

Supplementary material

Spatiotemporal dynamics of intermittent stream fish metacommunities in response to prolonged drought and reconnectivity

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Table S1. Name, species code and family of fishes collected from Hickory Creek and Clear Creek, Denton County, TX, USA

Common Name	Scientific Name	Species code	Family
Longnose gar	<i>Lepisosteus osseus</i>	Leposs	Lepisosteidae
Gizzard shad	<i>Dorosoma cepedianum</i>	Dorcep	Clupeidae
Grass carp ^A	<i>Ctenopharyngodon idella</i>	Cteide	Cyprinidae
Common carp	<i>Cyprinus carpio</i>	Cypcar	Cyprinidae
Central stoneroller ^A	<i>Campostoma anomalum</i>	Camano	Cyprinidae
Red shiner	<i>Cyprinella lutrensis</i>	Cyplut	Cyprinidae
Redfin shiner	<i>Lythrurus umbratilis</i>	Lytumb	Cyprinidae
Bullhead or fathead minnow	<i>Pimephales</i> spp.	Pimsp.	Cyprinidae
Smallmouth buffalo	<i>Ictiobus bubalus</i>	Ictbub	Catostomidae
Spotted sucker	<i>Minytrema melanops</i>	Minmel	Catostomidae
Black bullhead	<i>Ameiurus melas</i>	Amemel	Ictaluridae
Yellow bullhead	<i>Ameiurus natalis</i>	Amenat	Ictaluridae
Channel catfish	<i>Ictalurus punctatus</i>	Ictpun	Ictaluridae
Tadpole madtom	<i>Noturus gyrinus</i>	Notgyr	Ictaluridae
Freckled madtom ^A	<i>Noturus nocturnus</i>	Notnoc	Ictaluridae
Blackstripe or blackspot topminnow	<i>Fundulus</i> spp.	Funsp.	Fundulidae
Western mosquitofish	<i>Gambusia affinis</i>	Gamaff	Poeciliidae
White bass ^A	<i>Morone chrysops</i>	Morchr	Moronidae
Green sunfish	<i>Lepomis cyanellus</i>	Lepcya	Centrarchidae
Warmouth sunfish	<i>Lepomis gulosus</i>	Lepgul	Centrarchidae
Orangespotted sunfish	<i>Lepomis humilis</i>	Lephum	Centrarchidae
Bluegill sunfish	<i>Lepomis macrochirus</i>	Lepmac	Centrarchidae
Longear sunfish	<i>Lepomis megalotis</i>	Lepmeg	Centrarchidae
Redear sunfish	<i>Lepomis microlophus</i>	Lepmic	Centrarchidae
Lepomis yoy	<i>Lepomis yoy</i>	Lepyoy	Centrarchidae
Largemouth or spotted bass	<i>Micropterus</i> spp.	Micsp.	Centrarchidae
White or black crappie	<i>Pomoxis</i> spp.	Pomsp.	Centrarchidae
Bluntnose darter	<i>Etheostoma chlorosoma</i>	Ethchl	Percidae
Orangethroat darter	<i>Etheostoma spectabile</i>	Ethspe	Percidae
Bigscale logperch	<i>Percina macrolepida</i>	Permac	Percidae
Freshwater drum ^A	<i>Aplodinotus grunniens</i>	Aplgru	Sciaenidae

^ASpecies collected in Clear Creek only.

Table S2. The mean (± 1 s.d.), range and statistical analysis of species' abundances during each hydro-period within Hickory Creek

'>' indicates direction of significant size differences and '=' indicate non-significance in ANOVA post-hoc tests

