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crease with time (Kleerekoper et al. 1974; W. W. Reynolds unpublished data). The stress of infection, mediated by pyrogens, can increase the preferendum by several degrees (Reynolds et al. 1976a; Reynolds and Covert 1977; Reynolds 1977c), which somehow enhances survival from the infection (J. B. Covert and W. W. Reynolds unpublished data). Stress-enhanced thermoregulation might "fine-tune" the physiological responses of the organism, such as the immune response to infection or escape reactions from harmful stimuli. Fish maintained in laboratory temperature and photoperiod conditions comparable to those of the spawning season may also be in perpetual breeding condition (Banner and Hyatt 1975; Smith 1975), so their preferenda might reflect spawning optima.

Another possible interpretation of initially high laboratory preferenda involves initial overshoot during gravitation to the final preferendum (cf. Badenhuizen 1967; Beiting and Magnuson 1976), a phenomenon not uncommon in physiological responses to temperature changes (Prosser 1965; Peterson and Anderson 1969; Reynolds 1977b). Alternatively, the laboratory responses may be considered to represent the pure species-specific temperature preferendum, since every effort is made to remove extraneous stimuli, while

a multitude of nonthermal stimuli interfere in a complex fashion with thermal responses in nature, making thermal distributions in the field less predictable. In extended laboratory tests, fish might similarly begin to respond to nonthermal factors, modifying the observed thermal distributions. Nutrition level may have an effect. Perhaps more significantly, social interactions in groups of fish seem to increase following the initial exploratory phase in a novel environment (W. W. Reynolds unpublished data), and such social interactions have been shown to affect thermal distributions and behavior (Bacon et al. 1967; Regal 1971; Beiting and Magnuson 1975), especially in the case of subordinate individuals whose behavior is interfered with by socially dominant individuals. A great deal of further work is needed to more fully clarify all of the above considerations.

### Acknowledgments

I thank Dr J. J. Magnuson for reviewing an early draft of this paper. I thank Drs R. W. McCauley and L. I. Crawshaw for helpful discussions, and F. Paul Richards for organizing this symposium and thereby providing a forum for this much-needed examination of an important subject area.

## Compilation of Temperature Preference Data<sup>1</sup>

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COUTANT, C. C. 1977. Compilation of temperature preference data. *J. Fish. Res. Board Can.* 34: 739-745.

This report briefly summarizes current information from field and laboratory studies on temperature selection by fishes, with a tabulation of final temperature preferenda and upper and lower avoidance temperatures.

**Key words:** temperature, selection, preferendum, avoidance, preference, behavior, orientation

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On résume brièvement dans cet article les connaissances courantes acquises sur le terrain et en laboratoire sur le choix des températures par les poissons, avec tabulation des températures préférées finales et des températures d'évitement supérieures et inférieures.

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This paper summarizes information on temperatures selected by fishes in laboratory and field situations. Its primary purpose is to provide tabular data on three "endpoints" of temperature selection that have been found useful for setting temperature standards for water bodies and for describing and predicting the behavior of fishes near power station heated discharges (Table 1). These endpoints are the final preferendum and the upper and lower avoidance temperatures. A significant amount of additional data has been published since Coutant (1975) summarized reports through 1973.

Despite different study objectives and methods among the research reports summarized in Table 1, a pattern of temperature preference appears in the results for many species. Species specificity is

clearly demonstrated with reasonable consistency among laboratory and field results. For some species, the tabular summary clarifies the need for research directed toward resolving contradictions. Discrepancies among results indicate where caution should be used in applying these data in impact assessments. Some tabulated values represent my own interpretation of the authors' data, which may differ from theirs. Certainly, the original papers should be fully understood before these data are used for power plant impact analyses or for other purposes.

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TABLE 1. Summary of available data on final preferendum and upper and lower avoidance temperatures of fish from field and laboratory studies. Numbers here may vary somewhat from the original author's interpretation. Sp = spring; W = winter; F = fall; Su = summer; YOY = young of the year.

