Quantification of the success and potential impacts of new rock ramp fish passage in the Saginaw Bay watershed

Tracy Galarowicz (Department of Biology, Central Michigan University (CMU)), Brent Murry (Department of Biology, CMU), Daniel Hayes (Department of Fisheries and Wildlife, Michigan State University (MSU)), Daelyn Woolnough (Department of Biology, CMU), Donald Uzarski (Department of Biology, CMU), Clarence Fullard (MS student, CMU), Gabriel Madel (MS student, CMU), and Jacob Stoller (MS student, MSU)

Project description: Dam removals and construction of fish passages are rapidly becoming the dominant initiatives associated with Great Lakes' fishery and ecosystem restoration. Rigorous scientific assessment of whether or not fish passages are meeting their intended conservation goals and evaluation of potential negative effects are, however, lacking in the Great Lakes region. We evaluated: 1) the success of a recently built (Shiawassee River) and a pending (Cass River) rock ramp fish passage at meeting their intended restoration goals (i.e., increased upstream fish movement and reproductive success), and 2) changes to existing fish assemblages upstream and downstream of the dam and rock ramp.

Objective 1: *Evaluate the success of a recently built and a pending rock ramp passage at meeting their intended restoration goals.* To accomplish the first objective, we sampled fish during spring migration periods with a boat electrofisher above and below the rock ramp (Shiawassee River) and dam (Cass River) (Table 1). Electrofishing data were collected in collaboration with the Michigan Department of Natural Resources and the US Fish and Wildlife Service. Several species including White Sucker, Redhorse spp., Northern Hogsucker, Rockbass, and Smallmouth Bass were found above and below the rock ramp on the Shaiwasee River during spring electrofishing surveys; however, Walleye were only found below the rock ramp (Figure 1). Similar patterns were observed above and below the Cass River during spring electrofishing surveys, although Yellow Perch were an additional species captured only below the dam (Figure 2).

Sucker species (including White Sucker, Golden Redhorse, Quillback, Greater Redhorse, Northern Hogsucker, Shorthead Redhorse, and Silver Redhorse) were the most commonly captured fishes during spring electrofishing (Table 1, Appendix 1), collectively contributing more than 50% of total catch. These species, with the exception of Golden and Greater Redhorse, showed substantially higher catches below the rock ramp structure than above. A similar pattern was seen above and below the dam in the Cass River, with the exception of Quillback, which was uncommon in the Cass River. Among the other species commonly encountered in both rivers, Walleye were caught in substantially lower numbers below the rock ramp, and were never caught above the dam. Rock Bass and Smallmouth Bass, however, were caught in greater numbers above the barriers than below.

In addition, we fin clipped 406 fish in 2011 and dart-tagged 300 fish (individually numbered and with the lead investigators phone number to promote angler reports) in spring 2012 and 463 fish in 2013 below the rock ramp to quantify any movement above the rock ramp (Table 2). In 2011, we did not recapture any of the fish fin-clipped above the rock ramp. In 2012, we recaptured eight of 78 walleye dart tagged, and all were recaptured below the rock ramp. In 2013, we

recaptured twelve fish - eight in the downstream reach where they were tagged and four fish (two Greater Redhorse and two Walleye) upstream of the rock ramp.

We sampled egg and larval fish density above and below the rock ramp in the Shiawassee River as well as above and below the dam on the Cass River. Egg densities (#/egg mat) were greater below the rock ramp and dam relative to above the rock ramp and dam (Figure 3). Similarly, densities of larval Catostomidae spp. were greater below the rock ramp and dam (Figure 4).

To evaluate the effect of the rock ramp on summer resident fish assemblages, we electrofished the summer-resident fish community using barge electrofishing at three sites above and below the rock ramp, three sites above and below the dam on the Cass River, and six sites on the Flint River (Stoller 2013). During the 2011 and 2012 field seasons, we also PIT tagged 970 Rock Bass and Smallmouth Bass in the Cass, Shiawassee, and Flint Rivers and recaptured 65 fish (all of which were recaptured in the same sites in which they were originally captured and tagged). As such, the summer tagging data did not provide direct evidence for or against fish movement across the rock ramp.

Freshwater mussels were sampled and identified upstream and downstream of the rock ramp on the Shiawasee River and dam on the Cass River. Freshwater mussel densities were higher in river reaches both above the rock ramp and the dam (Table 3), although the species composition differed.

Objective 2: *Evaluate changes to existing fish assemblages upstream and downstream of the dam and rock ramp.* Fish assemblages upstream and downstream of the dam and rock ramp are reported in detail in Stoller (2013), Fullard (2014), and Madel (2013). Overall, results indicate that the patterns of distribution in the summer fish assemblage in the Shiawassee River (rock ramp) were indicative of partial, but not full, restoration of ecosystem connectivity.

Fullard, C. D. J. 2014. Diet and energy pathway perturbations of rock bass and smallmouth bass in three round goby invaded Great Lakes tributaries. M.S. thesis, Central Michigan University, Mt. Pleasant, MI.

