

Table 4. Turbidity tolerance and velocity associations of adult and juvenile (j) fishes. The strength of association is indicated as l=low, m=medium, and h=high. A blank indicates that no information was found to indicate the turbidity tolerance, or that the species utilizes a particular velocity class.

Common Name	Turbidity tolerant?	Velocity class				References
		Pool	Riffle	Run	Rapid	
american brook lamprey						S&C; B83
american brook lamprey (j)	no	h				Inferred from S&C
northern brook lamprey						S&C; B83
northern brook lamprey (j)	no	h				Inferred from S&C
silver lamprey						S&C; B83
silver lamprey (j)	no	h				Inferred from S&C
sea lamprey						S&C; B83
sea lamprey (j)	no	h				Inferred from S&C
lake sturgeon		h	l	m		S&C; B83; Houston 1987; Seyler 1997
lake sturgeon (j)		h ¹		h ²		Seyler 1997 ¹ ; inferred from Kempinger 1996 (for age 0 fish) ²
longnose gar	no ¹	h ²		m ²		¹ T81; ² S&C & T81; turbidity yes – Leslie Pers. Obs. – agric. Ditch, Duck Ck., Mitchell Bay.
bowfin	l	h		m		S&C; T81
american shad						
gizzard shad	yes	h				Williamson and Nelson 1985
gizzard shad (j)	yes	h				Williamson and Nelson 1985
pink salmon						
coho salmon						
coho salmon (j)		h				During late summer of first year S&C
chinook salmon						
chinook salmon (j)						
rainbow trout						
rainbow trout (j)						
Atlantic salmon						
Atlantic salmon (j)		h	m	m		Bremset and Berg 1997
brown trout		h ¹				¹ Inferred from Raleigh et al 1986
brown trout (j)		h ^{1,2}	m ²	m ²		¹ Inferred from Raleigh et al 1986; ² Bremset and Berg 1997
arctic charr						
brook trout		h	l	l		Inferred from Kozel & Hubert 1989; Cunjak & Green 1983
brook trout (j)		h	l	l		Same as adult, as inferred from Raleigh 1982
lake whitefish		h				George Coker Pers. Obs.
cisco		h		h		Inferred from S&C
pygmy whitefish						
rainbow smelt	no					Muth et al 1986; Hudson et al 1986
northern pike	no ¹	h ²		m ²		¹ Chapman and Mackay 1984; ² Inferred from S&C
northern pike (j)	no ¹	h ²		m ²		¹ Chapman and Mackay 1984; ² Inferred from S&C
muskellunge	no ¹	h ²		m ²		¹ Cook and Solomon 1987; ² Inferred from S&C
muskellunge (j)	no ¹	h ²		m ²		¹ Cook and Solomon 1987; ² Inferred from S&C
grass pickerel	no ¹	h ²		m ²		¹ T81; ² S&C & Crossman 1962
central mudminnow	no	h				T81; S&C; turbidity yes – Leslie and Timmins 1990 – Agric. Ditches, Duck Ck.
mooneye	no	h	h	h		S&C; T81
quillback		h		m		B83; Woodward and Wissing 1976.
longnose sucker	no					Inferred from S&C
white sucker	yes ¹	h ²		h ²		¹ T81; ² Aadland 1993
white sucker (j)			h	h		Inferred from Aadland 1993
lake chubsucker	yes	h				J&B;T81
northern hogsucker	no	h	h			S&C

Common Name	Turbidity tolerant?	Velocity class				References
		Pool	Riffle	Run	Rapid	
northern hogsucker (j)		h	h			Inferred from Aadland 1993
bigmouth buffalo	yes	h		m		Inferred from Goodchild 1990b
spotted sucker	no	h		m		Parker and McKee 1984
silver redhorse		h				S&C; J&B
black redhorse	no ¹	h ²	h ²	h ²		¹ T81; ² Kott and Rathmann 1985; ^{1,2} J&B
golden redhorse	yes	h	m			S&C; T81; J&B
shorthead redhorse		h		h		Inferred from S&C; Aadland 1993; J&B; and George Coker Pers. Obs.
greater redhorse	no ¹		h ²	h ²		¹ T81; ² Inferred from Yoder and Beaumier 1986, but too few specimens to provide confidence.
river redhorse	no ¹	h ²		h ²		¹ T81; ² Yoder and Beaumier 1986; ^{1,2} J&B
goldfish	yes	h		m		T81
northern redbelly dace		h				S&C.
finescale dace		h				S&C.
redside dace	no	h	h			B83
lake chub						
common carp	yes	h				T81
cutlips minnow	no	h		h		S&C; J&B
brassy minnow		h				S&C.
eastern silvery minnow	no	h				T81
hornyhead chub	l ¹	h ²				¹ T81; ² Dalton 1989a.
river chub	no ¹	h ²	h ²	h ²		¹ T81; ² Dalton 1989b; ^{1,2} J&B
golden shiner	yes	h				T81; turbidity no – Timmins unpubl 1998; Leslie and Timmins 1993.
pugnose shiner	no	h		m		Parker et al 1987b; turbidity yes – Timmins unpubl 1998; Leslie and Timmins 1993.
emerald shiner	no ¹	h ²		m ²		¹ T81; ² B83; ^{1,2} J&B
bridle shiner		h				S&C
common shiner	no ¹	h ²				¹ T81; ² Aadland 1993; ^{1,2} J&B
blackchin shiner	no	h				T81
blacknose shiner	no	h				T81
spottail shiner	no ¹	h ²	h ³			¹ T81; ² Lobb and Orth 1991; Vadas and Orth 1997; ³ Aadland 1993.
rosyface shiner	no ¹	m ²	h ²	h ²	h ²	¹ S&C; ² Lobb and Orth 1991.
spotfin shiner	yes ¹	h ²	l ²	l ²		¹ T81; ² Inferred from Lobb and Orth 1991.
sand shiner		h	h			T81
redfin shiner	yes ¹	h ²				¹ T81; ² S&C.
mimic shiner		h	h			T81
pugnose minnow	no	h				Parker et al 1987a; turbidity yes – Timmins unpubl. 1998 – Canard R.
bluntnose minnow	yes ¹	h ²	m ²	h ²		¹ T81; ² Inferred from Aadland 1993.
fathead minnow	yes	h		h		T81
blacknose dace	l	h	h	h		T81; Vadas and Orth 1997
longnose dace			h		h	S&C
creek chub	yes ¹	h ²		h ²		¹ T81; ² McMahon 1982.
fallfish	no	h		h		Trial et al 1983
pearl dace	no ¹	h ²	l ²	m ²		¹ S&C; ² Tallman and Gee 1982; J&B most common in pools
silver shiner	no	h	h	h		T81
central stoneroller		h	h	m		B83; Vadas and Orth 1997
striped shiner	no	m	m	h		Inferred from Goodchild 1993b
ghost shiner	yes	h		h		Holm and Houston 1993
black bullhead	yes	h		h		S&C
black bullhead (j)		h				Aadland 1993
yellow bullhead	yes	h		h		S&C; Leslie and Timmins 1998 – Duck Ck.

