Effects of Environmental Pool Management on backwater fish communities over 25 years in Upper Mississippi River Pool 26

.

Amanda Carter

Impacts of dams

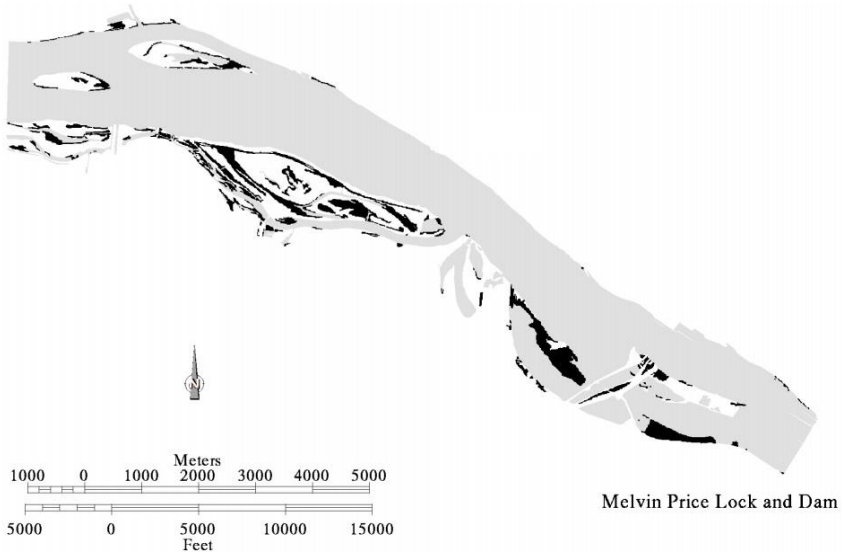
- Upper Mississippi River (UMR) is dammed for navigation
- Stabilized natural water level fluctuations
  - Submerged floodplains
  - Decrease habitat variation
  - Stripped vegetation from littoral zones
    - Used by most fish at different stages of life

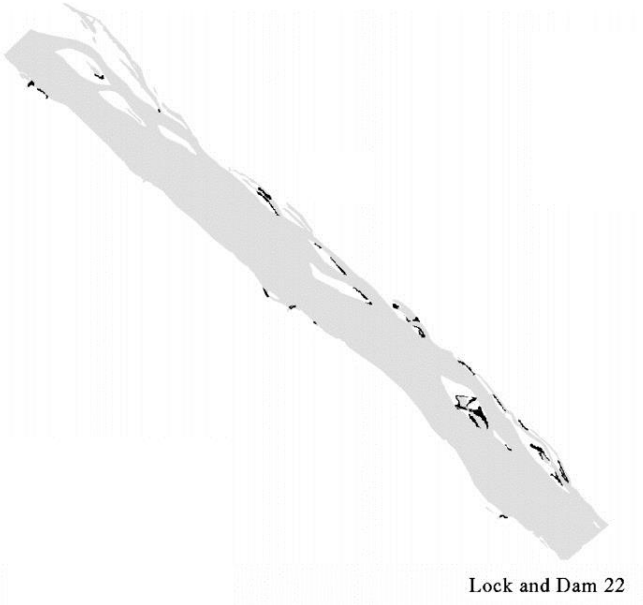
Environmental Pool Management (EPM)

- Pools 24, 25, 26 since 1994
- EPM in Pool 26
  - Drawdown of >0.5-ft for >30 days between May 1 and July 31
  - Slow recovery <0.1-ft per day to normal elevation
- Emergent Vegetation
  - Lower Pool 26 surveyed by USACE
  - Dominated by millet and smart weed
  - Require 30 days to grow 10 inches

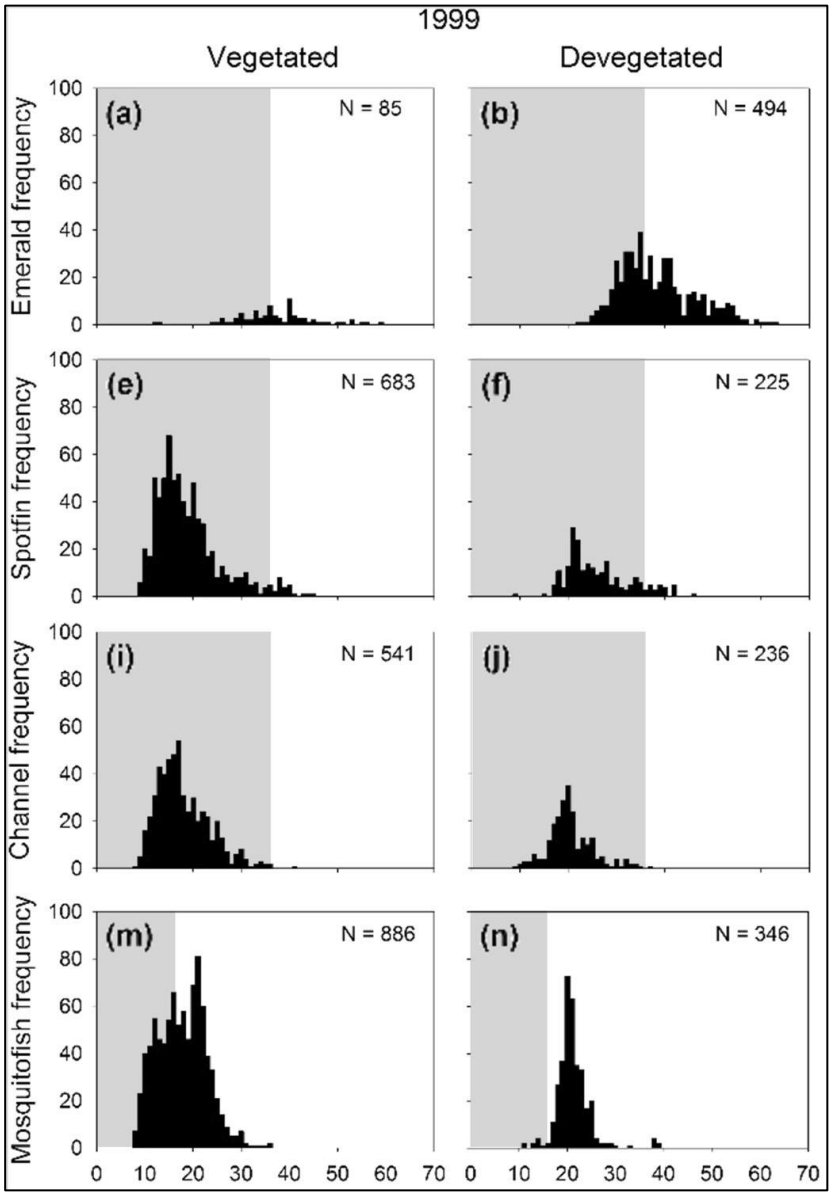
EPM past studies

- Wlosinski et al. (2000)
  - EPM in Pools 24, 25, 26 in 1995 and 1996
  - Compared to Pool 22 where EPM does not occur
  - Plants covered significantly more shoreline





- Coulter et al. (2019)
  - EPM in Pool 25 in 1999, 2000, and 2001
  - Fishes surveyed in vegetated vs devegetated plots
  - Total fish abundance was higher in vegetated plots
  - Burdis et al. (2020) observed a decrease of emerald shiners within vegetation in Pool 4

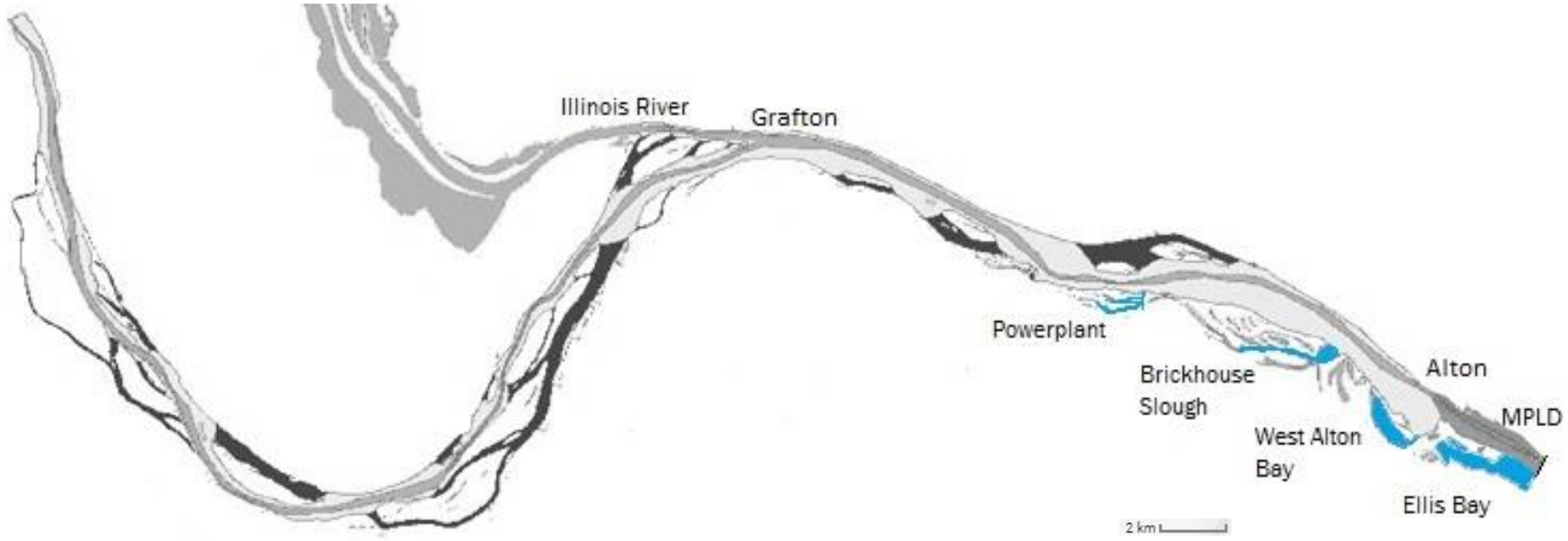


Purpose

- Short-term fish response to EPM has been assessed in backwaters
  - Few years, few sites
- Current study assessed 25 years of fish community data within 4 backwater habitats of Pool 26
- Identify if EPM explains a significant amount of variation in backwater fish communities