Species	Size or age	Temp (°C)			Location	Reference
		Upper avoidance	Final preferendum	Lower avoidance		
<i>Alburnus alburnus</i> (bleak)	Large	20			Lab	Alabaster and Downing 1966
<i>Alosa chrysocloris</i> (skipjack herring)	Large	29		22	Wabash R., Ind.	Gammon 1973
<i>A. pseudoharengus</i> (alewife)	Adult (Sp)	22.0	18.8	8.0	Cayuga L., N.Y. L. Michigan Lab	Galligan 1951 Wells 1968 Reutter and Herdendorf 1974
			21.3			
<i>A. sapidissima</i> (American shad)	Small	30			Connecticut R., Conn.	Marcy et al. 1972
<i>Ambloplites rupestris</i> (rock bass)			21.3		Wisconsin Lakes	Hile and Judy 1941
			20.7		S. Ontario streams	Ferguson 1958
			27-27.8*		L. Monona, Wis.	Neill 1971
	Small	29.0	26.2	25.5	L. Monona, Wis.	Neill 1971
	Small	29.5	28.8	26.0	Lab <sup>b</sup>	Neill 1971
	Adult (W)		21.6		Lab	Reutter and Herdendorf 1974
<i>Aplodinotus grunniens</i> (freshwater drum)	Adult (Sp)		20.5		Lab	Reutter and Herdendorf 1974
	Adult (F)		22.8		Lab	Reutter and Herdendorf 1974
	All	33	24.5-32.5		Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Anchoa mitchilli</i> (bay anchovy)						
<i>Aplodinotus grunniens</i> (freshwater drum)	Large		22.2		Norris Res., Tenn.	Dendy 1948
	Large	30	29.5-30.3*	22	Wabash R., Ind.	Gammon 1973
	Small		27.5-29*		L. Monona, Wis.	Neill 1971
	Small		31.3		L. Monona, Wis.	Neill 1971
	YOY (Su)		26.5		Lab	Reutter and Herdendorf 1974
	Adult (Su)		19.6		Lab	Reutter and Herdendorf 1974
<i>Arius felis</i> (sea catfish)	All	37			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Atherinops</i> sp <sup>c</sup> (silverside species)		28	25.2	22	California coast	Doudoroff 1938
<i>Brevoortia patronis</i> (gulf menhaden)	All	30			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Capostoma anomalum</i> (stoneroller)	All	23.8	26.8		New R., Va.	Sauffer et al. 1975 <sup>a</sup> Stauffer et al. 1975 <sup>a</sup> Cherry et al. 1975
	Adult	33	29	24		
<i>Carassius auratus</i> (goldfish)	Small		28.1		Lab	Fry 1947
	Small	33	30		Lab	Roy and Johansen 1970
	Adult (W)		24.2		Lab	Reutter and Herdendorf 1974
	Adult (Sp)		25.3		Lab	Reutter and Herdendorf 1974
	Adult (Su)		27.0		Lab	Reutter and Herdendorf 1974
	Adult (F)		24.0		Lab	Reutter and Herdendorf 1974
	Medium		27.9		Lab	Reynolds and Covert 1977
<i>Carpoides carpio</i> (river carpsucker)	Large	34.5		26	Wabash R., Ind.	Gammon 1973

