81 (5) | 35.1 (2) | 38 | 192 | 100 |
| Beeds (Franklin) | 43 | 2.9 | 3 (1) | 60.4 (4) | 45 | 467 | 200 |
| Big Creek (Polk) | 358 | 5.4 | 32 (4) | 12.6 (5) | 29 | 422 | 178 |
| Clear (Cerro Gordo)[c] | 1,443 | 2.7 | 27 (2) | 18.4 (2) | 38 | 280 | 138 |
| Cold Springs (Cass) | 6 | 2.1 | 212 (3) | 66.7 (1) | 65 | 212 | 104 |
| Green Valley (Union) | 161 | 2.9 | 159 (3) | 67.7 (1) | 76 | 253 | 107 |
| Kent (Johnson) | 11 | 2.3 | 105 (1) | 39.7 (1) | 74 | 196 | 101 |
| McBride (Johnson) | 329 | 4.9 | 97 (1) | 32.5 (1) | 59 | 272 | 98 |
| Miami (Monroe) | 57 | 2.9 | 126 (1) | 42.6 (1) | 57 | 264 | 98 |
| Prairie Rose (Shelby) | 83 | 3.1 | 137 (1) | 57.9 (2) | 90 | 247 | 137 |
| Spirit (Dickinson)[c] | 2,168 | 5.2 | 82 (4) | 27.9 (4) | 46 | 408 | 138 |
| Viking (Montgomery) | 58 | 4.5 | 88 (1) | 37.1 (2) | 37 | 198 | 101 |

[a] Mean value; number of years represented is in parentheses.

[b] Same years represented as for chlorophyll.

[c] Natural lakes; all other water bodies are reservoirs.

in a broad range of lakes of similar depth and contributes to our understanding of processes that determine the potential of individual lakes to produce fish.

The fish yield–chlorophyll-*a* relationship should be a useful basis for predicting an expected sustained harvest of sportfishes by anglers in other midwestern lakes and reservoirs. Summer chlorophyll-*a* concentrations vary within and among years in any given lake (Bachmann and Jones 1974; Kalff and Knoechel 1978), so several samples over more than 1 year will be required to use this variable as a reliable estimate of trophic state to estimate sportfish harvest. A predicted value, with confidence intervals (Fig. 1), should be treated as an estimate of the average potential for a midwestern lake of a given trophic state to produce sportfishes. This value can be used to compare lakes and develop appropriate management tactics. The relationship may not apply to (a) lakes with high inputs of allochthonous organic matter, (b) lakes treated with algalcides, (c) lakes in which fish are winter-killed or exposed to high concentrations of toxicants, (d) lakes with high densities of nonsportfishes, or (e) lakes outside the region.

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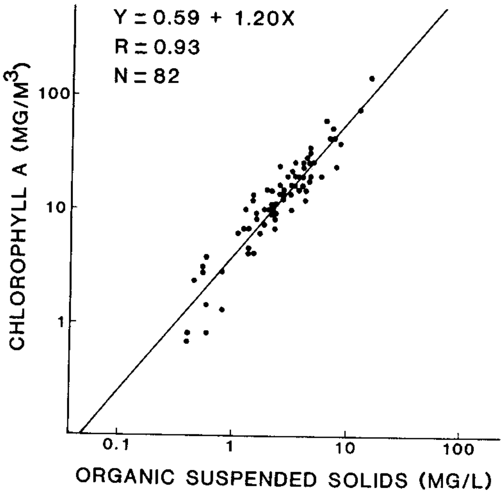

FIGURE 2.—*Relationship between mean summer chlorophyll-*a *concentrations (*Y, *mg/m*$^3$*) and mean summer organic suspended solid concentrations (*X, *mg/liter) for reservoirs in Missouri and Iowa.*

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