Species	Pre-drought (PR)		Drought (DR)		Post-drought (PO)		ANOVA			
	Mean	Range	Mean	Range	Mean	Range	<i>F</i>	d.f.	<i>P</i>	Post-hoc
Leposs	3.0 \pm 2.6	0–5	0.4 \pm 0.7	0–2	0.4 \pm 0.5	0–1	5.1	2, 12	0.025	PR > DR = PO
Dorcep	0.6 \pm 1.1	0–2	0		1.6 \pm 1.8	0–4	1.2	2, 12	0.347	
Cypcar	0		0		0.2 \pm 0.4	0–1				
Cyplut	57.3 \pm 40.7	14–95	18.2 \pm 16.8	0–42	7.6 \pm 4.6	0–12	5.7	2, 12	0.018	PR > DR = PO
Lytumb	102.0 \pm 43.3	52–128	2.1 \pm 2.4	0–6	53.6 \pm 24.6	26–93	21.7	2, 12	<0.001	PR > PO > DR
Pimspp.	13.0 \pm 3.4	11–17	1.1 \pm 1.2	0–3	7.2 \pm 8.2	0–18	6.2	2, 12	0.014	PR = PO > DR
Ictbub	0		0.3 \pm 0.5	0–1	1.8 \pm 3.4	0–8	3.8	2, 12	0.062	
Minmel	1.3 \pm 2.3	0–4	2.4 \pm 2.3	0–6	54.2 \pm 101	0–235	1.3	2, 12	0.303	
Amemel	12.6 \pm 19.3	1–35	0		0					
Amenat	6.0 \pm 3.4	2–8	4.5 \pm 4.2	0–10	0		4.0	2, 12	0.057	
Ictpun	0		0.1 \pm 0.3	0–1	0					
Notgyr	5.6 \pm 8.9	0–16	5.2 \pm 3.5	1–12	1.4 \pm 1.1	0–3	1.3	2, 12	0.300	
Funssp.	22.0 \pm 7.0	17–30	119.4 \pm 72.2	9–188	32.8 \pm 12.4	15–47	5.8	2, 12	0.017	DR > PR = PO
Gamaff	33.6 \pm 32.1	9–70	130.7 \pm 78.4	12–251	153.8 \pm 157	30–405	1.3	2, 12	0.320	
Lepcya	117.3 \pm 47	77–169	62.5 \pm 35.2	21–131	34.4 \pm 8.9	21–46	6.4	2, 12	0.013	PR = DR > PO
Lepgul	7.6 \pm 4.9	2–11	7.1 \pm 7.3	2–23	8.6 \pm 9.0	0–21	0.1	2, 12	0.948	
Lephum	29.3 \pm 9.8	18–36	3.5 \pm 3.6	0–11	25.2 \pm 17.8	3–49	7.9	2, 12	0.006	PR = PO > DR
Lepmac	51.0 \pm 20.6	32–73	63.2 \pm 37.4	16–130	58.0 \pm 53.3	5–119	0.1	2, 12	0.910	
Lepmeg	157.6 \pm 121	86–298	126.5 \pm 90.9	57–316	43.8 \pm 25.3	13–68	2.2	2, 12	0.151	
Lepmic	0	0–0	0.2 \pm 0.7	0–2	0					
Lepyoy	2.3 \pm 4.0	0–7	20.5 \pm 16.2	0–43	55.6 \pm 117.6	0–266	0.6	2, 12	0.540	
Micspp.	28.6 \pm 42.7	2–78	53.7 \pm 39.8	5–110	115.6 \pm 252	2–566	0.4	2, 12	0.685	
Pomspp.	8.3 \pm 6.5	2–15	3.4 \pm 2.6	0–8	0		6.1	2, 12	0.015	PR = DR > PO
Ethchl	1.3 \pm 1.5	0–3	3.0 \pm 3.1	0–9	11.0 \pm 8.0	3–24	4.6	2, 12	0.033	PO > PR = DR
Ethspe	0		0		0.4 \pm 0.8	0–2				
Permac	1.6 \pm 2	0–4	0		1.8 \pm 2.4	0–6	2.1	2, 12	0.171	

Table S3. The mean (± 1 s.d.), range and statistical analysis of species' abundances during each hydro-period within Clear Creek