Study Area

- 4 backwaters in lower quarter of Pool 26
  - Other backwaters too far upstream or were not sampled every year

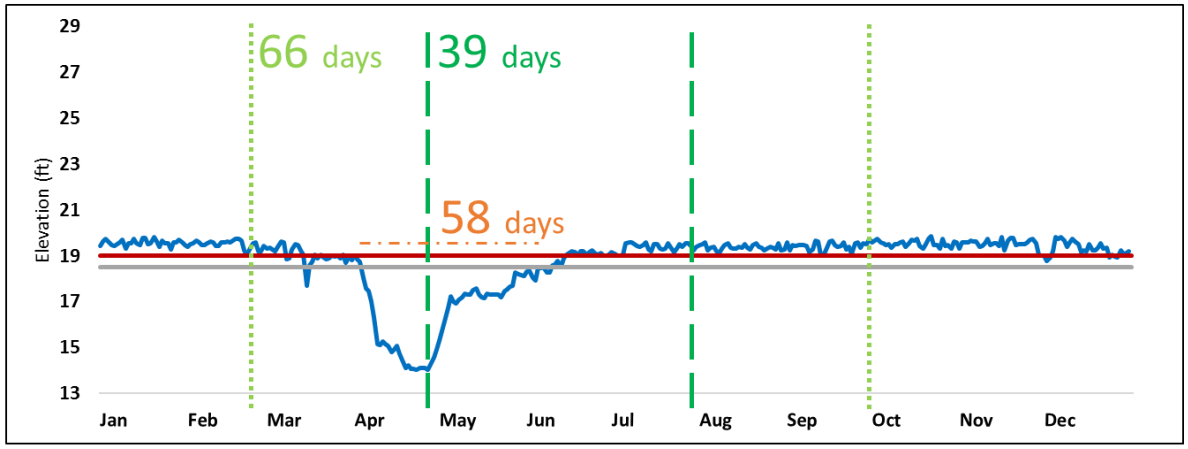


Fish

- Sampled each year over 18 weeks by Illinois Natural History Survey
- Boat electrofishing, fyke nets, and mini fyke nets

Environmental Variables

1. Total number of days below 0.5-ft between May and July (MayJuly)
   - USACE goal window
2. Total number of days below 0.5-ft between March and September (MarSept)
   - Counted if drawdown extended beyond May-July goal
3. Longest duration below 0.5-ft (Duration)
   - Fluctuation would negatively affect vegetation growth

