APPENDIX G; FISH CARRYING CAPACITY ARRANGED BY SPECIES AND MAJOR RESERVOIR GROUPS

Appendix G

Fish Carrying Capsc ty Arranged by Species snd Malar Reservoir Groups

Species or Species Group	Carrying Capacity	Carrying Capac1r:y Bi ss in Pounds per Acre Supported by Each Food Compartment				
		Detritus	Bent-has	Zooplankton	Fish	Terrestrial
	Culf and South Atlantic Drainage Area					
Gars	0.6				0.6	
Bowfin	0.5				0.5	
Gizzard shad	25.5	24.2	1.3			
Threadfin shad	6.4	4.5	1.9			
Picker 15	0.8				0.8	
Carp	18.1	10.9	5.	1.8		
Minnows	0.7		0.1	0.6		
Carpsuckers						
Suckers	5.2	4.2	0.3	0.8		
H.og sucke..s						
Buffalofbhes						
Redhoraes	5.2		5.2			
Bullheads	2.5	0.7	1.4		0.5	
Catfish s	6.8		1.2		5.5	
Mad toms						
Silversides						
Temperate basses	0.8				0.8	
Sunfish	18.8	0.9	12.8		1.7	3.4
Black basses	10.0		0.8		8.6	0.6
Crappies	8.2	*0.3*	1.7	1.5	4.8	*0.6*
Perches	1.4		0.3	0.3	0.9	
Freshwater drUID						
All other species	1.2		1.2			
Total	112.8	45.7	33.6	4.9	24.7	4.0
	Buckhorn, Flannagan• Sutton. and Summersville Reservoirs Drainage Area					
Gars						
Bowfin						
Gizzard Shad						
Threadfin shad	0.8	0.5	0.2			
Pickerels						
Carp	1.4	0.9	0.4	0.1		
Minnows	1.2		0.2	1.0		
Carpsuckers	0.2	0.2	0.01	0.03		
Suckers	0.2	0.2	0.01	0.03		
Hog suckers	1.1	0.9	0.1	0.2		
Buffalof1sbes						
Redhorses	1.7.8		17.8			
Bullheads	0.8	0.2	*0.5*		0.2	
Catfisbes	3.2		0.6		2.7	
Madtoms						
Silversides						
Temperate basses	0.1				0.1	
Sunfish	17.6	0.9	12.0		1.6	3.2

(Continued)

Appendix G (Continued)

Species or Species Group	Carr)'ing Capacity	Carrying Capacity Biomass in Pounds per Acre Supported by Each Food COilpartment: Detritus	I1enthos	Zooplankton	Fish	Terreatrial
Buckhorn. Flannagan, Sutton, and Summersville Reservoirs Drainage Area (Continued)						
Black baues	11.5		0.'		,''	0.7
Crappies	3.1	0.1	0.'	0.'	1.8	
Perches	O.,		0.1	0.1	0.3	
Freshwater drum	1.4	0.1	0.8		0.5	
All other species	0.1		0.1			
Total	61.0	3.'	34.3	2.0	17.D	3.'
Green and Cumberland Rivers and Dewey Reservoir Drainage Area						
Gars	0.1				0.1	
Bowfin						
Gizzsrd shad	60.6	57.6	3.0			
Threadfin shad	5.'	3.'	1.7			
Pickerels						
Carp	32.4	19.4	'.7	3.2		
Minnows	0.5		0.1	0.4		
Carpsuckera	0.4	0.3	0.02	0.1		
Suckers	4.1	3.3	0.2	0.'		
Hog suckers						
Buffalofiahes	16.7	7.5	0.8	8.3		
Redhorses	15.8		15.8			
Bullheads	2.0	0.5	1.1		0.4	
Catfishes	'.2		1.1		5.1	
Madtoms						
Silveraides						
Temperate basses	1.3				1.3	
Sunfish	15.8	0.8	10.7		1.4	2.8
Black basses	11.5		0.'		,''	0.7
Crappies	8.2	0.3	1.7	1.5	4.8	
Perches	1.5		0.3	0.3	0.'	
Freshwater drum	10.8	0.'	'.3		3.7	
All other species	0.3		0.3			
Total	193.9	94.6	53.8	14.4	27.6	3.5
Lower Mississippi Valley Drainage Area						
	4.'				4.'	
Bowfin	0.4				0.4	
Gizzard shad	62.5	59.4	3.1			
Threadfin shad						
Pickerels						
Carp	'.2	5.5	2.8	0.'		
Minnows	4.3		0.'	3.4		
Carpsuckera	0.4	0.3	0.02	0.1		
Suckers	3.5	2.8	0.2	0.5		
ltog suckers						
Buffalofishes	70.9	31.9	3.'	35.5		
Redhorses	0.4		0.4			

(Continued)

Appendix G (Continued.)

Species or Species Group	Carrying Capacity	Carrying Capacity Biomass in Pounds per Acre Supported by Each Food Compartment: Detritus	Benthos	Zooplsnkton	Fish	Terrestrial
	Lower Kissi ssippi Valley Drainage Area (Continued)					
Bullheads	0.'	0.1	0.2		0.1	
Catfishea	24.9		'.5		20.4	
Madtoms	0.2	0.1	0.1		0.04	
SUversides						
Temperate basses	1.0				1.0	
Sunfish	10.4	0.5	7.1		0.'	1.,
Black bssses	15.5		1.2		13.3	O.'
Crappies	17.8	0.7	1.6	3.1	10.3	
Perches						
Freshwater drum	26.1	2.1	15.1		8.'	
All other species	0.1		0.1			
Total	253.1	103.4	42.9	43.6	60.4	2.8
	Blue Mountain, Nimrod, and Wister Reservoirs Drainage Area					
Gars	17.3				17.3	
Bowfin						
Gizzard shad	49.7	47.2	1.5			
Threadf in shad						
Pickerels						
Carp	39.2	23.5	11.7	3.'		
Minnows	1.1		0.1	O.'		
Carpsuckers						
Suckers	7.8	6.3	0.'	1.2		
Hog suckers						
S"ffalofishes	264.2	11B.9	13.2	132.1		
Redhorses						
8ullheads	0.3	0.1	0.1		0.1	
Catfishes	12.1		1.1		;';	
Madtoms						
Silversides						
Temperste basses	'.O				6.0	
Sunfish	10.3	0.5	7.0		O.'	1.,
Black basses	16.6		1.3		14.3	1.0
Crappies	26.3	1.1	5.3	'.7	15.3	
Perches						
Freshwater drum	55.4	;';	32.1		18.8	
All othet speci..s						
Total	506.3	201.9	76.1	142.8	B2.6	1.'
	Arkansas River hain Drainage Area*					
Gars	1.7				1.7	
Bowfin						
Gizzard shad	125.8	119.5	6.3			
Threadfin shad	1.3	O.'	O.'			
Pickerels						
Carp	58.0	34.B	17.4	5.8		

(Continued)

* Bl"e Hbuntain, Nimrod, Wister, and Greal Salt Plains excluded.