This paper summarizes information on temperatures selected by fishes in laboratory and field situations. Its primary purpose is to provide tabular data on three "endpoints" of temperature selection that have been found useful for setting temperature standards for water bodies and for describing and predicting the behavior of fishes near power station heated discharges (Table 1). These endpoints are the final preferendum and the upper and lower avoidance temperatures. A significant amount of additional data has been published since Coutant (1975) summarized reports through 1973.

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			21.3			
<i>A. sapidissima</i> (American shad)	Small	30			Connecticut R., Conn.	Marcy et al. 1972
<i>Ambloplites rupestris</i> (rock bass)			21.3		Wisconsin Lakes	Hile and Judy 1941
			20.7		S. Ontario streams	Ferguson 1958
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	Small	29.5	28.8	26.0	Lab <sup>b</sup>	Neill 1971
	Adult (W)		21.6		Lab	Reutter and Herdendorf 1974
<i>Aplodinotus grunniens</i> (freshwater drum)	Adult (Sp)		20.5		Lab	Reutter and Herdendorf 1974
	Adult (F)		22.8		Lab	Reutter and Herdendorf 1974
	All	33	24.5-32.5		Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Anchoa mitchilli</i> (bay anchovy)						
<i>Aplodinotus grunniens</i> (freshwater drum)	Large		22.2		Norris Res., Tenn.	Dendy 1948
	Large	30	29.5-30.3*	22	Wabash R., Ind.	Gammon 1973
	Small		27.5-29*		L. Monona, Wis.	Neill 1971
	Small		31.3		L. Monona, Wis.	Neill 1971
	YOY (Su)		26.5		Lab	Reutter and Herdendorf 1974
	Adult (Su)		19.6		Lab	Reutter and Herdendorf 1974
<i>Arius felis</i> (sea catfish)	All	37			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Atherinops</i> sp <sup>c</sup> (silverside species)		28	25.2	22	California coast	Doudoroff 1938
<i>Brevoortia patronis</i> (gulf menhaden)	All	30			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Capostoma anomalum</i> (stoneroller)	All	23.8	26.8		New R., Va.	Sauffer et al. 1975 <sup>a</sup> Stauffer et al. 1975 <sup>a</sup> Cherry et al. 1975
	Adult	33	29	24		
<i>Carassius auratus</i> (goldfish)	Small		28.1		Lab	Fry 1947
	Small	33	30		Lab	Roy and Johansen 1970
	Adult (W)		24.2		Lab	Reutter and Herdendorf 1974
	Adult (Sp)		25.3		Lab	Reutter and Herdendorf 1974
	Adult (Su)		27.0		Lab	Reutter and Herdendorf 1974
	Adult (F)		24.0		Lab	Reutter and Herdendorf 1974
	Medium		27.9		Lab	Reynolds and Covert 1977
<i>Carpoides carpio</i> (river carpsucker)	Large	34.5		26	Wabash R., Ind.	Gammon 1973

