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Evaluation of Fish Stocking in Southeastern South Dakota Ponds

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EVALUATION OF FISH STOCKING IN SOUTHEASTERN SOUTH DAKOTA PONDS

by

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This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor

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PJP

EVALUATION OF FISH STOCKING IN SOUTHEASTERN SOUTH DAKOTA PONDS

Abstract

PAUL J. PEETERS

A mail survey was sent to owners of 220 ponds which had received hatchery fish. Based on 187 pond owner responses, at most 45 (24%) of the ponds still contained the fishes stocked. Pond dryness and/or winterkill attributed to the failure of 121 (65%) of the ponds. A subsequent field survey of 30 ponds identified fish populations of recreational value.

Attempts were made to identify important pond parameters that contributed to successful fish populations. A_t (percent harvestable fish), F/C (forage to carnivore ratio), balance (in or out), and a scale of balance were the dependent variables used to describe successful fish populations. Statistical analysis of the field survey data identified several significant (P .10) correlations. Alkalinity was negatively correlated with A_t (percent harvestable fish). That is, as alkalinity levels increased, A_t estimates decreased. Estimated pond size and secchi disk visibility were positively correlated with a scale of balance. That is, as estimated pond size increased or the depth to which the secchi disk was visible increased balance improved. Largemouth bass <u>(Micropterus</u>

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

INTRODUCTION

There are an estimated 100,000 artificial impoundments in South Dakota; 38,000 of which contain fishable populations (C. Backlund, pers. comm.). Most were specifically constructed to provide water for livestock, but many have been stocked with fishes and are utilized for recreational purposes.

A popular species combination for stocking has been largemouth bass (Micropterus salmoides) and bluegill (Lepomis macrochirus). The evolution of this stocking combination was largely a result of the work by Swingle and associates (Reiger 1962). In theory, largemouth bass and bluegill are stocked to maximize pond usage. Largemouth bass keep bluegill numbers in check, bluegill provide a food base for largemouth bass, and both provide recreational fishing. Extensive research has been done on the largemouth-bluegill combination for stocking ponds (Swingle 1951; Reiger 1963; Dillard and Hamilton 1969). Workers in different geographic areas of the United States have demonstrated that factors such as pond fertilization (Smith and Swingle 1942; Meehan 1933) and stocking rates (Swingle 1951; Dillard and Hamilton 1969) influence the success of the stocking attempts. Results of past research have indicated that the influence of these factors vary regionally. Thus, wise and successful pond management in one region of the country may be poor and unsuccessful in another region.

There have been no studies attempted to identify those factors which most affect the success of fish stocking in South Dakota ponds. This study was conducted to determine the relative success of stocking attempts in South Dakota and to identify factors contributing to the success or failure of stocking attempts.

The study consisted of two phases. The first phase was a mail survey to pond owners. The purposes of the survey were: (1) to gain an overview of what had happened to fishes stocked in South Dakota ponds; (2) to identify ponds suitable for field evaluation; and (3) to receive permission from the landowners to conduct field research in their ponds. The second phase of the study involved field evaluation of ponds determined during the first phase to be suitable for such research.

STUDY AREA

South Dakota has a continental-type climate characterized by cold winters and warm to hot summers. The average mean low is -29 C (-20 F) and the average mean high is 38 C (100 F). The to about 7 C (44 F) in the north. The annual average precipitation in South Dakota varies from 33 cm (13 in) in the northwest to 64 cm (25 in) in the southeast. The majority of the precipitation falls in spring and early summer (Spuhler and Lytle 1971). Precipitation for most of the eastern two-thirds of South Dakota was below normal in the years 1973 through 1976. Some parts of the study area received less than half average precipitation in one or more of these years (S. D. Exp. Sta. Weather Sta. unpublished).

All of South Dakota east of the Missouri River was glaciated and is covered with varying amounts of glacial deposits. West of the Missouri River, soils were formed from Upper Cretaceous sandstones and siltstones. The relief of South Dakota, with the exception of the Black Hills, ranges from nearly level in the glacial lake plains to undulating and rolling in the glaciated eastern area and to rough and broken in some of the western areas. Native vegetation, with the exception of the Black Hills, varies from tall grass prairie in the east to mid and short grass prairie in the west (Westin et al. 1967).

Ponds surveyed in this study were basically restricted to southern and eastern South Dakota (Figure 1). Location of ponds by county is provided in Appendix 1. Pond ownership and mailing address are provided in Appendix 2.