Appendix C (Continued)

Species or Species Group	Carrying Capacity	Carrying Capacity Biomass in Pounds per Acre Supported by Each Food Compartment: Detritus	Benthos	Zooplankton	Fish	Terrestrial
Arkansas River Basin Drainage Area (Continued)						
Minnows	0.'		0.1	0.3		
Carpsuckers	36.4	29.1	1.,		.'	
Suckers						
Hog suckers						
Buffalofishes	86.1	38.8	'.3	43.1		
Redhorses	4''		4 ■			
Bullheads	3.7	1.0	2.1		0.7	
Catfishes	21.8		3.'		11.9	
Madtoms						
Silversides						
Temperate bas•••	'.3				'.3	
Sunfish	17.1	0.'	11.6		1.,	1.1
Black basses	13.5		1.1		11.6	0.'
Crappies	19.0	0.'	3.'	1.'	11.0	
ferche.						
Freshwater drum	49,2	3.•	28.6		16.7	
All other apecie.						
Total	446.9	229.6	85.9	58.0	69.5	1.'
Red River Basin Drainage Ar..						
Cars	1.3				1.3	
Bow;in	0.'				0.'	
Gizzard shad	66.8	63.4	3.1			
Threadfin shad	●●●	'.7	2••			
Pickerels	0.'				0.'	
Carp	'.2	4''	2.'	0.'		
Minnows	1.2		'.2	1.'		
Carpsuckers						
Suckers	;''	;';	'.3	0.'		
Hog sucker.						
Buffalofishes						
Redhorses	22.8		22.8			
Bullheads	●●0	'.2	▪▪;		'.1	
Catfish..	10.0		1.'		'.2	
Madtoms						
Silversides	'.1		0.03	'.1		
Temperate basses	3.'				1.0	
Sunfish	35.8	1..	24.3		1.2	■■
Black b.....s	17.5		1.4		15.1	1.1
Crappia.	7.2	'.3	1.4	1.3	4.2	
Perches	'';;		0.1	0.1	'.3	
frellhw.ter drum	'.0	0.'	'.7		2.7	
All other species	0.1		'.1			
Tot.l	196.1	80.4	65.3	4.1	39.3	7.'

(Continued)

Appendix G (Concluded)

Species 0' Species Group	Carrying Capacity	Carrying Capacity Bioma•• in Pounds per Acre Supported by Each Food Compartment				
		Detritus	Benthos	Zoophnkton	Fish	Terrestri.l
	White River Basin Drainage Area					
Gars	0.1				0.1	
Bowfin						
Gizzard shad	66.9	63.6	3.3			
Threadfin shad	'.O	;';	2.1			
Pickerels						
Carp	10.8	'' ;	1.2	1.1		
Minnows	0.7		0.1	O.'		
Carpsuckers	2••	2.'	0.1	O.'		
Suckers	2.'	1.9	0.1	0.'		
Hog suckers						
Buffalofishes	27.8	12.S	1''	13.9		
Redhor...	34.9		34.9			
Bullheads	0.8	0.2	O.'		0.2	
Catfish••	;• 7		1.7		;' ;	
Madtoms	0.2	0.1	0.1		0.04	
Silversides	0.'		0.1	O.'		
Temperate b•••es	;';				;';	
Sunfish	19.5	1.0	U.2		1.8	;';
Black b.....	14.1		1.1		12.1	0.'
Crappies	;''	0.2	1.1	1.0	'.2	
Perch••	1.5		O.'	0.1	O.'	
Freshwater drum	2.'	0.2	1.5		O.'	
All other species	0.'		0.1			
Total	211.4	93.3	65.3	17.9	30.6	4.3

APPENDIX H: ANNUAL FISH HARVEST

Appendix H: Part I

Annual Sport Fish Harvest

Drainage Areas	Area-Weighted Sport Fish Harvest	Area-Weighted Sport Fish Harvest Supported by Each Food Compartment*											
		Plant Material		Detritus		Benthos		Zooplankton		Fish		Terrestrial	
		lb/acre	% TH	lb/acre	% TH	lb/acre	% TH	lb/acre	% TH	lb/acre	% TH	lb/acre	% TH
Central and South Pacific	27.5	2.3	8.4	1.1	4.0	14.3	52.0	1.0	3.6	6.1	22.2	2.7	9.8
Central Valley	31.1	2.0	6.4	1.2	3.8	10.2	32.8	2.5	8.0	13.4	43.1	1.8	5.8
Columbia Basin	4.8	0.2	4.2	0.04	0.8	2.2	45.8	0.5	10.4	1.6	33.3	0.3	6.2
Great Basin	26.8	1.3	4.8			15.9	59.3	4.0	14.9	2.9	10.8	2.7	10.1
Colorado Basin	7.1	0.4	5.6	0.03	0.4	2.8	39.4	0.6	8.4	2.6	36.6	0.6	8.4
Missouri Basin	5.1	0.4	7.8	0.6	11.8	1.5	29.4	0.4	7.8	2.2	43.1	0.2	3.9
White River Basin	25.9	1.3	5.0	0.6	2.3	5.5	21.2	1.7	6.6	16.2	62.5	0.8	3.1
Arkansas River Basin	51.0	2.7	5.3	2.0	3.9	11.9	23.3	4.2	8.2	28.4	55.7	0.8	1.6
Red River Basin	32.1	1.6	5.0	1.1	3.4	10.9	34.0	1.7	5.3	14.9	46.4	1.9	5.9
Rio Grande and Gulf	57.5	2.6	4.5	2.2	3.8	13.1	22.8	3.4	5.9	33.9	59.0	2.1	3.6
Lower Mississippi	8.8	0.5	5.7	0.4	4.5	2.2	25.0	0.9	10.2	4.5	51.1	0.2	2.3
Upper Mississippi	12.7	2.1	16.5	2.5	19.7	3.5	27.6	0.8	6.3	3.2	25.2	0.2	1.6
Tennessee Valley	10.3	0.5	4.8	0.4	3.9	2.7	26.2	0.8	7.8	5.8	56.3	0.2	1.9
Ohio Basin	12.4	0.8	6.4	0.6	4.8	3.8	30.6	0.7	5.6	5.9	47.6	0.6	4.8
South - Gulf	11.7	0.6	5.1	0.4	3.4	3.0	25.6	0.8	6.8	6.3	50.8	0.5	4.3
South - Atlantic	7.6	0.3	3.9	0.2	2.6	1.6	21.0	0.6	7.9	4.7	61.8	0.2	2.6
Middle Atlantic	19.0	1.5	7.9	1.3	6.8	6.1	32.1	0.6	3.2	8.2	43.2	1.3	6.8
New England	2.5	0.1	4.0	0.045	1.8	0.8	32.0	0.2	8.0	1.3	52.0	0.1	4.0
Great Lakes and St. Lawrence	11.7	0.9	7.7	0.8	6.8	3.0	25.6	1.2	10.2	5.8	49.6	0.1	0.8
Area-Weighted Average	12.1	0.6	5.0	0.4	3.3	3.4	28.1	0.9	7.4	6.3	52.1	0.5	4.1