Madel, G. M. 2014. Testing trophic guild classifications in temperate river fish communities using stable isotopes. M.S. thesis, Central Michigan University, Mt. Pleasant, MI.

Stoller, J. B. 2013. Effects of a rock ramp structure on summer fish assemblage in the Shiawassee River. M.S. thesis, Michigan State University, East Lansing, MI.

Table 1. Number of fish captured during spring electrofishing downstream and upstream and the ratio of fish captured upstream to downstream (upstream:downstream) of the rock ramp on the Shiawasee River (2011-2012) and the dam on the Cass River (2011-2013).

Species	Shiawasee River			Cass River			
	Downstream	Upstream	Upstream: Downstream	Downstream	Upstream	Upstream: Downstream	Total
White Sucker *Catostomus commersoni*	738	311	0.42	295	5	0.02	1349
Golden Redhorse *Moxostoma erythrurum*	161	293	1.82	100	359	3.59	913
Walleye *Sander vitreus*	501	36	0.07	19	0	0.00	556
Emerald Shiner *Notropis atherinoides*	1	0	0.00	377	0	0.00	378
Smallmouth Bass *Micropterus dolomieu*	14	38	2.71	47	101	2.15	200
Quillback *Carpiodes cyprinus*	136	23	0.17	1	3	3.00	163
Greater Redhorse *Moxostoma valenciennesi*	23	48	2.09	9	74	8.22	154
Northern Hogsucker *Hypentelium nigricans*	47	27	0.57	53	15	0.28	142
Cyprinid spp.	0	0	N/A	14	119	8.50	133
Bluntnose Minnow *Pimephales notatus*	0	0	N/A	128	4	0.03	132
Rock Bass *Ambloplites rupestris*	2	4	2.00	24	88	3.67	118
Shorthead Redhorse *Moxostoma macrolepidotum*	36	3	0.08	45	0	0.00	84
Common Shiner *Luxilus cornutus*	0	4	N/A	69	0	0.00	73

Spottail Shiner *Notropis hudsonius*	0	0	N/A	16	39	2.44	55
Yellow Perch *Perca flavescens*	0	0	N/A	53	0	0.00	53
Silver Redhorse *Moxostoma anisurum*	25	0	0.00	15	11	0.73	51
Bluegill *Lepomis macrochirus*	0	0	N/A	6	37	6.17	43
Pumpkinseed *Lepomis gibbosus*	0	0	N/A	11	25	2.27	36
Northern Pike *Esox lucius*	10	2	0.20	12	6	0.50	30
Round Goby *Neogobius melanostomus*	0	0	N/A	28	0	0.00	28
Logperch *Percina caprodes*	0	0	N/A	16	0	0.00	16
Black Crappie *Pomoxis nigromaculatus*	2	0	0.00	7	5	0.71	14
Common Carp *Cyprinus carpio*	0	1	N/A	2	8	4.00	11
Largemouth Bass *Micropterus salmoides*	0	0	N/A	4	7	1.75	11
Brook Stickleback *Culaea inconstans*	0	0	N/A	1	9	9.00	10
Channel Catfish *Ictalurus punctatus*	5	3	0.60	0	0	N/A	8
Brook Silverside *Labidesthes sicculus*	0	0	N/A	7	0	0.00	7
Blackside Darter *Percina maculata*	1	0	0.00	5	0	0.00	6
Fantail Darter *Etheostoma flabellare*	0	0	N/A	6	0	0.00	6
Northern Redbelly Dace *Phoxinus eos*							

0	0	N/A	5	0	0.00	5
Freshwater Drum *Aplodinotus grunniens*						
1	0	0.00	2	0	0.00	3
Greenside Darter *Etheostoma blennioides*						
0	0	N/A	1	2	2.00	3
Bowfin *Amia calva*						
2	0	0.00	0	0	N/A	2
Green Sunfish *Lepomis cyanellus*						
0	0	N/A	1	1	1.00	2
Rainbow Darter *Etheostoma caeruleum*						
0	0	N/A	2	0	0.00	2
Black Bullhead *Ameiurus melas*						
0	0	N/A	1	0	0.00	1
Gizzard Shad *Dorosoma cepedianum*						
0	1	N/A	0	0	N/A	1
Hornyhead Chub *Nocomis biguttatus*						
0	1	N/A	0	0	N/A	1
Rainbow Trout *Oncorhynchus mykiss*						
0	0	N/A	1	0	0.00	1
Spotfin Shiner *Cyprinella spiloptera*						
0	1	N/A	0	0	N/A	1
Yellow Bullhead *Ameiurus natalis*						
0	0	N/A	0	1	N/A	1

Table 2. Number, sex (male, female, or unidentified (UID)), and mean (±SE) total length (TL; mm) of fish sampled and tagged during spring electrofishing and tagging efforts downstream and upstream the rock ramp on the Shiawasee River.

