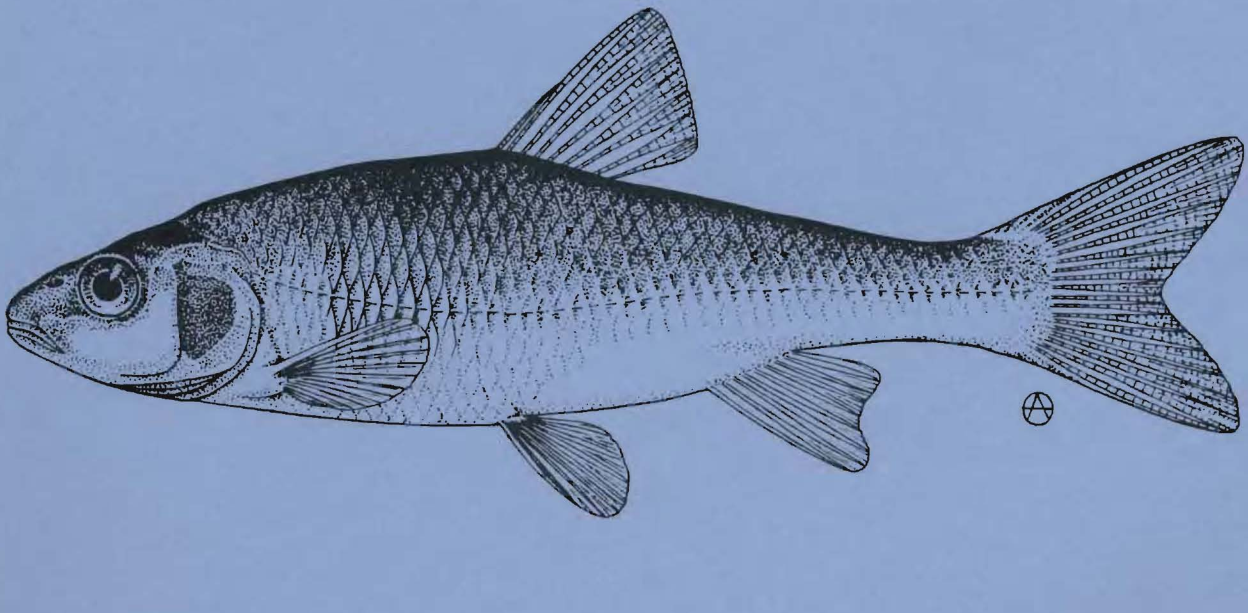
FWS/OBS-82/10.40
SEPTEMBER 1983

HABITAT SUITABILITY INFORMATION: COMMON SHINER



Fish and Wildlife Service

. Department of the Interior

This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

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September 1983

HABITAT SUITABILITY INFORMATION: COMMON SHINER

by

Joan G. Trial
Charles S. Wade
Jon G. Stanley
Maine Cooperative Fishery Research Unit
University of Maine
Orono, ME 04473

Patrick C. Nelson
Instream Flow and Aquatic Systems Group
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526

Project Officer

James W. Terrell
Habitat Evaluation Procedures Group
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526

Performed for
Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
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PREFACE

The habitat use information and Habitat Suitability Index (HSI) models presented in this document are an aid for impact assessment and habitat management activites. Literature concerning a species' habitat requirements and preferences is reviewed and then synthesized into subjective HSI models, which are scaled to produce an index between 0 (unsuitable habitat) and 1 (optimal habitat). Assumptions used to transform habitat use information into these mathematical models are noted, and guidelines for model application are described. Any models found in the literature which may also be used to calculate an HSI are cited, and simplified HSI models, based on what the authors believe to be the most important habitat characteristics for this species, are presented. Also included is a brief discussion of Suitability Index (SI) curves as used in the Instream Flow Incremental Methodology (IFIM), and a discussion of SI curves available for the IFIM analysis of common shiner habitat.

Use of habitat information presented in this publication for impact assessment requires the setting of clear study objectives. Methods for reducing HSI model complexity and recommended measurement techniques for model variables are presented in Terrell et al. (1982).[1] A discussion of HSI model building techniques is presented in U.S. Fish and Wildlife Service (1981).[2]

The HSI models presented herein are complex hypotheses of species-habitat relationships, <u>not</u> statements of proven cause and effect relationships. The models have not been tested against field data. For this reason, the U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help us increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send comments to:

Habitat Evaluation Procedures Group
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526

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[1]Terrell, J. W., T. E. McMahon, P. D. Inskip, R. F. Raleigh, and K. L. Williamson (1982). Habitat Suitability Index Models: Appendix A. Guidelines for riverine and lacustrine applications of fish HSI models with the Habitat Evaluation Procedures. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.A. 54 pp.

[2]U.S. Fish and Wildlife Service. 1981. Standards for the development of Habitat Suitability Index models. 103 ESM. U.S. Dept. Int., Fish Wildl. Serv., Div. Ecol. Serv. n.p.

CONTENTS

	Page
PREFACE	iii
ACKNOWLEDGMENTS	vi
HABITAT USE INFORMATION	1
General	1
Age, Growth, and Food	1
Reproduction	1
Specific Habitat Requirements	2
HABITAT SUITABILITY INDEX (HSI) MODELS	2
Model Applicability	2
Model Description - Riverine	3
Model Description - Lacustrine	5
Suitability Index (SI) Graphs for Model Variables	6
Riverine Model	9
Lacustrine Model	10
Interpreting Model Outputs	15
ADDITIONAL HABITAT MODELS	15
Model 1	15
INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM)	15
Suitability Index Graphs as Used in IFIM	16
Availability of Graphs for Use in IFIM	17
REFERENCES	21

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COMMON SHINER (*Notropis cornutus*)

HABITAT USE INFORMATION

General

The range of the common shiner (*Notropis cornutus*) extends from the Atlantic coast west through southern Great Lakes drainages to the eastern Dakotas. It is widely distributed in streams and lakes along the Atlantic coast, from Nova Scotia south to the James River system in Virginia. Populations are found as far north as southeastern Saskatchewan and southern Manitoba (Lee et al. 1980). In this report we consider *Notropis cornutus* specifically distinct from *Notropis chrysocephalus* (Lee et al. 1980).

Age, Growth, and Food

The common shiner is a short-lived, small minnow. Males grow faster than females and reach a larger size (Fee 1965). The adult size ranges from 64 to 102 mm (Lee et al. 1980); Scott and Crossman (1973) report some exceptionally large males in the 175 to 201 mm range. Males collected from the Des Moines River in Iowa had an average length of 46 mm at Age I. The females of the same age averaged 42 mm long. Age II males averaged 67 mm, while age II females averaged 61 mm (Fee 1965). Age-length relationships were similar in Squaw Creek, an intermittent stream in Iowa. Age I males and females were 44 mm and 42 mm, respectively. Age II males were 75 mm, while the females were 65 mm long. Age III males were 95 mm, and females were 80 mm long.

