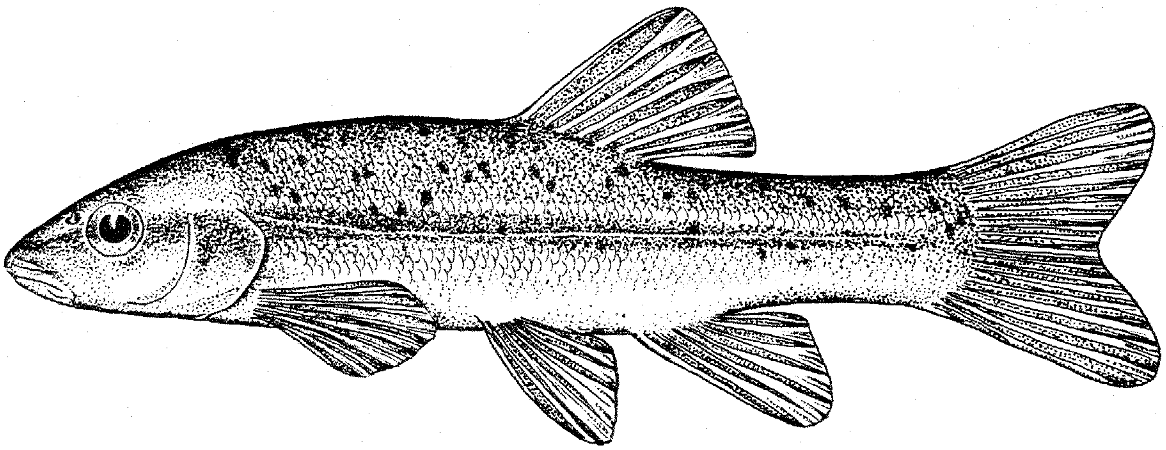
FWS/OBS-82/10.41
SEPTEMBER 1983

HABITAT SUITABILITY INFORMATION: BLACKNOSE DACE



Fish and Wildlife Service

. Department of the Interior

FWS/OBS-82/10.41
September 1983

HABITAT SUITABILITY INFORMATION: BLACKNOSE DACE

by

Joan G. Trial
and
Jon G. Stanley
Maine Cooperative Fishery Research Unit
University of Maine
Orono, ME 04469

Mary Batcheller
Glen Gebhart
and
O. Eugene Maughan
Oklahoma Cooperative Fishery Research Unit
Oklahoma State University
Stillwater, OK 74074

Patrick C. Nelson
Instream Flow and Aquatic Systems Group
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526

Project Officers

Robert F. Raleigh
James W. Terrell
Habitat Evaluation Procedures Group
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
Washington, DC 20240

This report should be cited as:

Trial, J. G., J. G. Stanley, M. Batcheller, G. Gebhart, O. E. Maughan, and P. C. Nelson. 1983. Habitat suitability information: Blacknose dace. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.41. 28 pp.

PREFACE

The habitat use information and Habitat Suitability Index (HSI) models presented in this document are an aid for impact assessment and habitat management activities. 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 blacknose dace habitat.

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

The HSI models presented herein are complex hypotheses of species-habitat relationships, not statements of proven cause and effect relationships. The models have not been tested against field data. For this reason, the FWS 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

---

[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

ACKNOWLEDGMENTS

We thank V. G. Bartnick and J. G. Gee for their suggestions and comments on earlier manuscripts. Word processing was provided by C. Gulzow and D. Ibarra. Editorial review was by C. Short. K. Twomey assisted with finalizing the manuscript. The cover illustration is from Freshwater Fishes of Canada 1973, Bulletin 184, Fisheries Research Board of Canada, by W. B. Scott and E. J. Crossman.

BLACKNOSE DACE (*Rhinichthys atratulus*)

HABITAT USE INFORMATION

General

The blacknose dace (*Rhinichthys atratulus*) is distributed from Manitoba to Nebraska, east to the Maritime Provinces, and south along both sides of the Appalachian Mountains to Georgia and Alabama (Lee et al. 1980). Three subspecies are recognized within this range: *R. a. obtusus*; *R. a. atratulus*; and *R. a. meleagris* (Lee et al. 1980). Artificial hybrids of blacknose dace and longnose dace (*R. cataractae*) can be produced in the laboratory but do not occur in nature because of behavioral isolating mechanisms (Bartnik 1970a; Howell and Villa 1976).

Age, Growth, and Food

Blacknose dace usually mature at age II (Schwartz 1958; Noble 1965; Bartnik 1970a; Bragg and Stasiak 1978), although, in Manitoba, spawning did not occur until age III (Gibbons 1971). The blacknose dace is short-lived (Scott and Crossman 1973). Noble (1965) reported that few fish reach age III. Fry, 5 mm long at hatching (Traver 1929), grow quickly and are 29 mm long by age I and 45 mm long by age II (Noble 1965). The species seldom reaches 102 mm (Trautman 1957).

Blacknose dace eat primarily aquatic invertebrates, such as chironomids and other nymphs and larvae (Breder and Crawford 1922; Traver 1929; Churchill and Over 1938; Noble 1965; Tarter 1970; Gibbons and Gee 1972). The diet may also include terrestrial insects (Tarter 1970) and plants (Breder and Crawford 1922; Flemer and Woolcott 1966). Foraging by fry occurs on invertebrates in quiet, shallow water with soft, silty substrates (Tarter 1970). As the fish grow, they forage on invertebrates associated with riffles and deep eddying pools (Tarter 1970).

Reproduction

Blacknose dace breed in May, June, and July (Raney 1940; Schwartz 1958; Noble 1965; Bartnik 1970a), at temperatures ranging from 15.6 (Schwartz 1958) to 22° C (Traver 1929). Spawning in the northern part of the range begins when the water temperature reaches 21° C (Raney 1940; Scott and Crossman 1973). Blacknose dace spawn in shallow water of streams (Traver 1929). Water depths of less than 25 cm (Schwartz 1958), velocities of 20 to 45 cm/sec

(Bartnik 1970b), and uniform gravel substrates (Raney 1940; Bartnik 1970a; Bragg and Stasiak 1978) are preferred. The most common spawning sites are riffles, although spawning may occur in pools (Traver 1929; Raney 1940; Schwartz 1958; Bartnik 1970a; Bragg and Stasiak 1978).

Conflicting descriptions of blacknose dace spawning behavior reflect the difference between subspecies (Raney 1940; Scott and Crossman 1973). Male _R. a. meleagris_ establish and defend territories (Churchill and Over 1938; Harlan and Speaker 1951; Bartnik 1970a). Territorial males spawn singly with a sequence of several females. In contrast, males of _R. a. atratulus_ (Traver 1929) and _R. a. obtusus_ (Schwartz 1958) are not territorial. Nonterritorial males mate in mass with one female (Raney 1940). Vigorous movements during spawning cause a depression in the substrate, producing a poorly constructed nest (Raney 1940; Schwartz 1958; Bartnik 1970a; Bragg and Stasiak 1978). Females lay from 428 to 1,116 eggs, averaging 746 (Traver 1929). Fecundity increases with body length of the female (Noble 1965).