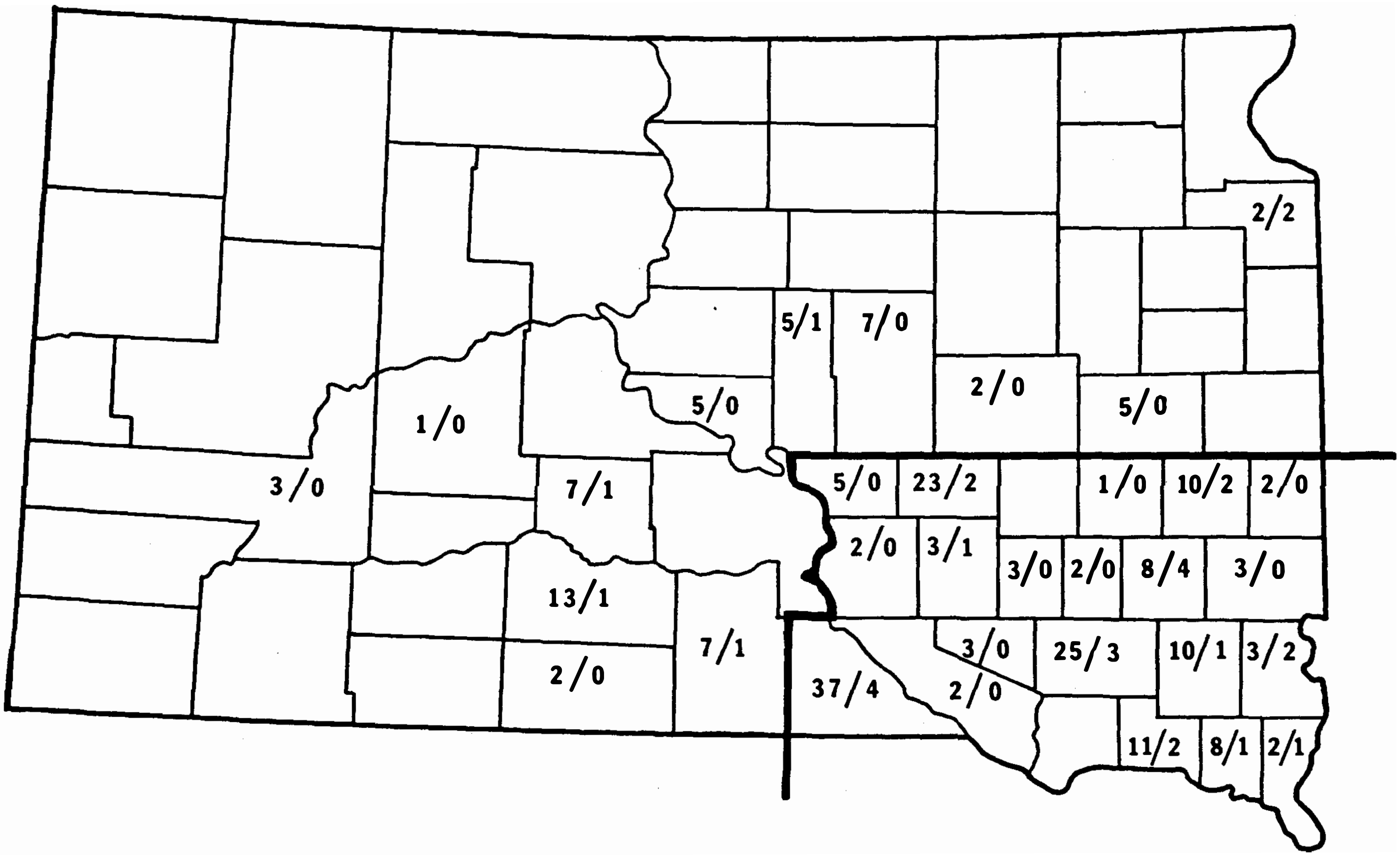

Figure 1. Distribution map of ponds studied in the evaluation of fish stocking attempts in South Dakota, 1976. One hundred sixty one of the 220 mail survey ponds (73 percent) and 23 of the 30 field survey ponds (76 percent) were located south and east of the heavy dark line. Numbers within each county represent mail survey/field survey.

MATERIALS AND METHODS

Mail Survey

The ponds selected for this study had to meet certain criteria. Ponds were to be new waters in South Dakota, never having had fishes before. Also, the ponds were to have been stocked with a known combination of largemouth bass and bluegill, with or without channel catfish (*Ictalurus punctatus*).

Stocking records were verified for ponds stocked by the Gavins Point National Fish Hatchery. Gavins Point National Fish Hatchery records for the years 1967 through 1973 were reviewed. Ponds which appeared to meet criteria needed for this study were sorted from the record files. The hatchery records yielded 220 ponds which appeared to fit the study. Owners of these ponds were sent a letter informing them of the proposed study. Also provided was a self-addressed stamped postcard upon which a series of yes or no questions was asked (Figure 2). Mailings were made on 12 August 1975 and 5 September 1975. An additional mailing was made to non-responding landowners on 20 January 1976.

Reply card answers which made the pond acceptable for the second phase of the study were: The records are correct; additional fish have not been added; the pond has not been completely dry; a large loss of fish during winter was not suspected; and a field evaluation of the pond may be conducted.

DESCRIPTION OF POND IN QUESTION

According to our records your pond was stocked with bass and bluegill in 19____. Is this correct? Yes ___ No ___

Have any additional fish been stocked since the initial stocking? Yes ___ No ___

Has the pond been completely dry since 19____? Yes ___ No ___

Do you have reason to believe that there has been a large loss of fish during any of the winters since 19____? Yes ___ No ___

Would you allow a field evaluation of your pond? (This would include the capture and live return of only a small number of fish.) Yes ___ No ___

Would you like a copy of the finished report? Yes ___ No ___

Any other comments you feel are noteworthy: ____________________

Signature

Figure 2. Mail survey card sent to owners of 220 ponds in an evaluation of South Dakota pond stocking attempts, 1976.

The first question indicated whether the Gavins Point records were correct. If the records were not correct, stocking rates and ratios could not be documented for that particular pond and it could not be used for further study. The question dealing with the stocking of additional fishes identified ponds in which the original stocking rate, ratio, and/or species composition had been altered. Such alteration obscured the original stocking conditions and made that pond unacceptable for field evaluation. If the owner indicated that the pond had been completely dry since stocking, the pond was unacceptable as the original stocking of fishes could no longer exist. The fourth question attempted to determine if winterkill may have occurred. If a winterkill was indicated, the pond was unacceptable. The fifth question was a request for permission to conduct the field evaluation pending the selection of that particular pond for the second phase of the study.

Field Survey

Various physical-chemical parameters were measured at each field survey pond. A map of each pond was drawn utilizing a microptic alidade. Pond area greater than 1 m in depth was plotted. Maximum depth was measured to the nearest tenth meter with a weighted line. Secchi disk visibility was measured to the nearest tenth meter. Conductivity, salinity and surface water temperature were measured with a Yellow Springs Instrument. Calcium hardness, pH, and alkalinity were measured with a Hach kit model DR-EL.

Fish samples were obtained with three different sized seines. The smallest seine was 7.9 m (26 ft) long, 1.5 m (5 ft) deep with 6.4 mm (0.25 in) mesh. This seine was used to check for fish reproduction by verifying the presence of fry or young-of-the-year largemouth bass and bluegill in the pond. The two larger seines were used to sample adult fishes. One of the large seines was 19.8 m (65 ft) long, 1.2 m (4 ft) deep with a 12.7 mm (0.50 in) mesh and a 1.8 m^3 (6 ft^3) bag in the middle. The largest seine was similar to one described by Beall (1959) and was built specifically for this study. It was 45.7 m (150 ft) long, 4.9 m (16 ft) deep in the middle tapering to 2.4 m (8 ft) deep at both ends, with a 19.0 mm (0.75 in) mesh. It also had a 1.8 m^3 (6 ft^3) bag in the center. Both large seines were not necessarily used at each pond. Rather, the seine best suited to the individual pond was utilized.