Common Name	Turbidity tolerant?	Velocity class				References
		Pool	Riffle	Run	Rapid	
brown bullhead	yes	h		h		S&C; Leslie and Timmins 1998 – Duck Ck., Cootes Paradise
channel catfish	l	h	h	h		McMahon and Terrell 1982.
stonecat	no		h			T81
tadpole madtom	l	h				S&C; T81
brindled madtom		h	m			Burr and Mayden 1982
northern madtom	l		h			Goodchild 1993c
American eel	yes	h				B83
banded killifish	no	h				Houston 1990b
blackstripe topminnow	yes	h				McAllister 1987
burbot		h		h		S&C
brook stickleback	no ¹	h ²		h ²		¹ T81; ² Inferred from S&C; George Coker Common Pers. Obs.
threespine stickleback		h		h		Inferred from S&C; Sandlund et al 1992; George Coker Pers. Obs.
ninespine stickleback		h		h		Inferred from S&C; George Coker Pers. Obs.
trout-perch	yes ¹	h ²				¹ S&C; ² T81; ³ Aadland 1993.
white perch		h ¹				¹ Inferred from J&B; George Coker Pers. Obs.
white bass	no	h ¹				S&C; T81; ¹ Inferred from S&C; T81; turbidity somewhat – Sternberg 1987 ISBN 86573-023-7
rock bass	yes	h				S&C; Pajak and Neves 1987; Timmins unpubl. 1998.
green sunfish	yes	h				T81; Stuber et al 1982c
green sunfish (j)	yes					Leslie and Timmins 1998 – Duck Ck.
pumpkinseed	no	h				T81
bluegill	l	h				T81
longear sunfish	no	h				T81; turbidity yes – Timmins unpubl. 1998.
smallmouth bass	no ¹	h	h			¹ T81; B83; Rankin; Vadas and Orth 1997 (pool only).
smallmouth bass (j)	no ¹	h ²				¹ T81; ² Edwards et al 1983
largemouth bass	no ¹	h				¹ T81; Stuber et al 1982b
largemouth bass (j)	yes					Leslie and Timmins 1998 – Duck Ck.
white crappie	yes	h				T81
black crappie	m	h				T81
warmouth	m	h				T81
orangespotted sunfish	yes	h				T81
yellow perch	no	h				T81
yellow perch (j)						
sauger	yes ¹	h ²		h ²		¹ S&C; ² Inferred from S&C and Paragamian 1989 and T81.
walleye	yes ¹	h ²		m ²		¹ S&C; ² Inferred from S&C and Paragamian 1989 and T81; low tolerance
walleye (j)	yes ¹	h ²		m ²		¹ S&C; ² Inferred from S&C and Paragamian 1989 and T81.; low tolerance
eastern sand darter	yes ¹	h ²		h ²		¹ Holm and Mandrak 1995; ² Daniels 1993
greenside darter	no		h			Dalton 1991; Bunt et al 1998.
rainbow darter	no	h	h			B83
Iowa darter	no	h				S&C
fantail darter	l ¹		h ²			¹ T81; ² Englert and Seghers 1983; ³ Vadas and Orth 1997.
least darter	no	h				S&C; T81.
johnny darter	yes ¹	h ²	m ²	h ²		¹ T81; ² S&C.
logperch		h	h			B83
channel darter	no	h		h		Inferred from T81.
blackside darter	l	h ¹				S&C; ¹ Aadland 1993.
river darter			h			T81
tesselated darter		h		h		Goodchild 1993a.
brook silverside	no	h		m		Inferred from Goodchild 1990a.

Common Name	Turbidity tolerant?	Velocity class				References
		Pool	Riffle	Run	Rapid	
freshwater drum	m'	h				B83; 'T81; turbidity yes – Timmins unpubl. 1998 – Canard R.
mottled sculpin	l	h	h			B83; Matheson and Brooks 1983
slimy sculpin		h	h			B83
spoonhead sculpin	yes					Houston 1990a
rudd		h				Inferred from Johansson 1987 and Eklov and Hamrin 1989.
ruffe	yes					Ogle 1995
round goby	yes					Leslie and Timmins 1998 – Duck Ck.
tubnose goby	yes					Leslie and Timmins 1998 – Duck Ck.

Table 5. Depth strata used for spawning by fishes. The strength of association is indicated as l=low, m=medium, and h=high. A blank indicates that no information was found to indicate that a species used a particular depth stratum.

Common Name	Depth Strata, cm					References
	0-20	21-60	61-100	101-200	>200	
american brook lamprey	h	h				B83
northern brook lamprey		h				S&C
silver lamprey						
sea lamprey		h				S&C
lake sturgeon			h	h	h	S&C; Houston 1987
longnose gar						
bowfin		h				S&C
american shad						
gizzard shad	m	h	h	m		Williamson and Nelson 1985
pink salmon		h	m			Kwain and Lawrie 1981
coho salmon	h	h				B83
chinook salmon		h	h			Carl 1984
rainbow trout		h	h	h	h	Raleigh et al 1984
Atlantic salmon		h				Beland et al 1982.
brown trout	m	h	h	h	h	Raleigh et al 1986
arctic charr				h	h	Moore 1975
brook trout	h	h	h			Witzel and MacCrimmon 1983; Reiser and Wesche 1979; Smith 1979
lake whitefish					h	S&C
cisco				h	h	S&C
pygmy whitefish						
rainbow smelt						
northern pike	h	h	h	h	h	0.5 - 2.6 m Farrell et al 1996
muskellunge	h	h	m			B83; S&C; Dombeck et al 1984
grass pickerel						
central mudminnow						
mooneye						
quillback						
longnose sucker	m	h				S&C.
white sucker						
lake chubsucker						
northern hogsucker	h					S&C
bigmouth buffalo		h				Goodchild 1990b
spotted sucker		h	h			B83
silver redhorse		h	h			S&C; Inferred from J&B
black redhorse	h	h				Kwak and Skelly 1992
golden redhorse	h	m				Inferred from J&B – very shallow runs/riffles
shorthead redhorse						
greater redhorse		h				Aadland 1993
river redhorse		h	h	m		Inferred from J&B – 0.2-1.2 m
goldfish	h					B83
northern redbelly dace						
finescale dace		h	h			B83
redside dace						
lake chub	h					B83
common carp	h	h	h	h		B83
cutlips minnow						
brassy minnow						
eastern silvery minnow		h				S&C
hornyhead chub	m	h				Dalton 1989a
river chub		m	h			Dalton 1989b

Common Name	Depth Strata, cm					References
	0-20	21-60	61-100	101-200	>200	
golden shiner						
pugnose shiner						
emerald shiner					h	B83
bridle shiner	h	h	m			Inferred from Harrington 1947
common shiner						
blackchin shiner						
blacknose shiner						
spottail shiner						
rosyface shiner						
spotfin shiner						
sand shiner						
redfin shiner						
mimic shiner						
pugnose minnow						
bluntnose minnow	h	h	h			S&C
fathead minnow			h			S&C
blacknose dace						
longnose dace	h					B83
creek chub						
fallfish	h	h				Trial et al 1983
pearl dace			h			B83
silver shiner						
central stoneroller		h				B83
striped shiner						
ghost shiner						
black bullhead		h	h			B83
yellow bullhead						
brown bullhead	h	h	h			S&C
channel catfish						
stonecat						
tadpole madtom						
brindled madtom						
northern madtom						
American eel						
banded killifish						
blackstripe topminnow						
burbot				h	h	S&C
brook stickleback						
threespine stickleback						
ninespine stickleback						
trout-perch						
white perch						
white bass		h	h	h		B83
rock bass	h	h	h			B83
green sunfish	h	m				S&C
pumpkinseed	h	m				S&C
bluegill			h			S&C
longear sunfish	h	m				S&C
smallmouth bass		h	h	h	h	S&C; Goff 1986
largemouth bass		h	h	h		B83
white crappie	h	h	h	h		B83
black crappie		h				S&C
warmouth	h	h	h			B83
orangespotted sunfish	h	h				B83
yellow perch		h	h	h	h	B83
sauger			h	h	h	S&C

Common Name	Depth Strata, cm					References
	0-20	21-60	61-100	101-200	>200	
walleye		m	h			Aadland et al 1991
eastern sand darter	h	h				Inferred from Holm and Mandrak 1995
greenside darter						
rainbow darter			h			B83
Iowa darter		h				B83
fantail darter	h	h				S&C
least darter		h				B83
johnny darter						
logperch						
channel darter						
blackside darter		m	h	h		Inferred from S&C
river darter			h			B83
tesselated darter		h				Goodchild 1993a
brook silverside						
freshwater drum	h	h	h	h		S&C – a considerable amount of uncertainty.
mottled sculpin	h					B83
slimy sculpin						
spoonhead sculpin						
rudd						
ruffe	h	h	h	h	h	Ogle 1995
round goby	h	h	h	h		Marsden et al 1996
tubenose goby						

Table 6. The relative utilization (low = l, medium=m, h= high) of various substrates for spawning. A blank indicates that no information was found indicating that a species used the particular substrate.