Specific Habitat Requirements

Adult. Blacknose dace typically are found in the pools of small streams (Traver 1929; Fish 1932) but may be found in other habitats (Whitworth et al. 1968). The species is collected occasionally in large rivers (Trautman 1957) and rarely in lakes (Fish 1932; Scarola 1973) and river impoundments (Harlan and Speaker 1951). Blacknose dace occupy clear streams (Trautman 1957; Armstrong and Williams 1971; Scott and Crossman 1973; Bragg and Stasiak 1978). Undercut banks, roots, brush, overhanging vegetation, and shaded areas are utilized as cover (Trautman 1957). Adult blacknose dace typically occur in rocky and gravelly streams (Harlan and Speaker 1951; Scarola 1973; Bragg and Stasiak 1978) with highest densities over gravel-cobble substrates (Gibbons and Gee 1972).

The blacknose dace prefers swift streams (Traver 1929; Harlan and Speaker 1951; Scarola 1973). Greatest densities of blacknose dace adults occur when surface water velocities are between 15 and 45 cm/sec (Gibbons and Gee 1972). The species is common at gradients of 11.4 and 23.3 m/km, but almost entirely absent at 67.2 m/km (Burton and Odum 1945). Low gradients (< 5 m/km) are also avoided (Trautman 1957; Gibbons and Gee 1972). The upper incipient lethal temperature for blacknose dace is 29.3° C (Hart 1952).

Blacknose dace migrate from cool headwater streams into rivers to overwinter (Noble 1965). Traver (1929) observed specimens in deep water during winter.

Embryo. The spawning sites preferred by the adults are assumed optimal for embryo survival. Blacknose dace eggs incubate in slow (Raney 1940; Bartnik 1970a) to fast (Scott and Crossman 1973) currents, varying from 7 to 60 cm/sec, but the majority are found at velocities between 20 and 45 cm/sec (Bartnik 1970b). Spawning occurs in water depths from several centimeters (Traver 1929) to 30.5 cm (Scott and Crossman 1973), the preferred depth being 25 cm (Schwartz 1958). Blacknose dace spawn on substrates of sand (Raney 1940), gravel (Traver 1929; Fish 1932; Raney 1940; Bragg and Stasiak 1978), and cobble (Harlan and Speaker 1951). Bartnik (1970a) found nests occurring in substrates with particles 2.5 cm or smaller. Water temperature ranges from 15 to 22° C during embryo incubation (Traver 1929; Schwartz 1958).

Fry. High densities of fry of the blacknose dace are observed over silt and sand substrates where the water velocity is less than 15 cm/sec (Gibbons and Gee 1972). Fry largely occupy shoals and pool margins (Traver 1929; Minckley 1963).

Juvenile. Juvenile blacknose dace occur over substrates of sand, reach highest densities over gravel, and frequent areas with small rocks and boulders (Witt 1970; Gibbons and Gee 1972). High numbers are associated with surface velocities from 15 to 30 cm/sec (Gibbons and Gee 1972).

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. The model applies throughout the range of the blacknose dace in North America.

Season. The model assesses the ability of a habitat to support self-sustaining populations of blacknose dace throughout the year.

Cover types. The model applies to freshwater streams, rivers, and lakes.

Minimum habitat area. The minimum area of contiguous suitable habitat for sustaining a population of blacknose dace has not been established.

Verification level. The blacknose dace model produces an index between 0 and 1 that we believe has a positive relationship to habitat carrying capacity. Model output has not been compared to production or standing crop estimates, 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 (Fig. 1) consists of six components: food-cover (C_{F-C}); water quality (C_{WQ}); reproduction (C_R); adult (C_A); juvenile (C_J); and fry (C_F).

The model uses a modified limiting factor approach. Model variables with values between 0.4 and 1.0 are used to compute component values. If component values, in turn, are between 0.4 and 1.0, they are used to compute the HSI value. However, any value less than 0.4 for variables or components is assumed to be limiting and, thus, overrides computed model values.