Common shiners are omnivorous, feeding on nearly equal amounts of plant and animal matter (Fee 1965). Water level variation is a major factor explaining feeding variability. Increased turbidity reduced the availability of insect larvae, resulting in an increase in the intake of plant matter (Fee 1965) Common shiners feed readily on the bottom, in the water column, and at the surface (Moyle 1973). Shiners of all sizes consume the same types of food (Fee 1965).

Reproduction

The common shiner is predominantly a stream-spawning fish (Raney 1940), but, in some inland lakes of Michigan, it may also spawn over gravel shoals (Hubbs and Cooper 1936). Substrate between 5 and 60 mm is utilized for spawning (Miller 1964). Common shiners excavate depression nests in gravel or sand or use nests built by other fish (Raney 1940; Miller 1964). Creek chub nests are typically used. The eggs are adhesive and lodge among the gravel. Most nests are built in riffles 13 to 44 mm deep (Miller 1964). At any one location, spawning lasts 10 to 20 days and is limited to the daylight hours (Raney 1940; Miller 1964). This species spawns from May to July, when water temperatures are 15.5 to 18.3° C (Scott and Crossman 1973). Spawning migrations in Maine coincided with high water and occurred at temperatures of 12 to 16° C (Rabeni et al., unpubl. data). Miller (1964) observed upstream migrations in late March and April on a New York tributary to the Susquehanna River.

Fecundity is closely related to body weight (Fee 1965). The regression of body weight (W) on fecundity (N) is described by the equation: $N = 190(W)-12$. A 10 cm female (about 12 g) contained 2,000 eggs (Richardson 1935).

Specific Habitat Requirements

Adult. The common shiner typically occurs in small and medium-sized streams with clear, cool water, a moderate current; and an unvegetated gravel to rubble bottom (Lee et al. 1980). These minnows frequent pools in streams more often than the rapids (Adams and Hankinson 1928). They congregate in pools immediately below cascades, but not in deadwater or long pools, which are common at stream mouths. Large individuals were observed in lakes in Minnesota 0.5 to 1 m above aquatic plants, which were 1 to 4 m below the surface (Moyle 1973). In New York, shiners were collected over hard, sandy bottoms along open, exposed shores of lakes (Adams and Hankinson 1928). When the pH drops below 5.8, reproduction ceases and populations decline or disappear (Harvey 1980). No data were available on the effects of higher pH levels; however, a pH range of 6.5-8.5 is considered essential for good growth of most temperate freshwater fish (Stroud 1967).

Fry-Juvenile. After emerging, the fry leave the nest area in the riffles and congregate just under the surface in pools, which serve as nursery and juvenile habitat. Small fish, about 15 mm long, school in pools that are typical of moderate gradient streams. They occasionally venture into faster water (Raney 1940).

Embryo. We assume that spawning sites provide optimal habitat for embryos. Spawning sites are depressions in sand or gravel over which the current forms an eddy (Raney 1940). This creates conditions in the nest that enhance water circulation, preventing siltation and increasing oxygen availability.

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. The model is applicable throughout the northeastern range of the common shiner in North America as described by Lee et al. (1980).

Season. The model provides an assessment of the ability of a habitat to support a self-sustaining population of common shiners throughout the year.

Cover types. The model is applicable to freshwater riverine and lacustrine habitats as described by Cowardin et al. (1979).

Minimum habitat area. Minimum habitat, the minimum area of contiguous suitable habitat required to sustain a population, has not been established for common shiners.

Verification level. The common shiner model produces an index between 0 and 1 that we believe has a positive relationship to habitat carrying capacity. The model has not been compared to production or standing crops of common shiner populations, but field testing is planned. HSI's calculated from sample data sets appeared to be reasonable. These sample data sets are discussed in greater detail following the presentation of the model.

Model Description - Riverine

The riverine model consists of three components: food and cover (C_{F-C}); water quality (C_{WQ}); and reproduction (C_R) (Fig. 1). The variables used to determine habitat suitability are based on the habitat requirements for all life stages, except for the reproductive component.

The model utilizes a modified limiting factor approach. We assume that model variables or components with suitability indices between 0.4 and 1.0 are not limiting, and interactions with other variables affect their importance in determining habitat suitability. However, variables or components with suitability index values less than 0.4 are considered limiting factors. Selection of 0.4 as a limiting level was arbitrary and simply quantifies the assumption that at some suboptimum level of suitability a variable becomes limiting.

Food-cover component. The percent pools (V_5) is included because riffles are required for reproduction and food production, and pools serve as holding and overwintering areas. Average current velocity (V_6) and pool class (V_7) are included to better define the quality of pools. Predominant substrate type (V_4) reflects food availability because the abundance of aquatic insects is correlated with substrate type.

Water quality component. The water quality component includes the variables maximum summer temperature (V_1), pH (V_2), and turbidity (V_3), all of which may affect growth and survival.

Reproduction component. The temperature (V_8) at the time of spawning and embryo incubation controls egg development rate. The dominant substrate type (V_4) and water velocity (V_9) influence the amount of oxygen reaching the developing eggs.