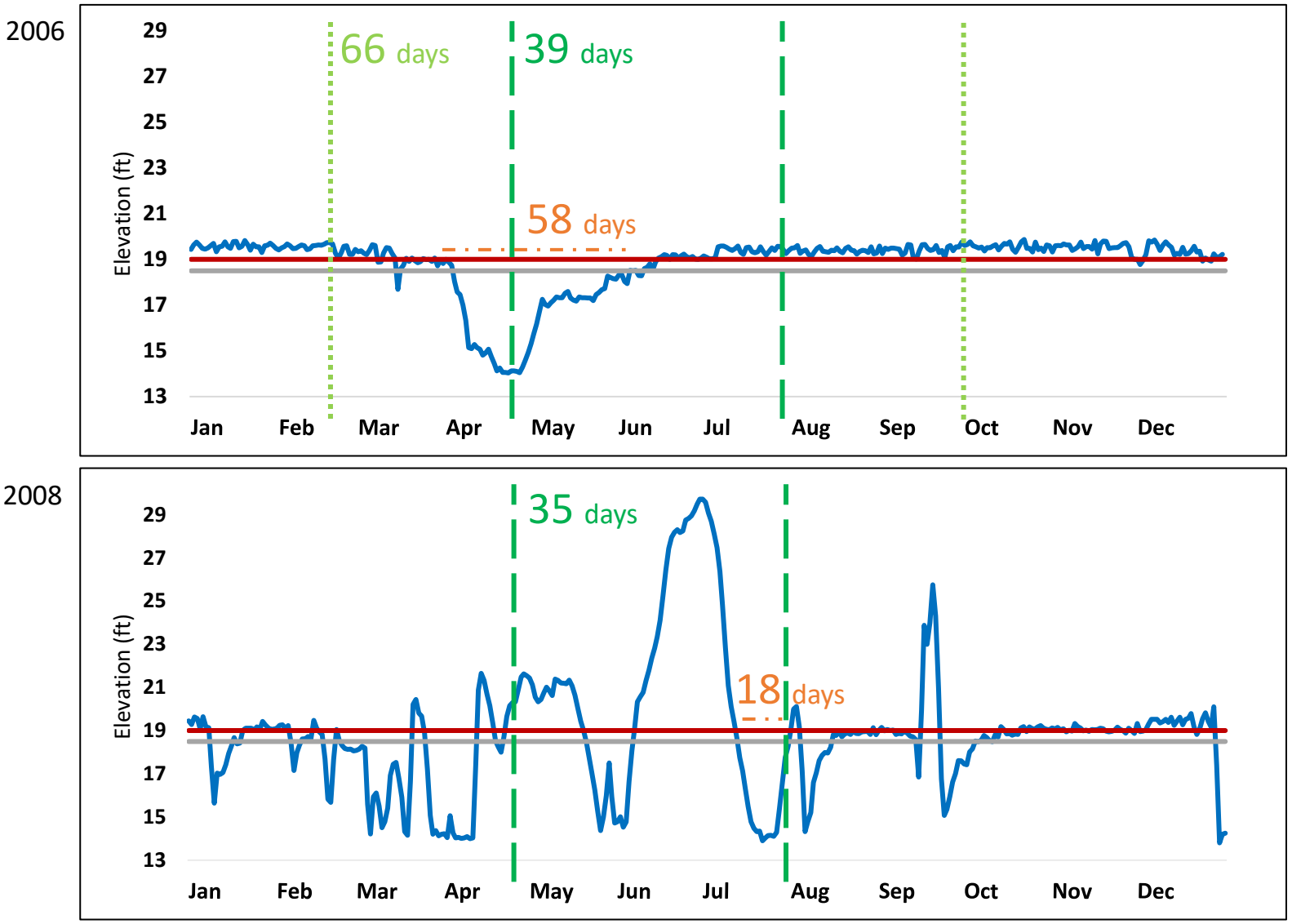


EPM data

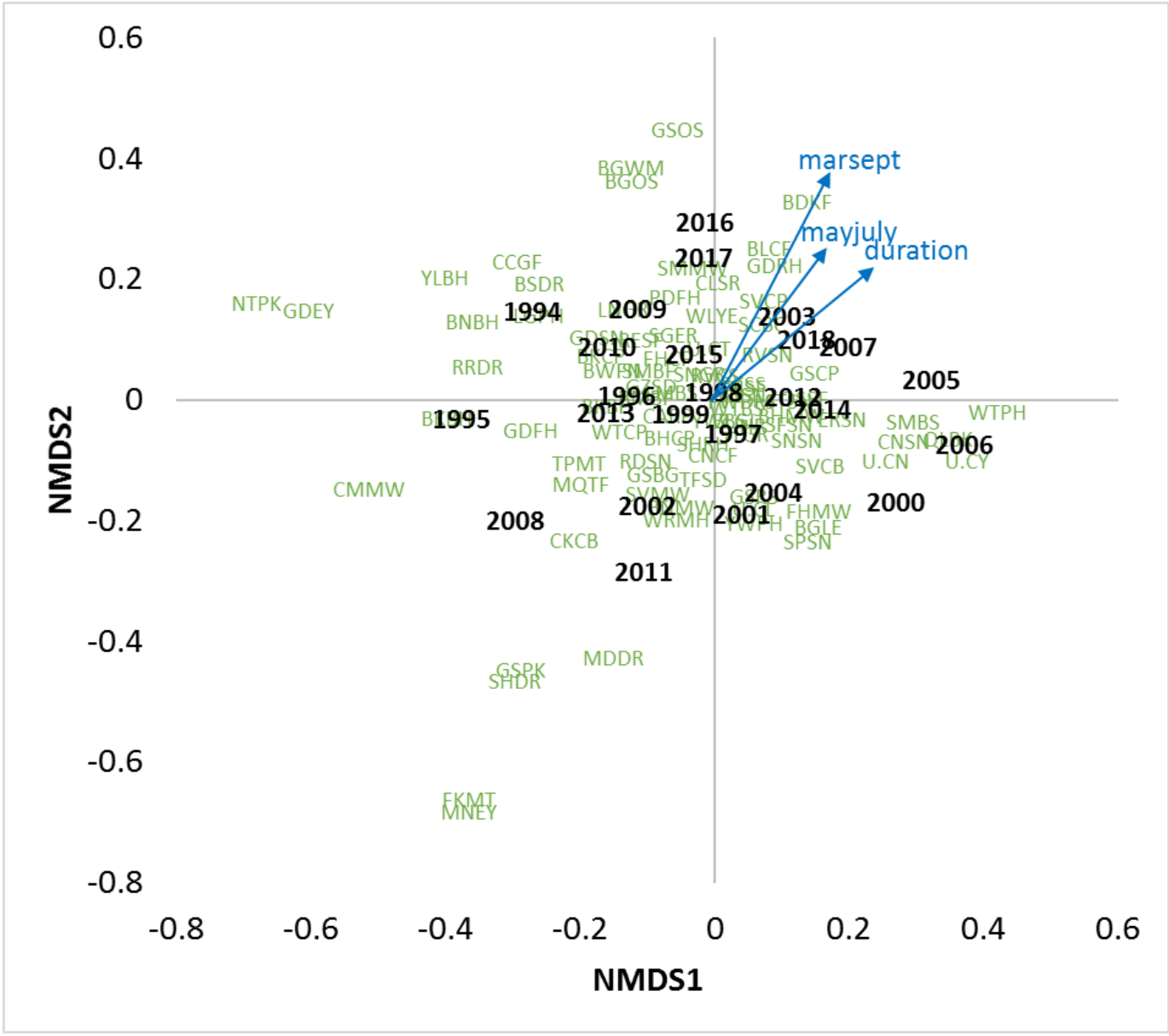
- 23 of 25 years were successful
  - 30+ days below 0.5-ft
- 2008 and 2010 unsuccessful due to natural flooding

Total number of days Pool 26 was 0.5-ft below normal pool between May and July (May July), between March and September (March Sept), and the highest number of days concurrently below 0.5-ft duration (Duration).

Year	May July	March Sept	Duration
1994	62	74	36
1995	45	90	37
1996	54	93	46
1997	71	71	68
1998	73	74	48
1999	59	71	42
2000	57	57	56
2001	46	46	34
2002	67	88	59
2003	85	92	54
2004	65	65	49
2005	44	71	33
2006	39	66	58
2007	53	103	60
2008	35	35	18
2009	60	60	55
2010	33	33	19
2011	36	51	35
2012	51	51	51
2013	42	42	34
2014	80	120	96
2015	50	121	61
2016	123	214	214
2017	85	141	85
2018	102	192	143

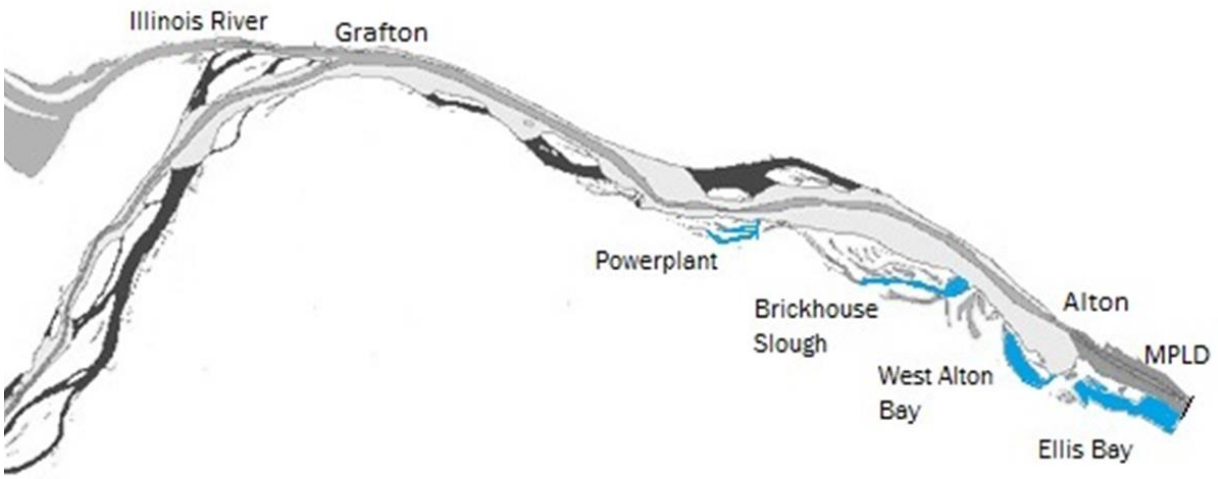

2006
66 days
39 days
58 days
Elevation (ft)
29
27
25
23
21
19
17
15
13
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2008
35 days
18 days
Elevation (ft)
29
27
25
23
21
19
17
15
13
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

- **All backwaters combined**, all individuals SSM
- Taxa (green)
- 25 years (**black**)
- Environmental variables (blue)
- P-values
  - Mayjuly – 0.010
  - Marsept – 0.003
  - Duration – 0.011



- Correlation between fish community structure and environmental factors exist in backwaters of Pool 26
  - Driven by correlations in both Brickhouse Slough and West Alton Bay

- Brickhouse Slough is about 6-km upstream from MPLD
- West Alton Bay is about 3-km upstream from MPLD
- Great locations for EPM to be successful