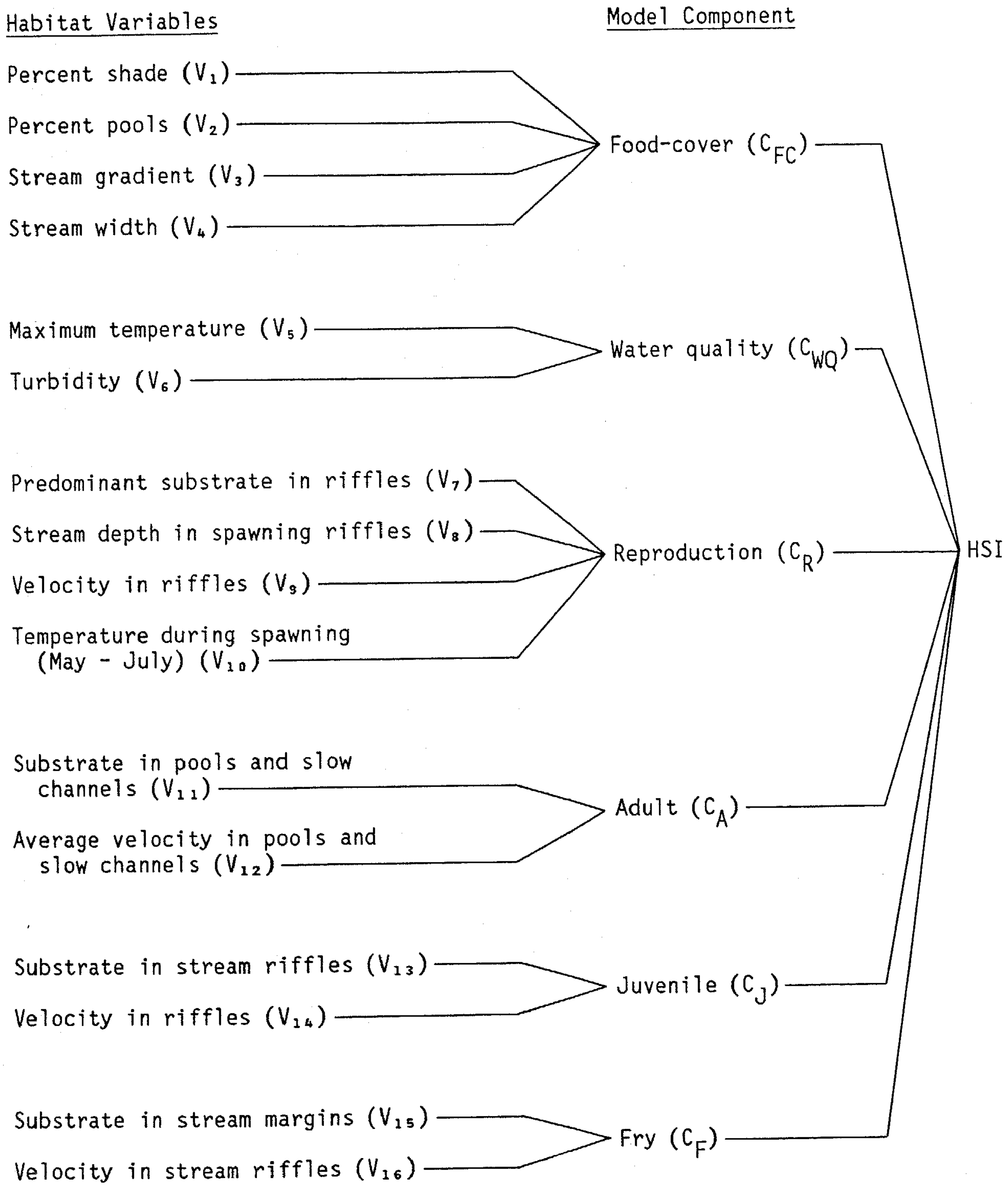


Figure 1. Diagram of the riverine HSI model illustrating the relationships among model variables and components.

Food-cover component. The area of shaded streambed expressed as a percentage of total streambed, is an estimate of instream cover (V_1). Percent pools (V_2), stream gradient (V_3), and stream width (V_4) are related to the amount and quality of cover available in a stream for all life stages of blacknose dace. Pool-riffle ratio also is an indirect measure of aquatic insect production.

Water quality component. Maximum temperature (V_5) is included because it affects growth, distribution, survival, and behavior. Turbidity (V_6) affects the distribution of blacknose dace.

Reproduction component. Spawning requirements are defined by the riffle substrate (V_7), stream depth in spawning riffles (V_8), and velocity in riffles (V_9). Water temperature (V_{10}) affects spawning and embryo development and survival.

Adult component. Adult habitat is defined by substrate (V_{11}) and velocity (V_{12}) in pools and slow channels, the two most important environmental variables. The model takes into account habitat partitioning between age groups.

Juvenile component. Substrate (V_{13}) and velocity (V_{14}) in riffles are adequate to describe juvenile habitat.

Fry component. Suitable habitat of fry can be defined by substrate (V_{15}) and velocity (V_{16}) in stream margins.

Model Description - Lacustrine

Blacknose dace are rare in lakes and river impoundments. The lacustrine model (Fig. 2), therefore, consists only of a water quality component (C_{WQ}).

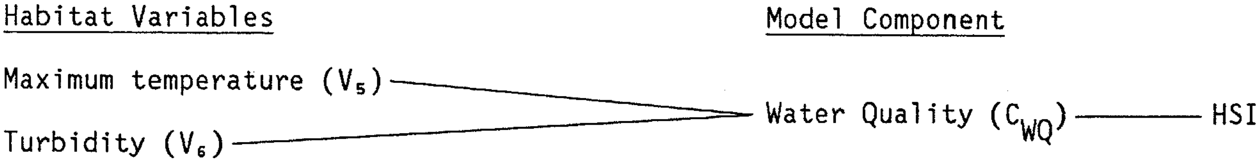
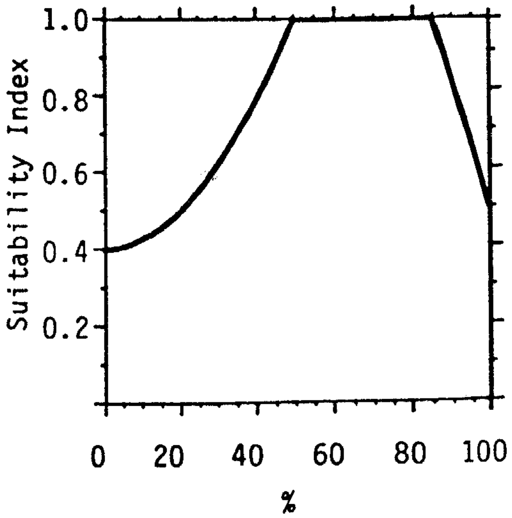
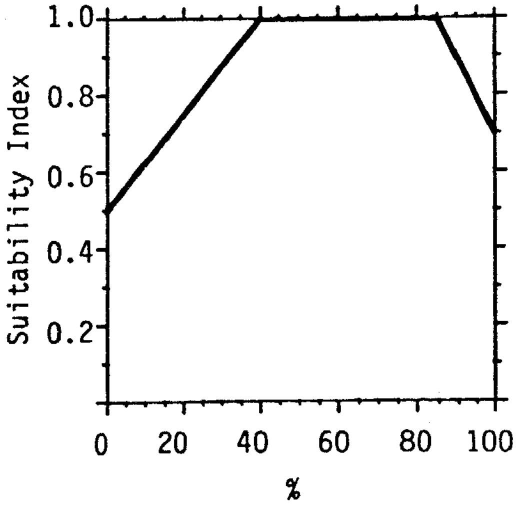


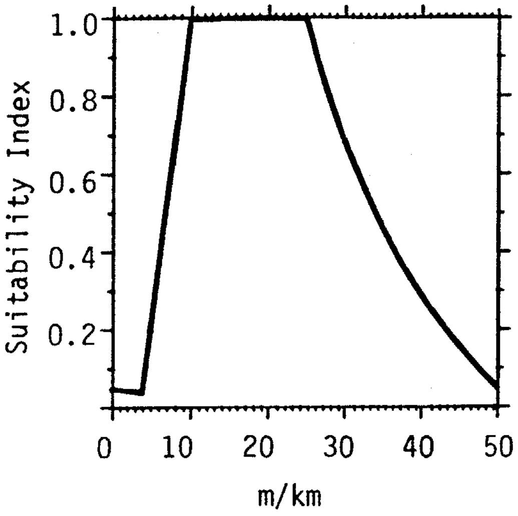
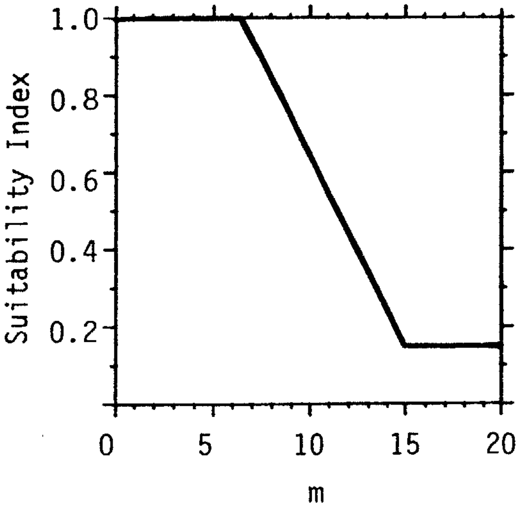
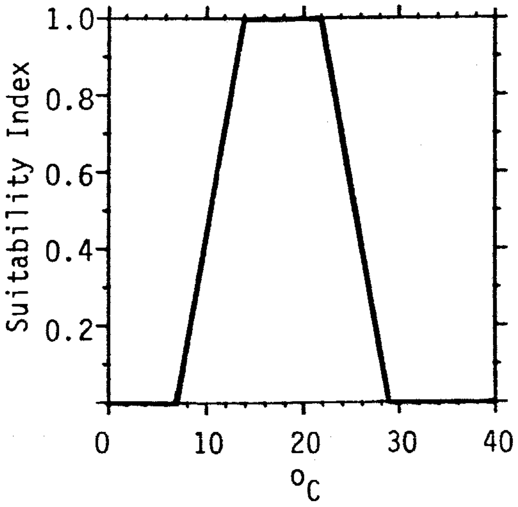
Figure 2. Diagram of the lacustrine model, illustrating the relationships between habitat variables, the water quality component, and the HSI.