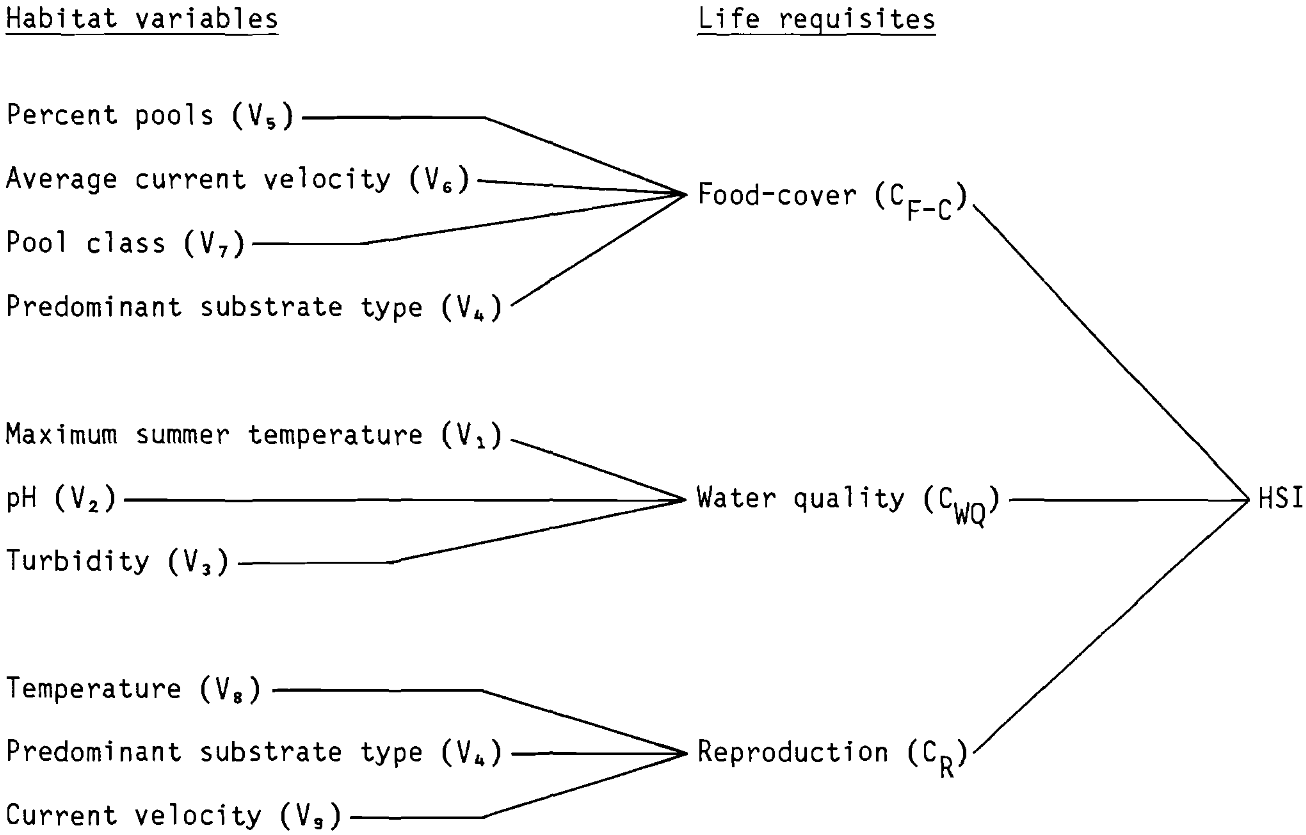


Figure 1. Tree diagram illustrating relationship of habitat variables and life requisites in the riverine model for common shiner.

Model Description - Lacustrine

The Lacustrine model consists of three components: food-cover (C_{F-C}); water quality (C_{WQ}); and reproduction (C_R) (Fig. 2). Common shiners successfully spawn on windswept shores and shoals. However, they usually inhabit lakes and ponds only in the northern portion of their range.

Food and cover component. Food and cover are provided by aquatic vegetation which is determined from the percent lake area vegetated (V_{10}).

Water quality component. The same water quality characteristics that are limiting in streams are important in lakes: temperature (V_1); pH (V_2); and turbidity (V_3).

Reproduction component. Temperature (V_8) at spawning and egg incubation affects egg survival. Dominant substrate type (V_4) and wind action determine the amount of oxygen available to the developing embryo.

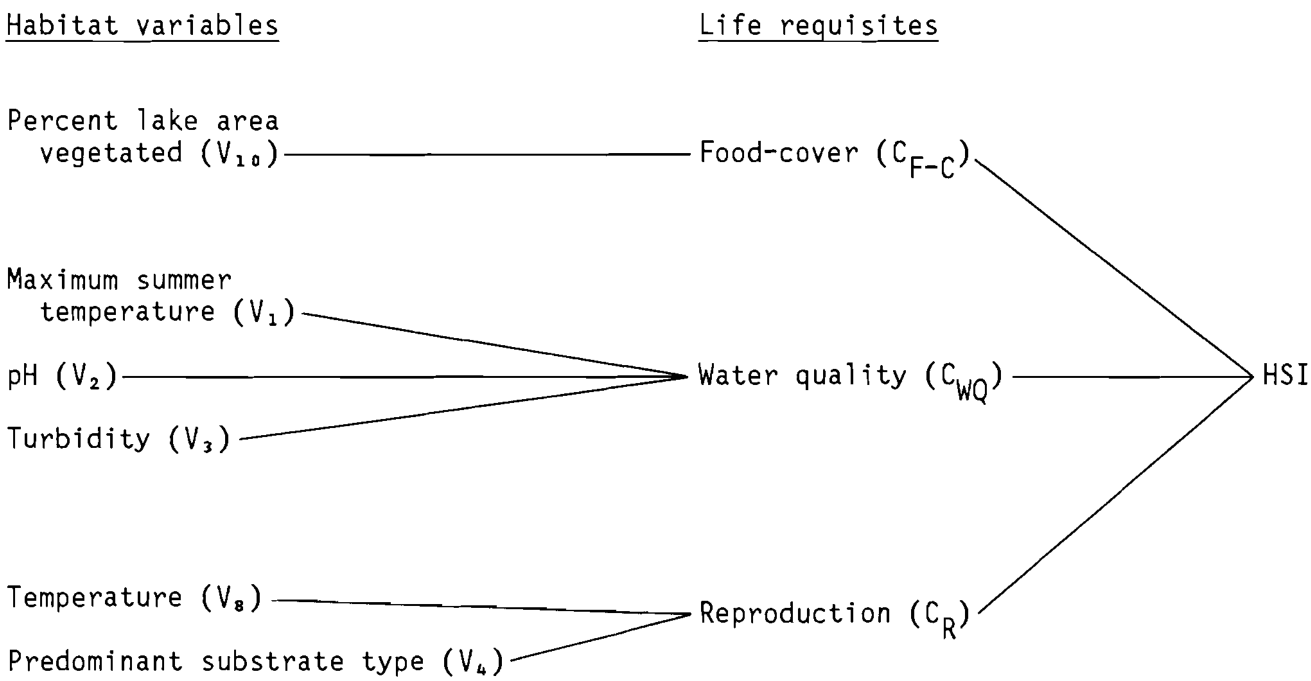
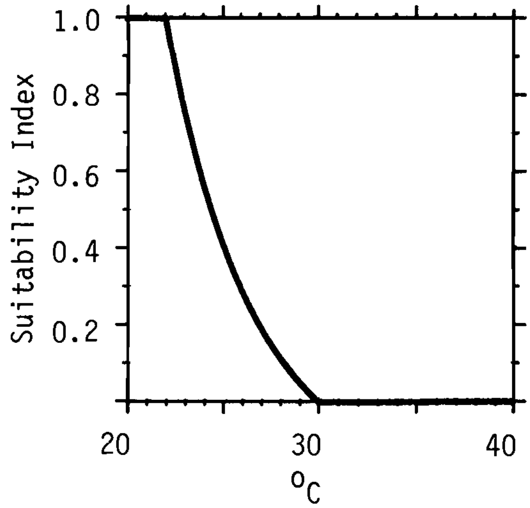
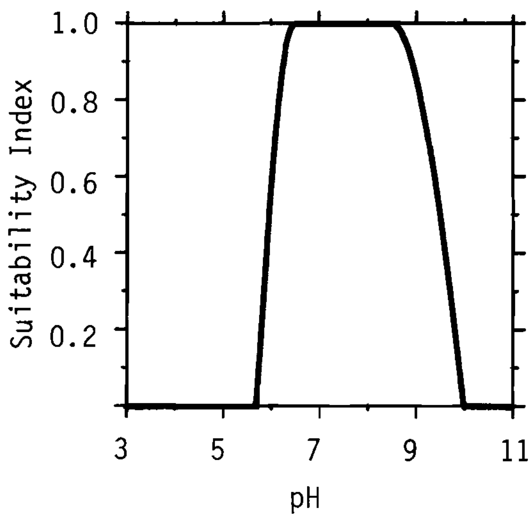
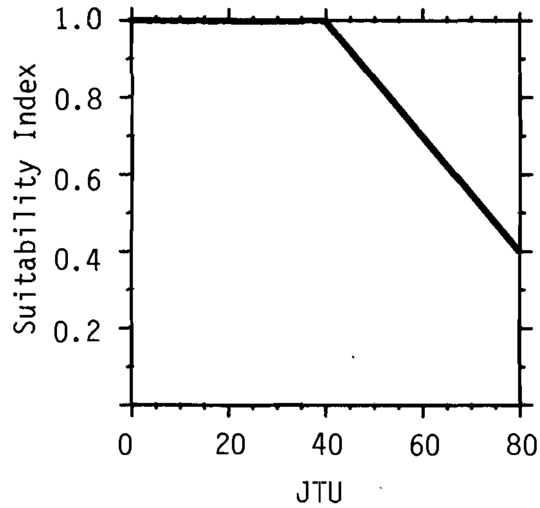
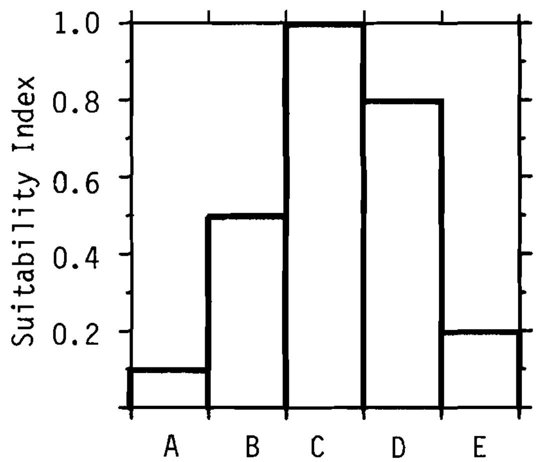
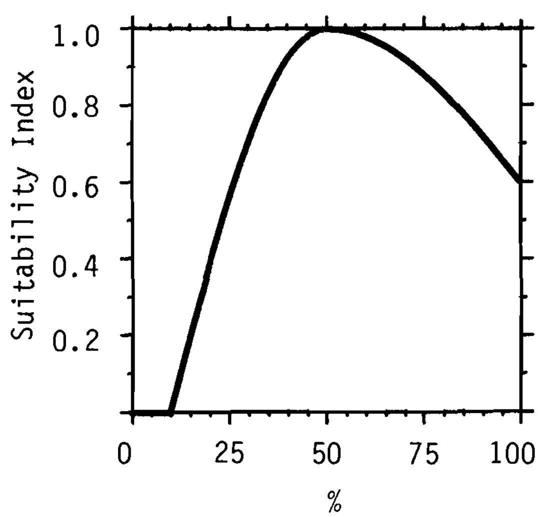