Adult fishes were collected and individually weighed. Two population indices, A_t (percent harvestable fish) and F/C (forage to carnivore ratio), were calculated based upon the weights of the fishes collected (Swingle 1950). Harvestable fishes included those which exceeded the minimum size acceptable to anglers (Swingle 1950). Minimum weights for species encountered and included in the population indices for this study were: largemouth bass and channel catfish, 180 g; bluegill and green sunfish (Lepomis cyanellus), 45 g; black bullhead (Ictalurus melas), 136 g. A_t is calculated by taking the cumulative weights of all harvestable fish collected, dividing that by the weight of all collected fish and multiplying by 100.

$$\frac{\text{weight of harvestable fish}}{\text{weight of all fish}} \times 100 = A_t$$

The F/C ratio is the cumulative weight of all forage species divided by the cumulative weight of all carnivorous species. All bluegills, green sunfish, and black bullheads were considered forage species. All largemouth bass and channel catfish were considered carnivores.

$$\frac{\text{cumulative weight of all forage species}}{\text{cumulative weight of all carnivore species}} = F/C$$

On the basis of 89 separate well established fish populations, Swingle (1950) defined most desirable ranges for the population parameters A_t and F/C. Balanced fish populations were found to have A_t values from 33 to 90 with 60 to 85 representing the most desirable. In addition, balanced fish populations had an F/C ratio between 1.4 and 10, with the most desirable falling between 3 and 6.

Balance is a condition where both largemouth bass and bluegill are able to reproduce annually, grow at satisfactory rates and yield annual harvestable crops of fishes (Swingle 1950). In this study the presence of species stocked in each pond along with the A_t and F/C values calculated for each pond were subjectively used to access balance. Two different scales of balance were assigned. The first assessment of balance made in this study was whether a pond was in or out of balance. A population containing both species stocked, largemouth bass and bluegill, and falling within the broad range of balance for both A_t and F/C was termed balanced. A population lacking either species or not falling within the accepted limits for either population value was termed out of balance. The second assessment of balance used the same criteria but was scaled as follows: 0, inadequate information to accurately assign a value; 1, completely unbalanced, one or both species absent and one or both population values outside the established wide range limits; 2, out of balance, both species present but one or both population values outside the established wide range limits; 3, borderline unbalanced, both species present and one or both population values approaching but not within the wide range limit; 4, balanced, both species present, one population value within the wide range limit and the other population value approaching but not within the limit; 5, good balance, both species present and both population values within the established wide range limit.

Multiple regression deals with linear relationships among more than two variables. Stepwise multiple regression was used to determine the relative importance of each variable and the significance of its effect.

Information on 23 independent and four dependent variables (Table 1) was collected. The variables used for this study were selected because they had been shown to influence fish and/or fish populations in other studies. Stocking rates and ratios have been shown to play important roles in pond fish populations (Swingle and Smith 1940; Swingle 1951; Dillard and Hamilton 1969; and Smith et al. 1955). Eleven of the 23 independent variables described fish stocking rates and ratios or the current population. Allen and Lopinot (1970) and Krumholz (1952) discussed pond size and depth as important pond characteristics. Five of the independent variables described these aspects of the ponds. Each of the remaining pond characteristics are described by one variable. Salinity and conductivity have been shown to affect fishes, especially fry (Peterka 1972). pH has been identified as an important pond variable (Swingle 1957). Alkalinity and hardness have been shown to affect fish production (Carlander 1955; Ryder 1965). Although it is not a direct measure of light penetration, secchi disk visibility does provide an index of light penetration. Murphy (1962) has shown that water turbidity affects the productivity of an aquatic environment, and Buck (1956) has linked reduced largemouth

Table 1. Independent and dependent variables used in stepwise multiple regression analysis of 30 South Dakota farm ponds, 1976.

Independent variables

- Pond size (estimated by the landowner)
- Pond size (measured in this study)
- Area of pond deeper than 1 meter
- Percent of the pond deeper than 1 meter
- Maximum depth
- Percent salinity
- Conductivity
- pH
- Calcium hardness
- Alkalinity
- Secchi disk visibility
- Aquatic vegetation (interfere with seining or not)
- Age of pond (years since stocking)
- Number of largemouth bass stocked per estimated hectare
- Number of bluegill stocked per estimated hectare
- Number of largemouth bass stocked per measured hectare
- Number of bluegill stocked per measured hectare
- Number of largemouth bass stocked per 100 bluegill
- Channel catfish stocked (yes or no)
- Channel catfish collected (yes or no)
- Other fish collected from pond (yes or no)
- Fry or young-of-the-year largemouth bass collected
- Fry or young-of-the-year bluegill collected

Dependent variables

- A_t (percent harvestable fish)
- F/C (forage to carnivore ratio)
- Balance (in or out)
- Balance (scaled to six different categories)

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bass growth with turbid ponds. Dense growth of aquatic vegetation can interfere with seining attempts. The pond variable, aquatic vegetation, indicates only if the vegetation interfered with the seining attempts or not.

RESULTS AND DISCUSSION

Mail Survey

Of the 220 reply cards sent, pond owners returned 148 within four months. An additional seven were returned as undeliverable. A second reply card sent to non-responding pond owners resulted in 38 replies. A total of 187 replies (85%) were received from pond owners. On the basis of the answers and/or comments on the reply cards, 151 ponds were eliminated from the field evaluation phase of the study; 36 ponds were selected as appearing suitable for further investigation.

The answers and/or comments which eliminated ponds from the field evaluation phase of the study could be divided into five broad categories. Winterkill and pond dryness were grouped together and accounted for 121 (80%) of the 151 rejected ponds. As water level in a pond became low, the chances of winterkill were increased. Therefore, it was probable that a good portion of the reported winterkill was attributable to the low water levels caused by drouth. Ponds were also rejected for the following reasons: additional fish added to the pond since the initial stocking, 23 (15%); information as taken from the hatchery records incorrect, 12 (8%); pond owners would not permit a field evaluation, 7 (5%); and replies on which comments (i.e., land on which pond is located has been sold) eliminated the pond, 13 (9%). Some ponds were eliminated for more than one reason: i.e., additional fish added and winterkill.