TABLE I (Continued)

Species	Size or age	Temp (°C)			Location	Reference
		Upper avoidance	Final preferendum	Lower avoidance		
<i>C. cyprinus</i> (quillback)	Large	34.5		27.0	Wabash R., Ind.	Gammon 1973
	Adult (F)		22.1		Lab	Reutter and Herdendorf 1974
<i>Catostomus catostomus</i> (longnose sucker)			11.6		Moosehead L., Me.	Cooper and Fuller 1945
<i>C. commersoni</i> (white sucker)			20.6		Wisconsin Lakes	Hile and Judy 1941
			18.3		Moosehead L., Me.	Cooper and Fuller 1945
	Large	18.9-21.1			Horsetooth Res., Colo.	Horak and Tanner 1964
<i>Chromis chromis</i> (damselfish)	Adult (F)	22.4			Lab	Reutter and Herdendorf 1974
			20	8	Lab	Cabanac and Judd 1971
<i>Coregonus artedii</i> (cisco)	Large	20	10		L. Nipissing, Ont.	Fry 1937
	Large		7.2		Cayuga L., N.Y.	Galligan 1951
<i>C. clupeaformis</i> (lake whitefish)	Small		11.9		Moosehead L., Me.	Cooper and Fuller 1945
	Larvae		12.7		Lab	Ferguson 1958
	Larvae		17		South Bay, Lake Huron, Ontario	Reckahn 1970
	12.9 mm	12-16			Lab	Hoagman 1974
<i>C. hoyi</i> (bloater)	17.8 mm	17	13.5	12	Lab	Hoagman 1974
	23.1 mm	19	15.5	14.5	Lab	Hoagman 1974
					L. Michigan	Wells 1968
<i>C. lucaretus</i> (n.c.n.)	Larvae	11-15.4			Lab	Mantelman 1958
	(60 days)	8-12			Lab	Mantelman 1958
<i>Cottus bairdii</i> (mottled sculpin)			16.5		S. Ontario streams	Ferguson 1958
<i>C. cognatus</i> (slimy sculpin)	Large	6		4	L. Michigan	Wells 1968
<i>Crenichthys baileyi</i> (White River killifish)			29.5		White R., Nev.	Deacon and Bradley 1971
<i>Cyprinodon macularius</i> (desert pupfish)	Adults	36.5	35.5-36.5		Salton Sea, Calif.	Barlow 1958
	Young	40			Quitobaquito, Ariz.	Lowe and Heath 1969
<i>Cyprinus carpio</i> (carp)	Large	34.5		27	Wabash R., Ind.	Gammon 1973
	Large		29.3-31.9*		L. Monona, Wis.	Neill 1971
	Large		28.2-30.7*		L. Monona, Wis.	Neill 1971
	Young	35	32	28	Lab	Pitt et al. 1956
	Young	33.5	31.9	30	Lab	Neill 1971
	Young	32.3	32	29.5	Lab	Neill 1971
	Adult (Sp)		27.4		Lab	Reutter and Herdendorf 1974
<i>Cynoscion arenarius</i> (sand seatrout)	Adult (Su)		29.7		Lab	Reutter and Herdendorf 1974
	Adult	> 31	29	24	Lab	Reynolds unpublished data
<i>Dorosoma cepedianum</i> (gizzard shad)	All	40	29-32		Galveston Bay, Tex.	Gallaway and Strawn 1974
			35		Galveston Bay, Tex.	Copeland and Bechtel in Gallaway and Strawn 1974
<i>Esox americanus</i> <i>vermiculatus</i> (grass pickerel)	Large	30		23.5	Wabash R., Ind.	Gammon 1973
	Large		23.0		Norris Res., Tenn.	Dendy 1948
	Adult (F)		20.5		Lab	Reutter and Herdendorf 1974
<i>F. masquinongy</i> (muskelunge)	Small		26		Lab	Ferguson 1958
<i>E. niger</i> (chain pickerel)	Medium	27	24	< 20	Lab	Reynolds unpublished data
<i>Gadus morhua morhua</i> (Atlantic cod)	Large	8.9	1.4-2.0	0.6	Field	Tatyankin 1972
		8-10	1-3		Field	Tatyankin 1972
			1.5-2		Field	Tatyankin 1972
	Small	15	9	1.0	Lab	Tatyankin 1972
		16-17			Lab	Boile 1974
<i>Gambusia affinis</i> (mosquitofish)	Adults	29.5	31		Field and Lab	Winkler 1973
	15-19 mm	32	27		Lab	Bacon et al. 1967
	< 15 mm	35			Lab	Bacon et al. 1967
<i>Gillichthys mirabilis</i> (longjaw mudsucker)		23	22	9	Lab	deVlaming 1971
<i>Girella nigricans</i> (topaleye)	Transforming		28-31.2		California coast	Norris 1963
	55-60 mm		26-28.2		California coast	Norris 1963
		30	26		Lab	Duodoroff 1938
<i>Heterodontus francisci</i> (horn shark)	Young		24		Lab	Norris 1963
					L. Michigan	Crawshaw and Hammel 1973