* TH = total harvest

Appendix H: Part II

Annual Commercial Fish Harvest

Drainage Area	Area-Weighted Harvest Supported by Each Food Compartment in Pounds Per Acre			
	Plant Material	Detritus	Benthos	Zooplankton	Fish
Colorado Basin	0.3	1.0	0.4	1.1	0.3
Missouri Basin	0.2	0.8	0.4	0.8	0.2
Upper Mississippi	2.5	9.1	4.4	10.1	2.9
Rio Grande and Gulf	0.3	1.0	0.5	1.1	0.3
Arkansas River Basin	0.4	1.3	0.6	1.4	0.4
Red River Basin	0.1	0.3	0.2	0.3	0.1
Tennessee Valley	1.3	4.6	2.2	5.1	1.4
Ohio Basin	0.3	1.1	0.5	1.2	0.3
Great Lakes and St. Lawrence	3.3	11.9	5.8	13.2	3.8
Area-Weighted Average	0.6	2.4	1.1	2.4	0.7

APPENDIX I: MAXIMUM SPECIFIC DAILY GROWTH RATES IN WEIGHT FOR RESERVOIR FISH SPECIES

Appendix I

Maximum Specific Daily Growth Rates in Weight for Reservoir Fish Species

Species	Age Class I	II	III	IV	V
Golden redhorse		0.00662	0.00274	0.00138	0.00130
Smallmouth buffalo		0.00250	0.00256	0.00139	0.00113
Bigmouth buffs10		0.00398	0.00289	0.000665	0.00144
Black buffalo		0.00190	0.00124	O.OOi71	
Carp		0.00560	0.00509	0.00245	*0.00195*
River carpsucker		0.00723	0.00377	0.00317	0.00270
Golden shiner		0.00344	0.000855	0.00103	0.000594
White sucker		*0.00520*	0.00255	0.00170	0.00212
Longnose sucker		0.00371	0.00207	0.00160	0.00156
Freshwater drum		0.00703	0.00342	0.00240	0.00181
Longnose gar		0.00177	0.000797	0.000652	0.000299
Paddlefish		0.00658			
Mountain whitefish				0.00282	0.00159
Round whitefish		0.0018]	0.000856		
Brook trout	0.021]	0.0216*	0.00270	0.000707	
Lake trout		0.00190	0.00207	0.0017)	0.00190
Brown trout		0.00727	*0.00267*	0.0028]	0.00169
Rainbow trout		0.00683	0.00302	0.00171	0.00082]
Cutthrost trout		*0.00516*	0.00234	0.00114	0.000734
Kokanee		0.00282	0.000593		0.000515
Largemouth bass	0.0291	0.00721	0.00344	*0.00395*	0.00283
Smallmouth ba··	0.0183*	0.0121*	0.00451	0.00180	0.00251
Spotted ba··		0.00287	0.00317	0.00166	0.000988
Green sWIft.h		0.00847	0.00679	0.00198	0.00145
Pumpkinseed	0.00349	0.OOll5	0.00163	0.00131	0.000716
81ue8111	0.00631	0.00681	0.00527	0.003))	0.002]2
Redear sunfish		*0.00533*	0.00360	0.00294	0.00199
SpotUd sunfish		0.00713			
Warmouth		0.00742	0.00414	0.00246	0.00169
Rock bass	0.00644	*0.005)7*	0.00210	0.00156	0.00130
White crappie		0.00226	0.00263	0.00237	0.00206
Black crappie		0.00669	0.00408	0.00180	0.00145
White bass		0.00812	0.00380	0.000967	0.00245
Yellow perch		0.00494	0.000821	0.00133	0.00109
Walleye		0.00351	0.00190	*O.OODS*	0.000902
Sauger		0.000715	0.00293	0.000945	0.000512
Chain pickerel		0.00303	0.00190	0.00262	0.00114
Northern pike		0.00684	0.00301	0.00411	0.00174
Channel catfish	0.0213	0.00853	0.00489	0.00184	0.00434
Flathead catfish		0.00913	0.00478	0.00291	0.00275

* Laboratory studies over limited time periods. All other data are from field studies and repr··ent the maximum values reported in the literature.

Appendix I (Concluded)

Species	Age Class I	II	III	IV	V
Blue catfish	0.00558	0.00377	0.00262	0.00140	0.00179
Yellow bullhead		0.00703	0.000913	0.000614	0.000509
Brown bullhead			0.000857		
Black bullhead		0.00522	0.00685	0.00350	0.00304
Silver redhorse		0.00496	0.00260	0.00188	0.00123
Northern redhorse		0.00560	0.00223	0.00440	0.000493

APPENDIX J: DIGESTIVE EFFICIENCIES AND FOOD CONSUMPTION OF FISH

Appendix J

Digestive Efficiencies and Food Consumption of Fish

Species	Study Location	Age, length, or weight	Assimilation Efficiency	Ecological Growth Efficiency	Daily Meal as % Body Weight	Comments	Reference
Largemouth bass	?	fingerling to 454 g			4.0=optimum level	Water temp.=21.1°C.	Thompson (1941)
Largemouth bass	Concrete ponds, AL	20-255 g		24.1		Fed on fish. Water temp.=26.7-32.2°C. Jun-Sep.	Prather (1950)
Largemouth bass	Laboratory	71-115 g, $\bar{x}$=89 g			7.01	Fed on mosquitofish or mollies. Water temp.=24-25°C.	Hunt (1960)
Largemouth bass	Laboratory		95.7 for protein N. 95.5 for lipid. 89.6 for energy.				Beamish (1972)
Largemouth bass	Laboratory	22 g 464 g		31.2 15.2	5.4 2.0	Water temp.=19.4-25.0°C, $\bar{x}$=21.3°C. Fed on minnows.	Williams (1959)
Largemouth bass	Crab Orchard Lake, IL	90-450 g 451-900 g 901-1350 g 1351-1800 g 1800+ g			4.0 3.5 3.5 1.6 1.5	Apr-Oct	Lewis et al. (1974)
Smallmouth bass	?	7.5 g 27.4 g 39.5 g 57.0 g 111.5 g		30.7 21.4 19.3 27.2 22.8	9.4 3.2 2.8 2.8 3.0	Water temp.=19.4-25.0°C, $\bar{x}$=21.3°C. Fed on minnows.	Williams (1959)
Rock bass	Lake Opinicon, Ontario, Canada	29-90 g			2-4	Jun	Keast and Welsh (1968)
White bass	Lake Mendota, WI and Laboratory	44-77 mm	66.0-69.2, $\bar{x}$=67.35	17.3-35.3, $\bar{x}$=27.25		Annual cycle	Wissing (1974)
Bluegill	Laboratory	20.2-148.5 g	80.0 @ 15°C 79.9 @ 20°C 80.0 @ 25°C	44 @ 15°C 33 @ 20°C 30 @ 25°C	1.97 @ 15°C 1.88 @ 20°C 2.94 @ 25°C	16-hr. photoperiod.	Pierce and Wissing (1974)
Bluegill	Maple and Grove Lakes, MN	100-211 mm 27-114 g			Maple Lake: 2.04 @ 27 g 2.2 @ 55 g 1.84 @ 114 g Grove Lake: 1.67 @ 64 g 1.38 @ 95 g	Avg. water temp.=22.2°C. Summer.	Seaburg and Moyle (1964)

(Continued)

Appendix J (Continued)