		Downstream					Upstream				
Species	Date	# tagged	Male	Female	UID	TL (SE)	# tagged	Male	Female	UID	TL (SE)
Black Crappie											
	23-Mar-12	0	0	0	1	269.0 (0)	-	-	-	-	-
Bowfin											
	23-Mar-12	2	1	0	2	494.5 (63.5)	-	-	-	-	-
Channel Catfish											
	23-Mar-12	0	0	0	1	554.0 (0)	-	-	-	-	-
	26-Mar-13	0	0	0	1	542.0 (0)	-	-	-	-	-
	23-Apr-13	0	0	0	1	540.0 (0)	-	-	-	-	-
	26-Apr-13	0	0	0	3	517.3 (95.3)	-	-	-	-	-
Emerald Shiner											
	23-Mar-12	0	0	0	1	-	-	-	-	-	-
Freshwater Drum											
	23-Mar-12	1	0	0	1	495.0 (0)	-	-	-	-	-
Gizzard Shad											
	26-Apr-13	0	0	0	1	340.0 (0)	-	-	-	-	-
Golden Redhorse											
	23-Mar-12	59	1	4	54	349.7 (5.7)	-	-	-	-	-
	26-Mar-13	34	0	0	34	359.6 (6.4)	-	-	-	-	-
	16-Apr-13	16	0	2	14	354.4 (7.7)	-	-	-	-	-
	23-Apr-13	5	0	0	8	337.1 (11.4)	-	-	-	-	-
	26-Apr-13	10	0	1	11	355.8 (9.7)	0	2	6	38	340.1 (8.4)
Greater Redhorse											
	23-Mar-12	11	1	0	10	490.7 (25.4)	-	-	-	-	-
	26-Mar-13	13	0	0	13	464.4 (17.5)	-	-	-	-	-
	4-Apr-13	-	-	-	-	-		0	0	1	469.0 (0)
	9-Apr-13	-	-	-	-	-		0	0	1	389.0 (0)
	16-Apr-13	2	0	0	3	349.7 (32.1)	-	-	-	-	-
	23-Apr-13	2	0	0	2	427.0 (25.0)	-	-	-	-	-
	26-Apr-13	1	0	0	6	446.2 (17.5)		1	0	12	384.2 (26.3)

Northern Hogsucker										
26-Mar-13	8	3	0	6	289.4 (11.5)	-	-	-	-	-
16-Apr-13	2	1	0	1	292.0 (3.0)	-	-	-	-	-
26-Apr-13	-	-	-	-	-	0	1	1	1	313.0 (18.5)
Northern Pike										
26-Mar-13	3	1	0	2	516.3 100.4)	-	-	-	-	-
16-Apr-13	3	1	2	0	628.0 944.8)	-	-	-	-	-
23-Apr-13	2	0	0	2	599.0 (70.0)	-	-	-	-	-
26-Apr-13	1	0	2	0	635.0 910.0)	0	0	2	0	669.5 (0.5)
Quillback										
23-Mar-12	15	1	0	15	401.4 (9.5)	-	-	-	-	-
26-Mar-13	3	0	1	2	422.7 (1.8)	-	-	-	-	-
4-Apr-13	-	-	-	-	-	0	0	0	1	405.0 (0)
9-Apr-13	-	-	-	-	-	0	0	0	1	382.0 (0)
16-Apr-13	15	7	0	8	429.1 (7.3)	-	-	-	-	-
23-Apr-13	42	23	2	17	424.2 (7.1)	-	-	-	-	-
26-Apr-13	0	13	1	36	450.2 (5.1)	-	-	-	-	-
Rockbass										
23-Mar-12	0	0	0	9	164.0 (0)	-	-	-	-	-
16-Apr-13	0	0	0	1	180.0 (0)	-	-	-	-	-
26-Apr-13	0	-	-	-	-	0	0	0	3	160.3 (16.8)
Shorthead Redhorse										
23-Mar-12	32	6	1	25	505.6 (33.0)	-	-	-	-	-
Silver Redhorse										
23-Mar-12	9	0	0	9	326.7 (31.0)	-	-	-	-	-
26-Mar-13	4	0	0	4	314.0 (4.1)	-	-	-	-	-
16-Apr-13	4	2	0	4	524.2 (23.4)	-	-	-	-	-
23-Apr-13	4	0	0	4	484.8 (57.9)	-	-	-	-	-
26-Apr-13	0	2	0	4	526.3 (33.4)	-	-	-	-	-
Smallmouth Bass										
23-Mar-12	1	0	0	3	326.7 (31.0)	-	-	-	-	-
26-Mar-13	6	0	0	7	300.0 (9.0)	-	-	-	-	-
16-Apr-13	1	0	0	4	313.8 (30.9)	-	-	-	-	-