Figure 2. Tree diagram illustrating relationships of habitat variables and life requisites in the lacustrine model for common shiner.

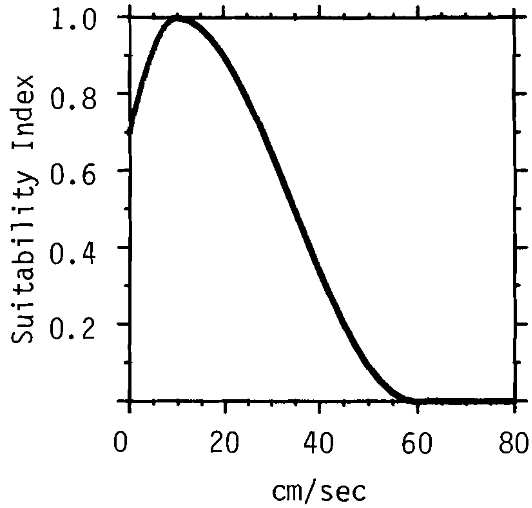
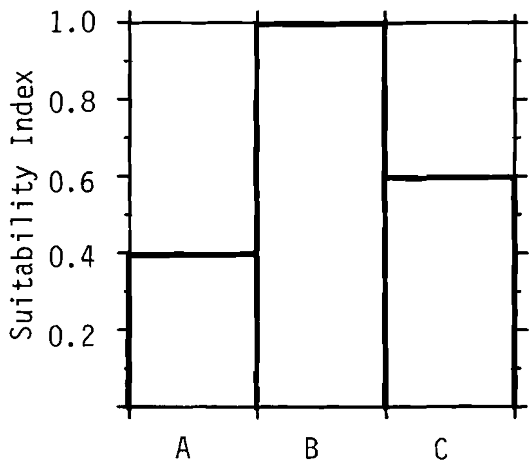
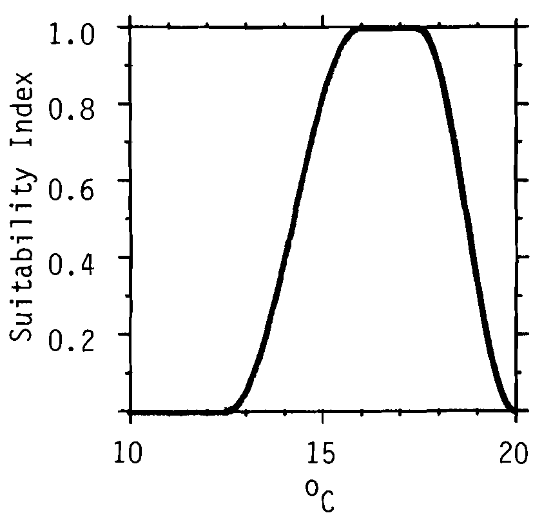
Suitability Index (SI) Graphs for Model Variables