Common Name	Substrate									References
	Bedrock	Boulder	Cobble	Rubble	Gravel	Sand	Silt/Clay	Hard-pan	Detritus	
american brook lamprey			h	h	h					S&C
northern brook lamprey			h	h	h					S&C
silver lamprey					h					S&C
sea lamprey				h	h	h				S&C
lake sturgeon		h	h	h	h	h				Houston 1987
longnose gar										
bowfin										
american shad										J&B pelagic spawners
gizzard shad			h ¹	h ¹	h ¹	h ²				¹ Williamson and Nelson 1985; ² S&C
pink salmon					h					S&C
coho salmon					h					S&C; B83
chinook salmon					h					Carl 1984
rainbow trout					h					S&C
Atlantic salmon					h					S&C
brown trout					h					S&C; Beard and Carline 1991; Raleigh et al 1986
arctic charr		m	m	m	h	h				Inferred from Moore 1975 and S&C
brook trout					h	h				S&C; Witzel and MacCrimmon 1983
lake whitefish	h	h	h	h	h	m				Inferred from S&C and Ihssen et al 1981
cisco		h	h	h	h					Inferred from S&C
pygmy whitefish					h					S&C
rainbow smelt					h					S&C
northern pike										
muskellunge										
grass pickerel										
central mudminnow										
mooneye										
quillback						h	h			S&C
longnose sucker				h	h					S&C
white sucker				h	h					S&C; C. Portt Pers. Obs.
lake chubsucker					h					S&C
northern hogsucker					h					S&C; Matheny and Rabeni 1995
bigmouth buffalo										
spotted sucker				h						Parker and McKee 1984
silver redhorse				h	h					S&C; J&B
black redhorse			h	h	h					Kwak and Skelly 1992
golden redhorse				h	h	h				T81

Common Name	Substrate									References
	Bedrock	Boulder	Cobble	Rubble	Gravel	Sand	Silt/Clay	Hard-pan	Detritus	
shorthead redhorse				m	h					S&C; Curry & Spacie 1984; Inferred from J&B
greater redhorse										
river redhorse		h ¹	h ¹	h ²	h ²					¹ Parker 1988; ² J&B
goldfish										
northern redbelly dace										
finescale dace							h		h	B83
redside dace					h					S&C
lake chub				h	h		h		h	B83
common carp										
cutlips minnow					h					Van Duzer 1939
brassy minnow							h			S&C
eastern silvery minnow							h			S&C
homyhead chub					h					Dalton 1989a
river chub					h					Dalton 1989b
golden shiner					h	h	h		h	Inferred from Shao 1997 as same as pumpkinseed.
pugnose shiner										
emerald shiner					h					J&B typically over gravel but will use other types, pelagic spawning in lakes
bridle shiner										
common shiner					h					S&C
blackchin shiner										
blacknose shiner						h				B83
spottail shiner				h		h				S&C; Mansfield 1984
rosyface shiner					h					S&C
spotfin shiner										J&B eggs deposited in crevices formed by loose bark on fallen logs or stumps
sand shiner					h	h				S&C
redfin shiner					h	h				T81
mimic shiner										
pugnose minnow										
bluntnose minnow										
fathead minnow										
blacknose dace					h					S&C
longnose dace					h					S&C
creek chub					h					S&C
fallfish					h					S&C.
pearl dace					h	h				B83
silver shiner										
central stoneroller					h					B83
striped shiner					h					B83

Common Name	Substrate									References
	Bedrock	Boulder	Cobble	Rubble	Gravel	Sand	Silt/Clay	Hard-pan	Detritus	
ghost shiner										
black bullhead						h				B83
yellow bullhead										
brown bullhead						h	h			S&C
channel catfish						h				B83
stonecat		h	h	h						Inferred from S&C
tadpole madtom						h				B83; Whiteside and Burr 1986
brindled madtom							h		h	S&C
northern madtom										
American eel										
banded killifish										
blackstripe topminnow										
burbot					h	h				S&C
brook stickleback										
threespine stickleback						h				S&C
ninespine stickleback				h						Foster 1977
trout-perch				h	h	h				S&C; B83
white perch			h	h	h	h				J&B sandy and rocky shoals in rivers & tribs
white bass				h	h	h				B83
rock bass					h	h	h			Inferred from S&C.
green sunfish					h	h				Stuber et al 1982c
pumpkinseed					h	h	h		h	S&C; B83
bluegill					h	h				B83; Stuber et al 1982a
longear sunfish					h	m	m			S&C
smallmouth bass				h	h	h				S&C
largemouth bass					m	h	h		h	S&C
white crappie						h	h	h		B83
black crappie					h	h	h			S&C
warmouth						h	h		h	B83
orangespotted sunfish						h	h		h	B83
yellow perch					h	h				S&C
sauger				h	h	h				B83; S&C
walleye			h	h						S&C
eastern sand darter						h				Inferred from Holm and Mandrak 1995
greenside darter	h	h	h	h	h					S&C; Dalton 1991
rainbow darter				h	h	h				S&C
Iowa darter					h	h				B83
fantail darter		h			h					S&C
least darter										
johnny darter					h	h				B83

Common Name	Substrate									References
	Bedrock	Boulder	Cobble	Rubble	Gravel	Sand	Silt/Clay	Hard-pan	Detritus	
logperch					h	h				B83
channel darter					h					S&C
blackside darter					h	h				S&C
river darter	h	h	h	h	h					B83
tesselated darter			h		h	h				Goodchild 1993a
brook silverside				h	h	h				Goodchild 1990a
freshwater drum										
mottled sculpin				h	h	m	m			B83; inferred from Savage 1963
slimy sculpin				h						
spoonhead sculpin										
rudd										
ruffe					h	h	h			Simon and Vondruska 1991; Ogle 1995
round goby			h	h	h	m				Marsden et al 1996; Jude et al 1992, 1996
tubenose goby			h	h	h	m				Jude et al 1992, 1996

Table 7. Strength of association (low = l, medium=m, h= high) with various forms of cover during spawning. The vegetation types include e-emergent, s-submergent, ft-flooded terrestrial, in-inshore terrestrial. A blank indicates that no information was found to indicate that a species has an affinity for cover during spawning.

Common Name	Cover						References
	Vegetation	Type	Algae	Wood	Substrate	Overhead	
american brook lamprey					h		S&C
northern brook lamprey					h		S&C
silver lamprey					h		S&C
sea lamprey					h		S&C
lake sturgeon							
longnose gar	h	s					S&C
bowfin	h	s		h			S&C
american shad							J&B nocover, pelagic river spawners
gizzard shad	h						Williamson and Nelson 1985.
pink salmon							
coho salmon							
chinook salmon							
rainbow trout							likely not important -Raleigh et al 1984
Atlantic salmon							
brown trout							
arctic charr							
brook trout				h			Witzel and McCrimmon 1983
lake whitefish							
cisco							
pygmy whitefish							
rainbow smelt							
northern pike	h	ft, 2s,f					Casselman and Lewis 1996; 4Farrell et al 1996
muskellunge	h	ft, 2s,f		m	m		S&C; B83; Dombeck et al 1984; 2Farrell et al 1996.
grass pickerel	h	ft					S&C.
central mudminnow	h	ln,ft					S&C; Peckham and Dineen 1957
mooneye							
quillback							
longnose sucker							
white sucker							
lake chubsucker	h						Inferred from S&C & J&B
northern hogsucker							
bigmouth buffalo	h	s					Goodchild 1990b
spotted sucker							
silver redhorse							
black redhorse							
golden redhorse							
shorthead redhorse							
greater redhorse							
river redhorse							
goldfish	h						S&C
northern redbelly dace			h				S&C
finescale dace				h			B83; Staciak 1978
redside dace							
lake chub							
common carp	h						S&C
cutlips minnow				h	h		Van Duzer 1939
brassy minnow							

Common Name	Cover						References
	Vegetation	Type	Algae	Wood	Substrate	Overhead	
eastern silvery minnow	h	e*					S&C - * grass and reeds
hornyhead chub							
river chub							
golden shiner	h		h		h ¹		B83; S&C
pugnose shiner							
emerald shiner							
bridle shiner	h	s					Harrington 1947
common shiner							
blackchin shiner							
blacknose shiner							
spottail shiner							
rosyface shiner							
spotfin shiner				h	h		S&C; T81
sand shiner							
redfin shiner							
mimic shiner	h						B83
pugnose minnow							
bluntnose minnow				h	h	h	S&C
fathead minnow				h	h	h	S&C
blacknose dace							
longnose dace							
creek chub							
fallfish				h			Trial et al 1983
pearl dace							
silver shiner							
central stoneroller						h	B83
striped shiner							
ghost shiner							
black bullhead	h			h		h	S&C; B83
yellow bullhead				h	h	h	S&C
brown bullhead	h			h		h	S&C
channel catfish				h		h	McMahon and Terrell 1982
stonecat					h		S&C
tadpole madtom				h	h		Inferred from S&C
brindled madtom	l ¹			h	h		¹ S&C; Burr and Mayden 1982.
northern madtom					h		Goodchild 1993c
American eel							
banded killifish	h	s	h				S&C
blackstripe topminnow	h	s					McAllister 1987
burbot							
brook stickleback	h		h				S&C
threespine stickleback							
ninespine stickleback					h		Foster 1977
trout-perch							
white perch							J&B nocover, over open substrate
white bass							
rock bass							
green sunfish	h			h			B83
pumpkinseed	m						S&C
bluegill							
longear sunfish							
smallmouth bass				h	h		S&C
largemouth bass	h						S&C
white crappie	h					h	B83
black crappie	h					m	B83
warmouth	h			h			B83