'>' indicates direction of significant size differences in ANOVA post-hoc tests

Species	Pre-drought (PR)		Drought (DR)		ANOVA			
	Mean	Range	Mean	Range	F	d.f.	P	
Leposs	16.6 \pm 22.8	3–43	3.6 \pm 3.2	0–9	3.8	1, 11	0.077	
Dorcep	9.0 \pm 7.8	0–14	13.3 \pm 20.4	0–52	0.1	1, 11	0.735	
Cteide	0	0–0	0.3 \pm 0.4	0–1				
Cypcar	0.3 \pm 0.5	0–1	2.7 \pm 2.6	0–8				
Camano	28.6 \pm 38.5	3–73	1.6 \pm 4.0	0–13	6.0	1, 11	0.033	PR > DR
Cyplut	994.3 \pm 192	787–1167	264.4 \pm 314	54–878	14.1	1, 11	0.003	PR > DR
Lytumb	6.6 \pm 4.9	1–10	1.1 \pm 2.1	0–7	8.6	1, 11	0.014	PR > DR
Pimspp.	134.0 \pm 51	82–184	156.4 \pm 205	11–625	0.0	1, 11	0.859	
Ictbub	9.0 \pm 9.0	0–18	17.2 \pm 23.0	0–56	0.3	1, 11	0.569	
Minmel	0.6 \pm 1.1	0–2	3.3 \pm 5.1	0–13	0.7	1, 11	0.407	
Amemel	3.0 \pm 1.0	2–4	0.1 \pm 0.3	0–1				
Amenat	29.6 \pm 50.2	1–87	45.9 \pm 80.2	0–210	0.1	1, 11	0.750	
Ictpun	0	0–0	8.4 \pm 8.9	0–22				
Notgyr	0	0–0	0.6 \pm 1.0	0–3				
Notnoc	6.0 \pm 7.2	0–14	2.7 \pm 4.7	0–15	0.9	1, 11	0.365	
Funssp.	30.0 \pm 19.0	9–46	181.8 \pm 236	14–758	1.2	1, 11	0.305	
Gamaff	24.6 \pm 21.5	8–49	55.4 \pm 104	0–344	0.2	1, 11	0.633	
Morchr	0.3 \pm 0.5	0–1	0	0–0				
Lepcya	45.3 \pm 15.5	29–60	29.7 \pm 22.7	2–62	1.2	1, 11	0.295	
Lepgul	1.0 \pm 1.7	0–3	1.1 \pm 1.4	0–4	0.0	1, 11	0.921	
Lephum	39.0 \pm 15.1	27–56	39.2 \pm 30	10–98	0.0	1, 11	0.992	
Lepmac	31.6 \pm 18.1	17–52	23.3 \pm 25.6	1–75	0.3	1, 11	0.613	
Lepmeg	105.3 \pm 22.3	80–122	259.3 \pm 226	32–545	1.3	1, 11	0.279	
Lepmic	0	0–0	1.0 \pm 1.8	0–5				
Lepyoy	17.3 \pm 30	0–52	29.8 \pm 56.4	0–180	0.1	1, 11	0.726	
Micspp.	22.0 \pm 34.6	1–62	27 \pm 35.2	0–94	0.0	1, 11	0.833	
Pomspp.	0	0–0	0.7 \pm 0.8	0–2				
Ethchl	0	0–0	0.3 \pm 0.6	0–2				
Ethspe	12.3 \pm 17	1–32	2.5 \pm 4.8	0–15	3.1	1, 11	0.106	
Permac	0.3 \pm 0.5	0–1	0.2 \pm 0.6	0–2				
Aplgru	4.0 \pm 6.0	0–11	0.2 \pm 0.4	0–1				

Table S4. The mean body sizes (± 1 s.d.), range and statistical analyses (ANOVA and HSD Tukey) for species collected during each hydro-period from Hickory Creek

‘*n*’ represents the number of fishes measured (not abundance), ‘>’ indicates direction of significant size differences and ‘=’ indicates non-significance in ANOVA post-hoc tests