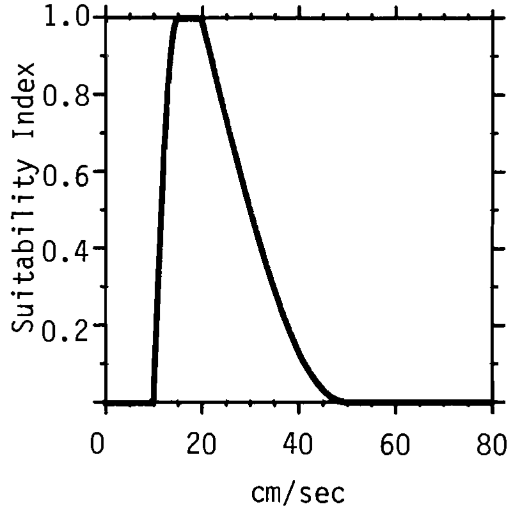
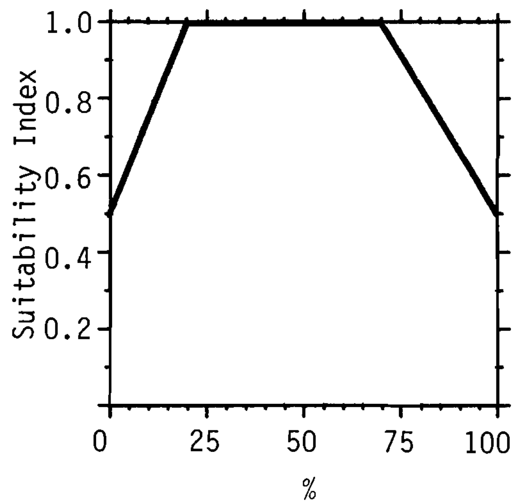
Suitability index graphs for the 10 variables discussed in the model description pertain to riverine (R) or lacustrine (L) habitats, or both.

Habitat	Variable		Suitability graphs
R,L	V_1	Maximum summer temperature persisting for longer than 1 week.	
R,L	V_2	Least suitable pH level occurring during the year.	

Habitat	Variable		Suitability graph
R,L	V_3	Average turbidity.	
R,L	V_4	Predominant substrate type in riffles or windy shore or shoal. A. Mud, silt, and detritus B. Fine sand C. Sand and gravel D. Rubble E. Large rocks and bedrock	
R	V_5	Percent pools.	

Note: The area must be on a windy shore or shoal for the lacustrine model.

Habitat	Variable		Suitability graph
R	V_6	Average current velocity at 60% of depth in pools.	
R	V_7	Predominant pool class. A. Large and deep, "deadwater" pool found at mouths of streams. B. Moderate size and depth, commonly found below falls or riffle-run areas; 5-30% of bottom obscured by depth or turbulence. C. Small or shallow or both, no surface turbulence and little structure.	
R,L	V_8	Average water temperature (°C) in spawning habitat during months of spawning.	

Habitat	Variable		Suitability graph
R	V_9	Average current velocity just above substrate in riffle areas.	
L	V_{10}	Percent lake area vegetated.	

Riverine Model

The riverine model utilizes the life requisite approach and consists of three components: food-cover; water quality; and reproduction.

Food-Cover (C_{F-C}).

$$C_{F-C} = \frac{V_4 + V_5 + V_6 + V_7}{4}$$

Or, if any variable ≤ 0.4, $C_{F-C} = V_4$, V_5, V_6, or V_7, whichever is lowest.

Water Quality (C_{WQ}).

$$C_{WQ} \quad (V_1 \times V_2 \times V_3)^{1/3}$$

Or, if any variable ≤ 0.4, $C_{WQ} = V_1$, V_2, or V_3, whichever is lowest.

Reproduction (C_R).

$$C_R = (V_8^2 \times V_4 \times V_9)^{1/4}$$

Or, if any variable ≤ 0.4, $C_R = V_4$, V_8, V_9, or C_R, whichever is lowest.

HSI determination.

If the value for any component ≤ 0.4, the HSI = the minimum component value. Otherwise,

$$HSI = (C_{F-C} \times C_{WQ} \times C_R)^{1/3}$$

Lacustrine Model

This model utilizes the life requisite approach and consists of three components: food-cover; water quality; and reproduction.

Food-Cover (C_{F-C}).

$$C_{(F-C)} = V_{10}$$

Water Quality (C_{WQ}).

$$C_{WQ} = (V_1 \times V_2 \times V_3)^{1/3}$$

Or, if any variable ≤ 0.4, $C_{WQ} = V_1$, V_2, or V_3, whichever is lowest.

Reproduction (C_R).

On windy shores of lakes only: $C_R = (V_8 \times V_4)^{1/2}$

Or, if any variable ≤ 0.4, $C_R = V_4$ or V_8, whichever is lowest.

Except, $C_R = 0$ if windy shores of lake or pond have no suitable substrate for spawning.

HSI determination.

$$HSI = (C_{F-C} \times C_{WQ} \times C_R)^{1/3}$$

Or, if the value for any component ≤ 0.4, the HSI = the minimum component value.

Sources of data and assumptions used to develop the suitability indices are presented in Table 1.

Sample data sets for the riverine and lacustrine models are listed in Tables 2 and 3, respectively. The data sets are not actual field measurements, but represent combinations of conditions that could occur in a riverine or lacustrine habitat. We believe the HSI's calculated from the data reflect what the carrying capacity trends would be in riverine and lacustrine habitats with the listed characteristics.

Table 1. Data sources for common shiner suitability indices.

	Variable and source	Assumption
V_1	Kowalski et al. 1978	Temperatures below critical thermal maxima or incipient lethal temperatures are suitable. One week of sustained high temperatures makes habitat unsuitable.
V_2	Stroud 1967 Harvey 1980	pH levels below which populations cease to reproduce are unsuitable. pH levels considered adequate for freshwater fish are optimal.
V_3	Scott and Crossman 1973	Clear water is optimal. An average turbidity less than 30 JTU is clear.
V_4	Hubbs and Cooper 1936 Tarzwell 1936 Raney 1940 Lee et al. 1980	The sandy-gravel bottom is optimal and provides substrate for spawning. Gravel is best for food production.
V_5	Adams and Hankinson 1928 Lee et al. 1980	A 1:1 pool to riffle ratio is optimal. Riffles are needed for spawning, but adults seek cover and overwinter in pools.
V_6	Hankinson 1928 Fee 1965 Menzel 1978	Both pool and riffle areas are utilized. However, slower velocities are preferred, except during spawning.
V_7	Adams and Hankinson 1928 Moyle 1973	Class of pools where fish are most often observed is optimal.
V_8	Scott and Crossman 1973 Kowalski et al. 1978 Rabeni et al. (unpubl.)	The entire temperature range where spawning has been observed is optimal.
V_9	Adams and Hankinson 1928 Fee 1965 Menzel 1978	Optimal velocities will maintain substrate suitable for spawning.
V_{10}	Adams and Hankinson 1928 Moyle 1973 Scott and Crossman 1973	Common shiners eat both vegetation and insects. They spawn in gravel areas. A 50% vegetated area is optimal. Completely vegetated littoral areas would prohibit spawning.