Species	Study Location	Age, length, or weight	Assimilation Efficiency	Ecological Growth Efficiency	Daily Meal as % Body Weight	Comments	Reference
Bluegill	Laboratory	29.7 g	97.2 (protein absorption)	32=Maximum protein utilization for growth.	1.00=maintenance. 3.5=maximum intake.	Avg. water temp.= 24.6°C.	Gerking (1955)
Bluegill	White Oak Lake, TN	III, IV		4.2=Apr-Oct	0.8-3.2, $\bar{x}$=1.75	Jun-Jan	Kolehmainen (1974)
Bluegill	Wyland Lake, IN	II-V 14-85 g		17.2 for protein.	3.6 in Lab.	Avg. water temp.= 23.9°C. Data are a revision of Gerking (1962). Summer.	Gerking (1972)
Bluegill	Lake Opinicon, Ontario, Canada	11.1-58 g			2-4	Jun	Keast and Welsh (1968)
Carp	Laboratory		74	31		Fed on Chironimids.	Ivlev (1939)
Carp	White Oak Lake, TN	I-VII		8.0	3.9	Annual cycle.	Kevern (1966)
Carp			95			Data in doubt.	Kobashi and Deguchi (1971)
Blue catfish	Laboratory	3.78 g 8.69 g		35.5		20°C, 16-hr. photoperiod.	Tyler and Kilambi (1973)
Channel catfish	Laboratory	5.5 g 23 g		62.5 62.5		12-hr. photoperiod.	Stickney and Andrews (1971)
Channel catfish	Laboratory	4 g		55.6 @ 22°C 41.7 @ 18°C 52.6 @ 26°C 16.7 @ 18°C 33.3 @ 22°C 30 @ 26°C 9.4 @ 18°C 18.2 @ 22°C 28.6 @ 26°C	2 2 2 4 4 4 6 6 6		Andrews and Stickney (1972)
Channel catfish	Laboratory			9.56		32°C=optimum temperature for food conversion. 14-hr. photoperiod @ 32°C.	Kilambi et al. (1970)
Black crappie	Maple and Grove Lakes, MN	122-368 mm			Maple Lake: 2.12 @ 64 g 2.00 @ 104 g 1.58 @ 190 g	Avg. water temp.= 22.2°C. Summer.	Seaburg and Moyle (1964)

(Continued)

Appendix J (Continued)

Species	Study Location	Age, length, or weight	Assimilation Efficiency	Ecological Growth Efficiency	Daily Meal as % Body Weight	Comments	Reference
Black crappie (Con't)	Maple and Grove Lakes, MN (Con't)				Grove Lake: 2.00 @ 32 g 1.00 @ 100 g 0.58 @ 159 g		
Florida gar	Laboratory	70-132 g, $\bar{x}$=110 g 30, 35 g			2.81 4.26	Fed mosquitofish or mollies. Water Temp. 24-25°C.	Hunt (1960)
Longnose gar	Missouri creeks and rivers, and Laboratory	6.00 g 13.88 g 24.69 g 33.49 g $\bar{x}$=20.96 g		64.0 49.5 40.9 34.7 $\bar{x}$=43.1	10.1 11.3 7.3 8.0 $\bar{x}$=9.1	Water temp.-26.4°C.	Netsch and Witt (1962)
Goldfish	Laboratory		71.5-86.5			At maintenance level @ 21.5°C.	Davies (1964)
Blueback herring	James River, VA and Laboratory	1.16-3.97 g	80.0	9.3		Water temp.=16.4-28.7°C. Constant light. Jun-Nov.	Burbidge (1974)
Muskellunge	Laboratory	17 g		36.7	6.4	Water temp.=17-22°C, $\bar{x}$=19.5°C. Fed on minnows. 12-hr photoperiod.	Gammon (1963)
Yellow perch	Lake Opinicon, Ontario, Canada	7.8-26.5 g			2-4	Jun	Keast and Welsh (1968)
Northern pike	Lake Windemere, Great Britain	150 g	72	30		Data in doubt. Fed minnows. Annual cycle.	Johnson (1966)
Northern pike	Laboratory				5.0	Fed minnows and insects	Mongeau (1954, 1955)
Pumpkinseed	Lake Opinicon, Ontario, Canada	18-62 g				Jun	Keast and Welsh (1968)
Pumpkinseed	Maple and Grove Lakes, MN	100-179 mm 36-114 g			Maple Lake: 1.38 @ 36 g 1.03 @ 68 g 1.0 @ 127 g Grove Lake: 1.13 @ 77 g 0.61 @ 114 g	Summer. Avg. water temp.=22.2°C.	Seaburg and Moyle (1964)

(Continued)

Appendix J (Continued)

Species	Study Location	Age, length, or weight	Assimilation Efficiency	Ecological Growth Efficiency	Daily Meal as % Body Weight	Comments	Reference
Sockeye salmon	Laboratory	Fingerlings		$\bar{x}$=20, maximum=25	Y=0.542 + 0.308X. X=temp. °C. =5.2 @ 15°C.	Optimum temp.=15°C. Spring-Fall.	Brett et al. (1969)
Sockeye salmon	Laboratory	Young			1.5-11.3 for fingerlings. $\bar{x}$=5 1.5-7.6 for yearlings.	Annual consumption amounts to 8-9 times final weight, which is typical of plantivores.	Krokhin (1959)
Brown trout	Laboratory	40.7 g 85.2 g		12.9 12.0		Fed on Gammarus.	Pentelow (1939)
Cutthroat trout	Laboratory	Under-yearling	84.9-86.1, $\bar{x}$=85.5	5.2-11.8 in the field.		10°C minimum assimilation efficiency.	Brocksen (1966)
Walleye	Laboratory	160-205 g, II-VI	E_2=96.851-0.0045W; r=0.824	14.3 @ 20°C	4.0=optimum	Fed on age 0 perch.	Kelso (1972)
			E_2=82.103-0.0041W; r=0.859	12.7 @ 16°C		Fed on amphipods.	
			E=83.535-0.0045W	11.3 @ 8-16°C		Fed on crayfish.	
			E=97.871-0.0045W	13.9 @ 12°C		Fed on emerald shiner. W=weight (g), E= assimilation efficiency. 14-hr photoperiod.	
Walleye and Sauger	Lake of the Woods, Ontario, Canada	III, IV		16.9 for Jun. 20 for other months.	1.0 in Jun, 2.0 in Jul, 3.0 in Aug-Sep.	Jun-Sep	Swenson and Smith (1973)
Warmouth	Laboratory	72-113 g, $\bar{x}$=93 g			4.37	Fed on mosquitofish or mollies. Water temp.=24-25°C.	Hunt (1960)
Reticulate sculpin	Laboratory	Yearling	78.4-84.4, $\bar{x}$=81.9	38.6=optimum @ 8.3-15.0°C.		10°C minimum assimilation efficiency.	Davis and Warren (1965)
Stickleback	Laboratory	Adult			1.8-5.1, $\bar{x}$=2.7		Krokhin (1959)

(Continued)