Species	Pre-drought			Drought			Post-drought			ANOVA			
	<i>n</i>	Mean	Range	<i>n</i>	Mean	Range	<i>n</i>	Mean	Range	<i>F</i>	d.f.	<i>P</i>	Post-hoc
Leposs	9	44.1 \pm 36	6.0–92	3	12.5 \pm 3.7	8.8–16	2	75 \pm 8.4	69–81	2.5	2, 11	0.130	
Dorcep	2	20.1 \pm 1.5	19–21	0			8	13.8 \pm 1.0	13–15	3.1	1, 8	0.101	
Cypcar	0			0			1	45.0 \pm 0					
Cyplut	159	5.4 \pm 0.9	2.0–7.7	128	5.8 \pm 0.8	2.8–7.5	38	5.7 \pm 0.9	4.0–7.8	7.8	2, 322	<0.001	PO = DR > PR = PO
Lytumb	274	4.6 \pm 0.8	1.5–7.0	15	5.4 \pm 0.9	3.1–6.4	236	5.0 \pm 1.2	1.5–7.6	11.4	2, 522	<0.001	DR = PO > PR
Pimspp.	39	5.1 \pm 0.8	3.4–7.5	8	6.0 \pm 0.5	1.8–8.6	36	6.3 \pm 1.0	4.5–8.6	15.1	2, 80	<0.001	DR = PO > PR
Ictbub	0			2	56.8 \pm 1.6	55–58	6	45.4 \pm 21	3.8–60	2.0	1, 6	0.193	
Minmel	4	3.7 \pm 0.5	3.4–4.6	17	24.1 \pm 8.2	5.2–37	138	5.0 \pm 3.6	2.0–14	151.2	2, 156	<0.001	DR > PR = PO
Amemel	38	10.7 \pm 3.3	5.0–21	0			0						
Amenat	18	11.2 \pm 3.0	7.2–19	32	14.6 \pm 2.7	11–24	0			15.9	1, 48	<0.001	DR > PR
Ictpun	0			1	33.2 \pm 0		0						
Notgyr	17	6.1 \pm 0.5	5.4–7.1	37	4.3 \pm 1.1	3.0–8.0	7	5.3 \pm 1.0	3.8–6.8	19.7	2, 58	<0.001	PR = PO > DR
Funspp.	66	4.4 \pm 1.7	1.2–7.2	686	3.9 \pm 0.8	1.8–7.3	162	5.9 \pm 0.7	2.8–7.5	287.4	2, 912	<0.001	PO > PR > DR
Gamaff	101	3.0 \pm 1.0	1.4–6.8	769	2.8 \pm 0.8	0.9–6.9	611	3.2 \pm 1.0	1.0–6.0	3.2	2, 867	0.051	
Lepcya	347	7.4 \pm 2.6	2.5–18	425	8.8 \pm 3.5	1.5–19	172	6.8 \pm 3.1	2.0–17	31.6	2, 941	<0.001	DR > PR = PO
Lepgul	23	6.6 \pm 2.5	4.0–13	50	9.4 \pm 2.0	6.6–17	43	6.1 \pm 1.9	3.6–15	30.8	2, 113	<0.001	DR > PR = PO
Lephum	88	4.8 \pm 0.9	3.2–7.5	25	6.3 \pm 0.8	5.0–8.7	122	5.0 \pm 1.1	2.6–12	17.9	2, 232	<0.001	DR > PR = PO
Lepmac	153	6.5 \pm 2.4	2.8–14	417	7.2 \pm 4.9	1.5–85	255	4.9 \pm 1.5	2.4–11	50.3	2, 822	<0.001	PR = DR > PO
Lepmeg	382	6.8 \pm 2.2	2.5–15	742	7.2 \pm 2.6	2.1–16	211	6.6 \pm 2.3	2.5–14	6.2	2, 1332	0.002	DR > PR = PO
Lepmic	0			2	8.7 \pm 0.1	8.6–8.8	0						
Lepyoy	7	1.4 \pm 0.1	1.3–1.7	144	1.8 \pm 0.3	1.0–2.5	95	1.7 \pm 0.2	1.1–2.6				
Micspp.	86	4.6 \pm 4.4	2.0–26	330	7.0 \pm 3.9	1.7–33	89	4.3 \pm 2.5	1.9–15	2.5	2, 201	<0.0001	DR > PR = PO
Pomspp.	25	14.2 \pm 4.7	7.4–29	24	13 \pm 3.5	7.4–20	0			2.8	1, 47	0.117	
Ethchl	4	4.4 \pm 0.2	4.2–4.7	21	4.2 \pm 0.4	3.5–5.1	55	3.7 \pm 1.1	1.3–5.5	2.5	2, 77	0.085	
Ethspe	0			0			2	4.3 \pm 0	4.3–4.3				
Permac	5	7.2 \pm 0.6	6.4–8.1	0			7	5.3 \pm 2.0	3.1–8.3	4.1	1, 10	0.081	