	23-Apr-13	3	0	0	3	373.0 (39.6)	-	-	-	-	-
	26-Apr-13	0	0	0	4	335.0 (36.1)	0	0	0	11	276.6 (9.2)
Walleye											
	23-Mar-12	77	68	1	8	464.1 (6.2)	-	-	-	-	-
	26-Mar-13	47	31	4	12	514.1 (11.0)	-	-	-	-	-
	4-Apr-13	-	-	-	-	-	0	4	2	1	494.7 (32.4)
	9-Apr-13	-	-	-	-	-	2	13	4	2	463.2 (13.6)
	16-Apr-13	80	75	2	3	488.8 (5.8)	-	-	-	-	-
	23-Apr-13	8	6	1	1	482.0 (17.3)	-	-	-	-	-
	26-Apr-13	1	26	1	0	496.7 (10.6)	-	-	-	-	-
White Sucker											
	23-Mar-12	92	60	10	22	441.1 (3.4)	-	-	-	-	-
	26-Mar-13	40	12	0	29	434.4 (8.1)	-	-	-	-	-
	4-Apr-13	-	-	-	-	-	0	81	35	16	419.8 (4.7)
	9-Apr-13	-	-	-	-	-	0	18	37	8	429.8 (8.7)
	16-Apr-13	78	27	41	10	466.1 (5.3)	-	-	-	-	-
	23-Apr-13	28	20	4	4	434.2 (6.7)	-	-	-	-	-
	26-Apr-13	0	33	2	2	443.3 (4.1)	0	16	1	7	423.2 (7.5)

Table 3. Number (#/person-hr) of freshwater mussels sampled downstream and upstream the rock ramp on the Shiawasee River and downstream and upstream the dam on the Cass River.

	Shiawasee River		Cass River	
	Downstream	Upstream	Downstream	Upstream
	(#/person-hr)	(#/person-hr)	(#/person-hr)	(#/person-hr)
Creek Heelsplitter *Lasmigona compressa*	-	-	0.44	-
Elktoe *Alasmidonta marginata*	-	1.33	0.22	0*
Ellipse *Venustachoncha ellipsiformis*	-	8.00	-	-
Fat Mucket *Lampsilis siliqoidea*	0.22	-	0.67	0*
Fluted Shell *Lasmigona costata*	-	0.89	2.00	2.67
Fragile Papershell *Leptodea fragilis*	-	-	0.67	0*
Kidneyshell *Ptychobranchus fasciolaris*	-	0.44	-	-
Mapleleaf *Quadrula quadrula*	-	-	1.11	0.89
Mucket *Actinonaias ligamentina*	0.67	-	21.56	50.67
Pink Heelsplitter *Potamilis alatus*	-	-	0.44	-
Plain Pocketbook *Lampsilis cardium*	6.22	2.67	1.11	0.44
Rainbow *Villosa iris*	0.22	6.67	-	-
Round pigtoe *Pleurobema sintoxia*	0.67	7.11	-	-
Threeridge *Amblema plicata*	-	-	7.33	10.67
Wabash Pigtoe *Fusconaia flava*	0.89	4.44	0.22	-
White Heelsplitter *Lasmigona complanata*	0.22	4.44	1.33	-