Species	Study Location	Age, length, or weight	Assimilation Efficiency	Ecological Growth Efficiency	Daily Meal as % Body Weight	Comments	Reference
Green sunfish	Laboratory	II-IV or 68-110 mm		28		Avg. water temp.= 24.7°C. Jul-Aug	Gross et al. (1965)
Green sunfish	Laboratory	7.1-48.5 g max. age=IV	92.3 (nitrogen absorption) 95.7 (protein absorption)	38.7 for 7.1 g wet wt. (1.59 g dry wt.)=gross protein utilization for growth. 32.6 for 11.2 g wet (2.18 dry). 29.8 for 18.2 g wet (3.54 dry). 19.2 for 48.5 g wet (12.37 dry).		Avg. water temp.= 24.5-25.5°C. Fed mealworms.	Gerking (1952a)
Longear sunfish	Laboratory	9.1-103.3 g max. age=VI	94.0 (nitrogen absorption) 97.4 (protein absorption)	32 for 9.1 g wet wt. (2.56 dry wt.)=gross protein utilization for growth. 27.8 for 23.6 g wet (6.64 dry). 29.4 for 28.2 g wet (7.92 dry). 23.4 for 57.9 g wet (17.19 dry). 4.6 for 103.3 g wet (30.68 dry).		Avg. water temp.= 24.5-25.5°C. Fed mealworms.	Gerking (1952a)
Brook trout Brown trout Rainbow trout	Hatchery	98-240 mm			6.0 for 98-122 mm fish. 2.0 for 220-240 mm fish.	Max. allowances for growth @ 15.6°C.	Third Ed. N.Y. State Hatchery Feeding Chart (1952)
Cichlasoma bimaculatum	Laboratory		82.8 @ 20°C 84.0 @ 24°C 88.6 @ 28°C 85.6 @ 32°C 69.6 @ 36°C	33.7 44.0 51.7 43.4 14.5		Fed on Tubifex.	Warren and Davis (1967)

(Continued)

Appendix J (Concluded)

Species	Study Location	Age, length, or weight	Assimilation Efficiency	Ecological Growth Efficiency	Daily Meal as % Body Weight	Comments	Reference
Roach	Laboratory and River	21.2 g	78.9	5.5		Egestion and excretion assumed to be 20% of food intake. Seasonal temperature fluctuations. Annual cycle.	Mann (1965)
Bleak	Thames, Great Britain	34.3 g	79.5	6.6			
Dace		2.8 g	79.4	4.1			
Perch		3.1 g	79.2	4.8			
Gudgeon		4.5 g	79.4	4.6			
$\bar{x}$			79.4	6.0			
Plaice	Laboratory	Young		20			Colman (1970)
Bleak	Laboratory	Young	69.9	19.6		Water temp. 20°C. Egestion=30.1%.	Ivlev (1961)
Carnivorous fish			80	20		General budget based on review of various results up to 1956.	Winberg (1956)

APPENDIX K: ANNUAL, DAILY, AND INSTANTANEOUS NATURAL MORTALITY RATES FOR VARIOUS FISH SPECIES

Appendix K

Annual, Da11y, and lnstantan ous Natural Mort 11ty Ratea for Various Fish Species

Sp cies	Study Location	Age or Length	Annual Natural Mor ality Rate	Daily N tural Kort lity Rate	Instant neOUB Natural Mortality Rate	Comments	Refer nee
Large outh bass	Browns Lak , WI		..0.136	0.00037			Mraz and Thre!nen (1955)
	Gordy Lak , IN	•V	.0.24	0.00066		Poor sumpl •	Cerking (1952b)
	Beaver Reservoir, AR	All ages	0.437-0.716	0.0015	0.575-1.259	1968-1975	HOuser (unpublish d)
Rock b sII	Nebish Lake, WI	X-Xl	0.66	0.0018		Unexp10ited population	Ricker (1947)
		Xl-XlI	0.71	0.0019			
		XU-XIll	0.78	0.0021			
		XIII-XIV	0.79	0.0022			
Bluegill	Lodge Lake, MI		0.8519	0.0023	1.91		PatrIarche (1968)
	Jewett Lake, MI		0.7961	0.0022	1. 9	% dist. of natural mort.: 7 (spring), 81 (summ r), 12 (fall), O (wint r).	Patriarche (1968)
	Cordy Lake, IN	≥IV	≈0.47	0.0013			G rking (1952b)
	Muskel1ung Lake, IN (1942-43)		≈0.49	0.0013			Ricker (19451
	Shoe Lak , IN (1941-42)		-0.57	0.0016			Ricker (l945)
	Shoe L ke, IN (1942-43)		-0.59	0.0016			Ricker (1945)
	Wawasee Lake, IN		≈0.68	0.0019		20% st. xploitation rate.	Ricker (1945)
	Gordy Lak , IN	ll-111	0.38	0.0010	0.481		Gerking (1952b)
		Ill-IX	0.49	0.0013	0.667		
Brown bullhead	Clear L k , CA		0.17	0.00047			HcCammon and Se 1 y (1961)
	FolsOll Lake, CA		0.34	0.00093			Rawstron (1967)
Channel c tfi8h			0.314	0.00086	0.376		Ricker (1958)
White c fish	Cle r Lake, CA		0.19	0.00052	0.21		McCammon and Se 1 y (1961)
	FolsOll Lak , CA		0.57	0.0016			Rawstron (1967)
Freshwat r drum	Missis lppi River		0.257	0.00070			Butler (1965)
Northern pike	Ball Club Lake, MN	III-VIll	0.60	0.0016			Johnson and Pet r.on (1955)
	Lake in MN	III-VIII	0.769	0.0021			Cro bner (1960)
	Lake in MN	Ill-VIII	0.708	0.0019			Croebner (1960)
	MN		0.497	0.0014			Scidmore (1955)
Sauger	Lake Nipigon, Ontario, Cansda	VIII-a	0.231	0.00063		Unexploit d population	Ricker (1947)
		lX-X	0.26	0.00071			
		X-Xl	0.30	0.00082			
		Xl-XU	0.34	0,00093			
		XII-XIII	0.47	0.0013			
		XIII-XIV	0.60	0.0016			

(Cont Inued)

Appendix K (Concluded)

Species	Study Location	Age or Length	Annual Natural Mortality Rate	Daily Natural Hortality Rate	Instantaneous Natural Mortality Rate	Comments	Reference
American shad	Connecticut Rive.r		0.73	0.0020			Walburg (1961)
Longnose sucker	Great Slave Lake, Northwest Territories. Canada		0.55	*0.0015*			Ceen et al. (1966); Harris (1962); Harrh (1952)
Redear sunfish	Cordy Lake, IN	>IV	≃ 0.40	0.0011			Cerking (1952h)
Brook trout	Pigeon River, MI				0.012	Spring-Summer	Latta (1962)
	East fish Lake. MI				0.003-0.004		Alexander and Shetter (1961)
	New York Lakes				1.34	Summer average	Hatch and Webster (1961)
	Lawrence Creek, WI				0.56	Winter average	Hatch and Webster (1961)
	Ford and Hemlock Lakes, MI				0.75-0.96		McFadden (1961)
Cutthroat trout			0.16-0.75	0.00044-0.0021			Hansen (1971)
	Yellowstone Lake. WY		0.614	0.0017			Ball and Cope (1961); Welsh (1952)
Rainbow trout	finger Lakes. NY		0.66	0.0018	1.08		Hartman (1959)
Walleye	Many Points Lake. MN	I-VII	0.0479	0.00013	0.0491		Olson (1957)
Whitefish	Lake Opeongo. Ontario, Canada	VI-VII	0.41			Unexploited population	Ricker (1947)
		VII-VIIi	0.46				
		VIII-IX	0.48				
		IX-X	0.51				
		X-XI	0.56				
		XI-XII	0.56				
		XII-XIII	0.59				
	Shakespeare Island lake. Ontario. Canada	Xl-X11	0.08			Une.xploited population	Ricker (1947)
		XII-XIII	0.09				
		XIII-XIV	0.10				
		XIV-XV	0.11				
		XV-XVI	0.11				
		XVI-XVII	0.12				
		XVII-XVIII	0.13				
		XVIII-XiX	0.15			Unexploited population	Ricker (1947)
		XIX-XX	0.17				
		XX-XXI	0.21				
		XXI-XXII	0.24				
		XXII-XXIII	*0.27*				
		XXIII-XXIV	0.32				
		XXIV-XXV	0.36				
		XXV-XXVI	0.40				
		XXVI-XXVII	0.45				
	Georgian Bay of Lake Huron, Ontario, Canada	>III	0.41				Cucin lind Regier (1965)