TABLE I (Continued)

Species	Size or age	Temp (°C)			Location	Reference
		Upper avoidance	Final preferendum	Lower avoidance		
<i>Hiodon alosoides</i> (goldeye)	Large	28.5		22	Wabash R., Ind.	Gammon 1973
<i>H. tergisus</i> (mooneye)	Large	27		22	Wabash R., Ind.	Gammon 1973
<i>Ictalurus natalis</i> (yellow bullhead)	Adult (Su)		28.3		Lab	Reutter and Herdendorf 1974
<i>I. nebulosus</i> (brown bullhead)	Adult (W)	11.9			Lab	Reutter and Herdendorf 1974
	Adult (Sp)	23.5			Lab	Reutter and Herdendorf 1974
	Adult (Su)	24.9			Lab	Reutter and Herdendorf 1974
	Adult (F)	23.6			Lab	Reutter and Herdendorf 1974
	93-193 mm	27.3			Lab	Richards 1974
	Adult	29-31			Lab	Crawshaw 1975 <sup>a</sup>
<i>I. punctatus</i> (channel catfish)	Large	32		26	Wabash R., Ind.	Gammon 1973
	Large	34			White R., Ind.	Proffitt 1969
	Adult (Su)		25.2		Lab	Reutter and Herdendorf 1974
	Adult (F)		25.3		Lab	Reutter and Herdendorf 1974
		35	30.5	23	Lab	Cherry et al. 1975
<i>Ictalurus</i> sp. (buffalo species)	Large	34.5		27	Wabash R., Ind.	Gammon 1973
<i>Leiostomus xanthurus</i> (spot)	All	37.5			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Lepisosteus osseus</i> (longnose gar)	Large		30-31.8		L. Monona, Wis.	Neill 1971
	Large	34.5			Wabash R., Ind.	Gammon 1973
	YOY (Su)		25.3		Lab	Reutter and Herdendorf 1974
	Adult (Su)		33.1		Lab	Reutter and Herdendorf 1974
<i>L. platostomus</i> (shortnose gar)	Large	34.5		27	Wabash R., Ind.	Gammon 1973
<i>Lepomis cyanellus</i> (green sunfish)	< 74 mm	30	27.3	24	Lab	Jones and Irwin 1965
	Adult	33	30.6	23	Lab	Cherry et al. 1975
	Small	30.3	28.2	26.5	Lab	Bettenger et al. 1975
<i>L. gibbosus</i> (pumpkinseed)	Large		28.5-32 <sup>a</sup>		L. Monona, Wis.	Neill 1971
	Large		27-29 <sup>b</sup>		L. Monona, Wis.	Neill 1971
	Small		31.5		Lab	Ferguson 1958
	Adult (Sp)		24.2		Lab	Reutter and Herdendorf 1974
	Adult (Su)		27.7		Lab	Reutter and Herdendorf 1974
	Large	> 31	26	< 22	Lab	Reynolds unpublished data
<i>L. macrochirus</i> (bluegill)			29.4-31.3		L. Monona, Wis.	Neill 1971
	53-99 mm		28.8-31.2 <sup>a</sup>		L. Monona, Wis.	Neill 1971
	53-99 mm		27-29 <sup>b</sup>		L. Monona, Wis.	Neill 1971
	100-193 mm		29.6-32.6 <sup>a</sup>		L. Monona, Wis.	Neill 1971
	100-193 mm		27.2-29 <sup>b</sup>		L. Monona, Wis.	Neill 1971
			32.3		Lab	Ferguson 1958
	Young	32.1	30.2	28.5	Lab <sup>b</sup>	Neill 1971
	Young	32.5	31.5	28.5	Lab <sup>b</sup>	Neill 1971
	Young	33.1	31.2	29.3	Lab	Bettenger 1974
	Adult (W)		27.4		Lab	Reutter and Herdendorf 1974
	Adult	35	32	26	Lab	Cherry et al. 1975
	45-110 mm	33.0	32.3	26	Lab	Reynolds and Casterlin 1976 <sup>a</sup>
	120-155 mm		30.5		Lab	Reynolds et al. 1976 <sup>a</sup>
<i>Leuresthes sardina</i> (gulf grunion)	25-160 days old	37	—32	< 20	Lab	Reynolds and Thomson 1974 <sup>a</sup>
<i>L. tenuis</i> (Calif. grunion)	Adult	34	25	< 20	Lab	Reynolds et al. 1977 <sup>a</sup>
<i>Lota lota lacustris</i> (burbot)	Small		21.2		Lab	Crossman et al. 1953 cited by Ferguson 1958
<i>L. lota maculosa</i> (burbot)			11.4		Moosehead L., Me.	Cooper and Fuller 1945
<i>Melanogrammus aeglefinus</i> (haddock)			5-6		Field	Tatyankin 1972
<i>Membras martinica</i> (rough silverside)	All	33			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Menidia beryllina</i> (tidewater silverside)	All	34			Galveston Bay, Tex.	Gallaway and Strawn 1974 <sup>a</sup>
<i>M. menidia</i> (Atlantic silverside)			32		Lab	Meldrim 1970
<i>Micropogon undulatus</i> (Atlantic croaker)	All	38			Galveston Bay, Tex.	Gallaway and Strawn 1974 <sup>a</sup>
<i>Micropterus dolomieu</i> (smallmouth bass)			21.3		Nebish L., Wis.	Hile and Judy 1941
	Small		21.4		S. Ontario streams	Ferguson 1958
	YOY (W)		28.0		Lab	Ferguson 1958
	YOY (Sp)		18.0		Lab	Barans and Tubb 1976
			19-24		Lab	Barans and Tubb 1973