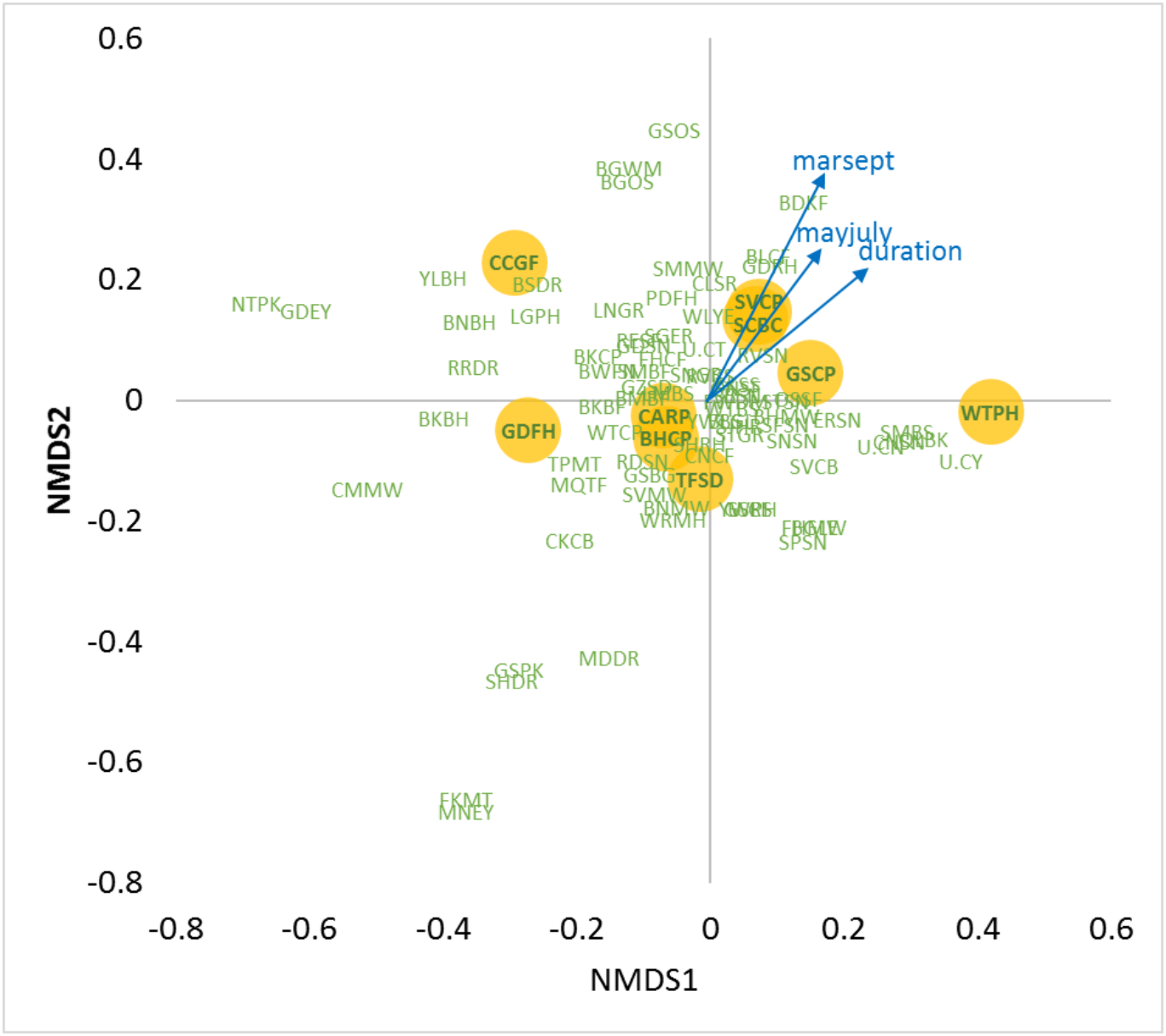


Brickhouse Slough

West Alton Bay

Ellis Bay

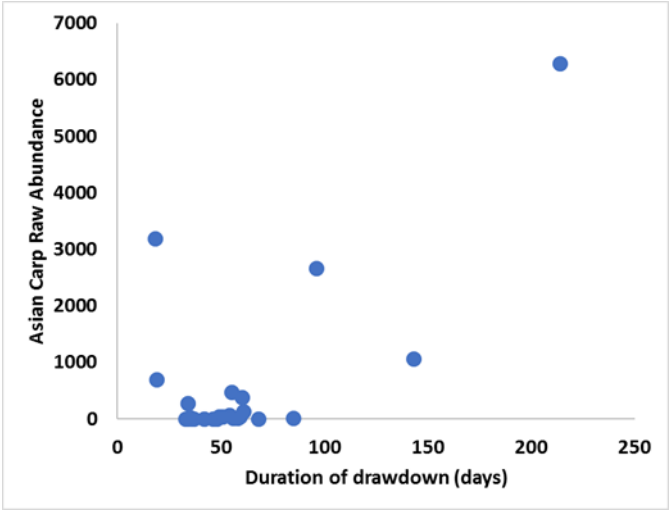
Powerplant


0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
NMDS2
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
NMDS1
marsept
mayjuly
duration
CCGF
GDFH
CARP
BHCP
TFSD
SVCP
SCBC
GSCP
WTPH
GSOS
BGWM
BGOS
BDKF
YLBH
BSDR
NTPK
GDEY
BNBH
LGPH
LNGR
PDFH
SMMW
CLSR
GDRH
WLYE
SGER
U.CT
RVSN
RRDR
BKCP
BWFS
BKBH
WTCP
TPMT
MQTF
RDSN
GSBG
SVMW
CNCF
SNSN
SVCB
U.CN
U.CY
SMBS
CMMW
CKCB
WRMH
SPSN
MDDR
GSPK
SHDR
FKMT
MNEY

Correlations between taxa and EPM

- Negative correlations
  - Bluegill
  - Bigmouth buffalo
  - Channel catfish
  - Largemouth bass
  - White crappie

- Positive correlations
  - River carpsucker
  - Sauger
  - Grass carp
  - Silver carp



Relationship between water levels and fish recruitment

- Beam (1983)
  - Increased rate of discharge resulted in loss of YOY white crappie
- Boxrucker et al. (2005)
  - High summer water levels improve survival of YOY largemouth bass
- Kahl et al. (2008)
  - Decreasing water level shortly after the spawning period was found to result in a total loss of the new roach year class

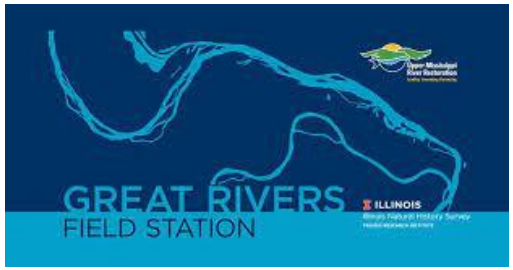
Next Steps

- Look at pools 25 and 24
  - Pool 22, etc.
- Additional gears – throw trap, backpack shocker, seines
- Measure actual area exposed during a drawdown
  - Create a better EPM vector

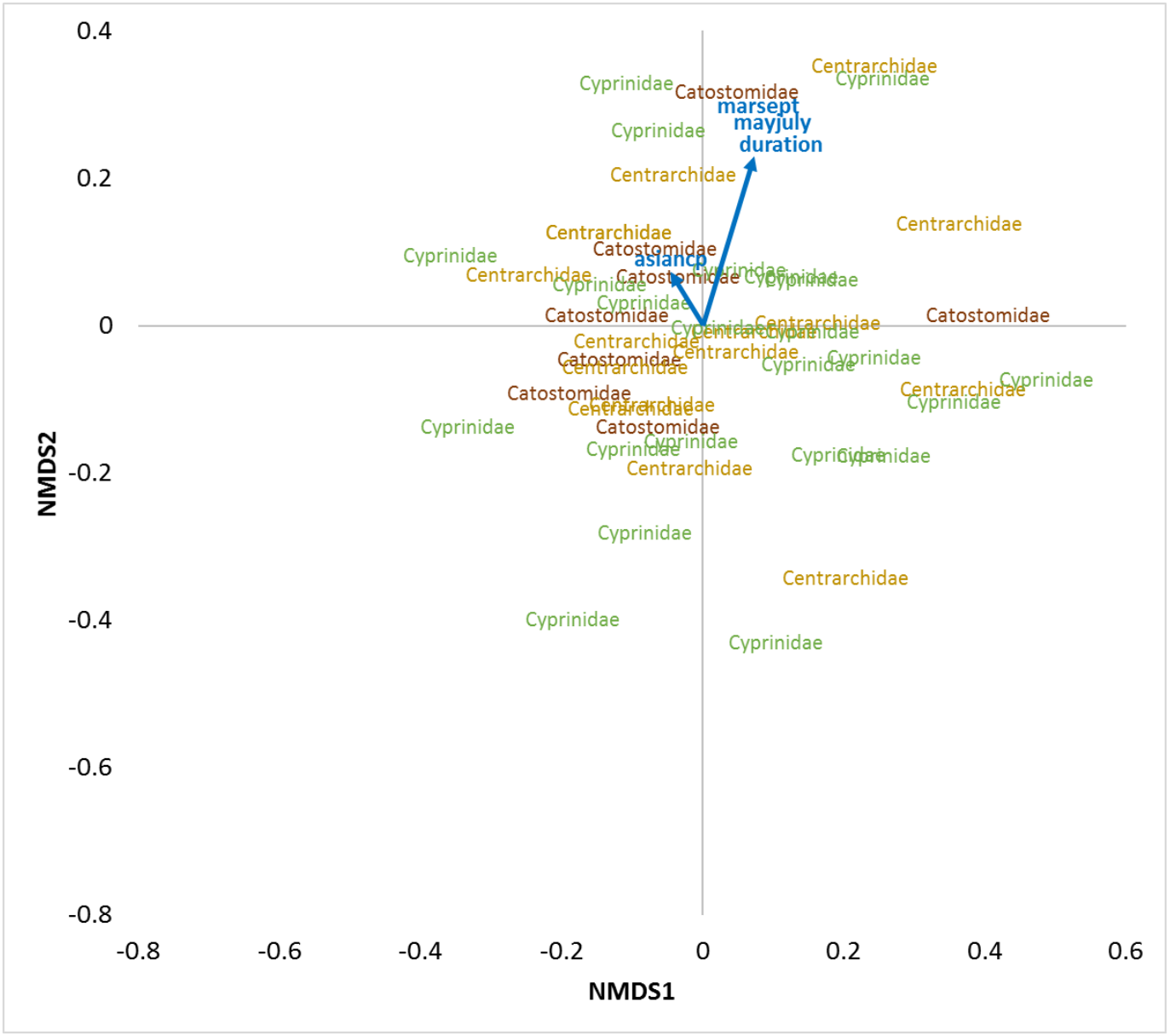
Thanks!