Table 2. Sample data sets using riverine HSI model.

Variable		Data set 1		Data set 2		Data set 3	
		Data	SI	Data	SI	Data	SI
Temperature - summer (°C)	V_1	20	1.0	23	0.8	26	0.3
pH	V_2	6.5	1.0	6.5	1.0	6.4	0.9
Turbidity (JTU)	V_3	28	1.0	45	0.9	50	0.8
Predominant substrate type	V_4	C	1.0	B	0.5	A	0.1
% pools	V_5	50	1.0	40	0.9	90	0.7
Velocity-pools (cm/s)	V_6	15	1.0	10	1.0	0	0.7
Pool class	V_7	B	1.0	C	0.6	A	0.4
Temperature - spawning (°C)	V_8	16	1.0	16	1.0	19	0.3
Velocity-riffles (cm/sec)	V_9	20	1.0	20	1.0	0.5	0.0
Component SI							
C_{F-C} =			1.0		0.75		0.1
C_{WQ} =			1.0		0.90		0.3
C_R =			1.0		0.84		0.0
HSI =			1.0		0.83		0.0

Table 3. Sample data sets using lacustrine HSI model.

Variable		Data set 1		Data set 2		Data set 3	
		Data	SI	Data	SI	Data	SI
Temperature - summer (°C)	V_1	20	1.0	26	0.3	30	0.0
pH	V_2	6.0	0.6	6.4	0.9	6.8	1.0
Turbidity (JTU)	V_3	27	1.0	30	1.0	65	0.6
Predominant substrate type	V_4	D	0.8	B	0.5	B	0.5
Temperature - spawning (°C)	V_8	16	1.0	16	1.0	17	1.0
% lake area vegetated	V_{10}	35	1.0	65	1.0	90	0.6
Component SI							
C_{F-C} =			1.00		1.00		0.6
C_{WQ} =			0.84		0.30		0.0
C_R =			0.89		0.71		0.7
HSI =			0.92		0.30		0.0

Interpreting Model Outputs

Model output has not been compared with population levels of common shiners. We believe that habitats with an HSI of 0 might contain some common shiners, while habitats with an HSI of 1 may contain few or none. Comparison of HSI and SI values with production or standing crop data should help identify those habitat variables with the greatest influence on carrying capacity in a specific area. Exact agreement between HSI values and population numbers is unlikely, even when habitat requirements are accurately described, because populations are not only controlled by the habitat variables listed in the model, but also habitat disturbances such as floods or drought. The model should be viewed as conceptual at this stage of development. Any attempt to use the model as a predictive tool should be preceeded by model evaluation utilizing actual field data.

ADDITIONAL HABITAT MODELS

Model 1

Optimal riverine common shiner habitat is characterized by the following conditions: clear (< 30 JTU), moderate-sized pools (class B), interspersed with riffle areas for spawning (1:1 pool-riffle ratio); maximum summer temperature below 25° C; and minimum pH between 6.5 and 8.5.

$$HSI = \frac{\text{number of above criteria}}{4}$$

INSTREAM FLOW INCREMENTAL METHODOLOGY (IFIM)

The U.S. Fish and Wildlife Service's Instream Flow Incremental Methodology (IFIM), as outlined by Bovee 1982, is a set of ideas used to assess instream flow problems. The Physical Habitat Simulation System (PHABSIM), described by Milhous et al. 1981, is one component of IFIM that can be used by investigators interested in determining the amount of available instream habitat for a fish species as a function of streamflow. The output generated by PHABSIM can be used for several IFIM habitat display and interpretation techniques, including:

1. Optimization. Determination of monthly flows that minimize habitat reductions for species and life stages of interest;

2. Habitat Time Series. Determination of impact of a project on habitat by imposing project operation curves over historical flow records and integrating the difference between the curves; and

3. Effective Habitat Time Series. Calculation of the habitat requirements of each life stage of a fish species at a given time by using habitat ratios (relative spatial requirements of various life stages).

Suitability Index Graphs as Used in IFIM

PHABSIM utilizes Suitability Index graphs (SI curves) that describe the instream suitability of the habitat variables most closely related to stream hydraulics and channel structure (velocity, depth, substrate, temperature, and cover) for each major life stage of a given fish species (spawning, egg incubation, fry, juvenile, and adult). The specific curves required for a PHABSIM analysis represent the hydraulic-related parameters for which a species or life stage demonstrates a strong preference (i.e., a pelagic species that only shows preferences for velocity and temperature will have very broad curves for depth, substrate, and cover). Instream Flow Information Papers 11 (Milhous et al. 1981) and 12 (Bovee 1982) should be reviewed carefully before using any curves for a PHABSIM analysis. SI curves used with the IFIM that are generated from empirical microhabitat data are quite similar in appearance to the more generalized literature-based SI curves developed in many HSI models (Armour et al. 1983). These two types of SI curves are interchangeable, in some cases, after conversion to the same units of measurement (English, metric, or codes). SI curve validity is dependent on the quality and quantity of information used to generate the curve. The curves used need to accurately reflect the conditions and assumptions inherent to the model(s) used to aggregate the curve-generated SI values into a measure of habitat suitability. If the necessary curves are unavailable or if available curves are inadequate (i.e., built on different assumptions), a new set of curves should be generated (data collection and analyses techniques for curve generation will be included in a forthcoming Instream Flow Information Paper).

There are several ways to develop SI curves. The method selected depends on the habitat model that will be used and the available database for the species. The validity of the curve is not obvious and, therefore, the method by which the curve is generated and the quality of the data base are very important. Care also must be taken to choose the habitat model most appropriate for the specific study or evaluation; the choice of models will determine the type of SI curves that will be used. For example, in an HSI model, an SI curve for velocity usually reflects suitability of average channel (stream) velocity (i.e, a macrohabitat descriptor); in an IFIM analysis, SI curves for velocity are assumed to represent suitability of the velocity at the point in the stream occupied by a fish (i.e., a microhabitat descriptor) (Armour et al. 1983).

A system with standard terminology has been developed for classifying SI curve sets and describing the database used to construct the curves in IFIM applications. The classification is not intended to define the quality of the data or the accuracy of the curves. There are four categories in the classification. A literature-based curve (category one) has a generalized description or summary of habitat preferences from the literature as its database. This type of curve usually is based on information in published references on the upper and lower limits of a variable for a species (e.g., juveniles are usually found at water depths of 0.3-1.0 m). Occasionally, the reference also contains information on the optimal or preferred condition within the limits of tolerance (e.g., juveniles are found at water depths of 0.3-1.0 m, but are most common at depths from 0.4-0.6 m). Unpublished data and expert opinion also can be used to develop these curves. Virtually all of the SI curves published in the HSI series for depth, velocity, and substrate, are category one curves.