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<i>M. punctulatus</i> (spotted bass)	YOY (Su)	31		Lab	Barans and Tubb 1973		
	YOY (F)	24-27		Lab	Barans and Tubb 1973		
	YOY (F)	26.6		Lab	Reutter and Herdendorf 1974		
	YOY	35	31.1	25	Reynolds and Casterlin 1976 <sup>a</sup>		
	Adult (W)	12-13		Lab	Barans and Tubb 1973		
	Adult (Sp)	15-16		Lab	Barans and Tubb 1973		
	Adult (Su)	30.0		Lab	Barans and Tubb 1973		
	Adult (F)	21-23		Lab	Barans and Tubb 1973		
<i>M. punctulatus</i> (spotted bass)		33	31.3	26	Cherry et al. 1975		
	Large		24.4		Dendy 1948		
	Large	27		22	Gammon 1973		
<i>M. salmoides</i> ( largemouth bass)	Large	34	32.5	27	Cherry et al. 1975		
	Large	30	26.6-27.7		Dendy 1948		
	72-99 mm		27-30		Clugston 1973		
	100-408 mm		29.3-30.9		Neill 1971		
	100-408 mm		29.3-32 <sup>b</sup>		Neill 1971		
	Adult	29	27	25.5	Neill 1971		
	Small		30-32		Coutant 1975		
	Small	30.7	29	27.5	Ferguson 1958		
<i>Moapa coriacea</i> (Moapa dace)	Adult	30		Pond C., Savannah R.	Neill 1971		
	110-160 mm		30.1	Plant, S.C.	Siler and Clugston 1975		
	YOY			Lab	Reynolds et al. 1976 <sup>a</sup>		
	110-150 mm	34	30	21	Lab	Reynolds and Casterlin 1976 <sup>a</sup>	
<i>Morone americana</i> (white perch)	YOY			Lab	Reynolds et al. 1976 <sup>b</sup>		
	50-460 g		30.2		Deacon and Bradley 1971		
<i>M. chrysops</i> (white bass)			29.5				
	Small	35	32	Lab	Meldrim and Gift 1971		
	Large	29					
	YOY (W)		10-13	Wabash R., Ind.	Gammon 1973		
	YOY (Sp)		16-18	Lab	Barans and Tubb 1973		
	YOY (Su)		31.0	Lab	Barans and Tubb 1973		
	YOY (F)		28.0	Lab	Barans and Tubb 1973		
	YOY (Su)		27.8	Lab	Reutter and Herdendorf 1975		
	Adult (W)		12-17	Lab	Barans and Tubb 1973		
	Adult (Sp)		12-17	Lab	Barans and Tubb 1973		
<i>M. mississippiensis</i> (yellow bass)	Adult (Su)		28-30	Lab	Barans and Tubb 1973		
	Adult (F)		16-17	Lab	Barans and Tubb 1973		
<i>M. saxatilis</i> (striped bass)	Large		27.5-29.8 <sup>a</sup>	L. Monona, Wis.	Neill 1971		
	Large		27-28.7 <sup>b</sup>	L. Monona, Wis.	Neill 1971		
<i>Moxostoma</i> sp. (redhorse species)	Small	34.4		Lab	Meldrim 1970, Meldrim and Gift 1971		
	3 yr old	24	22	21	Coutant and Carroll unpublished data		
<i>Myoxocephalus quadricornis</i> (fourhorn sculpin)	Large	26		Small Tenn. Lakes	Gammon 1973		
	10	4.5		Lab			
<i>Nemacheilus leptocephalus</i> (bluehead chub)	Adult	17	15.0	10	Wabash R., Ind.		
					Gammon 1973		
<i>Notemigonus crysoleucas</i> (golden shiner)	Adult (W)		16.8	Lab	Reutter and Herdendorf 1974		
	Adult (Sp)		23.7	Lab	Reutter and Herdendorf 1974		
	Adult (Su)		22.3	Lab	Reutter and Herdendorf 1974		
	Adult (F)		21.0	Lab	Reutter and Herdendorf 1974		
<i>Notropis atherinoides</i> (emerald shiner)	YOY (W)		10-12	Lab	Barans and Tubb 1973		
	YOY (Sp)		13-15	Lab	Barans and Tubb 1973		
	YOY (S)		22-23	Lab	Barans and Tubb 1973		
	YOY (F)		13-14	Lab	Barans and Tubb 1973		
	Adult (W)		5-6	Lab	Barans and Tubb 1973		
	Adult (Sp)		16.0	Lab	Barans and Tubb 1973		
	Adult (S)		22-24	Lab	Barans and Tubb 1973		
	Adult (F)		15-16	Lab	Barans and Tubb 1973		
<i>N. hudsonius</i> (spottail shiner)	Adult (W)		9.3	Lab	Reutter and Herdendorf 1974		
	Large	> 22		13	L. Michigan	Wells 1968	
<i>N. rubellus</i> (rosyface shiner)	Adult (W)		10.2	Lab	Reutter and Herdendorf 1974		
	Adult (Sp)		14.3	Lab	Reutter and Herdendorf 1974		
<i>N. spilopterus</i> (spotted shiner)	Adult	31	26.8	21	Lab	Cherry et al. 1975	
	Adult	35	29.5	26	Lab	Cherry et al. 1975	
<i>Notorus flavus</i> (stonecat)	Adult (W)		5.5	Lab	Reutter and Herdendorf 1974		
	Adult (F)		25.1	Lab	Reutter and Herdendorf 1974		