USGS
science for a changing world

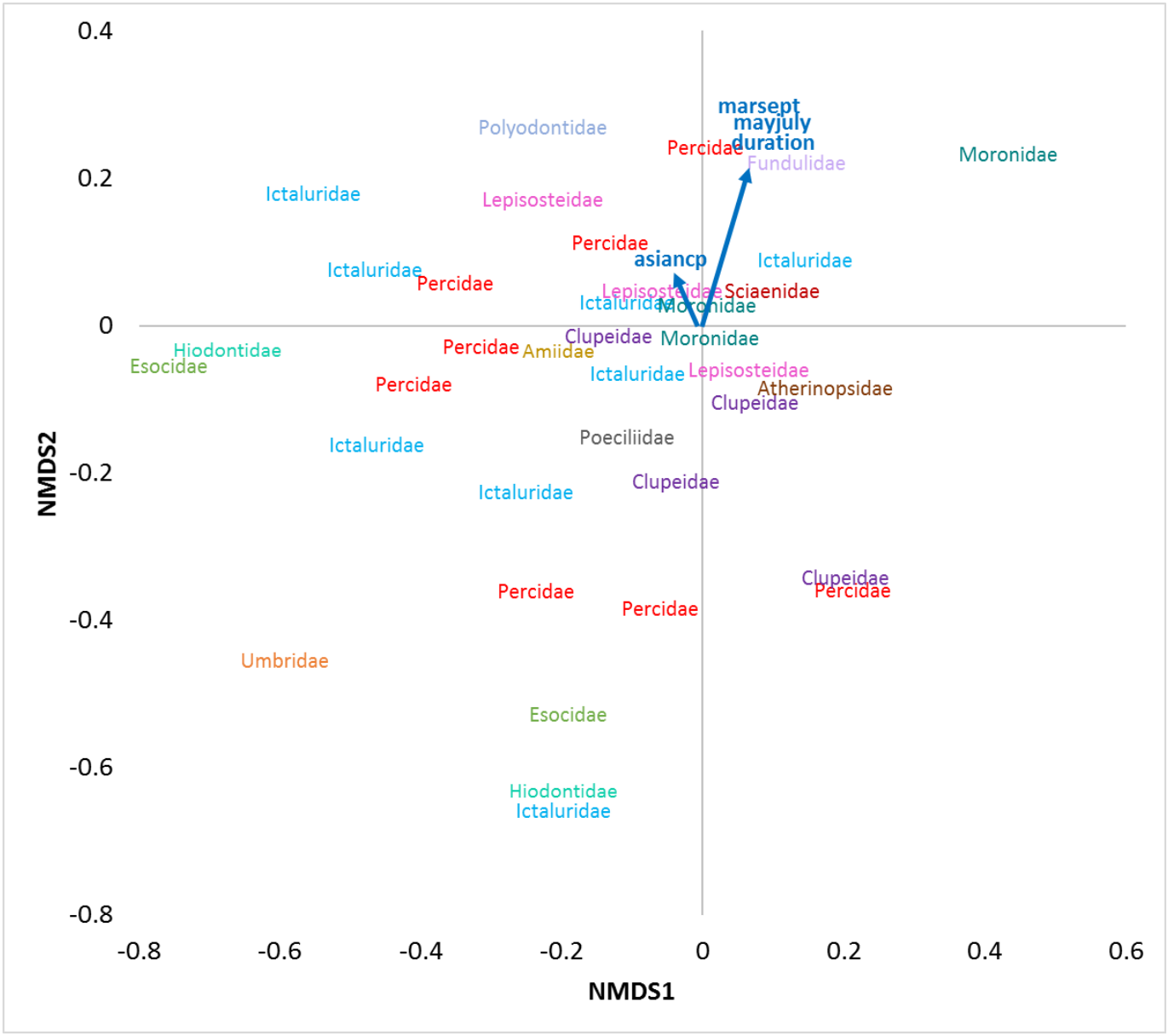
ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE



SIUe
COUGARS



8 Catostomidae
16 Centrarchidae
23 Cyprinidae


0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
NMDS2
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
NMDS1
marsept
mayjuly
duration
asiancp
Polyodontidae
Percidae
Fundulidae
Moronidae
Ictaluridae
Lepisosteidae
Percidae
Ictaluridae
Percidae
Ictaluridae
Lepisosteidae
Sciaenidae
Ictaluridae
Moronidae
Clupeidae
Moronidae
Hiodontidae
Esocidae
Percidae
Amiidae
Ictaluridae
Lepisosteidae
Percidae
Atherinopsidae
Clupeidae
Ictaluridae
Poeciliidae
Clupeidae
Ictaluridae
Clupeidae
Percidae
Percidae
Percidae
Umbridae
Esocidae
Hiodontidae
Ictaluridae

Effects of dams

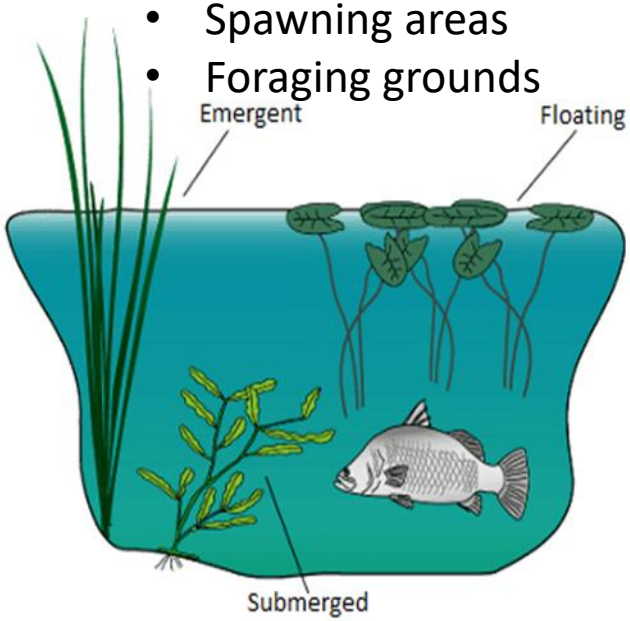
- Impede fish passage
  - Migratory fishes need to travel
  - High velocities exceed maximum swimming speed
  - Some species more likely to pass within the lock
  - Some avoid structures

Dams on UMRS

- 29 locks and dams with moveable Tainter gates
  - Control channel depth
  - Do not provide flood control
  - Other US dams built for other purposes
  - Created a series of pools

Vegetation

- Used by most fish at different stages of life
  - Shelters
  - Spawning areas
  - Foraging grounds



Vegetation

- Submerged, floating, and emergent macrophytes
  - Stabilize velocity
  - Reduce turbidity
  - Provide food and shelter for wildlife

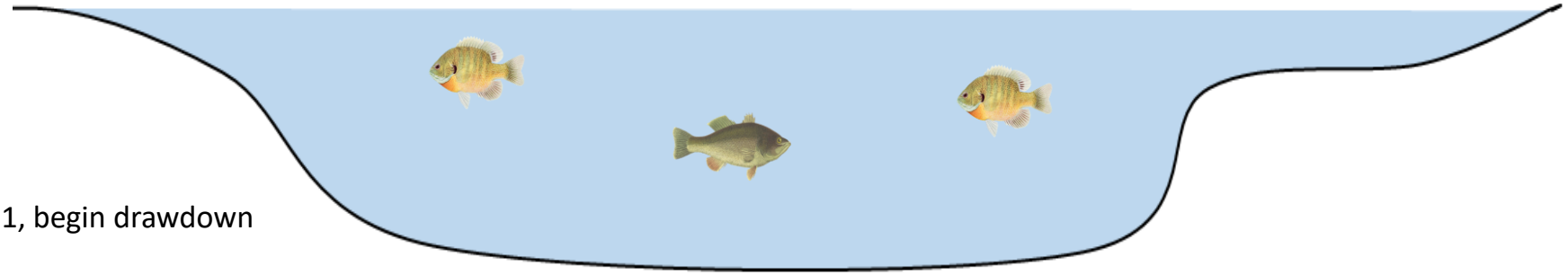
Water level management

- Raise level to increase fish recruitment
- Lower level to increase emergent vegetation

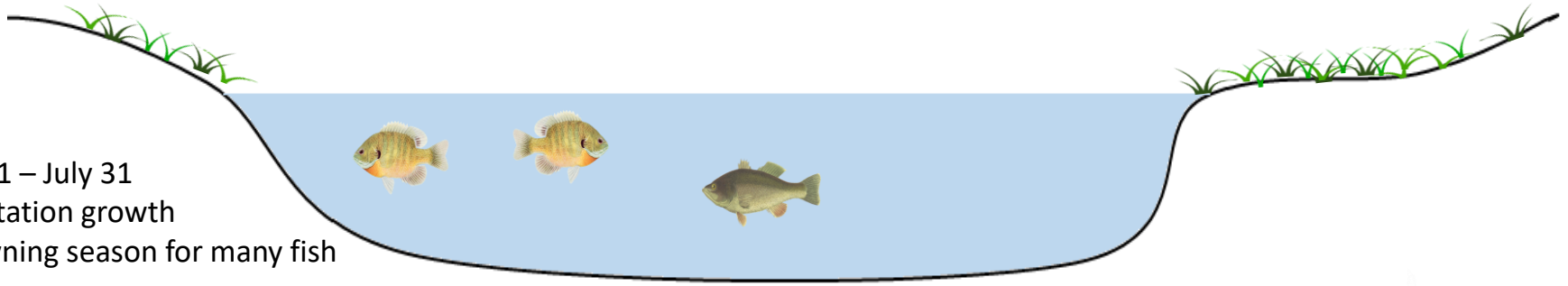
On average, 23 samples taken from Ellis Bay, 6 from West Alton Bay, 14 from Brickhouse Slough, and 6 from Powerplant, per year