Common Name	Cover						References
	Vegetation	Type	Algae	Wood	Substrate	Overhead	
orangespotted sunfish							
yellow perch	h			h			S&C
sauger							
walleye							
eastern sand darter							
greenside darter			h				S&C; Dalton 1991
rainbow darter							
iowa darter	h					h	B83
fantail darter					h	h	T81
least darter	h				l		S&C
johnny darter				h	h		B83
logperch							
channel darter					h		S&C
blackside darter							
river darter							
tesselated darter					h		Goodchild 1993a.
brook silverside	h						Goodchild 1990a
freshwater drum							
mottled sculpin					h	h	S&C; Downhower and Brown 1979
slimy sculpin					h	h	S&C
spoonhead sculpin							
rudd	h						Inferred from Rheinberger et al 1987
ruffe	h			m	m		Ogle 1995
round goby	h			h	h		Marsden et al 1996
tubenose goby							

Table 8. Turbidity tolerance and strength of association (low = l, medium = m, high = h) of spawning fishes with four velocity categories. A blank indicates that no information was found to indicate the turbidity tolerance or that the species uses a particular velocity range.

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
american brook lamprey	no ¹		h			B83; ¹ inferred from T81; inferred from J&B	stones 25-152 mm, May-June, high gradient habitat. (peak spawning water temp 16.7 - S&C).
northern brook lamprey	no ¹		h			T81; ¹ inferred from T81	prefers creeks and small rivers, spawning is early May-June at 12.8-15.6 degC. Generally prefer warmer water than brook trout requires (S&C)
silver lamprey	no ¹		h			S&C; ¹ inferred from T81	May&June, larger rivers (S&C)
sea lamprey	no ¹		h			S&C; ¹ inferred from T81	moderate current, mid-June, full range 11.1-24.4 deg(S&C)
lake sturgeon	no ¹		h		h	S&C; Houston 1987; ¹ T81	May-June; below waterfalls or rapids, spawn in lakes if no rivers, optimal temperature 13-18 deg (S&C)
longnose gar		h				S&C	Mid-June in Georgian Bay, Ontario. Spawning takes place over submerged vegetation, in the warm shallows of lakes and large streams. The adhesive eggs stick to aquatic vegetation (S&C).
bowfin		h				S&C.	Late April, May, and early June when water temperature was 16-19 deg. Males construct crude nests (S&C).
american shad							Spawn in open water near surface when water temperatures reach 12 degrees, with maximum spawning at 18.3 degrees. Eggs are non-adhesive (S&C). 13-20 C (J&B)
gizzard shad		h				S&C; Williamson and Nelson 1985	In Ohio, spawning occurred from early June to early July, at temperatures of 17.2-22.8 degrees (S&C).
pink salmon			h			Kwain and Lawrie 1981	At upstream end of riffles, at 11 - 13 degrees (Kwain and Lawrie 1981).
coho salmon			h			S&C	Spawn during November - January. Hatch in early spring (S&C). West Coast literature states that chinook salmon tend to reproduce in larger coolwater streams, while coho tend to reproduce more often in the smaller tributaries (Carl 1982).

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
chinook salmon			h			S&C; B83; 1983; Carl 1984	September, October, and November in Lake Michigan tributaries (Carl 1984). Most chinook salmon reproduction occurred in the larger trout streams around Lake Michigan, which agrees with West Coast literature that states that chinook salmon tend to reproduce in larger coolwater streams, while coho tend to reproduce more often in the smaller tributaries (Carl 1982).
rainbow trout			h			S&C	spring spawners, riffle above pool, temperature 10-15.5 deg (S&C)
Atlantic salmon			h	h		S&C	Gravel area above or below a pool (S&C). Mean water velocity 53 cm/s (Beland et al 1982).
brown trout			h			S&C; Beard and Carline 1991; Witzel and MacCrimmon 1983	late autumn, early winter; velocity=33-50 cm/s, temperature 6.7-8.8 deg
arctic charr		h ¹	h ²			¹ S&C; ² Moore 1975	Takes place during day at 4 degrees (S&C).
brook trout		h	m			Witzel and MacCrimmon 1983	Brook trout spawn in areas of groundwater upwelling in the fall when water temperatures are 4 - 13C (Witzel and MacCrimmon 1983).
lake whitefish							Spawning occurs in the autumn when water temperatures drop to 7.8 degrees (S&C). Early November in 1995 in the Abitibi River (Kevin Reid, Beak Consultants, personal communication). There appears to be no river spawning information, however, we assume that areas similar to their usual lacustrine spawning areas are used in or adjacent to the deep pools of rivers.
cisco		h				Fielder 1997	We assume that the same habitat used in lakes is also used in the lacustrine areas of large rivers, however, B83 suggests that this species rarely spawns in rivers. Spawning occurs at temperatures of 4 - 5 degrees (S&C). Early December is the usual time in Lake Simcoe (MacCrimmon and Skobe, 1970). Fielder (1997) found spawning areas in the lacustrine portions of the St Marys River, connecting Superior and Huron.
pygmy whitefish							Spawning may take place in rivers during November and December for Lake Superior fish, however, there is very little information on this species (S&C).
rainbow smelt			h			S&C.	Spawn in rivers and lake shoals with a current. Usually in March, April, or May when water temperature reaches about 8.9 degrees (S&C).

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
northern pike							spawn on flood plains, water temp 4.4-11.1 deg (S&C).
muskellunge							late Apr, early May, water temp 7.2-11.7 deg (S&C).
grass pickerel							spawn on flood plains, water temp 4.4-11.1 deg (S&C).
central mudminnow		h				Inferred from S&C; Peckham and Dineen 1957	Likely mid to late April in Ontario, when water temp are 12.8 deg. Spawn in shallow near-shore or flooded bank vegetation (S&C). T81 suggests that they will migrate up tributary streams a short way to suitable habitat.
mooneye			h	h		Wallus and Buchanan 1989.	Migrate during Apr - May, up large clear streams (S&C). Spawning occurs in flowing water in the Tennessee River (Wallus and Buchanan, 1989).
quillback		h				Inferred from S&C.	overflow areas of rivers, quiet areas (S&C), at water temperatures of 18.3-24.0 deg during April - August (Woodward and Wissing 1976).
longnose sucker			h			S&C.	A stream spawning species if streams are available. Usually mid-Apr to mid-May when water temperature exceeds 5 deg (S&C).
white sucker			h		h	S&C; B83	early May - early jun, in shallow water, water temp 10 deg (S&C).
lake chubsucker		h		h		Inferred from S&C and T81	In streams, eggs are scattered over a gravelly area cleaned by the male. Eggs take 6-7 days to hatch at 22-29.4 deg (S&C).
northern hogsucker		m	h			S&C	May, when water temperatures reach 15.6 deg (S&C).
bigmouth buffalo		h				Inferred from S&C and Goodchild 1990b	In Illinois, spawning occurred at the end of April in water 8-10 deg (Goodchild, 1990b)
spotted sucker		m	h			B83	Likely in May in Canada (Inferred from Parker and McKee, 1984). Water temperatures at spawning were 12-19 deg in Georgia creeks (Parker and McKee 1984).
silver redhorse			h			S&C; J&B	Swiftly flowing streams in spring when water temp reached 13.3 deg. In southern Ontario spawning has been observed in early June (S&C). Spawning temperature range is 11-15 C (J&B)
black redhorse			h			Kwak and Skelly 1992	In Ontario, mid May to early June when water temp ranged from 9-15 deg (Beak Consultants Limited, 1980).
golden redhorse			h			B83; Aadland 1993	In Ohio spawning occurred from late April to late May (Trautman). In Iowa, water temperatures at the start of spawning were 15-15.5 deg (S&C). Spawning temperature range is 10-22.5 C (J&B)