APPENDIX L: METABOLIC RATES OF FISH

Appendix L: Part I

Regression Equations Relating Active Metabolism at Various Temperatures to Fish Weight

Species	Temperature, °C	Regression Equation*	Reference
Brook trout	5	log Y = -0.730 + 0.942 log W	Job (1955)
	10	log Y = -0.461 + 0.862 log W	
	15	log Y = -0.391 + 0.851 log W	
	20	log Y = -0.075 + 0.750 log W	
Sockeye salmon	15	log Y = -0.050 + 0.970 log X	Brett (1965)

* Y = metabolic rate (mgO_2/hr)
  W =
  X = weight (g)

Appendix L: Part II

Regression Equations Relating Standard Metabolism at Various Temperatures to Fish Weight

Species	Temperature, °C	Regression Equation*	Reference
Goldfish	10	log Y = -1.568 + 0.882 log X	Beamish and Mookherjii (1964)
	20	log Y = -0.348 + 0.913 log X	
	30	log Y = -0.577 + 0.717 log X	
	35	log Y = -0.670 + 0.887 log X	
Carp	10	log Y = -1.735 + 0.983 log X	Beamish (1964a)
	20	log Y = -1.137 + 0.909 log X	
	30	log Y = -0.733 + 0.876 log X	
	35	log Y = -0.550 + 0.810 log X	
Brown bullhead	10	log Y = -1.696 + 0.998 log X	Beamish (1964a)
	20	log Y = -0.986 + 0.903 log X	
	30	log Y = -0.721 + 0.874 log X	
White sucker	10	log Y = -1.460 + 0.994 log X	Beamish (1964a)
	15	log Y = -0.772 + 0.828 log X	
	20	log Y = -0.497 + 0.770 log X	
Brook trout	10	log Y = -1.476 + 1.107 log X	Beamish (1964a)
	15	log Y = -0.996 + 1.014 log X	
	20	log Y = -0.905 + 1.036 log X	
Brown trout	10	log Y = -0.847 + 0.877 log X	Beamish (1964a)
Sockeye salmon	15	log Y = -0.632 + 0.775 log X	Brett (1965)

* Y = metabolic rate (mgO_2/hr)
X = weight (g)

Appendix L: Part III

Summary of Fish Metabolic Rates at Various Temperatures, Ages, and Weights

Species	Age	Wet Weight, g	Temperature, °C	Oxygen Consumption, $ml O_2/g/hr$						Active/ Standard	Routine/ Standard	Reference
				Standard	1/4 Active	1/2 Active	3/4 Active	Routine	Full Active			
Sockeye salmon	Yearling	36.7	5	0.0287					0.360	12.5		Brett (1964)
	Yearling	32.9	10	0.0420					0.439	10.5		
	Yearling	55.2	15	0.0497	0.0924	0.175	0.336		0.627	12.6		
	Yearling	62.9	20	0.0840					0.596	7.1		
	Yearling	52.2	24	0.137					0.594	4.3		
	Underyearling	3.38	15	0.161	0.231	0.322	0.462		0.644	4.0		Brett (1965)
	Underyearling	8.47	15	0.0770	0.130	0.210	0.361		0.581	7.5		
	Underyearling	19.1	15	0.0889					0.490	5.5		
	Adult (jacks)	746	15	0.0497	0.882	0.158	0.287		0.511	10.3		
	Adult	1432	15	0.308	0.0616	0.123	0.245		0.502	16.3		
Brook trout		?	5	0.0240*								Graham (1949)
		?	5	0.0259*								Flörke et al. (1954)
		15	5	0.0867*								Job (1955)
		164	10	0.0480*					0.217	4.5		Graham (1949)
		164	10						0.224*			Basu (1959)
		?	10	0.0434*								Flörke et al. (1954)
		15	10	0.153*								Job (1955)
		100	10	0.0555				0.0926			1.7	Beamish (1964a)
		100	15	0.0750				0.159			2.1	
		164	15	0.0800*					0.343	4.3		Graham (1949)
		164	15						0.343*			Basu (1959)
		?	15	0.0700*								Flörke et al. (1954)
		15	15	0.227*								Job (1955)
		15	20	0.287*								
		100	20	0.103*				0.152			1.5	Beamish (1964a)
		?	20	0.091*								Flörke et al. (1954)
		164	20	0.110*					0.245	2.2		Graham (1949)
		164	20						0.210*			Basu (1959)
		?	25	0.150*								Graham (1949)
Rainbow trout			5	0.0420*								Flörke et al. (1954)
			10	0.0700*								
			15	0.105*								
			20	0.140*								
Brown trout		100	10	0.0566								Beamish (1964a)

* Determined from a graph.

Appendix L: Part III (Continued)

Species	Age	Wet Weight, g	Temperature, °C	Oxygen Consumption, $ml O_2/g/hr$ Standard	1/4 Active	1/2 Active	3/4 Active	Routine	Full Active	Active/ Standard	Routine/ Standard	Reference
Lake trout	Age I	27.7	10	0.0350*					0.190	5.4		Gibson and Fry (1954)
		27.7	15	0.0600*					0.300	5.0		
		27.7	20	0.900*					0.280	3.1		
	Age II	82.8	10	0.0250*					0.205	8.2		
		82.8	15	0.0400*					0.265	6.6		
		82.8	20	0.0650*					0.265	4.1		
White sucker		100	10	0.0243				0.0572			2.4	Beamish (1964a)
		100	15	0.0550				0.0725			1.3	
		100	20	0.0773				0.0962			1.2	
Brown bullhead		15	5	0.0252*					0.0630	2.5		Fry (1947)
		15	10	0.0504*					0.147	2.9		
		15	15	0.105*					0.231	2.2		
		15	20	0.168*					0.378	2.3		
		15	25	0.273*					0.567	2.1		
		15	30	0.357*					0.756	2.1		
		15	35	0.399*					0.945	2.4		
		100	10	0.0140				0.0371			2.7	Beamish (1964a)
		100	20	0.0463				0.0680			1.5	
		100	30	0.0743				0.0946			1.3	
Carp		100	10	0.0119								Beamish (1964a)
		100	20	0.0336				0.0791			2.4	
		104	20						0.476*			Basu (1959)
		100	30	0.0732				0.140			1.9	Beamish (1964a)
		104	30						0.630*			Basu (1959)
		100	35	0.0821								Beamish (1964a)
Goldfish		3.8	5	0.0150*					0.0280	1.9		Fry and Hart (1948)
		3.8	10	0.0250*					0.0600	2.4		
		74	10						0.196*			Basu (1959)
		100	10	0.0110								Beamish and Mookherjii (1964)
		100	15	0.0140								
		3.8	15	0.0550*					0.115	2.1		Fry and Hart (1948)
		3.8	20	0.0800*					0.155	1.9		
		74	20						0.245*			Basu (1959)
		100	20	0.0211								Beamish and Mookherjii (1964)
		100	25	0.0315								
		3.8	25	0.145*					0.260	1.8		Fry and Hart (1948)
		3.8	30	0.175*					0.295	1.7		
		74	30						0.350*			Basu (1959)
		100	30	0.0504								Beamish and Mookherjii (1964)
		100	35	0.0889								