Utilization curves (category two) are based on a frequency analysis of fish observations in the stream environment with the habitat variables measured at each sighting [see Instream Flow Information Paper 3 (Bovee and Cochnauer 1977) and Instream Flow Information Paper 12 (Bovee 1982:173-196)]. These curves are designated as utilization curves because they depict the habitat conditions a fish will use within a specific range of available conditions. Because of the way the data are collected for second generation curves, the resulting function represents the probability of occurrence of a particular environmental condition, given the presence of a fish of a particular species, $P(E|F)$. Utilization curves are generally more precise for IFIM applications than literature-based curves because they are based on specific measurements of habitat characteristics where the fish actually occur. However, utilization curves may not be transferable to streams that differ substantially in size and complexity from the streams where the data were obtained.

A preference curve (category three) is a utilization curve that has been corrected for environmental bias. For example, if 50% of the fish are found in pools over 1.0 m deep, but only 10% of the stream has such pools, the fish are actively selecting that type of habitat. Preference curves approximate the function of the probability of occurrence of a fish, given a set of environmental conditions:

$$P(F|E) \approx \frac{P(E|F)}{P(E)}$$

Only a limited number of experimental data sets have been compiled into IFIM preference curves. The development of these curves should be the goal of all new curve development efforts.

The fourth category of curves is still largely conceptual. One type under consideration is a cover-conditioned, or season-conditioned, preference curve set. Such a curve set would consist of different depth-velocity preference curves as a function or condition of the type of cover present or the time of year. No fourth category curves have been developed at this time.

The advantage of category three and four curves is the significant improvement in precision and confidence in the curves when applied to streams similar to the streams where the original data were obtained. The degree of increased accuracy and transferability obtainable when applying these curves to dissimilar streams is unknown. In theory, the curves should be widely transferable to any stream in which the range of environmental conditions is within the range of conditions found in the streams from which the curves were developed.

Availability of Graphs for Use in IFIM

Most of the SI curves available for IFIM analysis of common shiner habitat are literature-based (category one) (Table 4). Preference curves are available

Table 4. Availability of curves for IFIM analysis of common shiner habitat.

	Velocity[a]	Depth	Substrate[b]	Temperature[a]	Cover
Spawning	Use SI curve for V_9.	Use SI[c] = 1.0 for 13-44 mm (see text, page 2).	Use SI[c] = 1.0 for gravel (see text, page 2).	Use SI curve for V_8.	No curve available.
Egg incubation	Use SI curve for V_9.	Use SI[c] = 1.0 for 13-44 mm (see text, page 2).	Use SI[c] = 1.0 for gravel (see text, page 2).	Use SI curve for V_8.	No curve available.
Fry	Use SI curve for V_6.	No curve available.	No curve available.	Use SI curve for V_1.	No curve available.
Juvenile	Use SI curve, Fig. 3.	Use SI curve, Fig. 3.	Use SI curve, Fig. 3.	Use SI curve for V_1.	No curve available.
Adult	Use SI curve for V_6.	Use SI[c] = 1.0 for depths $\geq$ 0.1 feet.	Use SI[c] = 1.0 for gravel and rubble (see text, page 2).	Use SI curve for V_1.	No curve available.

[a]When use of SI curves is prescribed, refer to the appropriate curve in the HSI model section.

[b]The following categories may be used for IFIM analyses. Gravel is the optimal bottom type for spawning, egg incubation, and it is equal in quality to rubble for adults. If other than an optimum type is present, a user must determine an appropriate SI value based on professional judgement and/or available information (see Bovee 1982):

1 = plant detritus/organic material
2 = mud/soft clay
3 = silt (particle size < 0.062 mm)
4 = sand (particle size 0.062-2.000 mm)
5 = gravel (particle size 2.0-64.0 mm)
6 = cobble/rubble (particle size 64.0-250.0 mm)
7 = boulder (particle size 250.0-4000.0 mm)
8 = bedrock (solid rock)

[c]Use SI = 1.0 if the habitat variable is optimal; but if the habitat variable is less than optimal, the user must determine, by judgement, what is the most appropriate SI value.

for the juvenile life stage for the velocity, depth, and substrate variables. These curves are based on frequency analyses of field data collected from 13 streams and rivers in Kansas from September to May 1981 (n = 105, temperatures 8-27° C, depths to 2.0 m, 9:00 am - 9:00 pm, all types of substrate, and velocities to 1.0 m/s), with the environmental bias removed (Fig. 3). No SI curves are available for cover; whether or not cover plays an important role in any life stage of the common shiner is unknown. Available data indicate that velocity and temperature are important variables during all life stages; depth and substrate may be important variables primarily during spawning and egg incubation. Professional judgement is needed to determine which curves are appropriate for use, which curves need to be altered before they can be used, and which curves for which life stages need to be regenerated. Data sources used to generate new curves should be reviewed and the curves evaluated by local fishery biologists before use in IFIM applications.