Field Survey

The 36 ponds selected for the field survey were evaluated from 18 May to 4 August 1976. Seven of these ponds were eliminated as not suitable for further study. Four of the ponds had to be eliminated because of decreased water levels; two were small marshes with a dugout; and the seventh pond was an active gravel quarry several hectares in size with a 21 m (70 ft) vertical dropoff and was therefore unseinable. An additional pond not in the mail survey was added to the study after landowner contact verified that this pond was suitable for the study and hatchery records were located.

Two pond measurements were utilized (Appendix 3). Pond size, as estimated by the landowners ranged from 0.30 to 4.05 ha. The average estimated pond size was 0.96 ha (2.37 acres). Pond size, as measured in this study ranged from 0.11 to 5.14 ha. The average measured pond size was 0.80 ha (1.98 acres).

Estimated pond size was taken from the Gavins Point National Fish Hatchery records where it had been estimated by the landowners on the fish stocking request form. Given a correct estimate range of plus or minus 20% of the measured pond size, estimated pond size was incorrect for 21 of the 30 study ponds. Four of the ponds had been subjected to severe size reduction due to drought and did not represent normal pool. Of the remaining 17 ponds, 13 had been overestimated by as much as 60% and 4 had been underestimated by as much as 60%. Similar trends can be seen in a study of Missouri farm ponds. Dillard and Hamilton (1969) reported that 86% of Missouri ponds had been overestimated by an average of two and one-half times.

Three measurements of pond depth were made (Appendix 3). Maximum depth ranged from 1.3 to 6.6 m. The average maximum depth for the 30 study ponds was 3.6 m (11.8 ft). Area of the pond deeper than 1 m varied from 0.03 to 3.09 ha with an average of 0.51 ha (1.26 acre). Percent of the pond deeper than 1 m ranged from 27 to 90%. The average pond area deeper than 1 m was 58.2%.

Allen and Lopinot (1970) made recommendations for minimum pond size and depth for Illinois farm ponds. A pond at least 0.4 ha (1 acre) in surface area and at least 3.1 to 3.7 m (10 to 12 ft) in depth was encouraged. U.S. Fish and Wildlife Service Region 3 farm pond stocking policy states that ponds to be stocked by that agency in South Dakota must be 0.4 ha (1 acre) in size and at least 3.1 m (10 ft) deep with flow or 3.7 m (12 ft) deep without flow. Eleven of the 30 ponds in the field survey were less than 0.4 ha (1 acre). Eleven of the field survey ponds were less than 3.1 m (10 ft) in depth.

The pH range for ponds in this study was 8.0 to 10.9 (Appendix 4). Therefore, all ponds were alkaline. The pH level in a pond is dynamic and can change several units in a day, largely as a result of plant activity (Swingle 1957). Therefore, any one-time measure of pH is useful only in indicating if the pond lies within a desirable range. Water becomes uninhabitable for fish at a pH below 4.0 and at a pH above 11.0. The most desirable range for good fish growth is 6.5 to 9 (Swingle 1957). Adult and young fish were found in the pond with a pH of 10.9. Therefore, pH levels were not considered limiting for fish in this study.

Salinity levels measured for the 30 field survey ponds ranged from 0.00 to 5.0% (Appendix 4). In a study of North Dakota waters, Peterka (1972) found conductivity levels of approximately 4,000 micromhos associated with non-hatching of walleye (Stizostedion vitreum) eggs and poor hatching (about 1%) of northern pike (Esox lucius) eggs. However, fathead minnow (Pimephales promelas) eggs were not adversely affected at that level. In this study both largemouth bass and bluegill young were present in the pond with the highest salinity and conductivity (5.0% salinity and 7,000 micromhos conductivity). Salinity and conductivity levels were not deleterious to largemouth bass and bluegill reproduction and therefore were not considered limiting for the ponds in this study.

The age of an impoundment was measured in terms of years since fish were stocked (Appendix 5). Fish populations varied in age from three to nine years. The average age of the 30 field survey ponds was six years.

Alkalinity varied from 40 to 344 mg/l (Appendix 4). The average alkalinity of the ponds was 111 mg/l. These alkalinity levels were within the normal range discussed by Lagler (1952). Hardness ranged from 40 to 1,500 mg/l calcium (Appendix 4). The average pond hardness was 288.5 mg/l. The hardness levels were within the normal range.

Secchi disk visibility ranged from 0.2 to 3.9 m (Appendix 4), with an average of 1.25 m. Although subjective, secchi disk visibility can express relative levels of plankton populations or suspended particulate matter such as clay (Lagler 1952). Although there was no quantitative measure of the agents causing the observed turbidity, the majority of the low measurements encountered in the 30 field survey ponds were the result of inorganic suspensoids.

Aquatic vegetation hampered seining attempts in nine of the 30 survey ponds. In two of these nine only a small sample of fishes was collected. These two ponds were described as having inadequate information to classify balance in Appendix 7.

Stocking data (Appendix 5) came directly from Gavins Point National Fish Hatchery records. Largemouth bass stocked per estimated hectare fluctuated from 165 to 1,235 with an average of 327/ha (132/acre) for the 30 field survey ponds. Largemouth bass stocked per measured hectare ranged from 97 to 3,409, with an average of 589/ha (238/acre). Bluegill stocked per estimated hectare varied from 247 to 4,118 with an average of 1,332/ha (539/acre). Bluegill stocked per measured hectare ranged from 292 to 16,363 with an average of 2,220/ha (898/acre). Documentation of stocking rates and ratios must be known as they have been shown to play important roles in affecting resultant fish populations (Smith et al. 1955; Graham 1973; Smith et al. 1975; Swingle 1951). The number of fishes stocked per unit area in any one year was influenced by the demand and availability of fishes in that year. This resulted in varying rates and ratios of largemouth bass and bluegill being stocked. Largemouth bass and bluegill were apportioned to each pond on the basis of the owner size estimate. However, because of the discrepancies between pond sizes as estimated by the landowner and actual pond sizes, stocking rates as reported in the Gavins Point records could differ from the actual stocking rates. Therefore, in this paper stocking rates of largemouth bass and bluegill are reported per estimated hectare and per measured hectare.