*Only shells were found

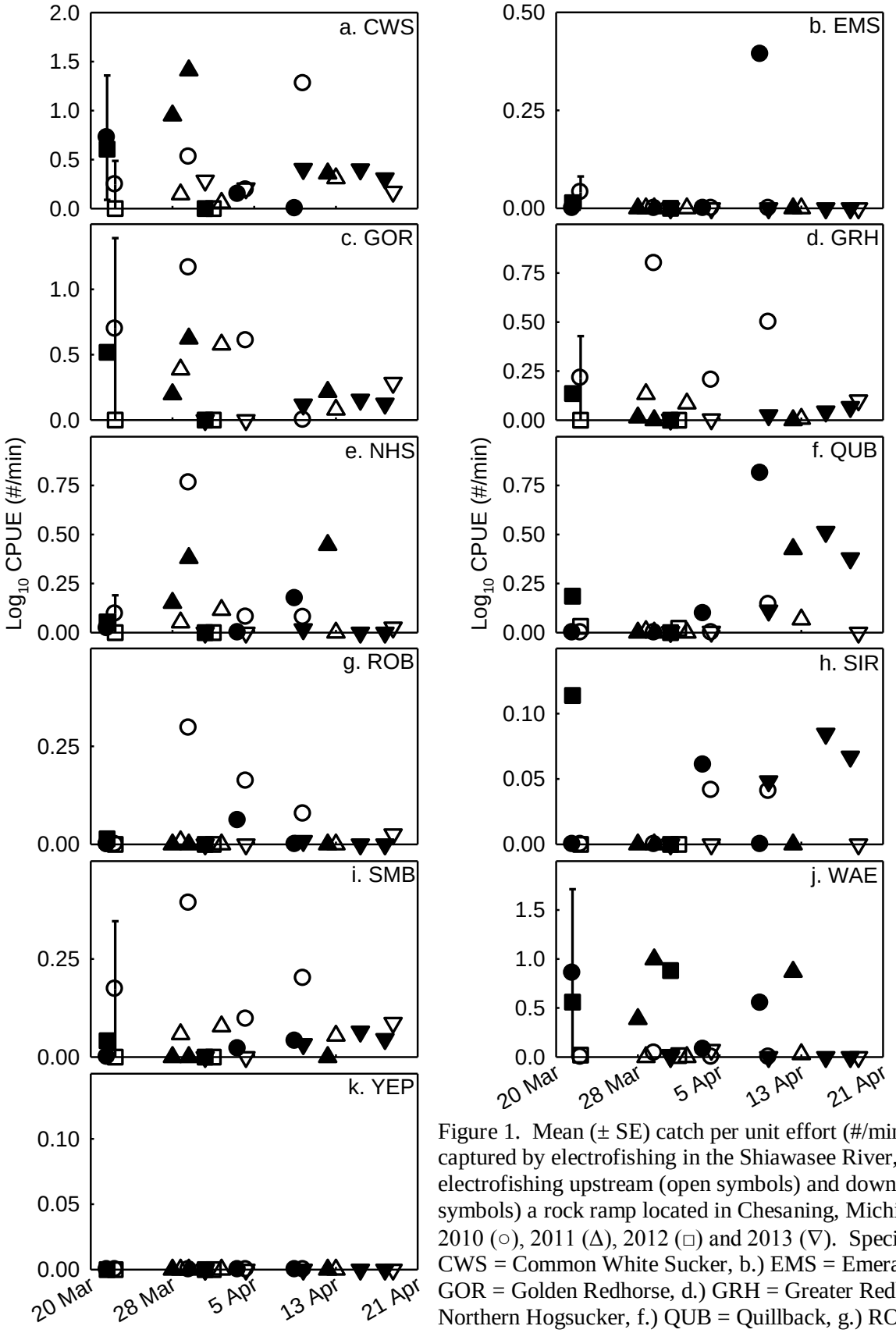

Figure 1. Mean (± SE) catch per unit effort (#/min) of species captured by electrofishing in the Shiawasee River, Michigan, by electrofishing upstream (open symbols) and downstream (closed symbols) a rock ramp located in Chesaning, Michigan, in spring 2010 (○), 2011 (Δ), 2012 (□) and 2013 (∇). Species include: a.) CWS = Common White Sucker, b.) EMS = Emerald Shiner, c.) GOR = Golden Redhorse, d.) GRH = Greater Redhorse, e.) NHS = Northern Hogsucker, f.) QUB = Quillback, g.) ROB = Rockbass, h.) SIR = Silver Redhorse, i.) SMB = Smallmouth Bass, j.) WAE = Walleye, and k.) YEP = Yellow Perch.