Analysis

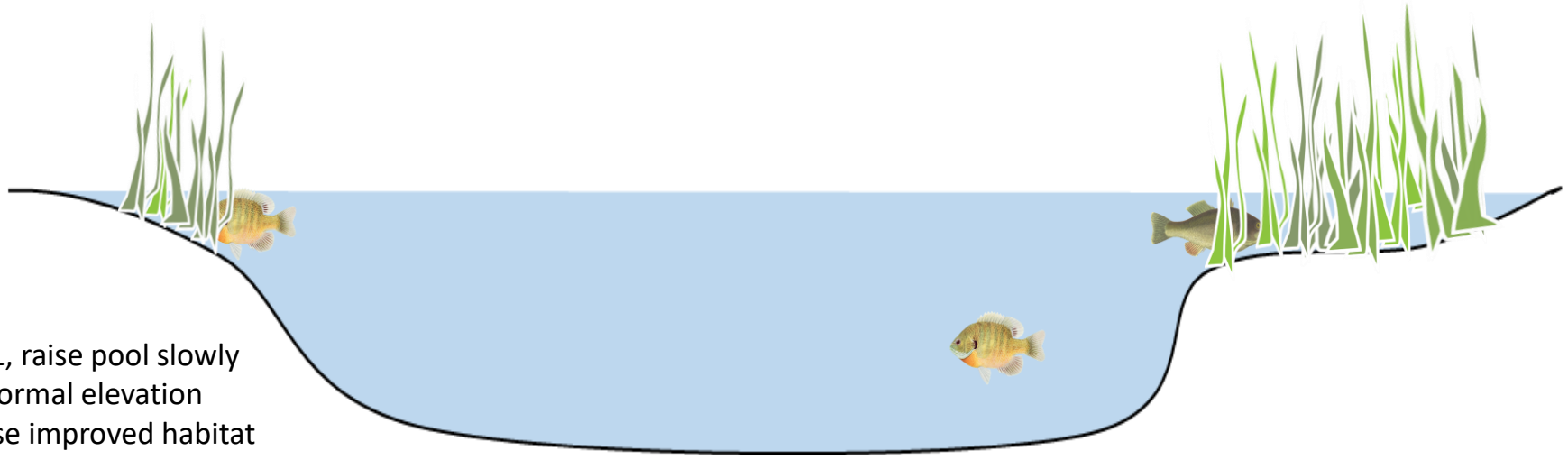
- R Studio - Vegan package
- Bray-Curtis method used to find dissimilarity index
- Nonmetric Multidimensional Scaling (NMDS) to produce the ordination
- Shepard diagram used to display stress
- ENVFIT function used to fit the direction and length of vector arrows



May 1, begin drawdown



May 1 – July 31
Vegetation growth
Spawning season for many fish



July 31, raise pool slowly
to normal elevation
Fish use improved habitat

- Standardize Dataset
  - Community Total (SCT)
    - Catch of species in one year divided by total individuals for same year
    - Affected by abundance of other taxa
  - Species Maximum (SSM)
    - Catch of species in one year divided by maximum catch for all years
    - Shows how well a species is doing compared to its best year
    - Controls variation of catch success for that taxon from year to year and provides greater weight to rare taxa

Raw

	Red	Yellow	Blue	**Total**
1994	1	5	10	**16**
1995	10	50	100	**160**
1996	10	5	5	**20**
1997	50	75	10	**135**
Total	**71**	**135**	**125**	
Max	**50**	**75**	**100**	

SCT

	Red	Yellow	Blue
1994	0.063	0.313	0.625
1995	0.063	0.313	0.625
1996	0.500	0.250	0.250
1997	0.370	0.556	0.074

SSM

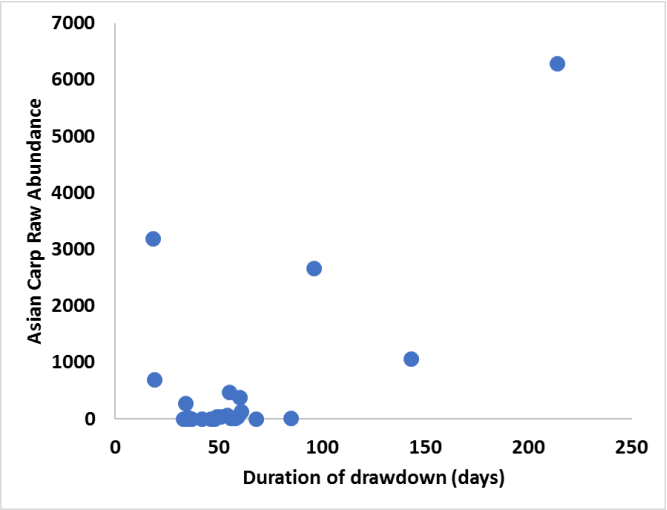
	Red	Yellow	Blue
1994	0.020	0.067	0.100
1995	0.200	0.667	1.000
1996	0.200	0.067	0.050
1997	1.000	1.000	0.100

Analysis

- 8 analyses performed on 4 backwaters plus all backwaters combined (5 datasets x 8 analyses)
- 40 total analyses
  1. All individuals SCT vs environmental variables in same year
  2. All individuals SSM vs environmental variables in same year
  3. Juvenile individuals SCT vs environmental variables in same year
  4. Juvenile individuals SSM vs environmental variables in same year
  5. All individuals SCT vs environmental variables in previous year
  6. All individuals SSM vs environmental variables in previous year
  7. Juvenile individuals SCT vs environmental variables in previous year
  8. Juvenile individuals SSM vs environmental variables in previous year

Data Quality - correlations

- All backwater total column v. EPM
  - No significant correlation
    - Catch success similar year to year regardless of drawdown duration
- Shannon-Weiner diversity index v. EPM
  - Significant negative correlation
    - Community less diverse when EPM more successful?
    - OR is sampling less effective?
    - Which species change diversity year to year?
- Asian carp abundance v. EPM
  - Significant positive correlation
    - Driven by largest catch during longest duration



Data Quality

- Combined fish abundance dataset of all 4 backwaters includes 177,056 individuals from 84 taxa representing 17 families

- Number of samples collected by each gear was consistent across years
- Analyses include all gear type samples pooled together

Total samples taken in all backwaters, split by gear type
Electrofishing (E), Fyke (F), and mini fyke (M)

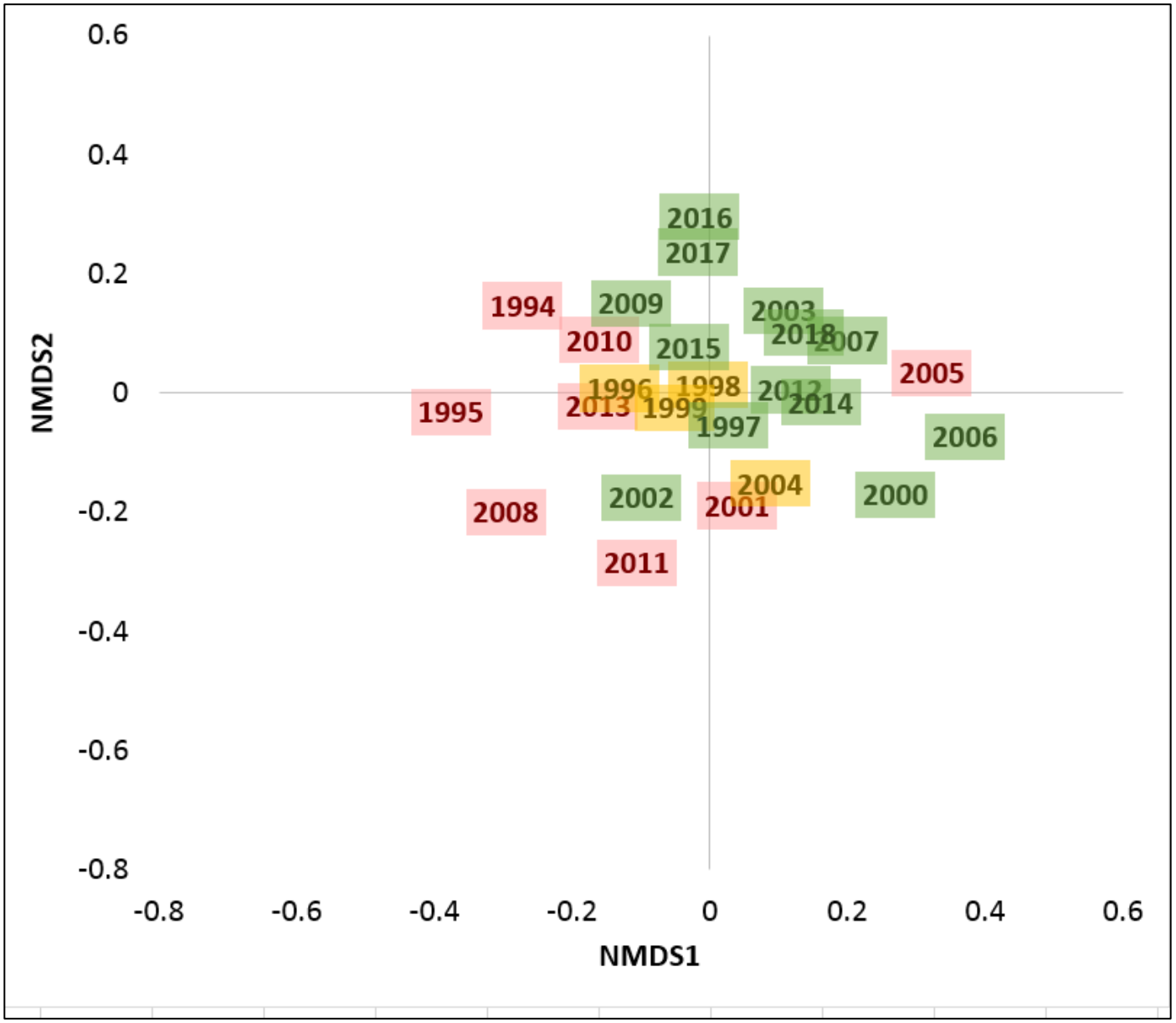
Year	E	F	M
1994	21	11	10
1995	21	16	11
1996	22	13	11
1997	17	12	15
1998	25	15	11
1999	18	14	14
2000	22	13	12
2001	18	19	12
2002	24	12	16
2003	18	21	10
2004	24	12	13
2005	16	11	10
2006	15	11	7
2007	21	23	13
2008	20	21	14
2009	22	20	11
2010	19	17	14
2011	24	16	14
2012	21	19	14
2013	25	16	16
2014	21	13	6
2015	26	21	12
2016	17	16	12
2017	21	21	14
2018	20	15	11
TOTAL	**518**	**398**	**303**
AVG	**21**	**16**	**12**