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
shorthead redhorse			h			S&C	Spring and early summer in Canada, likely when temperatures are approximately 11.1 deg, which is the spawning temperature in Iowa (S&C).
greater redhorse			h			Aadland 1993; Inferred from S&C.	Likely May to July in Canada. Very little is known about this species (S&C).
river redhorse			h			Parker 1988	Late May or early June. Recently spent specimens were collected at water temperatures of 20-22 deg in late June from the Mississippi River, Ontario (Parker 1988). Spawning temperature range is 18-24.3 C (J&B)
goldfish		h				Inferred from S&C	May-Jun. Eggs incubate at 18.5-29.5 deg (S&C).
northern redbelly dace		h				Inferred from S&C.	Spawn amid algae. mid-late June. In Michigan eggs hatched in 8-10 days at 21.1-26.7 deg (S&C)
finescale dace		h				Stasiak 1978	Late April and May, when water temperature exceeded 15 deg (Stasiak 1978).
redside dace			h			S&C	Spawning has been observed in late May (New York state) when water temperature exceeded 18 C. Spawning usually occurred near or in the gravelly nests of creek chub (S&C).
lake chub		h				Inferred from Brown et al 1970	April and May in Lake Ontario. Spawning run apparently initiated when water temperature in stream was 10 deg, while lake was still 4.5 deg (George A. Coker personal observation). Brown et al (1970) also states that the spawning run was initiated at 10 degrees in Sackatchewan.
common carp		h		h		Inferred from S&C; and T8.	spring, early summer, in weedy inshore shallows, when water temperature was >17 deg (S&C).
cutlips minnow		h		h		Van Duzer 1939; J&B	May-July, water temperature at start of breeding was 20 deg. Current was sufficient to ensure a constant change in water. Locations near excessive detritus or vegetation were avoided (Van Duzer, 1939). Nesting period late May to early June (16.1-21.5 C) in NY, spawning observed at 16.1-18.9 C (J&B)
brassy minnow	no ¹	h				¹ Inferred from S&C. S&C.	May-June, in quiet water over a silt bottom (S&C).
eastern silvery minnow		h				S&C	Likely in May in Canada, at temp of 13-20.5 deg. Moved into lower reaches of tributary stream, or into larger weedy sections of rivers (S&C).

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
homyhead chub	no	h ¹		h ¹		Inferred from S&C; and Dalton 1989a	During spring when water temperatures reach 23.9 deg (S&C).
river chub	no ¹	h ²		h ²		¹ Dalton 1989b; ² Inferred from Dalton 1989b	Spring spawning (S&C).
golden shiner		h				Inferred from S&C	Scatter eggs over attached alge and other vegetation. June - Aug, temperatures of 20 deg (S&C).
pugnose shiner		h				Inferred from S&C	Likely June in Ontario (S&C). There is almost no information on spawning for this rare species.
emerald shiner		h				Inferred from S&C	Generally spawn in lakes, June-Aug. Water temperature at spawning was 24 deg. Pelagic spawners (S&C). Spawns over gravel in streams (J&B)
bridle shiner		h				Harrington 1947	Assumed to be phytophylls. Spawn in May-July in New Hampshire, with water temperatures at 14.4-26.7 deg (Harrington 1947).
common shiner			h			S&C	May-June, some current, water temperatures 15.6-18.3 deg (S&C)
blackchin shiner							In central Illinois it spawned from May - June (S&C). Spawning habitat likely similar to adult habitat. Very little information on spawning habitat for this species.
blacknose shiner							Spawned in July in Lake Nipigon (S&C). Spawning habitat is likely similar to adult habitat. Very little information on this species.
spottail shiner		h ¹	h ²	h ¹		¹ Inferred form S&C; ² Mansfield 1984.	Spawning appears to take place over sand shoals in lakes (S&C), and likely occurs in similar fashion in rivers. Spottails moved into Lake Superior tributaries. There are other known instances of lake spottail shiners, migrating a short distance up tributary streams to spawn at riffle areas (Mansfield 1984). Spawning occurred when water temperatures in the tributary stream reached 18 deg on May 22 (Mansfield 1984).
rosyface shiner		h	h			S&C; J&B	Spawned in June in New York, at water temperatures of 26.1-28.9 deg (S&C).Range of spawning temperature reported is 20.0-29.8 (J&B)
spotfin shiner							May - mid Aug in New York (S&C).
sand shiner							June-August in Iowa (S&C). Aadland et al (1991) collected ripe sand shiners over gravel in riffles with a mean velocity of 44 cm/s and a mean depth of 29 cm.

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
redfin shiner		h	h			T81	In sluggish riffles, or pools with some current (S&C).
mimic shiner		h				B83	July in Shriner Lake, Indiana (S&C).
pugnose minnow							Spawns in mid June in Illinois (Parker et al 1987a). There apparently is almost no useful information on the spawning habits of this rare species.
bluntnose minnow		h				Inferred from S&C	Substrate irrelevant, except when it includes stones under which eggs may be laid. May-Aug when water temperatures reach 20 deg (S&C).
fathead minnow	Yes ¹	h ²				¹ T81; ² Inferred from S&C.	Substrate irrelevant, except when it includes stones under which eggs may be laid. May-Aug, starts at 15.6 deg (S&C)
blacknose dace			h			S&C	May-June, when temperatures reach about 21.1 deg (S&C)
longnose dace			h			S&C	generally May, June, or July when water temp reach about 11.7 deg (S&C)
creek chub				h		S&C	just above or below a riffle (S&C), current = 0.2-0.6 m/sec (McMahon 1982), beginning at temp of 12.8 deg (S&C).
fallfish				h		Inferred from S&C	Move from larger streams to smaller streams, and occurs after water temperatures reach 15 deg (Trial et al 1983). In Quebec, spawning started in tributary streams at 16.6 deg on May 20 (S&C).
pearl dace			h			B83	Spawn in spring when water temperatures were approximately 18 deg, in a weak or moderate current (S&C).
silver shiner							Spawning occurred in deeper water than they were usually captured. Occurred during June at water temp of 17-22 deg (McKee and Parker 1982).
central stoneroller		h	m			McKee and Parker 1982	mid May in the Thames River, with flow velocities of 0.3 - 0.45 m/s, and water temperatures of 14 - 16 C. Most spawning may occur in the smaller tributaries (McKee and Parker 1982).
striped shiner			h			B83	June in Canadian tributaries of Lake Erie, and at water temperatures of 15-18 deg in the US (Goodchild 1993b).
ghost shiner							June - Aug in Wisconsin (Becker 1983). Likely second half of June In Ontario, when water temperatures exceed 19 deg. Very little is known about the biology of this species (Holm and Houston 1993).

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
black bullhead		h				Inferred from S&C	May - June, or when water temperatures reach 21 deg (S&C).
yellow bullhead		h				Inferred from S&C	late May-June, possibly earlier than other bullhead species (S&C).
brown bullhead		h				Inferred from S&C	May-June when water temperatures reach 21.1 deg (S&C).
channel catfish		h		h		Inferred from S&C; and McMahon and Terrell 1982	Spawn between 23.9 and 29.5 deg, in secluded, semi-dark nests built in holes, log jams, undercut banks, or rocks (S&C).
stonecat			h			B83	Summer - Aug with June and July being best. Peak spawning water temp is 27.8 deg. Deposits sticky eggs beneath stones in riffles (S&C).
tadpole madtom		h		h		Inferred from Whiteside and Burr 1986.	Likely in late June - July in Canada (S&C). Likely in slow flowing water or pools (Inferred from S&C and Whiteside and Burr (1986)).
brindled madtom		h ¹	h ²			¹ most authors (Burr and Mayden 1982); ² T81.	July-early Aug in Ohio, when water temperatures were 25-27 deg (Parker and McKee 1987).
northern madtom							Egg masses collected from middle to late July in Michigan (Goodchild 1993c).
American eel							Spawn at sea.
banded killifish		h				Inferred from S&C.	Individual eggs attached to vegetation by adhesive threads. Preferred temperature has been reported as 21 deg, however, females in spawning condition have been reported from the Ottawa River at a temperature of approximately 23 deg (Houston 1990b).
blackstripe topminnow		h				McAllister 1987	Spawning takes place among aquatic vegetation (McAllister 1987).
burbot		h		h		Inferred from S&C.	Jan - March, when water temperatures are 0.6-1.7 deg. In deep sections of rivers, but usually in lakes (S&C).
brook stickleback		h				Inferred from S&C.	Apr-July, shallow water, minimum temperature of 8 deg, but spawning inhibited if temperature >19 deg (S&C).
threespine stickleback		h				Inferred from S&C.	June-July, in shallow water over a sand bottom. Nest is constructed of plant debris and small twigs. Eggs hatch in 7 days at 19 deg (S&C).
ninespine stickleback		h				Inferred from S&C and Foster 1977	Some populations spawn in submergent vegetation (Foster 1972). Spawns in summer (S&C).