Table S5. The mean body sizes (± 1 s.d.), range and statistical analyses (ANOVA) of for species collected during each hydro-period from Clear Creek

‘*n*’ represents the number of fishes measured (not abundance), ‘>’ indicates direction of significant size differences between hydro-periods in ANOVA tests

Species	<i>n</i>	Pre-drought		<i>n</i>	Drought		<i>F</i>	ANOVA		
		Mean	Range		Mean	Range		d.f.	<i>P</i>	
Leposs	50	58.2 ± 45	3.7–145	36	40.2 ± 20	8.6–77	5.1	1, 84	0.027	DR > PR
Dorcep	27	15.3 ± 1.6	11–18	132	20.1 ± 3.3	4.7–37	54.0	1, 157	<0.001	PR > DR
Cteide	0			3	78.3 ± 3.5	75–82				
Cypcar	1	41 ± 0		27	50.6 ± 8.4	38–78				
Camano	79	5.7 ± 1.8	2.7–11	15	5.5 ± 0.5	5.0–6.8				
Cyplut	886	4.2 ± 0.9	1.5–7.6	1029	3.5 ± 1.6	1.2–32	121.8	1, 1913	<0.001	PR > DR
Lytumb	20	4.7 ± 1.2	2.8–7.9	11	3.1 ± 0.6	2.1–4.1	18.7	1, 29	<0.001	PR > DR
Pimspp.	339	4.5 ± 1.3	1.8–8.4	739	3.4 ± 2.3	1.3–63	63.8	1, 1076	<0.001	PR > DR
Ictbub	27	21.4 ± 24	2.1–61	172	24.8 ± 20	5.2–61	0.6	1, 197	0.428	
Minmel	2	14.2 ± 2.4	13–16	33	7.1 ± 2.0	5.0–18	21.7	1, 33	<0.001	PR > DR
Amemel	9	12.8 ± 5.9	3.2–26	1	9.5 ± 0					
Amenat	89	3.9 ± 2.5	1.5–18	367	5.4 ± 2.0	3.0–20				
Ictpun	0			84	12.5 ± 12	2.0–57				
Notgyr	0			6	4.4 ± 1.2	3.1–6.7				
Notnoc	18	5.4 ± 2.8	2.1–11	27	4.7 ± 1.2	2.9–7.7	1.6	1, 43	0.219	
Funspp.	90	4.6 ± 1.3	1.7–7.2	935	3.8 ± 0.9	1.5–8.0	61.1	1, 1024	<0.001	PR > DR
Gamaff	74	2.9 ± 0.9	1.2–5.5	383	2.6 ± 0.7	1.0–6.3	8.0	1, 455	0.008	PR > DR
Morchr	1	28.0 ± 0		0						
Lepcya	136	6.5 ± 2.7	2.0–18	297	6.8 ± 2.3	2.5–18	1.1	1, 431	0.292	
Lepgul	3	4.3 ± 0.5	4.0–5.0	11	9.1 ± 2.1	3.6–11	14.8	1, 12	0.007	DR > PR
Lephum	117	4.6 ± 1.2	2.1–8.3	311	3.8 ± 1.2	2.1–7.0	32.7	1, 426	<0.001	PR > DR
Lepmac	93	5.7 ± 2.3	2.0–14.5	233	6.3 ± 2.2	2.1–13	4.7	1, 324	0.031	DR > PR
Lepmeg	316	6.8 ± 2.6	2.5–14	1404	4.5 ± 2.0	1.3–14	288.6	1, 1720	<0.001	PR > DR
Lepmic	0	0 ± 0	0–0	10	10.3 ± 2.1	6.0–12				
Lepyoy	52	1.8 ± 0.8	1.1–7.6	133	2.2 ± 1.8	1.0–23				
Micspp.	66	3.7 ± 3.4	1.7–18	251	7.7 ± 3.4	2.1–28	67.6	1, 315	<0.001	DR > PR
Pomspp.	0			7	20.1 ± 1.5	19–23				
Ethchl	0			3	3.5 ± 0.2	3.2–3.7				
Ethspe	37	3.2 ± 0.9	2.2–5.5	25	3.5 ± 0.4	3.0–4.7	1.3	1, 60	0.255	
Permac	1	9.1 ± 0		2	8.3 ± 1.0	7.6–9.1				
Aplgru	12	25.3 ± 3.8	18–31	2	19.3 ± 4.5	16–23	3.9	1, 12	0.067	