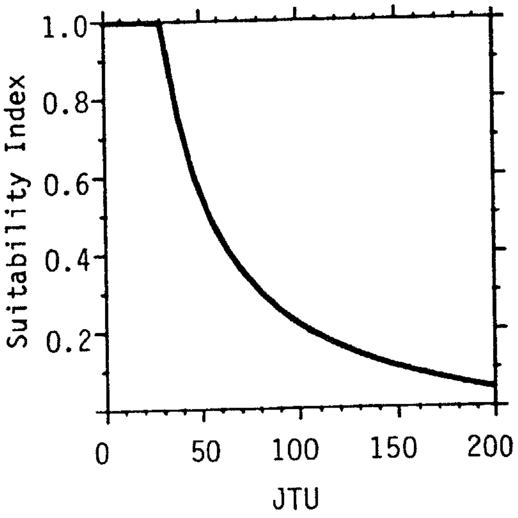
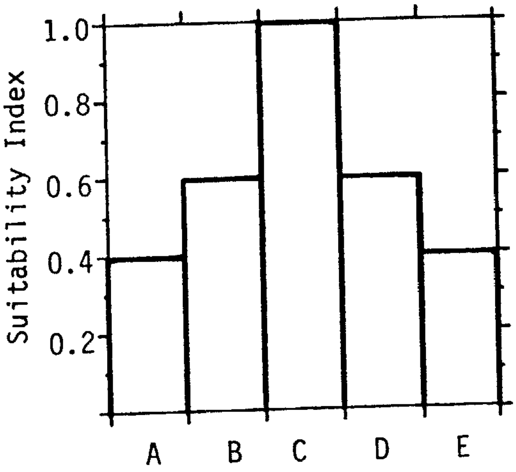
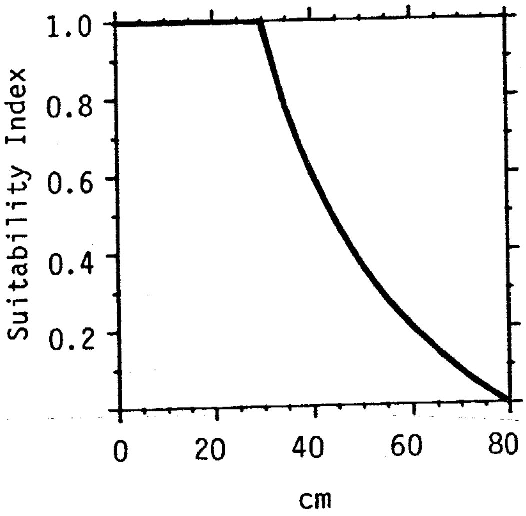
Water quality component. Maximum temperature (V_5) and turbidity (V_6) are included in this component because they are important limiting factors.

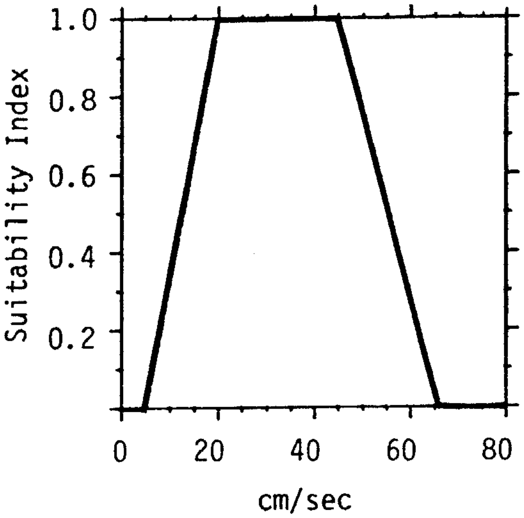
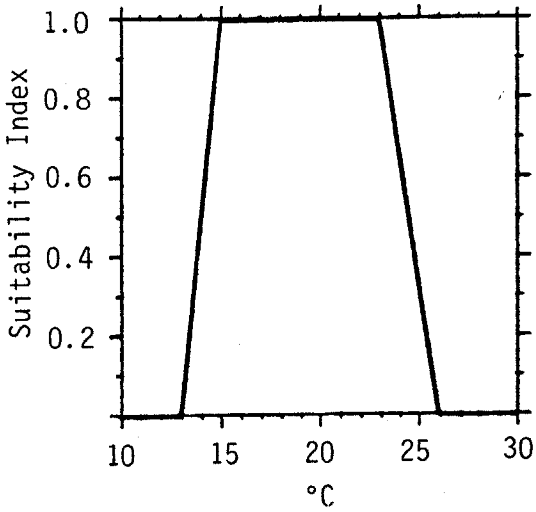
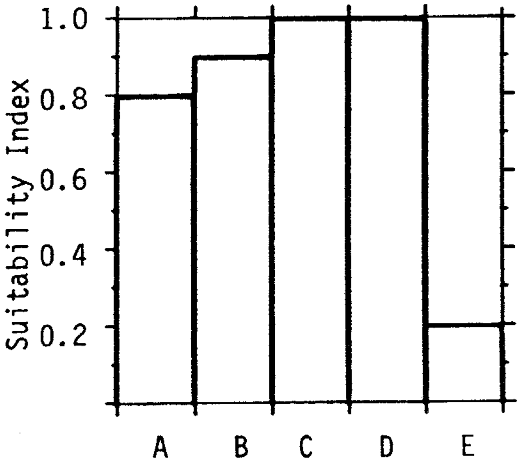
Suitability Index (SI) Graphs for Model Variables

Suitability index graphs for the 16 variables in the model descriptions pertain to riverine (R) or lacustrine (L) habitats, or both. Table 1 lists the information sources and assumptions used in constructing each SI graph.

Habitat	Variable		Suitability graph
R	V_1	Percent stream area shaded.	
R	V_2	Percent pools.	