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
trout-perch		h		h		Inferred from S&C.	Captured in May in the lower reaches of streams emptying into Lake Ontario (S&C).
white perch						S&C	C. Portt has observed large numbers of ripe adults in stream mouths on the Bay of Quinte, in quite fast water (runs) but no literature reports of spawning habitat found for streams.
white bass		h				Inferred from S&C.	Likely in May and June in Canada when water temperatures are 14.4-21.1 deg. Occurs in upper part of water column, with fertilized eggs dropping to the bottom where they stick to gravel, boulders, or vegetation (S&C).
rock bass		h				Inferred from S&C	likely June when water temperatures are 15.6-21.1 deg (S&C).
green sunfish		h				Stuber et al 1982c	mid-May to early August when water temperatures are 20-28 deg (S&C).
pumpkinseed		h				Inferred from S&C	nest building begins at 20 deg (S&C).
bluegill		h				Inferred from S&C	repeat spawners, spring through summer. Temperatures 17-31 deg (Stuber et al 1982a).
longear sunfish		h				Inferred from S&C	lake June to August, water temperatures 23.4-25 deg (S&C).
smallmouth bass	no	h		m		Inferred from Edwards et al 1983	late May- early July. Egg deposition takes place at 16.1-18.3 deg (S&C).
largemouth bass		h				Stuber et al 1982b	spawning takes place from 16.7-18.3 deg (S&C).
white crappie		h				Inferred from S&C	Early summer when temp are 14-23 deg (S&C).
black crappie		h				Inferred from S&C	Early summer when temp are 19-20 deg (S&C).
warmouth		h				Inferred from T81	May-June (B83)
orangespotted sunfish		h				Inferred from T81	Spawns in June in Canada. Spawning appears to begin at 18 deg in the US portion of its range (Noltie 1990).
yellow perch		h				Inferred from S&C	Spawns Apr - May at temperatures of 8.9-12.2 deg. Submerged aquatic vegetation, brush, or fallen trees are preferred for egg deposition, however, sand and gravel are sometimes used (S&C). Eggs are in gelatinous masses.

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
sauger					h	Inferred from S&C	usually after walleye, often using the same spawning shoals. Spawning is reported to begin at 6.1 deg (S&C).
walleye					h	S&C	early Apr, shortly after ice breakup when the water temp is 6.7-8.9 deg. Found in large rivers (S&C)
eastern sand darter		h		h		Inferred from Holm and Mandrak 1995; and Daniels 1993	Spawning in Ontario likely from June to July (Holm and Mandrak 1995). Water temperatures at spawning likely 20.5-25.5 deg (Facey 1995).
greenside darter	yes		h			Dalton 1991; T81	Generally in May (T81). When water temp reach 10.6 deg (Fahy 1954).
rainbow darter	no		h			S&C	
iowa darter		h				S&C	Apr-May. Eggs hatch at 13-16 deg (S&C).
fantail darter		h	h	h		T81	approximately April -June (S&C).
least darter		h				Inferred from S&C	likely May-june in Ontario. Eggs usually laid singly on the stem of aquatic plants. Eggs hatch in about 6 days at 18-20 deg (S&C).
johnny darter		h		h		Inferred from S&C	likely April, May in Ontario. Males guard eggs which are deposited on the underside of stones. Eggs hatch in 5-8 days at 22-24 deg (S&C).
loggerhead			h	h		B83	June (S&C).
channel darter		h		h		Inferred from S&C	Early summer when temp are 20.5-21.2 deg, in weak current (S&C).
blackside darter		h		h		S&C	May-June. Spawning observed at 16.5 deg in southern Michigan (S&C).
river darter		h		h		Inferred from S&C; and Dalton (1990b).	June-July? (S&C)
tesselated darter		h		h		Inferred from Goodchild 1993a.	Spawning occurs in moderate current. In Maryland this species spawned May-June over 12.5-18.5 deg of temperature (Goodchild 1993a).
brook silverside		h				Inferred from Goodchild 1990a.	Eggs anchored by long adhesive filaments. Sometimes spawn over gravel in slight current. Spawn during June and July in Ontario. US studies indicate that spawning starts at 20 deg (Goodchild 1990a).

Common Name	Turbidity Tolerant?	Velocity Category				References	Description/notes
		Pool	Riffle	Run	Rapid		
freshwater drum							Eggs bouyant, so substrate not important. Lake spawner, or lower portions of rivers (S&C). Pelagic spawners (J&B)
mottled sculpin						B83	Eggs deposited on the ceiling of a cavity. 'Apr - May
slimy sculpin						S&C	eggs deposited on the ceiling of a cavity. 'Apr-May, 10 deg in a stream, very similar to mottled sculpin (S&C)
spoonhead sculpin							late summer - autumn (Houston, 1990a). Very little information on this species.
rudd		h		h		Inferred from Rheinberger et al 1987.	This species likely spawns in the shallow, weedy sections of low gradient rivers and lakes (Inferred form Rheinberger et al 1987).
ruffe							mid-Apr to late July (Simon and Vondruska). Wide temperature range, 6-18 deg (Ogle, 1995).
round goby							9-26 deg (Marsden et al 1996); Prefer large interstitial spaces for spawning (Jude and DeBoe 1996).
tubenose goby							Spawn in shallow water during April and May. A shallow nest is made and guarded by the male (Jude et al 1992).

Table 9 Frequency of occurrence of adult and/or juvenile habitat associations for 141 species by depth, substrate and velocity categories along with the number of instances of no data for each habitat feature.

Habitat Categories	No data	Strength of association			
		Null	Low	Medium	High
<u>Depth interval</u>	39				
0-20		14	5	3	77
21-60		10	4	8	72
61-100		37	2	6	54
101-200		76	0	7	20
>200		86	0	0	16
<u>Substrate</u>	20				
Bedrock		75	29	4	6
Boulder		55	21	21	23
Cobble		46	13	30	28
Rubble		41	9	33	35
Gravel		12	8	14	79
Sand		20	10	11	78
Silt/Clay		32	13	27	45
Hard-pan		110	7	1	0
Detritus		63	23	18	14
<u>Velocity</u>	14				
Pool		8	0	2	116
Run		68	3	21	33
Riffle		87	5	7	27
Rapid		124	0	0	2
<u>Cover</u>	38				
Macrophytes		35	3	9	54
Algae		92	0	2	7
Wood		73	0	4	24
Substrate		57	1	3	38
Overhead		85	0	1	12

Table 10 Frequency of occurrence of spawning habitat associations for 127 species by depth, substrate, velocity, and cover categories along with the number of instances of no data for each habitat feature.

Habitat Categories	No data	Strength of association			
		Null	Low	Medium	High
<u>Depth interval</u>	56				
0-20		39	0	4	29
21-60		15	0	7	48
61-100		35	0	3	34
101-200		52	0	2	18
>200		59	0	0	13
<u>Substrate</u>	33				
Bedrock		91	0	0	3
Boulder		90	0	1	8
Cobble		78	0	1	16
Rubble		59	0	2	32
Gravel		21	0	1	73
Sand		47	0	5	42
Silt/Clay		76	0	2	16
Hard-pan		94	0	0	1
Detritus		87	0	0	8
<u>Velocity</u>	23				
Pool		35	0	2	68
Run		80	0	1	23
Riffle		60	0	2	39
Rapid		101	0	0	4
<u>Cover</u>	67				
Macrophytes		27	1	1	32
Algae		56	0	0	5
Wood		39	0	2	20
Substrate		34	1	2	23
Overhead		47	0	1	12

Appendix A. Great Lakes Basin Fish Species List (* indicates species excluded as being entirely lacustrine).