The ratio of largemouth bass stocked per 100 bluegill varied from 6 to 100. The average number of largemouth bass stocked per 100 bluegill was 39. Stocking ratios changed from year to year as the hatchery supply of the two species varied.

Channel catfish were stocked in 11 of the 30 field survey ponds, but were collected from only one pond. The pond that channel catfish were collected from was the smallest and shallowest pond sampled. This pond had experienced severe size reduction due to drought. Channel catfish are generally not reproductively successful in small impoundments without special nesting structures (Lopinot 1972). The effect of adding a small number of channel catfish (less than 250/ha) at the time of largemouth bass and bluegill stocking was considered negligible.

Largemouth bass and bluegill were simultaneously collected from 23 of the 30 field survey ponds. An additional pond had largemouth bass and fathead minnows but no bluegills. No fish were collected in three of the ponds.

Fishes other than those intentionally stocked by the Gavins Point National Fish Hatchery were found in 11 of the 30 field survey ponds. Three possible sources of fish additions were: accidental stocking, intentional stocking, and species invasion. Accidental stocking was the most probable source of the green sunfish collected from one pond. They may have been stocked as fry along with the bluegills. Rainbow trout (Salmo gairdneri) has been recently stocked in one pond by the pond owner. However, because the addition of the trout was recent, they were not entered into the population values. White suckers (Catostomus commersoni) were collected from one pond, a roadway borrow pit in nearly level terrain. Because of the location of the pond, species invasion by the white sucker was unlikely. This addition was probably intentional or accidental by area fishermen as this pond was utilized as a fishery. Black bullheads were collected from six ponds and fathead minnows from three ponds. The black bullheads and fathead minnows were also probably stocked accidentally or intentionally by area fishermen, although, species invasion could also have been the source.

Fry or young-of-the-year largemouth bass were collected from 17 of the 30 ponds. Fry or young-of-the-year bluegill were collected from 15 of the 30 ponds.

A_t values ranged from 0 to 100 (Appendix 6). Of the 30 surveyed fish populations 13 were within the desirable range of A_t values (33 to 90) and seven were within the most desirable range (60 to 85). F/C values ranged from 0 to 100. Of the 30 fish populations included, eight were within the desirable range of F/C values (1.4 to 10). Of these eight, two were within the most desirable range (3 to 6).

Four stepwise multiple regression selections, each using one of the dependent variables and the 23 independent variables were tested. Statistical analysis failed to identify any of the independent variables to be significantly ($P < .05$) correlated with the dependent variables.

The selection testing for correlation between A_t and the independent variables, identified alkalinity as having a significant

($P < .10$) negative correlation. That is, as alkalinity levels increased, A_t estimates decreased. There was no significant ($P < .10$) covariance between alkalinity and any of the other variables. Contribution of this variable to the reduction of the sum of squares was 21.5%. This one variable by itself is of little use in a predictive equation.

The selection testing for correlation between the independent variables and scaled balance identified four variables as significantly ($P < .10$) correlated. Estimated pond size and secchi disk visibility were positively correlated with balance. That is, as estimated pond size increased or the depth to which the secchi disk was visible increased, balance improved. Largemouth bass stocked per measured hectare and channel catfish present were negatively correlated with scaled balance. As number of bass stocked per measured hectare increased or if channel catfish were collected, balance degenerated. Collectively the four variables accounted for 37.6% reduction of the sum of squares. Estimated pond size and secchi disk visibility contributed 13.2% and 8.9%. Largemouth bass stocked per measured hectare and channel catfish collected accounted for 10% and 5.5%.

Estimated pond size has been demonstrated to be a poor indication of pond size in this study. At most 13 of the 30 survey ponds were estimated correctly (plus or minus 20% of the measured pond size). The validity of the interpretation of this variable as having an effect upon balance must be questioned. In addition, the variable channel catfish collected should be considered questionable. Having been collected at only one of the 30 field survey ponds, any correlation with balance could be coincidental. Secchi disk visibility was positively correlated with scaled balance. This could possibly be explained by the fact that largemouth bass are to a large extent sight feeders (Eddy and Underhill 1943), and if the water was highly turbid, their role as predator upon the bluegills could be adversely affected.

When the dependent variable balance (in or out) was tested against the independent variables, three variables were identified as significantly ($P < .10$) correlated. As in the statistical selection testing the independent variables against scaled balance, estimated pond size and secchi disk visibility were identified as to being positively correlated with balance. For the same reasoning as under scaled balance, estimated pond size might be considered to be of questionable value and secchi disk visibility could be considered an explainable correlation. Aquatic vegetation, although only measured as to whether it did or did not hamper seining attempts, might be explained with the same logic that secchi disk visibility was explained. That is, if there was sufficient aquatic vegetation present to interfere with seining attempts, it could also have interfered with the role of the largemouth bass as predator upon the bluegills. Estimated pond size and secchi disk visibility accounted for 22.1% and 11.8% of the reduction of the sum of squares. Aquatic vegetation present accounted for 24% of the reduction of the sum of squares.

Two additional selections were run comparing 21 independent variables with fry or young-of-the-year largemouth bass and fry or young-of-the-year bluegills. Neither of these selections identified any significant variables.

CONCLUSIONS

The mail survey portion of this study indicated that the majority of the South Dakota ponds stocked with largemouth bass and bluegill were not capable of sustaining these fishes through dry periods. On the basis of 187 responding pond owners, 121 (65%) ponds were no longer supporting fish life as a result of dryness and/or winterkill. An additional 11 ponds were no longer supporting fish life for various other reasons. Based upon answers given by landowners, it would appear that only 19 of the 151 non-evaluated ponds may have had largemouth bass and/or bluegill at the time of this study. Of the 36 ponds selected from the mail survey for field evaluation, 26 contained largemouth bass and/or bluegill. Therefore, at most 45 of the 187 ponds (24%) still contained largemouth bass and/or bluegills at the time of this study. Restocking after dry periods would appear to be required to maintain fishable populations in the ponds surveyed. Construction of deeper ponds and/or prevention of siltation might alleviate some of the problem.