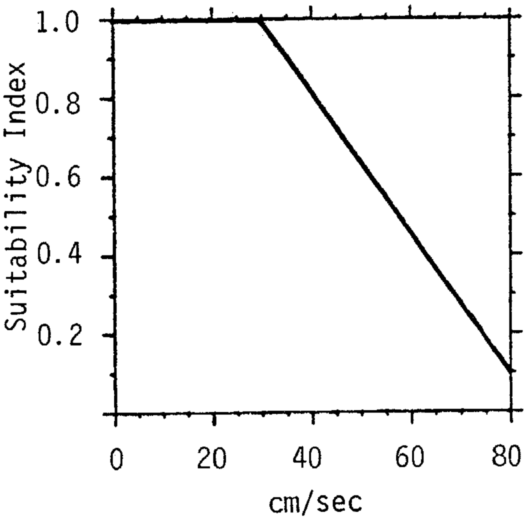
Habitat	Variable		Suitability graph
R	V_3	Stream gradient.	
R	V_4	Stream width.	
R,L	V_5	Most suitable maximum water temperature available during warmest time of year.	

Habitat	Variable		Suitability graph
R,L	V_6	Average turbidity during growing season.	
R	V_7	Predominant substrate in riffles. A. Mud, silt, sand, and debris B. Pebble C. Gravel D. Cobble E. Boulder and bedrock	
R	V_8	Stream depth in spawning riffles.	

Habitat	Variable		Suitability graph
R	V_9	Average velocity in riffles.	
R	V_{10}	Temperature during spawning (May-July).	
R	V_{11}	Predominant substrate in pools and slow channels (Adult). A. Mud, silt, sand, and debris B. Pebble C. Gravel D. Cobble E. Boulder and bedrock	

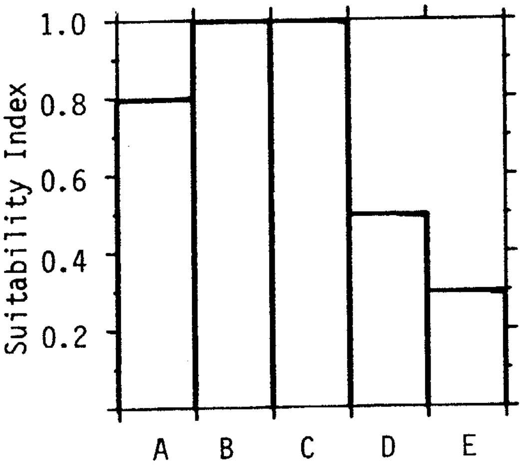
Habitat Variable Suitability graph

R V_{12} Average velocity in pools and slow channels (Adult).

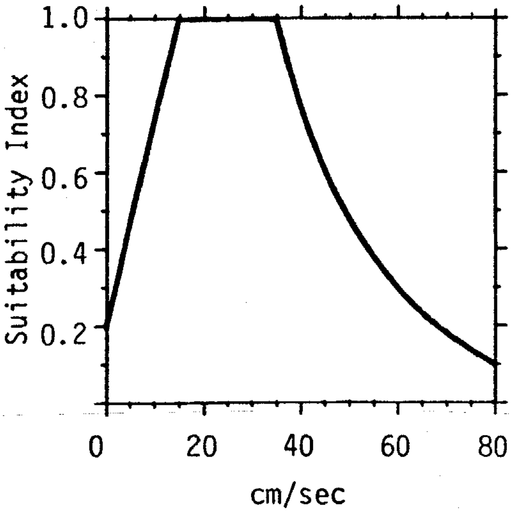


R V_{13} Predominant substrate in stream riffles (Juvenile).

A. Mud, silt, sand, and debris
B. Pebble
C. Gravel
D. Cobble
E. Boulder and bedrock



R V_{14} Velocity in riffles (Juvenile).



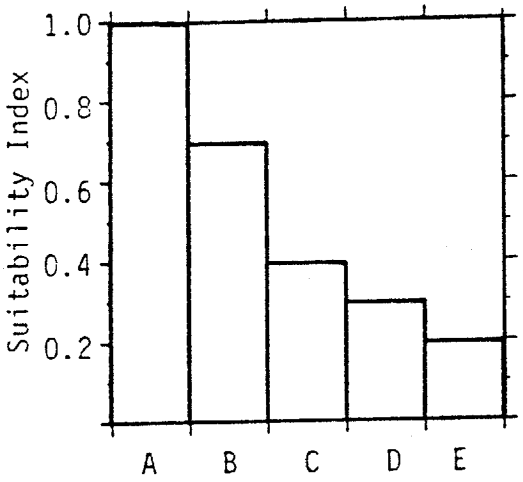
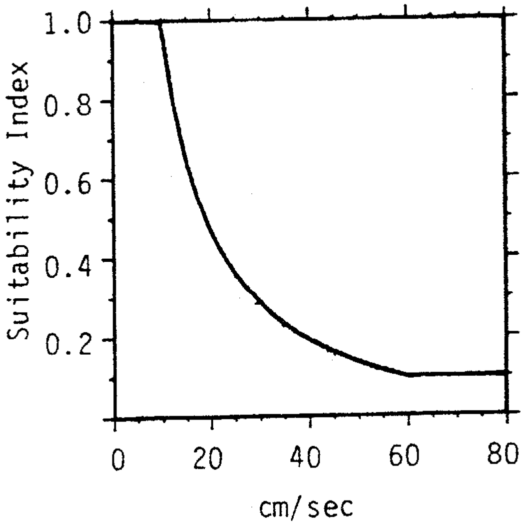
Habitat	Variable		Suitability graph
R	V_{15}	Predominant substrate along stream margins (Fry). A. Mud, silt, sand, and debris B. Pebble C. Gravel D. Cobble E. Boulder and bedrock	
R	V_{16}	Velocity along stream margins (Fry).	

Table 1. Data sources and assumptions for blacknose dace suitability indices.

Variable	Source	Assumption
V_1	Trautman 1957 Noble 1965	Since blacknose dace concentrate in areas with overhead cover and are seldom found where there is no canopy closure, the majority of the stream must have overhead cover. Percent of stream area shaded is an estimate of percent overhead cover.
V_2	Traver 1929 Schwartz 1958 Noble 1965 Whitworth et al. 1968 Tarter 1970 Scott and Crossman 1973	Blacknose dace require both pools and riffles; 50 to 80% pools provide optimum habitat for all life stages, reproduction, and food.
V_3	Burton and Odum 1945 Gibbons and Gee 1972	The gradients of streams where blacknose dace were abundant are optimal.
V_4	Fish 1932 Starrett 1950 Trautman 1957 Scarola 1973 Bragg and Stasiak 1978	Widths of streams where populations were large are optimal.
V_5	Hart 1952 Minckley 1963 Noble 1965 Terpin et al. 1976	Maximum summer temperatures in streams where blacknose dace were abundant are optimal. Temperatures between upper incipient lethal and optimal levels are suitable.
V_6	Trautman 1957 Armstrong and Williams 1971	Clear streams, where blacknose dace were abundant, are optimal. Clear streams have average turbidity less than 30 JTU.
V_7	Traver 1929 Fish 1932 Raney 1940 Harlan and Speaker 1951 Bartnik 1970a Bragg and Stasiak 1978	Substrates where most nests were built are optimal.