Code	Common name	Scientific Name	Code	Common name	Scientific Name
S011	American brook lamprey	<i>Lampetra appendix</i>	S136	Tiger muskellunge	<i>Esox hybrid 131x132</i>
S012	Northern brook lamprey	<i>Ichthyomyzon fossor</i>	S141	Central mudminnow	<i>Umbra limi</i>
S013	Silver lamprey	<i>Ichthyomyzon unicuspis</i>	S152	Mooneye	<i>Hiodon tergisus</i>
S014	Sea lamprey	<i>Petromyzon marinus</i>	S161	Quillback	<i>Carpoides cyprinus</i>
S031	Lake sturgeon	<i>Acipenser fulvescens</i>	S162	Longnose sucker	<i>Catostomus catostomus</i>
S041	Longnose gar	<i>Lepisosteus osseus</i>	S163	White sucker	<i>Catostomus commersoni</i>
S042*	Spotted gar	<i>Lepisosteus oculatus</i>	S164	Lake chubsucker	<i>Erimyzon sucetta</i>
S051	Bowfin	<i>Amia calva</i>	S165	Northern hognose sucker	<i>Hypentelium nigricans</i>
S061*	Alewife	<i>Alosa pseudoharengus</i>	S166	Bigmouth buffalo	<i>Ictiobus cyprinellus</i>
S062	American shad	<i>Alosa sapidissima</i>	S167	Spotted sucker	<i>Minytrema melanops</i>
S063	Gizzard shad	<i>Dorosoma cepedianum</i>	S168	Silver redhorse	<i>Moxostoma anisurum</i>
S071	Pink salmon	<i>Oncorhynchus gorbusha</i>	S169	Black redhorse	<i>Moxostoma duquesnei</i>
S072*	Chum salmon	<i>Oncorhynchus keta</i>	S170	Golden redhorse	<i>Moxostoma erythrurum</i>
S073	Coho salmon	<i>Oncorhynchus kisutch</i>	S171	Shorthead redhorse	<i>Moxostoma macrolepidotum</i>
S075	Chinook salmon	<i>Oncorhynchus tshawytscha</i>	S172	Greater redhorse	<i>Moxostoma valenciennesi</i>
S076	Rainbow trout	<i>Oncorhynchus mykiss</i>	S173	River redhorse	<i>Moxostoma carinatum</i>
S077	Atlantic salmon(l)	<i>Salmo salar</i>	S181	Goldfish	<i>Carassius auratus</i>
S078	Brown trout	<i>Salmo trutta</i>	S182	Northern redbelly dace	<i>Phoxinus eos</i>
S079	Arctic charr	<i>Salvelinus alpinus</i>	S183	Finescale dace	<i>Phoxinus neogaeus</i>
S080	Brook trout	<i>Salvelinus fontinalis</i>	S184	Redside dace	<i>Clinostomus elongatus</i>
S081*	Lake trout	<i>Salvelinus namaycush</i>	S185	Lake chub	<i>Couesius plumbeus</i>
S082	Splake	<i>Salvelinus hybrid 080x081</i>	S186	Common carp	<i>Cyprinus carpio</i>
S091	Lake whitefish	<i>Coregonus clupeaformis</i>	S187	Gravel chub	<i>Erimystax x-punctata</i>
S093	Cisco(lake herring)	<i>Coregonus artedi</i>	S188	Cutlips minnow	<i>Exoglossum maxillingua</i>
S094*	Bloater	<i>Coregonus hoyi</i>	S189	Brassy minnow	<i>Hybognathus hankinsoni</i>
S095*	Deepwater cisco(chub)	<i>Coregonus johanna</i>	S190	Eastern silvery minnow	<i>Hybognathus regius</i>
S096*	Kiyi	<i>Coregonus kiyi</i>	S191*	Silver chub	<i>Macrohybopsis storeriana</i>
S097*	Blackfin cisco	<i>Coregonus nigripinnis</i>	S192	Hornyhead chub	<i>Nocomis biguttatus</i>
S099*	Shortnose cisco	<i>Coregonus reighardi</i>	S193	River chub	<i>Nocomis micropogon</i>
S100	Shortjaw cisco	<i>Coregonus zenithicus</i>	S194	Golden shiner	<i>Notemigonus crysoleucas</i>
S101	Pygmy whitefish	<i>Prosopium coulteri</i>	S195	Pugnose shiner	<i>Notropis anogenus</i>
S102*	Round whitefish	<i>Prosopium cylindraceum</i>	S196	Emerald shiner	<i>Notropis atherinoides</i>
S121	Rainbow smelt	<i>Osmerus mordax</i>	S197	Bridle shiner	<i>Notropis bifrenatus</i>
S131	Northern pike	<i>Esox lucius</i>	S198	Common shiner	<i>Luxilus cornutus</i>
S132	Muskellunge	<i>Esox masquinongy</i>	S199	Blackchin shiner	<i>Notropis heterodon</i>
S133	Grass pickerel	<i>Esox americanus vermiculatus</i>	S200	Blacknose shiner	<i>Notropis heterolepis</i>
			S201	Spottail shiner	<i>Notropis hudsonius</i>
			S202	Rosyface shiner	<i>Notropis rubellus</i>

S203	Spotfin shiner	<i>Cyprinella spiloptera</i>	S316	Smallmouth bass	<i>Micropterus dolomieu</i>
S204	Sand shiner	<i>Notropis stramineus</i>	S317	Largemouth bass	<i>Micropterus salmoides</i>
S205	Redfin shiner	<i>Lythrurus umbratilis</i>	S318	White crappie	<i>Pomoxis annularis</i>
S206	Mimic shiner	<i>Notropis volucellus</i>	S319	Black crappie	<i>Pomoxis nigromaculatus</i>
S207	Pugnose minnow	<i>Opsopoeodus emiliae</i>	S323	Warmouth	<i>Lepomis gulosus</i>
S208	Bluntnose minnow	<i>Pimephales notatus</i>	S324	Orangespotted sunfish	<i>Lepomis humilis</i>
S209	Fathead minnow	<i>Pimephales promelas</i>	S331	Yellow perch	<i>Perca flavescens</i>
S210	Blacknose dace	<i>Rhinichthys atratulus</i>	S332	Sauger	<i>Stizostedion canadense</i>
S211	Longnose dace	<i>Rhinichthys cataractae</i>	S334	Walleye(yellow pickerel)	<i>Stizostedion vitreum vitreum</i>
S212	Creek chub	<i>Semotilus atromaculatus</i>	S335	Eastern sand darter	<i>Ammocrypta pellucida</i>
S213	Fallfish	<i>Semotilus corporalis</i>	S336	Greenside darter	<i>Etheostoma blennioides</i>
S214	Pearl dace	<i>Margariscus margarita</i>	S337	Rainbow darter	<i>Etheostoma caeruleum</i>
S215	Silver shiner	<i>Notropis photogenis</i>	S338	Iowa darter	<i>Etheostoma exile</i>
S216	Stoneroller	<i>Campostoma anomalum</i>	S339	Fantail darter	<i>Etheostoma flabellare</i>
S217	Striped shiner	<i>Luxilus chrysocephalus</i>	S340	Least darter	<i>Etheostoma microperca</i>
S218	Ghost shiner	<i>Notropis buchmanii</i>	S341	Johnny darter	<i>Etheostoma nigrum</i>
S231	Black bullhead	<i>Ameiurus melas</i>	S342	Logperch	<i>Percina caprodes</i>
S232	Yellow bullhead	<i>Ameiurus natalis</i>	S343	Channel darter	<i>Percina copelandi</i>
S233	Brown bullhead	<i>Ameiurus nebulosus</i>	S344	Blackside darter	<i>Percina maculata</i>
S234	Channel catfish	<i>Ictalurus punctatus</i>	S345	River darter	<i>Percina shumardi</i>
S235	Stonecat	<i>Noturus flavus</i>	S346	Tessellated darter	<i>Etheostoma olmstedii</i>
S236	Tadpole madtom	<i>Noturus gyrinus</i>	S361	Brook silverside	<i>Labidesthes sicculus</i>
S237	Brindled madtom	<i>Noturus miurus</i>	S371	Freshwater drum	<i>Aplodinotus grunniens</i>
S244	Northern madtom	<i>Noturus stigmosus</i>	S381	Mottled sculpin	<i>Cottus bairdi</i>
S251	American eel	<i>Anguilla rostrata</i>	S382	Slimy sculpin	<i>Cottus cognatus</i>
S261	Banded killifish	<i>Fundulus diaphanus</i>	S383	Spoonhead sculpin	<i>Cottus ricei</i>
S262	Blackstripe topminnow	<i>Fundulus notatus</i>	S384	Deepwater sculpin	<i>Myoxocephalus thompsoni</i>
S271	Burbot	<i>Lota lota</i>	S601	CarpXGoldfish	Hybrid 181x186
S281	Brook stickleback	<i>Culaea inconstans</i>	S220	Rudd	<i>Scardinius erythrophthalmus</i>
S282	Threespine stickleback	<i>Gasterosteus aculeatus</i>	S355	Ruffe	<i>Gymnocephalus cernuus</i>
S283	Ninespine stickleback	<i>Pungitius pungitius</i>	S366	Round goby	<i>Neogobius melanostomus</i>
S284*	Fourspine stickleback	<i>Apeltes quadracus</i>	S367	Tube-nose goby	<i>Proterorhinus marmoratus</i>
S291	Trout-perch	<i>Percopsis omiscomaycus</i>			
S301	White perch	<i>Morone americana</i>			
S302	White bass	<i>Morone chrysops</i>			
S311	Rock bass	<i>Ambloplites rupestris</i>			
S312	Green sunfish	<i>Lepomis cyanellus</i>			
S313	Pumpkinseed	<i>Lepomis gibbosus</i>			
S314	Bluegill	<i>Lepomis macrochirus</i>			
S315	Longear sunfish	<i>Lepomis megalotis</i>			