The field survey indicated that there are ponds in southeastern South Dakota with fish populations of recreational value. Statistical analysis of data collected during the field survey identified several pond parameters which may influence the outcome of fish stocking attempts in terms of a desirable fish population. However, the samll number of significant variables identified and the small contribution to the reduction of the sum of squares, limits the use of these variables in a predictive equation. The inability of this study to identify a larger number of significant pond parameters could have been influenced by several factors. Ponds in the study were non-homogeneous (ponds included stock dams, dugouts, and roadway borrow pits). Pond parameters measured in this study did not differentiate among some of the diverse types of ponds (aspects of the pond dealing with watershed size and slope along with livestock use and abuse could not be identified from the data collected). The survey was conducted during a time in which South Dakota was experiencing a prolonged drought; many of the ponds were either dry or had low water levels. Also, although data from 30 ponds was used in this analysis, only 13 of the ponds contained fish populations of recreational value. It is possible that an insufficient sample size of successful ponds was used in the attempt to identify important pond parameters.

Pond construction represents a substantial financial investment for landowners. The Soil Conservation Service will financially assist landowners in pond construction, which is estimated from $2,600 to $4,000 (Watson, pers. comm.) at 75% of the total cost, up to a maximum of $2,500 paid in any one year. Siltation is a threat to the life expectancy of any impoundment in South Dakota. Raw and trampled banks and waterways as a result of livestock abuse greatly accelerates siltation. Fencing and upland treatment (seeding of the waterway and banks with grass) are suggested by the Soil Conservation Service to control siltation and increase the life expectancy of the impoundment. Financial assistance at 50% of the cost of materials is available from the Soil Conservation Service for implementation of recommended management practices on new and existing impoundments.

The majority of the field survey ponds functioned as livestock watering ponds and fish stockings appeared to have been incidental. Few of the ponds were fenced to limit livestock access. Considering the cost and land consumption involved in pond construction, it would seem advisable to protect the investment with recommended management practices. In addition to extending the life expectancy, recommended management practices would help keep the pond inhabitable for fish. With 100,000 artificial impoundments in South Dakota, 38,000 of which hold fishable populations, there is a large recreational fishing potential. On the basis of this study, it would appear that a large proportion of this resource is underutilized.

LITERATURE CITED

Allen, J. S., and A. C. Lopinot. 1970. Small lakes and ponds: their construction and care. Illinois Dept. of Cons., Div. of Fish., Fishery Bull, No. 3. 23pp.

Beall, H. B. 1959. Sampling of fish populations in small impoundments selected for study and experimental use. West Virginia D. J. Project F-3-R-6, Job C. 24pp.

Buck, D. H. 1956. Effects of turbidity on fish and farming. Oklahoma Fish. Res. Lab. Rep. 56, 1-62.

Carlander, K. D. 1955. The standing crop of fish in lakes. J. Fish. Res. Board Can. 12(4):543-570.

Dillard, J. G., and M. Hamilton. 1969. Evaluation of two stocking methods for Missouri farm ponds. Missouri Dept. of Cons., Div. of Fish. 17pp.

Eddy, S., and J. C. Underhill. 1943. Northern fishes. Univ. of Minnesota Press, Minneapolis. 414pp.

Graham, L. K. 1973. Optimum size and number of bluegills for stocking ponds. Missouri Dept. of Cons., D. J. Project F-1-R-22. 8pp.

Krumholz, L. A. 1952. Management of Indiana ponds for fishing. J. Wildl. Manage. 16(3):254-257.

Lagler, K. F. 1952. Freshwater fishery biology. Wm. C. Brown Company, Dubuque, Iowa. 421pp.

Lopinot, A. C. 1972. Pond fish and fishing in Illinois. Illinois Dept. of Cons., Div. of Fish., Fishery Bull. No. 5. 72pp.

Meehan, O. L. 1933. The role of fertilizer in pond fish. Trans. Am. Fish. Soc. 64:151-154.

Murphy, G. I. 1962. Effect of mixing depth and turbidity on the productivity of freshwater impoundments. Trans. Am. Fish. Soc. 91(1):69-76.

Peterka, J. J. 1972. Effects of saline waters upon survival of fish eggs and larvae and upon the ecology of the fathead minnow in North Dakota. OWRR Project A-027-NDak. North Dakota State University, Dept. of Zoology. 11pp.

Reiger, H. A. 1962. On the evolution of the bass-bluegill stocking policies and management recommendations. Prog. Fish-Cult. 24(3)99-111.

________. 1963. Ecology and management of largemouth bass and bluegills in farm ponds in New York. N. Y. Fish and Game J. 10(1):1-89.

Ryder, R. A. 1965. A method for estimating the potential fish production of north-temperate lakes. Trans. Am. Fish. Soc. 94(3):214-218.

Smith, B. W., C. E. White Jr., and G. R. Hooper. 1975. Management techniques for largemouth bass in Alabama ponds. Pages 380-385 in R. H. Stroud and H. Clepper, eds. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Smith, E. V., and H. S. Swingle. 1942. Use of fertilizer for controlling several submerged aquatic plants in ponds. Trans. Am. Fish. Soc. 71:94-101.

Smith, W. A., Jr., J. B. Kirkwood, and J. F. Hall. 1955. A survey of the success of various stocking rates and ratios of bass and bluegill in Kentucky farm ponds. Kentucky Div. of Fisheries, Fisheries Bull. No. 16. 43pp.

Spuhler, W., and W. F. Lytle. 1971. Climate of South Dakota. Agricultural Experiment Station. S. D. State University, Brookings, Bull. 582. 30pp.

Swingle, H. S. 1950. Relationships and dynamics of balanced and unbalanced fish populations. Agric. Exp. Station., Alabama Polytechnic Institute, Bull. No. 274. 74pp.

________. 1951. Experiments with various rates of stocking bluegills and largemouth bass in ponds. Trans. Am. Fish. Soc. 80:218-230.