Table 1. (concluded).

Variable and source		Assumption
V_8	Traver 1929 Churchill and Over 1938 Schwartz 1958 Scott and Crossman 1973	Depth of water where nests were built is optimal.
V_9	Raney 1940 Bartnik 1970b Scott and Crossman 1973	Water velocity at spawning sites is optimal.
V_{10}	Raney 1940 Scott and Crossman 1973	The entire temperature range observed during spawning is optimal.
V_{11}	Starrett 1950 Trautman 1957 Gibbons and Gee 1972 Symons 1976 Bragg and Stasiak 1978	Substrate types where adults were abundant are optimal.
V_{12}	Bartnik 1970a Gibbons and Gee 1972 Gee 1974 Symons 1976	Average velocities where adults were collected in large numbers are optimal.
V_{13}	Witt 1970 Gibbons and Gee 1972	Substrate types where juveniles were abundant are optimal.
V_{14}	Gibbons and Gee 1972	Average velocities where juveniles were abundant are optimal.
V_{15}	Minckley 1963 Tarter 1970 Gibbons and Gee 1972	Substrate types where fry were abundant are optimal.
V_{16}	Minckley 1963 Tarter 1970 Gibbons and Gee 1972 Gee 1974	Average velocities where fry were abundant are optimal.

Riverine Model

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

$$C_{F-C} = \frac{V_1 + V_2 + V_3 + V_4}{4}$$

Or, if any value ≤ 0.4, $C_{F-C} = V_1$, V_2, V_3, or V_4, whichever is lowest.

Water Quality (C_{WQ}).

$$C_{WQ} = (V_5^2 \times V_6)^{1/3}$$

Or, if any value ≤ 0.4, $C_{WQ} = V_5$ or V_6, whichever is lowest.

Reproduction (C_R).

$$C_R = \frac{(V_7 \times V_8 \times V_9^2)^{1/4} + V_{10}}{2}$$

Or, if any value ≤ 0.4, $C_R = V_7$, V_8, V_9, or V_{10}, whichever is lowest.

Adult (C_A).

This is an optional component.

$$C_A = (V_{11} \times V_{12})^{1/2}$$

Or, if any value ≤ 0.4, $C_A = V_{11}$ or V_{12}, whichever is lowest.

Juvenile (C_J).

This is an optional component.

$$C_J = (V_{13} \times V_{14})^{1/2}$$

Or, if any value ≤ 0.4, $C_A = V_{13}$ or V_{14}, whichever is lowest.

Fry (C_F).

This is an optional component.

$$C_F = (V_{15} \times V_{16})^{1/2}$$

Or, if any value ≤ 0.4, $C_A = V_{15}$ or V_{16}, whichever is lowest.

HSI determination.

$$\text{Species HSI} = (C_{F-C} \times C_{WQ} \times C_R)^{1/3} \times (C_A \times C_J \times C_F)^{1/n}$$

Or, if any component ≤ 0.4, the HSI = C_{F-C}, C_{WQ}, C_R, C_A, C_J, or C_F, whichever is lowest.

C_A, C_J, and C_F are optional; n = number of components in parenthesis.

$$\text{Life stage HSI} = C_{F-C} \times C_{WQ} \times C_{\text{appropriate life stage}}$$

Lacustrine Model

Water Quality.

$$C_{WQ} = (V_5^2 \times V_6)^{1/3}$$

Or, if any value ≤ 0.4, $C_{WQ} = V_5$ or V_6, whichever is lowest.

HSI determination.

$$HSI = C_{WQ}$$

Interpreting Model Outputs

Blacknose dace are not common in lakes; therefore, care must be taken in interpreting the lacustrine model. The model only determines if suitable water quality exists in the lake. Because the species requires streams to spawn, a model considering both cover types would be necessary to adequately assess lake suitability.

Sample data sets for the riverine and lacustrine models are in Tables 2 and 3. The data are not field measurements but simulate streams and lakes within the range of the species. We believe the HSI's calculated from the data give a reasonable first cut estimation of the carrying capacity of the habitats depicted.

A species HSI can be produced that does not consider the specific requirements of different life stages. However, the life stage information may strengthen the model. The substrate and velocity data (Variables 11 to 16) must be gathered from the portions of streams specified for the different life stages. Failure to do this will result in HSI values that fail to reflect the ability of the fish to move to the best available habitat.

ADDITIONAL HABITAT MODELS

Model 1

This model is for rating streams in the optimum (average width < 8 m) size range. In these streams, optimum habitat is a 1:1 pool-riffle ratio, turbidity < 30 JTU, predominant substrate of sand and gravel, and maximum summer temperatures between 14 and 24° C.

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

Model 2

This model is nearly the same as the riverine HSI model described earlier, except that it does not contain life stage components. The food-cover component for this model consists of the following variables:

Bottom cover (V_1). Blacknose dace prefer areas with undercut banks, brush, roots, rock ledges, and substantial shade.

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
% stream shaded	V_1	50	1.0	30	0.6	10	0.4
% pools	V_2	50	1.0	40	1.0	70	1.0
Gradient (m/km)	V_3	10	1.0	25	1.0	5	0.3
Width (m)	V_4	4	1.0	10	0.6	14	0.2
Max. temperature (°C)	V_5	15	1.0	20	1.0	26	0.4
Turbidity (JTU)	V_6	30	1.0	30	1.0	80	0.3
Dominant substrate class in riffles	V_7	C	1.0	B	0.6	B	0.6
Depth (cm)	V_8	28	1.0	30	1.0	40	0.6
Velocity (cm/sec)	V_9	40	1.0	35	1.0	20	1.0
Temperature (°C)	V_{10}	20	1.0	20	1.0	23.5	0.9
Dominant substrate class in pools (Adult)	V_{11}	C	1.0	A	0.8	A	0.8
Velocity (cm/sec) (Adult)	V_{12}	13	1.0	11	1.0	3	1.0
Substrate class in riffles (Juvenile)	V_{13}	C	1.0	B	1.0	B	1.0
Velocity (cm/sec) (Juvenile)	V_{14}	35	1.0	36	1.0	15	1.0
Substrate class along margins (Fry)	V_{15}	A	1.0	A	1.0	A	1.0
Velocity (cm/sec) (Fry)	V_{16}	3	1.0	0	1.0	0	1.0

Table 2. (concluded)

Variable	Data set 1 Data	 SI	Data set 2 Data	 SI	Data set 3 Data	 SI
Component SI						
C_{FC} =		1.0		0.80		0.20
C_{WQ} =		1.0		1.00		0.30
C_R =		1.0		0.94		0.84
C_A =		1.0		0.89		0.89
C_J =		1.0		1.00		1.00
C_F =		1.0		1.00		1.00
HSI		1.0		0.87		0.20

Table 3. Sample data sets using lacustrine HSI model.