TABLE I (Continued)

Species	Size or age	Temp (°C)			Location	Reference
		Upper avoidance	Final preferendum	Lower avoidance		
<i>Oncorhynchus gorbuscha</i> (pink salmon)	Small	11.7			Lab	Brett 1952
	Newly emerged	11.7-12.8			Lab	Hurley and Woodall 1968
	50 days	9.3			Lab	Hurley and Woodall 1968
<i>O. keta</i> (chum salmon)	Small	14.1			Lab	Brett 1952
<i>O. kisutch</i> (coho salmon)	Adult (Sp)	11.4			Lab	Reutter and Herdendorf 1974
	Adult	16.6			L. Michigan	Spigarelli 1975
<i>O. nerka</i> (sockeye salmon)		21	10.6-12.8		Cultus L., B.C.	Foerster 1937
	Small		14.5		Horsetooth Res., Colo.	Horak and Tanner 1964
					Okanagan R., Wash.	Hajor and Michel 1966
<i>O. tshawytscha</i> (chinook salmon)	Small	11.7			Lab	Brett 1952
	Adult	17.3			L. Michigan	Spigarelli 1975
			6.6-8.3		Cayuga L., N.Y.	Galligan 1951
<i>Osmerus mordax</i> (rainbow smelt)		14	12.8		L. Michigan	Wells 1968
				6	L. Champlain, N.Y.	Greene 1930
<i>Perca flavescens</i> (yellow perch)	Small	12.2			Muskellunge L., Wis.	Hile and Judy 1941
	Large	20.2			Muskellunge L., Wis.	Hile and Judy 1941
		20.2			Silver L., Wis.	Hile and Judy 1941
		21.0			Nebish L., Wis.	Hile and Judy 1941
		20.8			Trout L., Wis.	Hile and Judy 1941
		19.7			L. Nipissing, Ont.	Ferguson 1958
		21.2			L. Opeongo, Ont.	Ferguson 1958
		21.0			Costello L., Ont.	Ferguson 1958
			11		L. Michigan	Wells 1968
	Small	21.0			Lab	Ferguson 1958
	Small	24.2			Lab	Ferguson 1958
	Small	26.5	23.3	20.2	Lab*	Neill 1971
	Small	25	22.5	19.5	Lab*	Neill 1971
	Small	23.3			Lab	McCauley and Read 1973
	Adults	20.1			Lab	McCauley and Read 1973
	YOY (W)	10-13			Lab	Barans and Tubb 1973
	YOY (Sp)	18.0			Lab	Barans and Tubb 1973
	YOY (S)	25-27			Lab	Barans and Tubb 1973
	YOY (F)	28.0			Lab	Barans and Tubb 1973
<i>P. fluviatilis</i> (Eurasian perch)	Adult (W)	7-12			Lab	Barans and Tubb 1973
	Adult (Sp)	13-16			Lab	Barans and Tubb 1973
	Adult (S)	27.0			Lab	Barans and Tubb 1973
	Adult (F)	22-25			Lab	Barans and Tubb 1973
	Adult (W)	14.1			Lab	Reutter and Herdendorf 1974
	Adult (S)	20.9			Lab	Reutter and Herdendorf 1974
	Adult (F)	19.9			Lab	Reutter and Herdendorf 1974
		28.5			Polish lakes	Horoszewicz 1973
<i>Percopsis omiscomaycus</i> (trout-perch)	Adult	16		10	L. Michigan	Wells 1968
<i>Pimephales promelas</i> (fathead minnow)		28.5			Lab	Opuszynski 1971
<i>P. notatus</i> (bluntnose minnow)	Adult	32	29	25	Lab	Cherry et al. 1975
	< 74 mm	28	23.4		Lab	Jones and Irwin 1965
<i>P. notatus</i> (bluntnose minnow)	Adult	31	29	21	Lab	Cherry et al. 1975
<i>Pleuronectes platessa</i> (plaice)	15-23 cm	16-17			Lab	Zahn 1963
<i>Poecilia reticulata</i> (guppy)	Adult male	28.2			Lab	Ruff and Zippel 1966
	Adult female	27.6			Lab	Ruff and Zippel 1966
	Adult	29			Lab	Ogilvie and Fryer 1971
<i>Polydactylus octonemus</i> (Atlantic threadfin)		33.5			Galveston Bay, Tex.	Gallaway and Strawn 1974
<i>Pomoxis annularis</i> (white crappie)	Large	27		22	Wabash R., Ind.	Gammon 1973
	Adult (W)	19.8			Lab	Reutter and Herdendorf 1974
	Adult (Sp)	18.3			Lab	Reutter and Herdendorf 1974
	Adult (F)	10.4			Lab	Reutter and Herdendorf 1974
<i>P. nigromaculatus</i> (black crappie)	Large	27.8-29.8*			L. Monona, Wis.	Neill 1971
	Large	27-28.2*			L. Monona, Wis.	Neill 1971
	Small	30		26.5	Lab*	Neill 1971
	Small	29.5		25.5	Lab*	Neill 1971
	Adult (W)	20.5			Lab	Reutter and Herdendorf 1974
	Adult (Sp)	21.0			Lab	Reutter and Herdendorf 1974
	Adult (Su)	21.7			Lab	Reutter and Herdendorf 1974
	Adult (F)	22.2			Lab	Reutter and Herdendorf 1974
<i>Prosopium cylindraceum</i> (round whitefish)	Medium	26	24	20	Lab	Reynolds unpublished data
			17.5		Moosehead L.	Cooper and Fuller 1945

TABLE 1 (Concluded)