________. 1957. Relationship of pH of pond waters to their suitability for fish culture. Symposium: The improvement and management of natural inland waters and impounds waters. Agric. Exp. Station, Alabama Polytechnic Institute, reprinted from Proceedings of Pacific Science Congress. 9(1957):1-4.

________, and E. V. Smith. 1940. Experiments on stocking fish ponds. Trans. N. Am. Wildl. Conf. 5:268-276.

Westin, F. C., L. F. Puhr, and G. J. Buntley. 1967. Soils of South Dakota. Soil Survey Series No. 3. S. D. State University, Brookings. 32pp.

APPENDIX

Appendix 1. Location by county of ponds studied in an evaluation of fish stocking attempts in South Dakota, 1976.

County	Number of mail survey ponds	Number of field survey ponds
Aurora	3	1
Beadle	2	0
Brule	2	0
Buffalo	5	0
Charles Mix	2	0
Clay	8	1
Davison	1	0
Douglas	3	0
Grant	2	2
Gregory	37	4
Haakon	1	0
Hand	7	0
Hanson	2	0
Hughes	5	1
Hutchinson	25	3
Hyde	5	1
Jerauld	23	2
Jones	7	1
Kingsbury	5	0
Lake	10	2
Lincoln	3	2
McCook	8	4
Mellett	13	1
Miner	1	0
Minnehaha	3	0
Moody	2	0
Pennington	3	0
Todd	2	0
Tripp	7	1
Turner	10	1
Union	2	1
Yankton	11	2
Total	220	30

Appendix 2. Ownership and mailing address of field survey ponds in an evaluation of fish stocking attempts in South Dakota, 1976.

Pond Number	Owner	Address
1	Robert Billings	410 E. 21st, Yankton, SD 57078
2	George Demary	Ramona, SD 57054
3	Donald Dwyer	Wessington Springs, SD 57382
4	Mike Gilbertz	White Lake, SD 57383
5	Demsel Kinsley	Murdo, SD 57559
6	Rex Kraemer	Parker, SD 57053
7	Don Kraft	Wessington Springs, SD 57382
8	Arnold Maag	RFD 2, Tripp, SD 57376
9	Aubrey Nelson	Hamill, SD 57534
10	Dale Peterson	Bonesteel, SD 57317
11	William Schutte	Highmore, SD 57345
12	John Smith	Montrose, SD 57048
13	Leonard Thompson	Winfred, SD 57076
14	Merritt Ulmer	RR 1, Menno, SD 57536
15	Arnold Webb	Harrold, SD 57536
16	Ray Williams	Bonesteel, SD 57317
17	George Clay	Route 2, Beresford, SD 57004
18	Dick Fossum	Route 1, Canton, SD 57013
19	Mrs. John Frick	1807 Douglas, Yankton, SD 57078
20	Ingamen Jensen	RR 1, Stockholm, SD 57264
21	John Karlin	Mission, SD 57555
22	Bernard Krier	Spencer, SD 57374
23	Bernard Krier	Spencer, SD 57374
24	Lenard Mayer	Burke, SD 57523
25	Wilmer Mehlhaf	Route 1, Menno, SD 57045
26	Hakon Nielsen	Marvin, SD 57251
27	Roggow brothers	Burke, SD 57523
28	E. E. Rozelli, Jr.	Elk Point, SD 57025
29	Ernest Stewart	RR 3, Beresford, SD 57004
30	Wilbur Katzer	Montrose, SD 57048

Appendix 3. Physical parameters measured in a study of fish stocking attempts in South Dakota farm ponds, 1976.

Pond Number	Estimated Pond Size (hectares)	Measured Pond Size (hectares	Pond Area Deeper than 1 Meter (hectares)	Percent Pond Area Deeper than 1 Meter	Maximum Depth (meters)
1	0.61	0.65	0.44	68	3.0
2	1.21	0.61	0.25	41	3.9
3	1.21	0.34	0.24	71	3.4
4	1.82	1.45	1.31	90	2.0
5	1.21	1.18	0.77	65	4.0
6	1.01	0.57	0.39	68	4.8
7	0.81	0.39	0.23	59	2.8
8	0.30	0.15	0.06	40	3.9
9	0.81	0.38	0.15	39	4.5
10	0.39	0.47	0.28	60	4.6
11	2.02	5.14	3.09	60	5.6
12	0.61	0.23	0.13	57	4.0
13	0.81	0.62	0.28	45	2.8
14	0.93	1.46	0.91	62	2.9
15	0.61	0.22	0.08	36	1.8
16	0.40	0.34	0.21	62	2.3
17	0.46	0.11	0.03	27	1.3
18	0.73	0.64	0.40	63	3.5
19	1.21	1.43	1.09	76	6.6
20	0.61	0.57	0.37	65	3.3
21	1.21	0.20	0.11	55	2.0
22	1.50	0.94	0.69	73	5.3
23	1.26	0.76	0.59	78	5.2
24	0.40	0.45	0.28	62	3.2
25	0.53	0.48	0.16	33	1.8
26	0.61	0.77	0.47	61	4.5
27	0.40	0.12	0.05	42	2.4
28	0.42	0.29	0.17	59	3.1
29	4.05	2.67	1.83	69	5.1
30	0.81	0.54	0.38	70	6.6

Appendix 4. Chemical and physical data collected in a study of fish stocking attempts in South Dakota farm ponds, 1976.