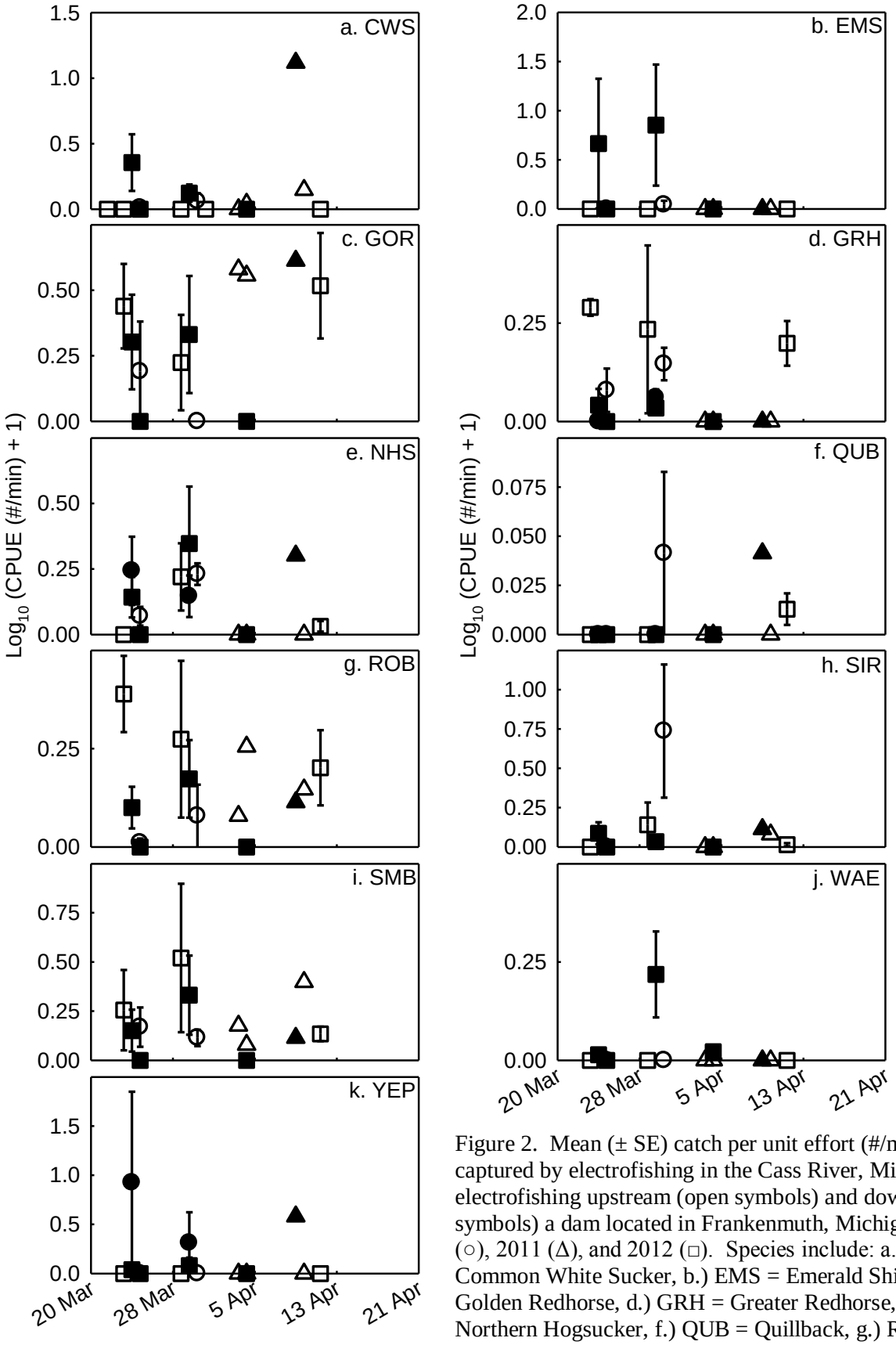

Figure 2. Mean (± SE) catch per unit effort (#/min) of species captured by electrofishing in the Cass River, Michigan, by electrofishing upstream (open symbols) and downstream (closed symbols) a dam located in Frankenmuth, Michigan, in spring 2010 (○), 2011 (Δ), and 2012 (□). Species include: a.) CWS = Common White Sucker, b.) EMS = Emerald Shiner, c.) GOR = Golden Redhorse, d.) GRH = Greater Redhorse, e.) NHS = Northern Hogsucker, f.) QUB = Quillback, g.) ROB = Rockbass, h.) SIR = Silver Redhorse, i.) SMB = Smallmouth Bass, j.) WAE = Walleye, and k.) YEP = Yellow Perch.