Species	Size or age	Temp (°C)			Location	Reference
		Upper avoidance	Final preferendum	Lower avoidance		
<i>Pylodictus olivaris</i> (flathead catfish)	Large	32		27	Wabash R., Ind.	Gammon 1973
<i>Rhodeus sericeus</i> (bitterling)	Adult		25		Lab	Zahn 1963
<i>Rutilus rutilus</i> (troach)	5-20 cm	25 28.5	27		River Trent, UK Lab Polish lakes	Alabaster and Downing 1966 Alabaster and Downing 1966 Horoszewicz 1973
<i>Salmo gairdneri</i> (rainbow trout)	Adult		18-9-21.1		Horsetooth Res., Colo.	Horak and Tanner 1964
	Red fingerlings	22			Lab	Javaid and Anderson 1967 <sup>a,b</sup>
	Starved fingerlings	18			Lab	Javaid and Anderson 1967 <sup>a,b</sup>
	Fingerlings	22-22	18-19	14	Lab	McCauley and Pond 1971
	Adult	13			Lab	Garside and Tait 1958
	Adult	16.5			L. Michigan	Spigarelli 1975
		19	18	13	Lab	Cherry et al. 1975
<i>S. trutta</i> (European rainbow trout)	Alevins	22	16-17	9	Lab	Mantelman 1958
	Fingerlings		14-15		Lab	Mantelman 1958
<i>S. salar</i> (Atlantic salmon)		14			Newfoundland lakes	Leggett and Power 1969
	Young		14		Lab	Fisher and Elson 1950
	Young		16		Lab	Mantelman 1958
	Underyearling		6-8		Lab	Ogilvie and Anderson 1965
	Young, fed		18		Lab	Javaid and Anderson 1967 <sup>a,b</sup>
	Young, starved		20		Lab	Javaid and Anderson 1967 <sup>a,b</sup>
<i>S. salar sebago</i> (landlocked Atl. salmon)			16.2		Moosehead L., Me.	Cooper and Fuller 1945
<i>S. trutta</i> (brown trout)		20	12		L. Oredon, France	James 1931
	Young		17.6		Lab	Alabaster and Downing 1966
	Adult		13.8		Lab	Ferguson 1958
					L. Michigan	Spigarelli 1975
<i>Salvelinus fontinalis</i> (brook trout)			19		Field	Creaser 1930
			20.3		Moosehead L., Me.	Cooper and Fuller 1945
			20.0		Redrock L., Ont.	Baldwin 1948
		20			Field studies	Smith and Saunders 1958
	Adult		15.7		S. Ontario streams	Ferguson 1958
	Adult		14.8		L. Michigan	Spigarelli 1975
	Small		16		Lab	Graham 1949
	Small, fall	20	16		Lab	Sullivan and Fisher 1953, 1954
	Small, winter		8-12		Lab	Sullivan and Fisher 1953, 1954
	Small, fed	20	18		Lab	Javaid and Anderson 1967 <sup>a,b</sup>
	Small, starved			14	Lab	Cherry et al. 1975
	Young		16		Lab	Javaid and Anderson 1967 <sup>a,b</sup>
			16		Lab	Peterson 1973
<i>S. namaycush</i> (lake trout)			14		White L., Ont.	Kennedy 1941
		13			Moosehead L., Me.	Cooper and Fuller 1945
		11			Lac La Ronge, NWT	Rawson 1956
			10		Louisa and Redrock L., Ont.	Martin 1952
			15.5		Cayuga L., N.Y.	Galligan 1951 (in Ferguson 1958)
	Young	15	11.7		Lab	McCauley and Tait 1970
	Young	14	11.5		Lab	Goddard et al. 1974
	Adult		11.8		L. Michigan	Spigarelli 1975
<i>S. fontinalis</i> ×			13.1		Jack and Sproule L., Ont.	Ferguson 1958
<i>S. namaycush</i> (spike)	Young		12.0		Lab	Ferguson 1958
<i>Scardinius erythrophthalmus</i> (rudd)		28.5			Polish lakes	Horoszewicz 1973
<i>Scorpaena scorpa</i> (scorpionfish)		26	20	8	Lab	Cabanac and Judd 1971
<i>Stizostedion canadense</i> (sauger)	Large	28	19.2		Norris Res., Tenn.	Dendy 1948
	Large			22	Wabash R., Ind.	Gammon 1973
<i>S. v. vitreum</i> (walleye)	Large		20.6		Trout Lake, Wis.	Hile and Juday 1941
	Large		23.2		Norris Res., Tenn.	Dendy 1948
<i>Thymallus thymallus</i> (grayling)		18			Lab	Alabaster and Downing 1966
<i>Tilapia mossambica</i> (Mozambique mouthbrooder)		33.5	28.5		Lab	Badenhuizen 1967
<i>T. nilotica</i>			28-29.5		Lab	Beamish 1970
<i>Tinca tinca</i> (tench)		26			Lab	Alabaster and Downing 1956

<sup>a</sup>Day; <sup>b</sup>Night; <sup>c</sup>May be other genera as well. See Reynolds et al. 1977a.