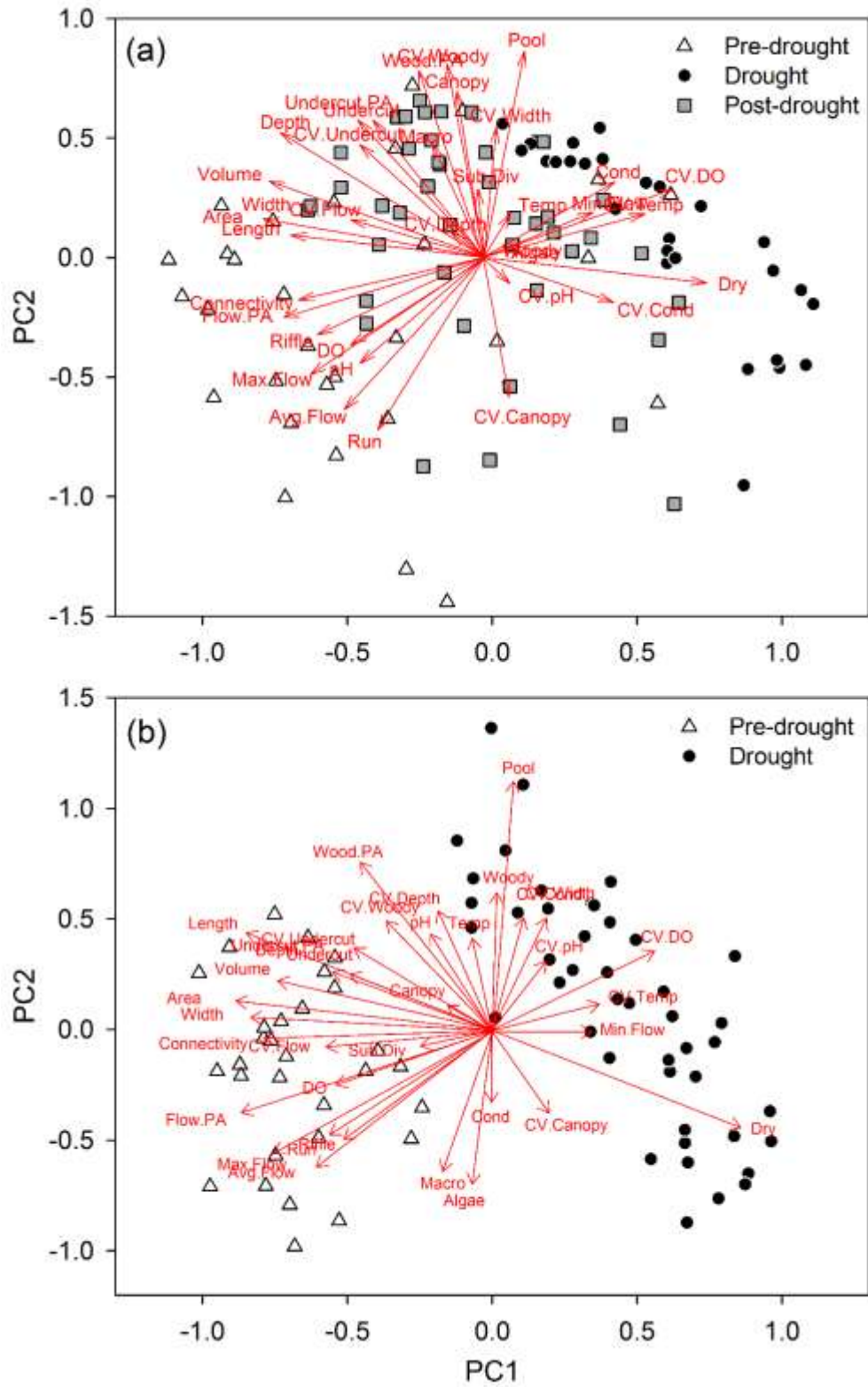


Fig. S1. PCA ordination of environmental parameters for Hickory Creek (a) and Clear Creek (b) among sites from each hydro-period.