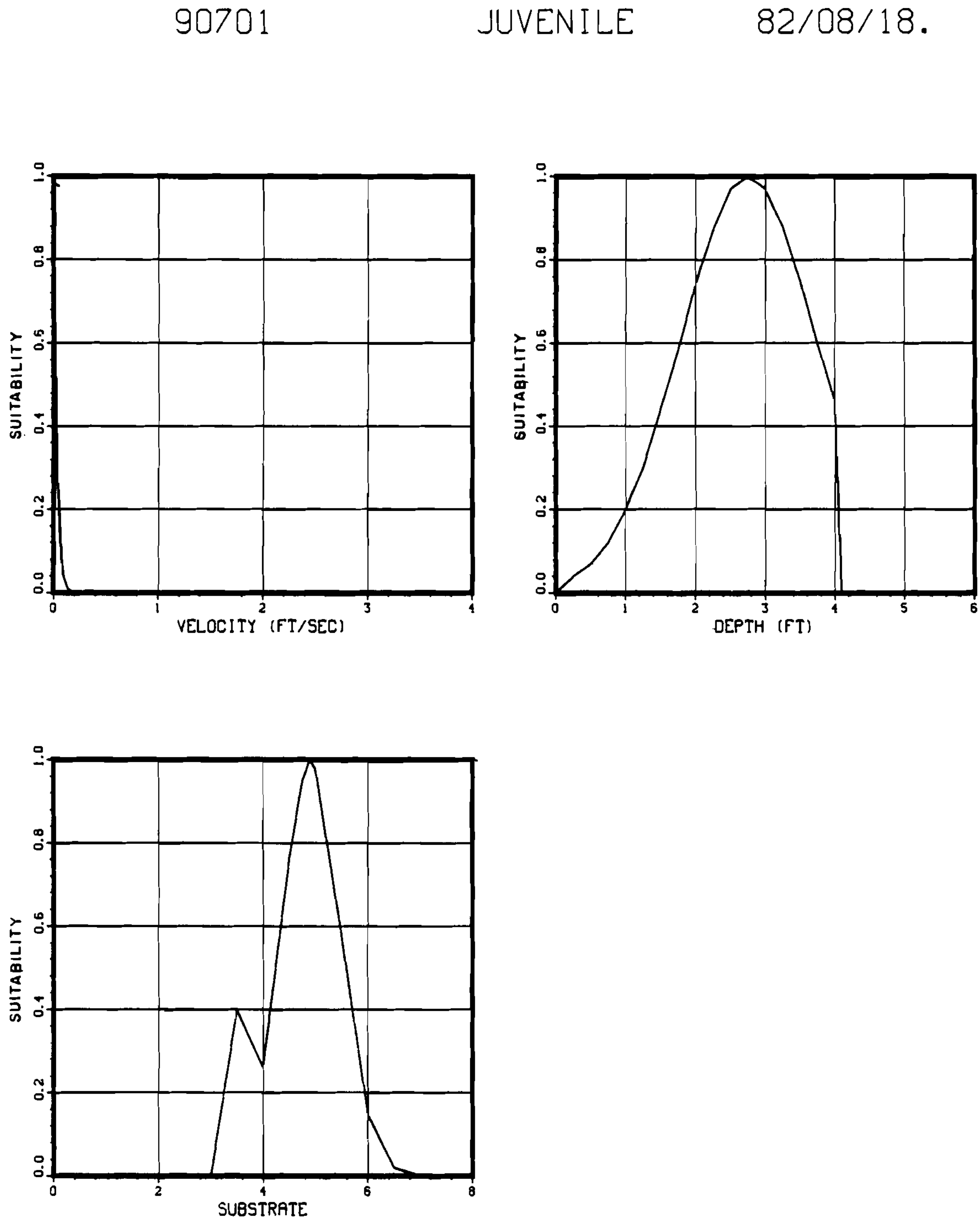


Figure 3. Category three SI curves for the juvenile common shiner (Kansas Department of Fish and Game unpubl. data).

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Joan G. Trial, Charles S. Wade, Jon G. Stanley, and Patrick C. Nelson

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A review and synthesis of existing information were used to develop riverine and lacustrine habitat models for the common shiner (Notropis cornutus). The models are scaled to produce indices of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for the northeastern range of the common shiner in North America. Habitat suitability indices are designed for use with the Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

Also included are discussions of Suitability Index (SI) curves as used in the Instream Flow Incremental Methodology (IFIM) and SI curves available for an IFIM analysis of smallmouth bass habitat.

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Instream Flow Incremental Methodology

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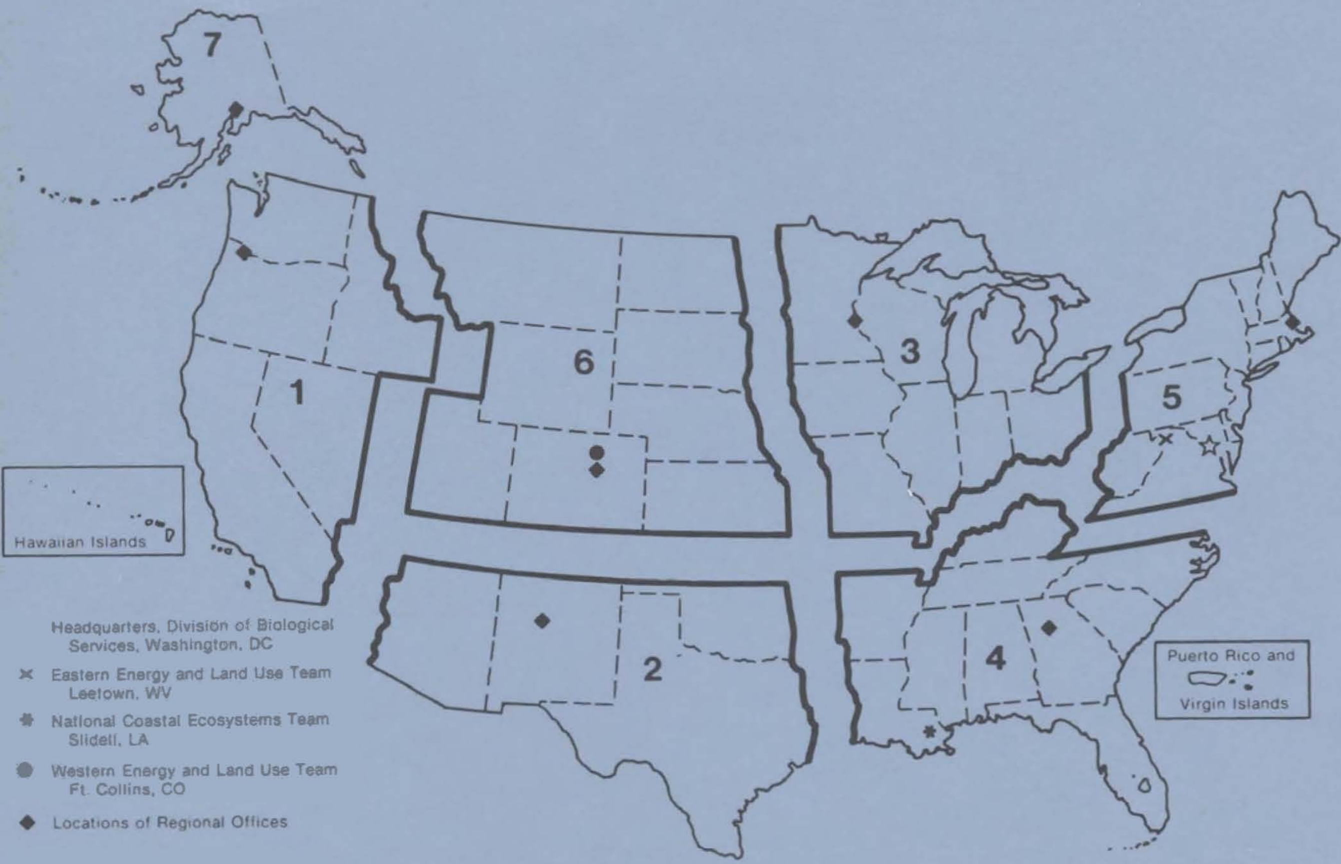

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