Asian Carp Raw Abundance

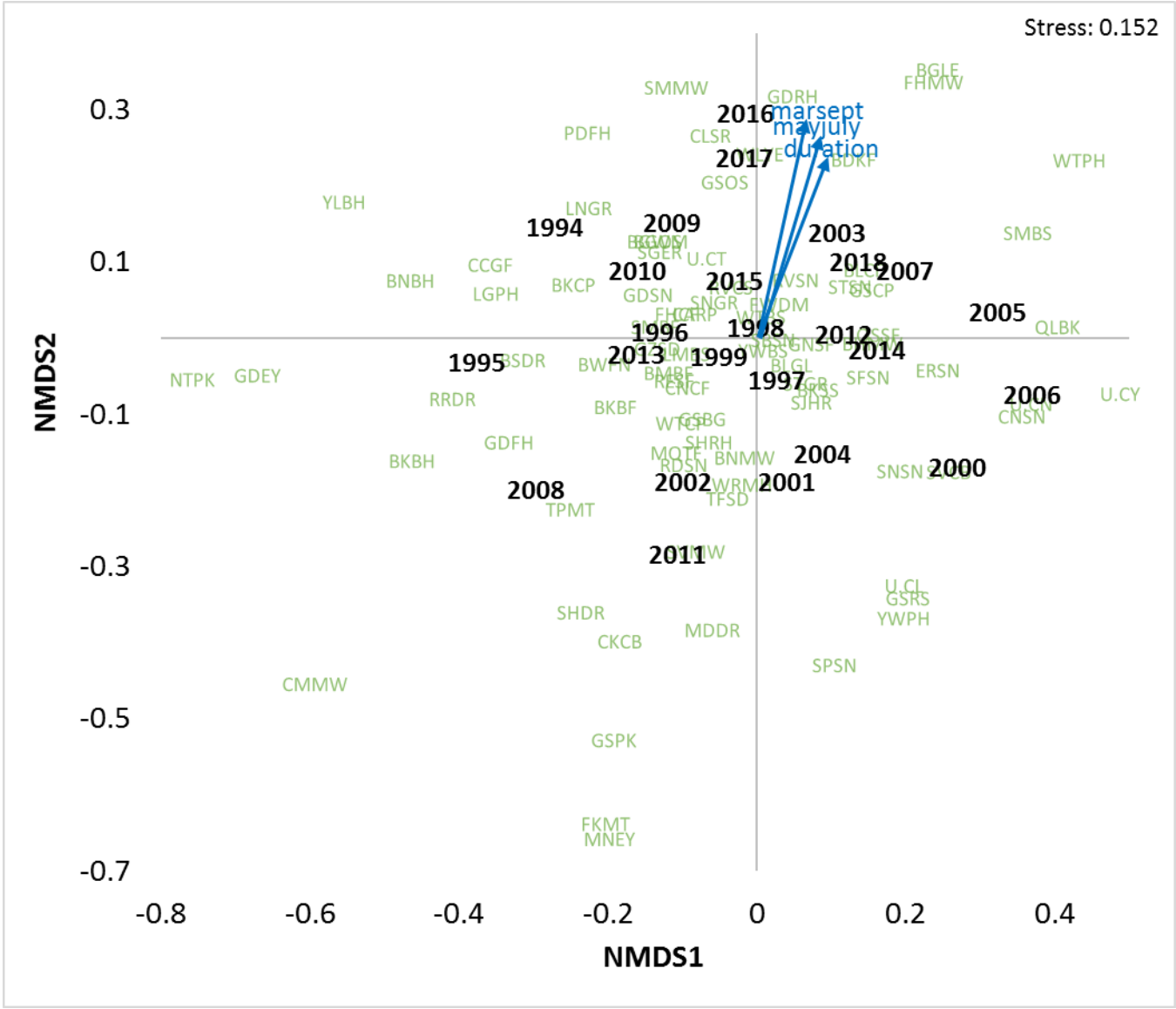
- Silver carp, bighead carp, and their hybrid
- 15,393 individuals
- Do not appear in dataset until 1997
  - major increase in 2007

Raw abundance of silver carp (SVCP), bighead carp (BHCP), silver x bighead carp hybrid (SCBC), and their combined totals (Combined).

Year	SVCP	BHCP	SCBC	Combined
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	1	0	1
1998	0	2	0	2
1999	0	5	0	5
2000	0	12	0	12
2001	0	1	0	1
2002	5	28	0	33
2003	5	67	0	72
2004	20	20	0	40
2005	0	1	0	1
2006	8	1	0	9
2007	370	4	0	374
2008	3151	39	0	3190
2009	455	12	1	468
2010	618	73	0	691
2011	18	7	0	25
2012	26	9	1	36
2013	204	69	0	273
2014	2619	40	0	2659
2015	135	0	0	135
2016	6291	0	0	6291
2017	7	1	0	8
2018	1066	1	0	1067
Total	14998	393	2	15393

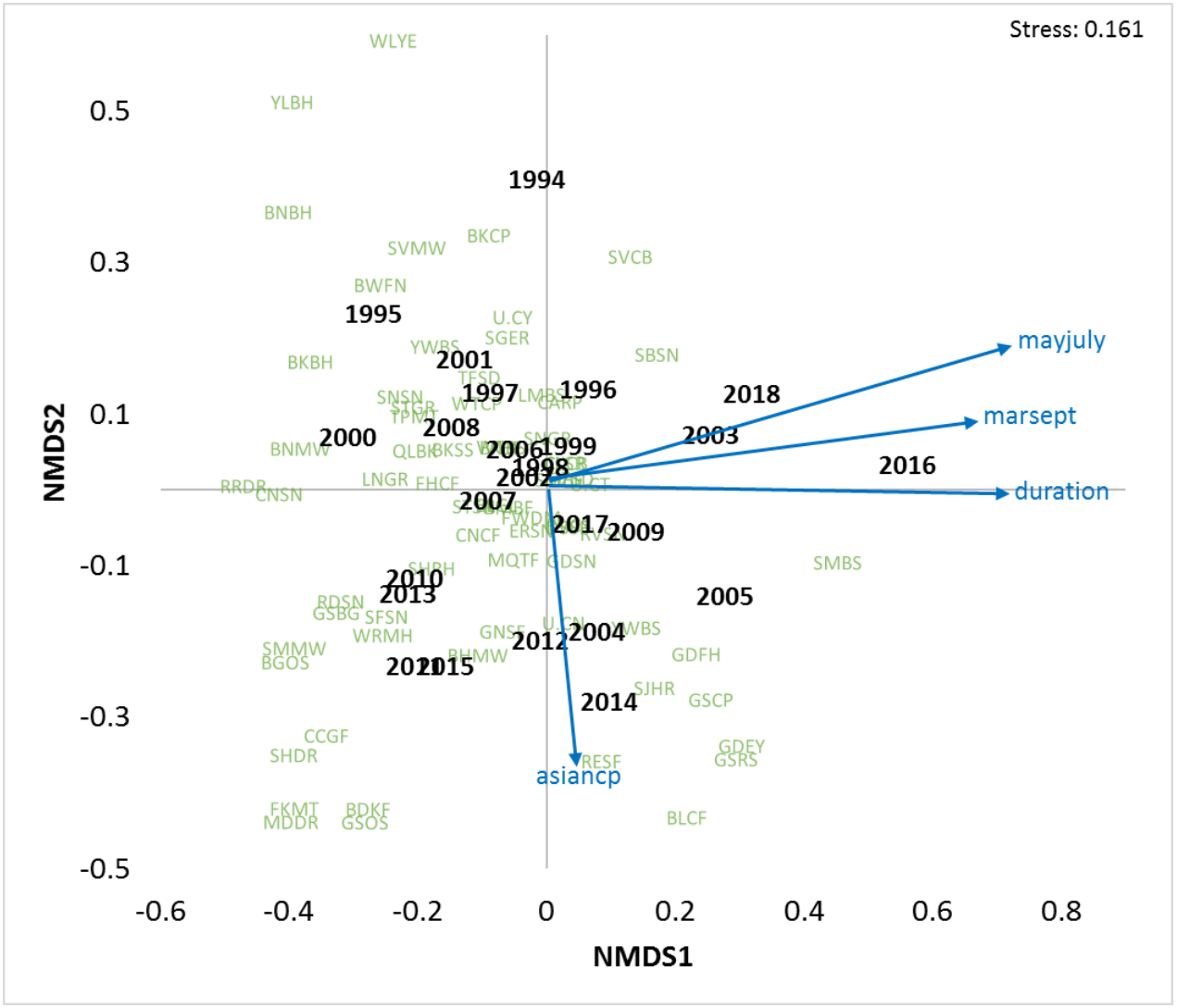

0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
NMDS2
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
NMDS1
2016
2017
1994
2009
2003
2010
2015
2018
2007
2005
1996
1998
2012
1995
2013
1999
2014
1997
2006
2004
2002
2000
2008
2001
2011