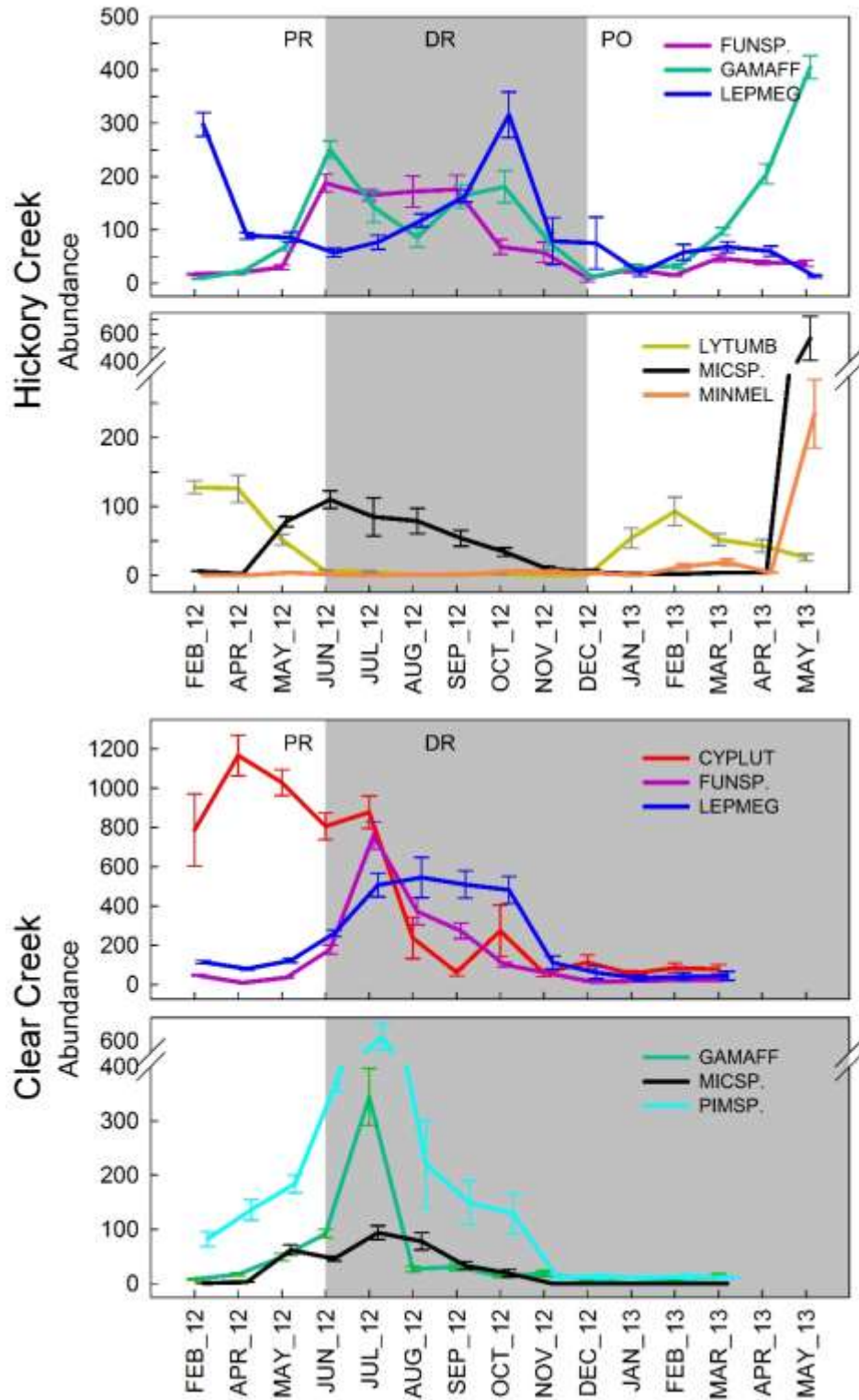


Fig. S2. The mean (\pm s.d.) abundances of select fish species over time for both Hickory and Clear creeks. Shaded areas signify pre-drought (PR), drought (DR) and post-drought (PO) hydro-periods.