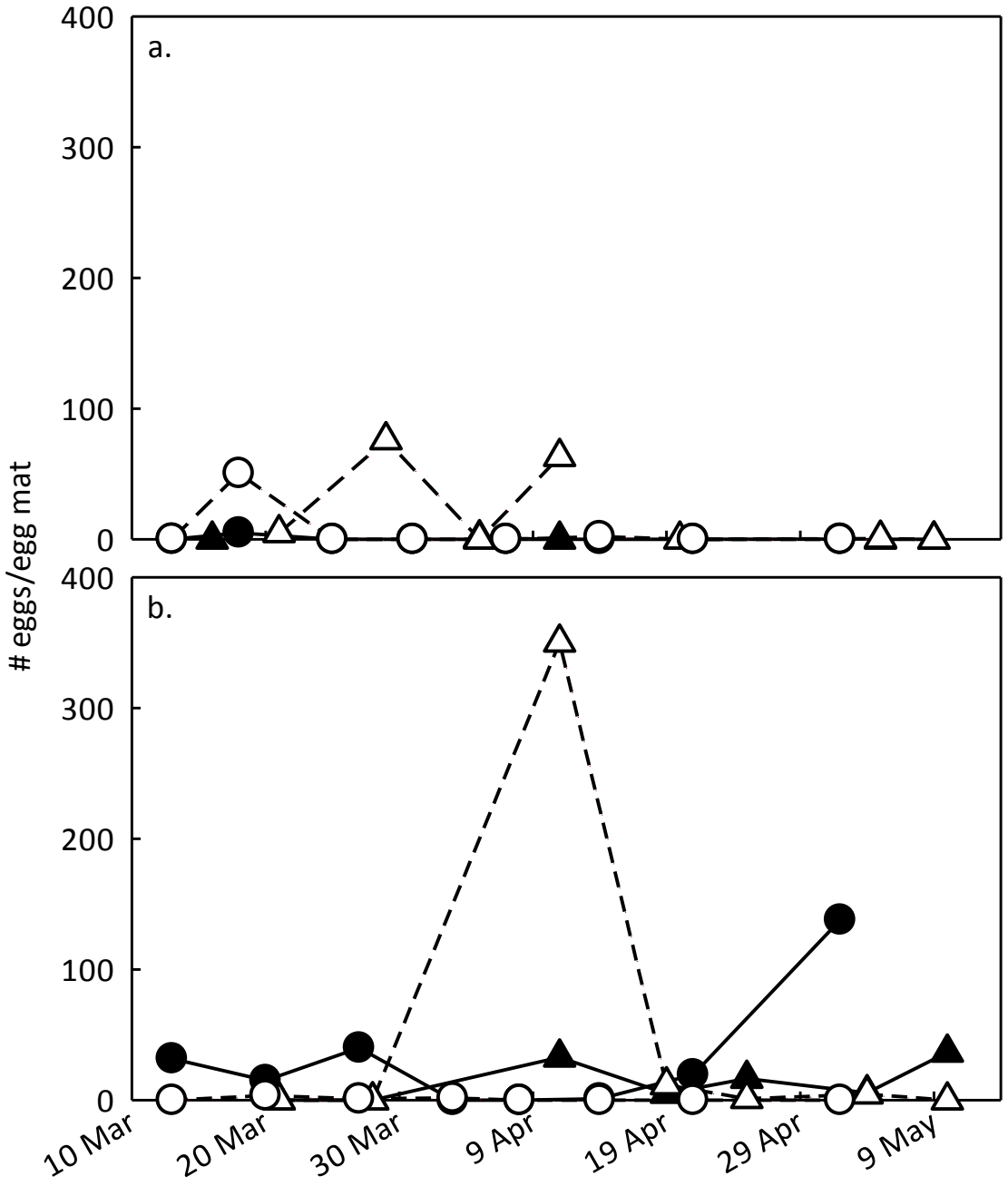

Figure 3. Mean number of eggs per egg mat in the upstream (solid line) and downstream (dashed line) the rock ramp in the Shiawasee River (a.) and the dam in the Cass River (b.) in 2012 (circles) and 2013 (triangles).

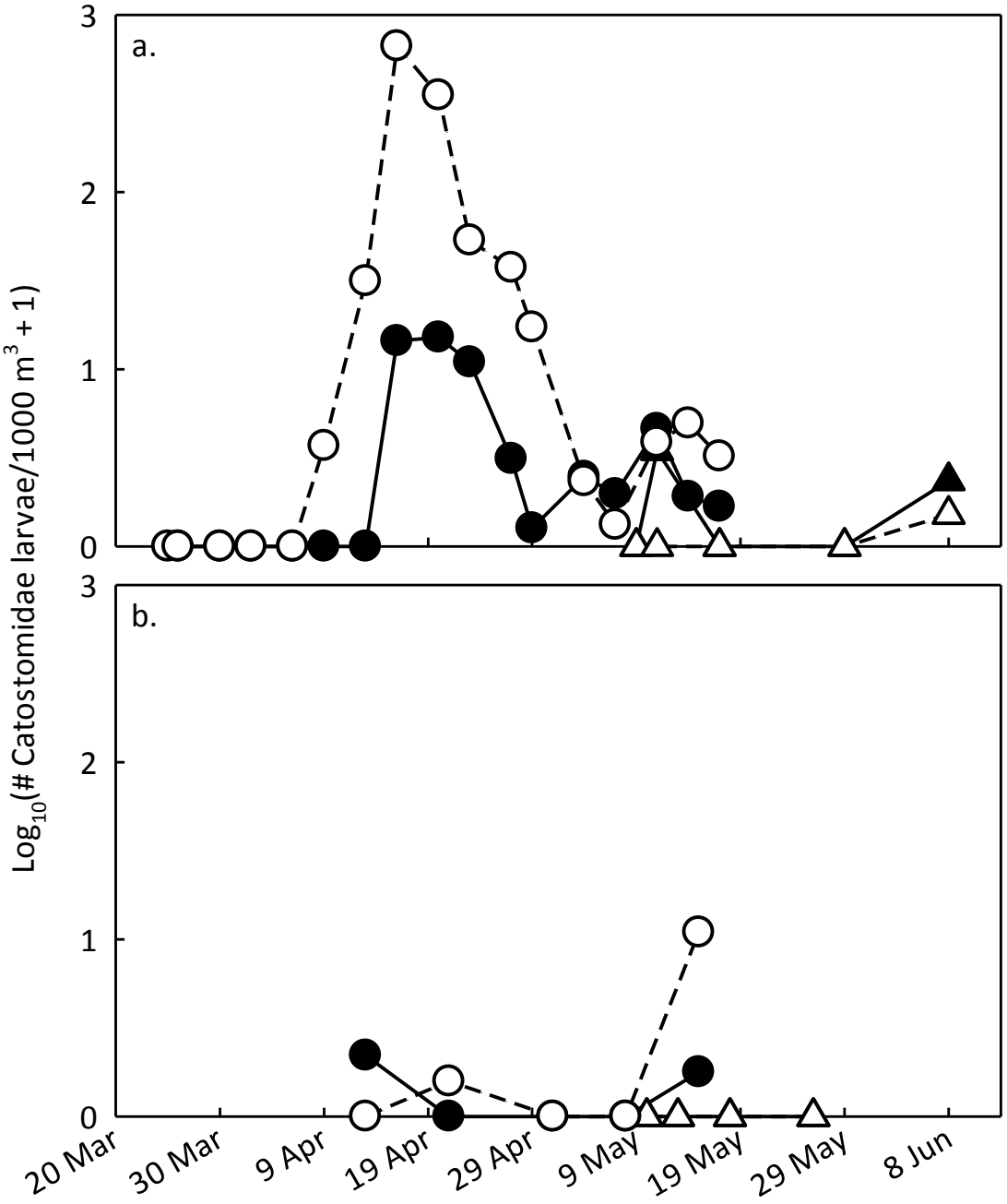

Figure 4. Mean number of Catostomidae larvae/1000 m^3 (log_{10} transformed) upstream (solid line) and downstream (dashed line) the rock ramp in the Shiawasee River (a.) and the dam in the Cass River (b.) in 2012 (circles) and 2013 (triangles).