Pond Number	Salinity Percent	Conductivity umho	pH	Hardness mg/l[1]	Alkalinity mg/l[1]	Secchi Disk m
1	0.10	185	8.0	500	140	1.1
2	0.20	235	9.0	95	60	0.6
3	0.80	1310	9.8	260	60	2.0
4	0.20	850	10.9	140	40	1.1
5	1.80	2250	8.4	480	65	1.1
6	0.40	660	8.5	190	160	1.2
7	0.02	455	9.3	80	125	0.8
8	0.00	205	9.7	110	110	1.2
9	0.02	670	10.6	40	220	0.8
10	0.50	800	8.7	160	70	1.1
11	0.90	1220	9.3	360	105	1.0
12	0.10	290	8.6	125	110	1.9
13	0.30	650	8.2	180	55	0.7
14	0.20	700	8.7	140	110	0.6
15	1.90	2600	9.6	1500	40	1.8
16	5.00	7000	8.7	800	140	2.3
17	0.50	220	8.8	80	135	0.2
18	1.80	2480	8.9	525	80	1.4
19	0.90	1400	8.7	280	115	0.8
20	0.10	370	8.4	110	150	0.9
21	0.01	295	8.4	70	165	0.2
22	1.00	1320	8.2	450	70	1.1
23	2.20	3050	8.9	800	80	2.9
24	0.01	235	9.2	40	80	2.4
25	0.90	1450	8.4	230	344	0.6
26	0.02	390	8.6	380	160	3.9
27	0.00	250	8.6	80	125	0.4
28	0.50	70	9.5	180	60	2.0
29	0.40	600	8.0	170	90	1.1
30	0.00	170	9.1	100	70	0.3

[1]measured in terms of calcium.

Appendix 5. Stocking data of the field study ponds in the evaluation of South Dakota fish stocking attempts, 1976.

Pond Number	Age of Pond[1]	Stocking Rate LMB Est Hec[2]	Stocking Rate LMB Meas Hec[3]	Stocking Rate BLG Est Hec[4]	Stocking Rate BLG Meas Hec[5]	Stocking Ratio LMB/BLG[6]	Channel Catfish Stocked
1	7	247	230	494	462	50	no
2	5	247	494	247	492	100	no
3	8	247	882	494	1764	50	no
4	6	247	310	494	621	50	no
5	8	247	254	741	763	33	no
6	6	247	641	494	1282	50	no
7	9	371	769	1112	2307	33	no
8	9	165	333	329	667	50	no
9	4	247	526	741	1578	33	no
10	9	515	426	2574	2128	20	no
11	7	247	97	741	292	33	no
12	4	247	652	741	1957	33	no
13	6	247	323	494	645	50	no
14	6	269	171	537	342	50	no
15	6	1235	3409	1647	4545	75	no
16	9	494	588	2471	2941	20	no
17	3	260	1090	3901	16363	7	yes
18	3	247	281	2334	2656	11	yes
19	3	247	210	741	629	33	yes
20	3	247	263	4118	4386	6	yes
21	5	247	1500	247	1500	100	yes
22	6	267	426	534	851	50	yes
23	7	239	395	478	789	50	no
24	8	741	667	1483	1333	50	yes
25	9	570	625	1711	1875	33	yes
26	3	247	195	4118	3247	6	yes
27	5	247	833	741	2500	33	no
28	8	247	345	741	1035	33	yes
29	4	247	375	741	1124	33	yes
30	3	247	370	3707	5523	7	no

1 Years since stocking.
2 Stocking rate largemouth bass/estimated hectare
3 Stocking rate largemouth bass/measured hectare
4 Stocking rate bluegill/estimated hectare
5 Stocking rate bluegill/measured hectare
6 Stocking ratio largemouth bass/100 bluegill

Appendix 6. Seining data collected from the field survey ponds in an evaluation of South Dakota fish stocking attempts, 1976.

Pond Number	A_t[1] Value	F/C[2] Ratio	Fry or Y/Y[3] Largemouth Bass Found	Fry or Y/Y[3] Bluegill Found	Channel Catfish Found	Other Fish Found	Vegetation interfere with seine
1	0	100.0	yes	yes	no	no	no
2	98	1.3	yes	no	no	no	no
3	70	25.0	no	no	no	yes	yes
4	85	91.0	yes	yes	no	yes	yes
5	97	39.0	no	no	no	yes	no
6	0	100.0	no	no	no	yes	no
7	86	1.3	yes	yes	no	yes	no
8	0	100.0	no	no	no	yes	no
9	6	2.1	yes	yes	no	no	no
10	56	16.0	yes	yes	no	no	no
11	70	13.0	no	no	no	no	yes
12	62	1.6	no	yes	no	no	no
13	0	0.0	no	no	no	no	no
14	57	8.6	yes	yes	no	yes	no
15	96	1.9	yes	yes	no	no	yes
16	20	100.0	yes	yes	no	no	yes
17	88	1.6	yes	no	no	no	no
18	42	100.0	yes	yes	yes	no	yes
19	76	100.0	yes	yes	no	no	no
20	100	0.0	yes	no	no	yes	no
21	0	27.0	yes	yes	no	no	no
22	96	5.0	no	no	no	yes	no
23	76	10.0	no	no	no	no	no
24	15	4.5	yes	yes	no	yes	yes
25	0	0.0	no	no	no	no	no
26	19	23.0	yes	yes	no	no	yes
27	0	0.0	no	no	no	no	no
28	85	0.9	no	no	no	no	yes
29	41	7.6	yes	yes	no	no	no
30	0	100.0	no	no	no	yes	no

[1]Percent harvestable fish
[2]Forage fish to carnivore fish ratio
[3]Young-of-the-year

Appendix 7. Balance assessment for the field study ponds in an evaluation of South Dakota fish stocking attempts, 1976.

Pond Number	Balance In or Out	Balance Scaled
1	out of balance	completely out of balance
2	out of balance	balanced
3	out of balance	borderline unbalanced
4	out of balance	inadequate information to classify
5	out of balance	borderline unbalanced
6	out of balance	completely out of balance
7	out of balance	balanced
8	out of balance	completely out of balance
9	out of balance	completely out of balance
10	out of balance	borderline unbalanced
11	out of balance	borderline unbalanced
12	balanced	good balance
13	out of balance	completely out of balance
14	out of balance	completely out of balance
15	out of balance	balanced
16	out of balance	completely out of balance
17	out of balance	balanced
18	out of balance	completely out of balance
19	out of balance	completely out of balance
20	out of balance	completely out of balance
21	out of balance	completely out of balance
22	out of balance	balanced
23	balanced	good balance
24	out of balance	out of balance
25	out of balance	completely out of balance
26	out of balance	out of balance
27	out of balance	completely out of balance
28	out of balance	inadequate information to classify
29	balanced	good balance
30	out of balance	completely out of balance