Variable		Data set 1 Data	 SI	Data set 2 Data	 SI	Data set 3 Data	 SI
Maximum temperature	V_5	20	1.0	25	0.6	30	0.0
Turbidity	V_6	30	1.0	20	1.0	40	0.8
Components							
C_{WQ}			1.0		.71		0.0
HSI			1.0		.71		0.0

Estimated percent of bottom shaded by a vertical projection of overhanging vegetation, undercut banks, brush, roots, and rock ledges:

		Rating
a)	> 50%	0.8-1.0
b)	25-50%	0.6-0.7
c)	< 25%	0.4-0.5

Percent pools (V_2). Blacknose dace require both pools and riffles. Spawning occurs in both pools and riffles, and the species overwinters in pools. Percent pools during normal flow:

		Rating
a)	15-75%	0.8-1.0
b)	10-14% or 76-85%	0.6-0.7
c)	< 10% or > 85%	0.4-0.5

Stream gradient (V_3). Blacknose dace prefer moderate to high gradient streams. Stream gradient:

		Rating
a)	8-25 m/km	0.8-1.0
b)	6-7m/km or 26-37 m/km	0.3-0.7
c)	< 6 or > 37 m/km	0.1-0.2

Width (V_4). Small streams are preferred. Stream width at normal flows:

		Rating
a)	< 8 m	0.8-1.0
b)	8-12 m	0.4-0.7
c)	> 12 m	0.2-0.3

The water quality component (C_{WQ}) for Model 2 consists of the following variables:

Maximum temperature (V_5). High blacknose dace densities are associated with low water temperatures. The species' upper incipient lethal temperature is 29.3° C. Maximum summer temperature:

		Rating
a)	16-24° C	0.8-1.0
b)	13-15° C or 25-27° C	0.3-0.7
c)	< 13 or > 27° C	0.0-0.2

Turbidity (V_6). Blacknose dace prefer clear streams. Turbidity at normal flows:

		Rating
a)	< 50 JTU	0.8-1.0
b)	50-90 JTU	0.4-0.7
c)	> 90 JTU	0.0-0.3

The reproduction component (C_R) for Model 2 consists of the following variables:

Substrate (V_7). Areas with substrate particles < 2.5 cm are preferred as spawning sites. Substrate in moderate current areas:

		Rating
a)	Silt, sand, pebble, or gravel (particle diameter ≤ 5.0 cm)	0.8-1.0
b)	Cobble or boulder (> 5.0 cm)	0.2-0.6
c)	Bedrock or rooted vegetation	0.1

Depth (V_8). Spawning occurs in shallow water < 30.5 cm. Average stream depth in May and June:

		Rating
a)	< 32 cm	0.8-1.0
b)	32-47 cm	0.3-0.7
c)	> 47 cm	0.0-0.2

Velocity (V_9). Blacknose dace spawn where water velocity is between 20 and 45 cm/sec. Average velocity during normal flows in May and June:

		Rating
a)	18-50 cm/sec	0.8-1.0
b)	10-17 cm/sec or 51-60 cm/sec	0.3-0.7
c)	< 10 cm/sec or > 60 cm/sec	0.0-0.2

Temperature (V_{10}). Spawning occurs when water temperature is between 15 and 22° C. Average May and June water temperature:

		Rating
a)	19-23° C	0.8-1.0
b)	17-18° C or 24-25° C	0.3-0.7
c)	< 17° C or > 25° C	0.0-0.2

Component and HSI equations

$$C_{F-C} = \frac{V_1 + V_2 + V_3 + V_4}{4}$$

$$C_{WQ} = (V_5^2 \times V_6)^{1/3}$$

$$C_R = \frac{(V_7 \times V_8 \times V^2)^{1/4} + V_{10}}{2}$$

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

Or, if any component value ≤ 0.4, the HSI = C_{F-C}, C_{WQ}, or C_R, whichever is the lowest.

INSTREAM FLOW INCREMENTAL METHODOLOGY

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 the 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 database 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). Most of the SI curves presently available for use with the IFIM, and virtually all of the SI curves published in the HSI series for depth, velocity, and substrate, are first generation 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 utilization 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 are 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

No curves have been developed by the Instream Flow Group for the blacknose dace. HSI model information and curves may be used for IFIM analyses (Table 4). An investigator should consider the information carefully to determine applicability in his area. No curves are available to describe depth preferences of adults, juveniles, or fry.

Table 4. Availability of curves for IFIM analysis of blacknose dace habitat.

	Velocity[a]	Depth[a]	Substrate[b,c]	Temperature[a]	Cover[a]
Spawning	Use SI curve for V_9.	Use SI curve for V_8.	Use SI[b] = 1.0 for sand, gravel, cobble (see text, pages 4 and 5).	Use SI curve for V_{10}.	No curve available.
Egg incubation	Use SI curve for V_9.	Use SI curve for V_8.	Use SI = 1.0 for sand, gravel, cobble (see text, pages 4 and 5).	Use SI curve for V_{10}.	No curve available.
Fry	Use SI curve for V_{16}.	No curve available.	Use SI = 1.0 for silt and sand (see text, page 5).	Use SI curve for V_5.	Use SI curve for V_1.
Juvenile	Use SI curve for V_{14}.	No curve available.	Use SI = 1.0 for sand, gravel, cobble, boulder (see text, page 5).	Use SI curve for V_5.	No SI curve for V_1.
Adult	Use SI curve for V_{12}.	No curve available.	Use SI = 1.0 for gravel and cobble (see text, page 4).	Use SI curve for V_5.	Use SI curve for V_1.

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

[b] 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.

[c] The following categories may be used for IFIM analyses (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)

REFERENCES

Armour, C. L., R. J. Fisher, and J. W. Terrell. 1983. Comparison and recommendations for use of Habitat Evaluation Procedures (HEP) and the Instream Flow Incremental Methodology (IFIM) for aquatic analyses. Unpublished draft report. U.S. Dept. Int., Fish Wildl. Serv., Western Energy and Land Use Team, Fort Collins, CO. 42 pp.

Armstrong, J. G., and J. D. Williams. 1971. Cave and spring fishes of the southern bend of the Tennessee River. J. Tenn. Acad. Sci. 46:107-115.

Bartnik, V. G. 1970a. Reproductive isolation between two sympatric dace, Rhinichthys atratulus and R. cataractae, in Manitoba. J. Fish. Res. Board Can. 27:2125-2141.