(Continued)

Appendix L: Part 111 (Concluded)

Species	Age	Wet Weight g	Temperature, °C	Oxygen Consumption, l02/s/hr								Reference
				Standard	1/4 Active	1/2 Active	3/4 Active	Routine	Pull Active	Active Standard	Routine Standard	
Goldfish (Cont.)		',8	35	0.220*					O.295	1.3		Fry and Hart (1948)
		32	23-25	0.0750*					0.]28	4.4		Spoor (1946)
Yellow perch		1	'	0.0126"								Flörke st.l. (1954)
		I	10	0.0259*								
		I	15	0.0420*								
		I	20	0.0700"								
		1	11	0.0980"								
Flsh in general								••			1.1	Winberg (19S6)

** See tables by Winberg (1956)

Appendix L: Part IV

Summary of Fish Metabolic Rates at 20°C*

Species	Wet Weight, g	Respiration, $mlO_2/g/hr$ Standard	Routine	Active	Reference
Sockeye salmon	62.9	0.0840		0.596	Brett (1964)
Brook trout	100	0.103	0.152		Beamish (1964b)
	?	0.091			Flörke et al. (1954)
	164			0.210	Basu (1959)
Rainbow trout	?	0.140			Flörke et al. (1954)
Lake trout	27.7	0.0900		0.281	Gibson and Fry (1954)
	82.8	0.0650		0.265	
White sucker	100	0.0773	0.0962		Beamish (1964b)
Brown bullhead	15	0.168		0.378	Fry (1947)
	100	0.0463	0.0680		Beamish (1964b)
Carp	100	0.0336	0.0791		
	104			0.476	Basu (1959)
Goldfish	3.8	0.0800		0.155	Fry and Hart (1948)
	74			0.245	Basu (1959)
	100	0.0211			Beamish and Mookherjii (1964)
Yellow perch	?	0.0700			Flörke et al. (1954)
Generalized reservoir fish (estimated values)	100	0.0500	0.150	0.300	

* For additional data see Winberg (1956).

APPENDIX M: FISH TEMPERATURE TOLERANCES

Appendix M: Part I

Temperature Tolerance and Preference Data for Various Fish Species

Species	Age or Length	Acclimation Temperature	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or (Preferred)	T_3	T_4 Upper Lethal Temperature	Comments	Reference
Gizzard shad		25	10.8				34.3		Hart (1952)
		30	14.5				35.9		
Carp		26					35.7	24-hr TL50	Black (1953)
Common shiner		5					26.7		Hart (1947)
		10					28.6		
		15	0.0				30.3		
		20	3.7						
		25	7.8				31.0		
		30					31.0		
Common shiner	Adult	5					26.7		Hart (1952)
		10					28.6		
		15					30.3		
		20					31.0		
		25					31.0		
Golden shiner		22.0					≈ 40		Alpaugh (1972)
Golden shiner	Adult	10					29.5		Hart (1952)
		15					30.5		
		20					32.0		
		25					33.5		
		30					34.5		
Emerald shiner					27				McCormick and Mischuk (1973)
Emerald shiner		5					23.2		Hart (1947)
		10					26.7		
		15	1.6				28.9		
		20	5.2				30.7		
		25	8.0				30.7		
Duskystripe shiner		21.5					32.0	Ultimate upper incipient lethal.	Hickman and Dewey (1973)
Bluntnose minnow		5					26.0		Hart (1947)
		10					28.3		
		15	1.0				30.6		
		20	4.2				31.7		
		25	7.5				33.3		

* All temperatures in °C.

Appendix M: Part I (Continued)

Species	Age or Length	Acclimation Temperature	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or (Preferred)	T_3	T_4 Upper Lethal Temperature	Comments	Reference
Flathead minnow		10					28.2		Hart (1947)
		20	1.5				31.7		
		30	10.5				33.2		
Creek chub		5					24.7		Hart (1952)
		10					27.3		
		15					29.3		
		20	0.7				30.3		
		25	4.5				30.3		
Chub		14					27.1	24 hr TL50	Black (1953)
Finescaled sucker		14					26.9	24 hr TL50	Black (1953)
White sucker		25					31.2		Brett (1944)
White sucker	Adult I-II	5					26.3		Hart (1947)
		10					27.7		
		15					29.3		
		20	2.5				29.3		
		25	6.0				29.3		
White sucker					27				McCormick (1973)
Brown bullhead		5					27.8		Hart (1952)
		10					29.0		
		15					31.0		
		20					32.5		
		25					33.8		
		30					34.8		
		34					34.8		
Brown bullhead		5					28.6		Brett (1944)
		10					30.2		
		15					31.8		
		20	-1.0				33.4		
		25	1.3				35.0		
		30	3.7				36.5		
Black bullhead		23					35		Black (1953)
Channel catfish	Yearling	25					35.5		Allen and Strawn (1968)
		35					38.0		
Channel catfish	Fingerling			18	30	34			Andrews and Stickney (1972)

(Continued)

Appendix M: Part I (Continued)

Species	Age or Length	Acclimation Temperature	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or (Preferred)	T_3	T_4 Upper Lethal Temperature	Comments	Reference
Channel catfish		15	0.0				30.3		Hart (1952)
		20	2.5				32.8		
		25	6.0				33.5		
Bluegill		21.5					35.5		Hickman and Dewey (1973)
Bluegill	Adult	15	2.5				30.7		Hart (1952)
		20	5.0				31.5		
		25	7.5						
		30	11.1?				33.8?		
Bluegill	Juvenile	12.1	3.2				27.5	96-hr TL 50	Banner and Van Arman (1973)
		32.9	15.3				37.3	96-hr TL 50	
Bluegill	II				22				McComish (1971)
Longear sunfish	Juvenile	25					35.6		Neill et al. (1966)
		30					36.8		
		35					37.5		
Pumpkinseed		25					24.5		Brett (1944)
Smallmouth bass	Juvenile	16-35	1.6 @ 35 10.1 @ 26		26.3		35.0	96-hr TL 50 (median tolerance limit)	Horning and Pearson (1973)
Smallmouth bass					28.3				Peck (1965)
Largemouth bass	Fry	15-30			27.5 and 30.0				Strawn (1961)
Largemouth bass		18-30			25				Niimi and Beamish (1974)
Largemouth bass		20	5.5				32.5		Hart (1952)
		25					34.5		
		30	11.8				36.4		
Black crappie		29			22-25		32.5		Hokanson and Kleiner (unpublished)
Yellow perch		5					21.3		Hart (1947)
		10	1.1				25.0		
		15					27.7		
		25	3.7				29.7		
Yellow perch		25					30.9		Brett (1944)
Yellow perch	Juvenile	24		20.0		23.3			McCauley and Read (1973)
	Adult	24		17.6		20.1			