Appendix B. Summary indicating availability of habitat preferences for Great Lakes Basin Fish Species List (Ad.+Juv. for adults and juveniles, Spwn for spawning; if present, D- Depth, S-Substrate, C-Cover, V-Velocity, and - (dash) indicates no data).

Common name	Ad.+Juv.	Spwn.						
American brook lamprey	-SCV	DSCV	Redside dace	DSCV	-S-V	Burbot	-SCV	DS-V
Northern brook lamprey	DSCV	DSCV	Lake chub	---	DS-V	Brook stickleback	DSCV	--CV
Silver lamprey	-SCV	-SCV	Common carp	DS-V	D-CV	Threespine stickleback	D-CV	-S-V
Sea lamprey	-SCV	DSCV	Gravel chub	---	---	Ninespine stickleback	--CV	-SCV
Lake sturgeon	DSCV	DS-V	Cutlips minnow	-SCV	-SCV	Trout-perch	DSCV	-S-V
Longnose gar	DSCV	--CV	Brassy minnow	DS-V	-S-V	White perch	D--V	-S--
Bowfin	DSCV	D-CV	Eastern silvery minnow	DSCV	DSCV	White bass	DS-V	DS-V
American shad	---	---	Homyhead chub	DSCV	DS-V	Rock bass	DSCV	DS-V
Gizzard shad	DSCV	DSCV	River chub	DS-V	DS-V	Green sunfish	DSCV	DSCV
Pink salmon	---	DS-V	Golden shiner	DSCV	-S-V	Pumpkinseed	DSCV	DSCV
Coho salmon	-SCV	DS-V	Pugnose shiner	-SCV	--CV	Bluegill	DSCV	DS-V
Chinook salmon	---	DS-V	Emerald shiner	DS-V	DS-V	Longear sunfish	DSCV	DS-V
Rainbow trout	DSC-	DS-V	Bridle shiner	-SCV	D-CV	Smallmouth bass	DSCV	DSCV
Atlantic salmon	-SCV	DS-V	Common shiner	DSCV	-S-V	Largemouth bass	DSCV	DSCV
Brown trout	DSCV	DS-V	Blackchin shiner	DSCV	-S--	White crappie	DSCV	DSCV
Arctic char	---	DS-V	Blacknose shiner	DSCV	-S--	Black crappie	DSCV	DSCV
Brook trout	DSC-	DSCV	Spottail shiner	DSCV	-S-V	Warmouth	DSCV	DSCV
Lake whitefish	---V	DS--	Rosyface shiner	DS-V	-S-V	Orangespotted sunfish	DSCV	DS-V
Cisco(lake herring)	---V	DS-V	Spotfin shiner	-SCV	--C-	Yellow perch	DSCV	DSCV
Shortjaw cisco	---	---	Sand shiner	DSCV	-S--	Sauger	-S-V	DS-V
Pygmy whitefish	---	-S--	Redfin shiner	DSCV	-S-V	Walleye(yellow pickerel)	DSCV	DS-V
Rainbow smelt	D---	-S-V	Mimic shiner	DSCV	--CV	Eastern sand darter	DSCV	DS-V
Northern pike	DSCV	D-C-	Pugnose minnow	DSCV	---	Greenside darter	DSCV	-SCV
Muskellunge	D-CV	D-C-	Bluntnose minnow	DS-V	D-CV	Rainbow darter	DSCV	DS-V
Grass pickerel	DSCV	--C-	Fathead minnow	DS-V	D-CV	Iowa darter	DSCV	DSCV
Central mudminnow	DSCV	--CV	Blacknose dace	DSCV	-S-V	Fantail darter	DSCV	DSCV
Mooneye	D--V	---V	Longnose dace	DSCV	DS-V	Least darter	DSCV	D-CV
Quillback	DS-V	-S-V	Creek chub	-SCV	-S-V	Johnny darter	DSCV	-SCV
Longnose sucker	--C-	DS-V	Fallfish	DS-V	DSCV	Logperch	DSCV	-S-V
White sucker	DSCV	-S-V	Pearl dace	-SCV	DS-V	Channel darter	-SCV	-SCV
Lake chubsucker	-SCV	-SCV	Silver shiner	-SCV	---	Blackside darter	DSCV	DS-V
Northern hognose sucker	DS-V	DS-V	Central stoneroller	DSCV	DSCV	River darter	DS-V	DS-V
Bigmouth buffalo	DSCV	D-CV	Striped shiner	DS-V	-S-V	Tessellated darter	-S-V	DSCV
Spotted sucker	-SCV	DS-V	Ghost shiner	DS-V	---	Brook silverside	DSCV	-SCV
Silver redhorse	-S-V	DS-V	Black bullhead	DSCV	DSCV	Freshwater drum	-S-V	D---
Black redhorse	DS-V	DS-V	Yellow bullhead	DSCV	--CV	Mottled sculpin	DSCV	DSC-
Golden redhorse	DS-V	DS-V	Brown bullhead	-SCV	DSCV	Slimy sculpin	DSCV	-SC-
Shorthead redhorse	-S-V	-S-V	Channel catfish	-SCV	-SCV	Spoonhead sculpin	--C-	---
Greater redhorse	-S-V	D--V	Stoneycat	DSCV	-SCV	Deepwater sculpin	---	---
River redhorse	-S-V	DS-V	Tadpole madtom	DSCV	-SCV	Rudd	--CV	--CV
Goldfish	--CV	D-CV	Brindled madtom	-SCV	-SCV	Ruffe	DS--	DSC-
Northern redbelly dace	DS-V	--CV	Northern madtom	-SCV	--C-	Round goby	DSC-	DSC-
Finescale dace	DS-V	DSCV	American eel	DSCV	---	Tubenose goby	DSC-	-S--
			Banded killifish	DSCV	--CV			
			Blackstripe topminnow	D-CV	--CV			

Appendix C. Data table for submitting new observations of habitat preferences for fish species occurring in the Great Lakes Basin.

Fish species:	Spawning	Juvenile (0 to age 1)	Adults (age 1+)
Depth strata (cm)			
0-20			
21-60			
61-100			
101-200			
>200			
Substrate			
Bedrock			
Boulder			
Cobble			
Rubble			
Gravel			
Sand			
Silt/Clay			
Hard-pan clay			
Detritus			
Vegetation			
None			
Vegetation			
Algae			
Wood			
Substrate			
Overhead			
Flow regime			
Pool			
Riffle			
Run			
Rapid			
Other notes			
Turbidity tolerant?			
Spawning temperature?			
Spawning season?			
Other observations?			
Source:			
Contributor: (Name, address, ph/fax/email)			

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OR FAX TO: 905-336-6437