Appendix 1. Number of fish captured during spring electrofishing and tagging efforts downstream and upstream of the rock ramp on the Shiawasee River and the dam on the Cass River.

	Shiawasee River						Cass River			
	Downstream			Upstream			Downstream		Upstream	
	2011	2012	2013	2011	2012	2013	2011	2012	2011	2012
Black Bullhead *Ameiurus melas*	0	0	0	0	0	0	0	1	0	0
Black Crappie *Pomoxis nigromaculatus*	2	0	0	0	0	0	0	7	3	2
Blackside Darter *Percina maculata*	1	0	0	0	0	0	0	5	0	0
Bluegill *Lepomis macrochirus*	0	0	0	0	0	0	0	6	1	36
Bluntnose Minnow *Pimephales notatus*	0	0	0	0	0	0	1	127	0	4
Bowfin *Amia calva*	0	2	0	0	0	0	0	0	0	0
Brook Silverside *Labidesthes sicculus*	0	0	0	0	0	0	0	7	0	0
Brook Stickleback *Culaea inconstans*	0	0	0	0	0	0	0	1	0	9
Channel Catfish *Ictalurus punctatus*	0	1	4	3	0	0	0	0	0	0
Common Carp *Cyprinus carpio*	0	0	0	1	0	0	1	1	0	8
Common Shiner *Luxilus cornutus*	0	0	0	4	0	0	0	69	0	0
Cyprinid spp.	0	0	0	0	0	0	14	0	119	0
Emerald Shiner *Notropis atherinoides*	0	1	0	0	0	0	0	377	0	0

Fantail Darter *Etheostoma flabellare*										
	0	0	0	0	0	0	0	6	0	0
Freshwater Drum *Aplodinotus grunniens*										
	0	1	0	0	0	0	0	2	0	0
Gizzard Shad *Dorosoma cepedianum*										
	0	0	0	0	1	0	0	0	0	0
Golden Redhorse *Moxostoma erythrurum*										
	55	69	37	247	0	46	31	69	170	189
Greater Redhorse *Moxostoma valenciennesi*										
	1	11	11	33	0	15	0	9	0	74
Green Sunfish *Lepomis cyanellus*										
	0	0	0	0	0	0	0	1	1	0
Greenside Darter *Etheostoma blennioides*										
	0	0	0	0	0	0	0	1	0	2
Hornyhead Chub *Nocomis biguttatus*										
	0	0	0	1	0	0	0	0	0	0
Largemouth Bass *Micropterus salmoides*										
	0	0	0	0	0	0	0	4	0	7
Logperch *Percina caprodes*										
	0	0	0	0	0	0	0	16	0	0
Northern Hogsucker *Hypentelium nigricans*										
	41	4	2	24	0	3	10	43	0	15
Northern Pike *Esox lucius*										
	3	0	7	0	0	2	1	11	2	4
Northern Redbelly Dace *Phoxinus eos*										
	0	0	0	0	0	0	0	5	0	0
Pumpkinseed *Lepomis gibbosus*										
	0	0	0	0	0	0	0	11	2	23
Quillback *Carpiodes cyprinus*										
	13	16	107	11	10	2	1	0	0	3
Rainbow Darter *Etheostoma caeruleum*										

0	0	0	0	0	0	0	2	0	0
Rainbow Trout *Oncorhynchus mykiss*									
0	0	0	0	0	0	0	1	0	0
Rock Bass *Ambloplites rupestris*									
0	1	1	1	0	3	3	21	14	74
Round Goby *Neogobius melanostomus*									
0	0	0	0	0	0	0	28	0	0
Shorthead Redhorse *Moxostoma macrolepidotum*									
3	32	1	3	0	0	5	40	0	0
Silver Redhorse *Moxostoma anisurum*									
0	9	16	0	0	0	3	12	2	9
Smallmouth Bass *Micropterus dolomieu*									
0	3	11	27	0	11	3	44	22	79
Spotfin Shiner *Cyprinella spiloptera*									
0	0	0	1	0	0	0	0	0	0
Spottail Shiner *Notropis hudsonius*									
0	0	0	0	0	0	0	16	0	39
Walleye *Sander vitreus*									
184	202	115	4	6	26	0	19	0	0
White Sucker *Catostomus commersoni*									
504	91	143	92	0	219	121	174	5	0
Yellow Bullhead *Ameiurus natalis*									
0	0	0	0	0	0	0	0	0	1
Yellow Perch *Perca flavescens*									
0	0	0	0	0	0	28	25	0	0