(Continued)

Appendix M: Part I (Continued)

Species	Age or Length	Acclimation Temperature	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or (Preferred)	T_3	T_4 Upper Lethal Temperature	Comments	Reference
Yellow perch	Fingerling	8			(18.6)				Ferguson (1958)
		10			(19.3)				
		15			(23.0)				
		20			(23.1)				
		25			(24.5)				
		30			(26.7)				
European perch							30-31	Independent of acclimation temperature	Weatherley (1963)
Sockeye salmon	Fry	5	0				22.2		Brett (1952)
		10	3.1				23.4		
		15	4.1				24.4		
		20	4.7				24.8		
Sockeye salmon	Juvenile	15		5	15	17			Brett et al. (1969)
Coho salmon	Fry	5	0.2				22.9		Brett (1952)
		10	1.7				23.7		
		15	3.5				24.3		
		20	4.5				25.0		
Chinook salmon	Fry				18.4				Olson and Foster (1955)
Northern pike	Larvae	17.7	3.2		26		28.4		Hokanson et al. (1973)
Northern pike	Juvenile	25					32.25		Scott (1964)
		27.5					32.75		
		30					33.25		
Lake trout	Yearling				(11.7)			Independent of acclimation temperature	McCauley and Tait (1970)
Lake trout				4(8)		(10) 18		Lake Louisa, Ontario, Canada	Martin (1952)
Lake trout				4(7)		(13) 18		Cayuga Lake, NY	Galligan (1962)
Lake trout				8		10.9		Lac la Ronge, Saskatchewan, Canada	Rawson (1961)
Lake trout				10		13		Moosehead Lake, MA	Cooper and Fuller (1945)
Lake trout	I-II	8, 15, 20			16.5		22.7, 23.5, 23.5		Gibson and Fry (1954)

(Continued)

Appendix M: Part I (Concluded)

Species	Age or Length	Acclimation Temperature	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or (Preferred)	T_3	T_4 Upper Lethal Temperature	Comments	Reference
Rainbow trout	Juvenile	18					26.5		Alabaster and Welcomme (1962)
Rainbow trout	Under-yearling 4-5 cm	15-20		17	(18.4)	20			McCauley and Pond (1971)
Brook trout		5					23.7		Fry et al. (1946)
		10					24.4		
		15					25.0		
		20					25.3		
		25	0.5				25.3		
Brook trout					13				Baldwin (1957)
Brook trout				14	16	19			Graham (1949)
Brook trout					15.4				McCormick et al. (1972)
Brown trout	Young				15.6				Pentelow (1939)
Brown trout					15.4				Wingfield (1940)
Brown trout					7-9 and 16-19				Brown (1946)
Brown trout					8-17, $\bar{x}$=125				Brett (1970)
Brown trout	Juvenile	5, 10, 20					22.2, 23.4, 23.5		Bishai (1960)
Mosquitofish		15	1.5				35.4		Hart (1952)
		20	5.5				37.3		
		25					37.3		
		30					37.3		
Goldfish		5					29.0		Fry et al. (1946)
		10					30.8		
		15					32.8		
		20	2.0				34.8		
		25	6.0				36.6		
		30	9.0				38.6		
Prickley sculpin		18-19					24.1		Black (1953)
Squawfish		19-22					28.9	24-hr TL50	Black (1953)
Muskellunge	Juvenile	25					32.25		Scott (1964)
		27.5					32.75		
		30					33.25		
Golden topminnow	Adult	35					38.5		Strawn and Dunn (1967)
Bayou killifish		35					38.5		Strawn and Dunn (1967)

Appendix M: Part II

Summary of Temperature Tolerances and Preferences for Reservoir Fish*

Species	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or Preferred	T_3	T_4 Upper Lethal Temperature
Gizzard shad	10.8 @ 25		16-18?		36.5 @ 35
Threadfin shad	≤1.1 in field				
Northern pike	3.2 @ 17.7 for larvae		26 (larvae)		33.3 @ 30 for juveniles
Grass pickerel			25.5		
Chain pickerel			26.0		≥36.7 in field
Muskellunge			24.0		33.3 @ 30 for juveniles
Carp	0.7		32.0		35.7 @ 26
Goldfish	0 @ 10		28.1		40.5 @ 35 (ultimate)
Golden shiner	1.5 @ 15				34.7 @ 30
Emerald shiner	1.6 @ 15		27		30.7 @ 25 (ultimate)
Common shiner	0 @ 15				32 @ 25-26
Spottail shiner					≥35 in field
Bluntnose minnow	1.0 @ 15				33.3 @ 25
Flathead minnow	1.5 @ 20				33.2 @ 30
Creek chub	0.7 @ 20				32.6 @ 25-26
Duskystripe shiner					32.0 @ 21.5
Longnose sucker					27 @ 11.5
White sucker	2.5 @ 20		27		31.2 @ 25-26
Largescale sucker					29.4 @ 19
Finescale sucker					26.9 @ 14
Brown bullhead	-1.0 @ 20				37.5 @ 36 (ultimate)
Black bullhead					35 @ 23
Channel catfish	0 at 15		30		38.0 @ 35 for yearlings
Banded killifish					≥38.3 in field
Golden topminnow					38.5 @ 35
Mosquitofish	1.5 @ 15				37.3 @ 20-35
Striped bass					32.2
Rock bass					35 @ 30

* All temperatures in ^{o}C.

Appendix M: Part II (Concluded)

Species	T_1 Lower Lethal Temperature	Best Temperature Range for Growth T_2	Optimum or Preferred	T_3	T_4 Upper Lethal Temperature
Longear sunfish	<7 in field				37.5 @ 35 for juveniles
Green sunfish					>34 in field
Redear sunfish	<6.5 in field				
Bluegill	2.5 @ 15		27.7		37.3 @ 32.9 for juveniles
Smallmouth bass	1.6 @ 15		27	28	35
Largemouth bass	5.2 @ 20	25	27	30	37.5 (average)
Pumpkinseed			31.5		24.5 @ 25
Black crappie		22		25	32.5 @ 29
Yellow perch	1.1 @ 10		24.2		30.9 @ 25
Rainbow trout	0		13.3		28
Brown trout		12	15.5	18	25.3 @ 20+ (ultimate)
Kokanee	0 @ 5		14.5		24.8 @ 20 for fry
Coho	0.2 @ 5				25.0 @ 20 for fry
Lake trout		8	12.0	12.0	23.5 @ 15 and 20
Brook trout	0.5 @ 25	10.8	12.8	14.8	26.6
Prickley sculpin					24.1 @ 18 and 19
Northern squawfish					29.3 @ 19-22