Bartnik, V. G. 1970b. Reproductive isolation between two sympatric species of dace, Rhinichthys cataractae and Rhicichthys atratulus, in the Mink and Valley Rivers, Manitoba. M.S. Thesis, Univ. Manitoba, Winnipeg. 84 pp. (Cited by Gee 1970).

Bovee, K. D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/26. 248 pp.

Bovee, K. D., and T. Cochnauer. 1977. Development and evaluation of weighted criteria, probability-of-use curves for instream flow assessments: fisheries. Instream Flow Information Paper 3. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-77/63. 39 pp.

Bragg, R. J., and R. H. Stasiak. 1978. An ecological study of the blacknose dace, Rhinichthys atratulus, in Nebraska. Proc. Nebr. Acad. Sci. Affil. Soc., 88:8. Abstract only. (Cited from Sport Fish. Abstr. 23(4):55.)

Breder, C. M., Jr., and D. R. Crawford. 1922. The food of certain minnows. Zoological (N.Y.) 2(14):287-327.

Burton, G. W., and E. P. Odum. 1945. The distribution of stream fish in the vicinity of Mountain Lake, Virginia. Ecology 26:182-194.

Churchill, E. P., and W. H. Over. 1938. Fishes of South Dakota. S.D. Dept. Game Fish. 87 pp.

Fish, M. P. 1932. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. Bull. U.S. Bur. Fish. 10, 47:293-398.

Flemer, D. A., and W. S. Woolcott. 1966. Food habits and distribution of the fishes of Tuckahoe Creek, Virginia, with special emphasis on the bluegill, Lepomis m. macrochirus Rafinesque. Chesapeake Sci. 7:75-89.

Gee, J. H. 1974. Behavioral and developmental plasticity of buoyancy in the longnose, Rhinichthys cataractae, and blacknose R. atratulus (Cyprinidae) dace. J. Fish. Res. Board Can. 31:35-41.

Gibbons, J. R. H. 1971. Comparative ecology of two sympatric species of dace Rhinichthys cataractae and Rhinichthys atratulus, in the Mink River, Manitoba. M.S. Thesis, Univ. Manitoba, Winnipeg. 67 pp. (Cited by Gibbons and Gee 1972).

Gibbons, J. R. H., and J. H. Gee. 1972. Ecological segregation between longnose and blacknose dace (genus Rhinichthys) in the Mink River, Manitoba. J. Fish. Res. Board Can. 29:1245-1252.

Harlan, J. R., and E. B. Speaker. 1951. Iowa fish and fishing, 2nd ed. Iowa Conserv. Comm. 238 pp.

Hart, J. S. 1952. Geographic variations of some physiological and morphological characters in certain freshwater fish. Univ. Toronto Stud. Biol. Ser. 60. Publ. Ont. Fish. Res. Lab. 72. 79 pp.

Howell, W. M., and J. Villa. 1976. Chromosomal homogeneity in two sympatric cyprinid fishes of the genus Rhinichthys. Copeia 1976:112-116.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer. 1980. Atlas of North American freshwater fishes. North Carolina Biol. Surv. Publ. 1980-12. 854 pp.

Milhous, R. T., D. L. Wegner, and T. Waddle. 1981. User's guide to the Physical Habitat Simulation System. Instream Flow Information Paper 11. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-81/43. 273 pp.

Minckley, W. L. 1963. The ecology of a spring stream, Doe Run, Meade County, Kentucky. Wildl. Monogr. 11. 124 pp.

Noble, R. L. 1965. Life history and ecology of western blacknose dace, Boone County, Iowa, 1963-1964. Iowa Acad. Sci. 72:282-293.

Raney, E. C. 1940. Comparison of the breeding habits of two subspecies of the blacknosed dace, Rhinichthys atratulus (Hermann). Am. Midl. Nat. 23:399-403.

Scarola, J. F. 1973. Freshwater fishes of New Hampshire. N.H. Fish Game Dept., Concord. 131 pp.

Schwartz, F. J. 1958. The breeding behavior of the southern blacknose dace, Rhinichthys atratulus obtusus Agassiz. Copeia 1958:141-143.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish. Res. Board Can. Bull. 184. 966 pp.

Starrett, W. C. 1950. Distribution of fishes in Boone County Iowa, with special reference to the minnows and darters. Am. Midl. Nat. 43:112-127.

Symons, P. E. K. 1976. Behavior and growth of juvenile Atlantic salmon (Salmo salar) and three competitors at two stream velocities. J. Fish. Res. Board Can. 33:2766-2773.

Tarter, D. C. 1970. Food and feeding habits of the western blacknose dace, Rhinichthys atratulus meleagris Agassiz, in Doe Run, Meade County, Kentucky. Am. Midl. Nat. 83:134-159.

Terpin, K. M., J. R. Spotila, and R. R. Koons. 1976. Effect of photoperiod on the temperature tolerance of the blacknose dace, Rhinichthys atratulus. Comp. Biochem. Physiol. A Comp. Physiol. 53:241-244.

Trautman, M. B. 1957. The fishes of Ohio. Ohio State Univ. Press, Columbus. 683 pp.

Traver, J. R. 1929. The habits of the blacknosed dace, Rhinichthys atronasus (Mitchell). J. Elisha Mitchell Sci. Soc. 45(1):101-129.

Whitworth, W. R., P. L. Berrien, and W. T. Keller. 1968. Freshwater fishes of Connecticut. State Geol. and Nat. Hist. Surv. of Conn. Bull. 101. 134 pp.

Witt, L. A. 1970. The fishes of the Nemaha Basin, Nebraska. Trans. Kans. Acad. Sci. 73:70-88.

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. FWS/OBS-82/10.41

2.

3. Recipient's Accession No.

4. Title and Subtitle
Habitat Suitability Information: Blacknose dace

5. Report Date
September 1983

6.

7. Author(s) J. G. Trial, J. G. Stanley, M. Batcheller, G. Gebhart, O. E. Maughan, P. C. Nelson

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Maine Cooperative Fishery Research Unit, Univ. of Maine, Orono;
Western Energy and Land Use Team, U.S. Fish and Wildlife Service,
Fort Collins, CO; Cooperative Fishery Research Unit, Oklahoma
State University, Stillwater, OK

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop riverine and lacustrine habitat models for Blacknose dace (Rhinichthys atratulus), a freshwater species. The models are scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for freshwater, marine and estuarine areas of the continental United States. Habitat suitability indexes (HSI's) are designed for use with 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 Blacknose dace.

17. Document Analysis a. Descriptors
Mathematical models
Fishes
Aquatic biology
Habitability

b. Identifiers/Open-Ended Terms
Blacknose dace
Rhinichthys atratulus
Habitat Suitability Index
Instream Flow Incremental Methodology

c. COSATI Field/Group

18. Availability Statement
Release unlimited

19. Security Class (This Report)
Unclassified

20. Security Class (This Page)
Unclassified

21. No. of Pages
26

22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983—681-464/520 REGION NO. 8