- **All backwaters combined**, all individuals SSM
- Species (green)
- 25 years (**black**)
- Environmental variables (blue)
- P-values
  - Mayjuly – 0.010
  - Marsept – 0.003
  - Duration – 0.011



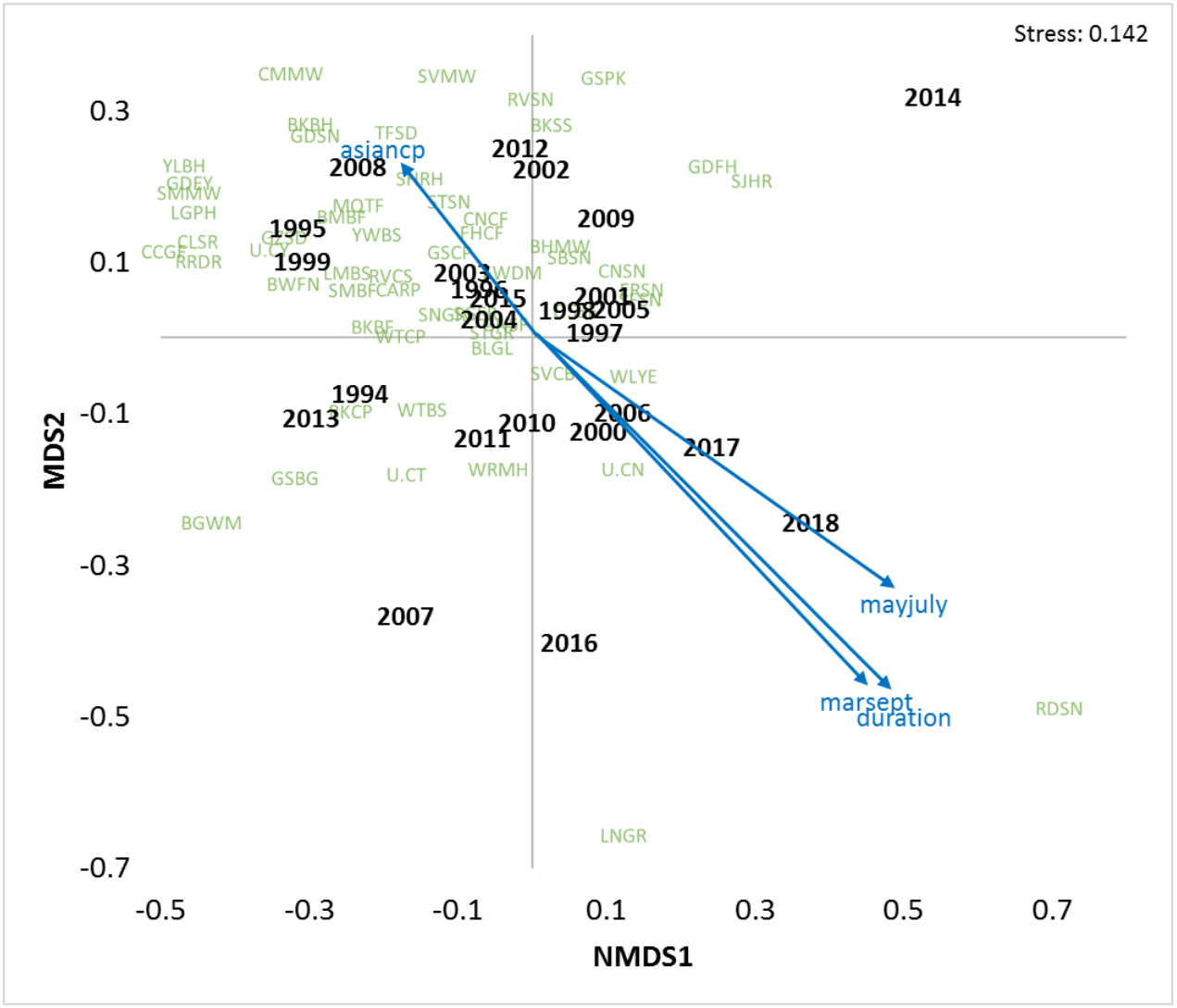
- **Brickhouse Slough**, all individuals SSM

- P-values
  - Mayjuly – 0.001
  - Marsept – 0.001
  - Duration – 0.001
  - Asiancp – 0.218



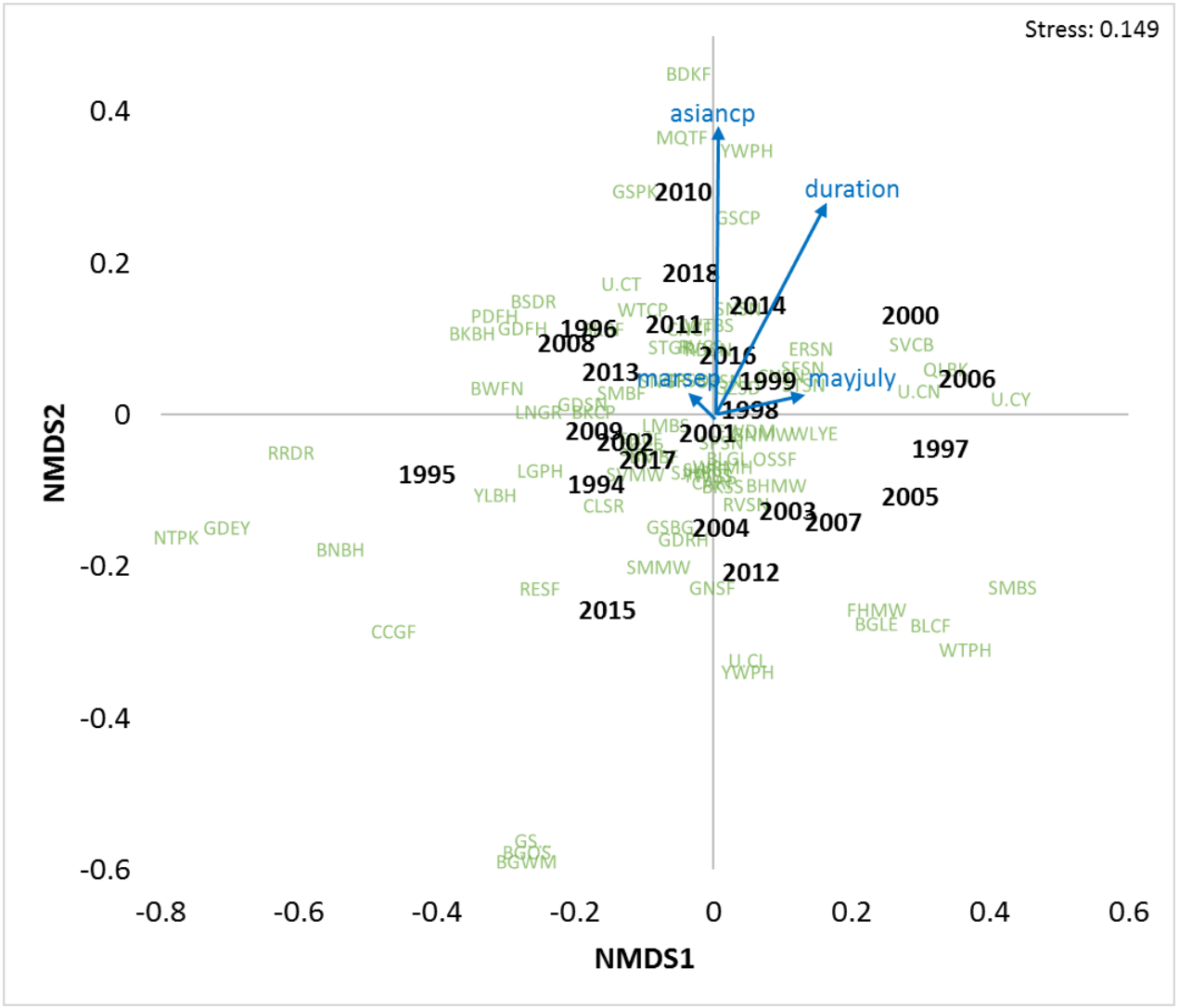
- **West Alton Bay**, all individuals SSM

- P-values
  - Mayjuly – 0.025
  - Marsept – 0.013
  - Duration – 0.004
  - Asiancp – 0.279



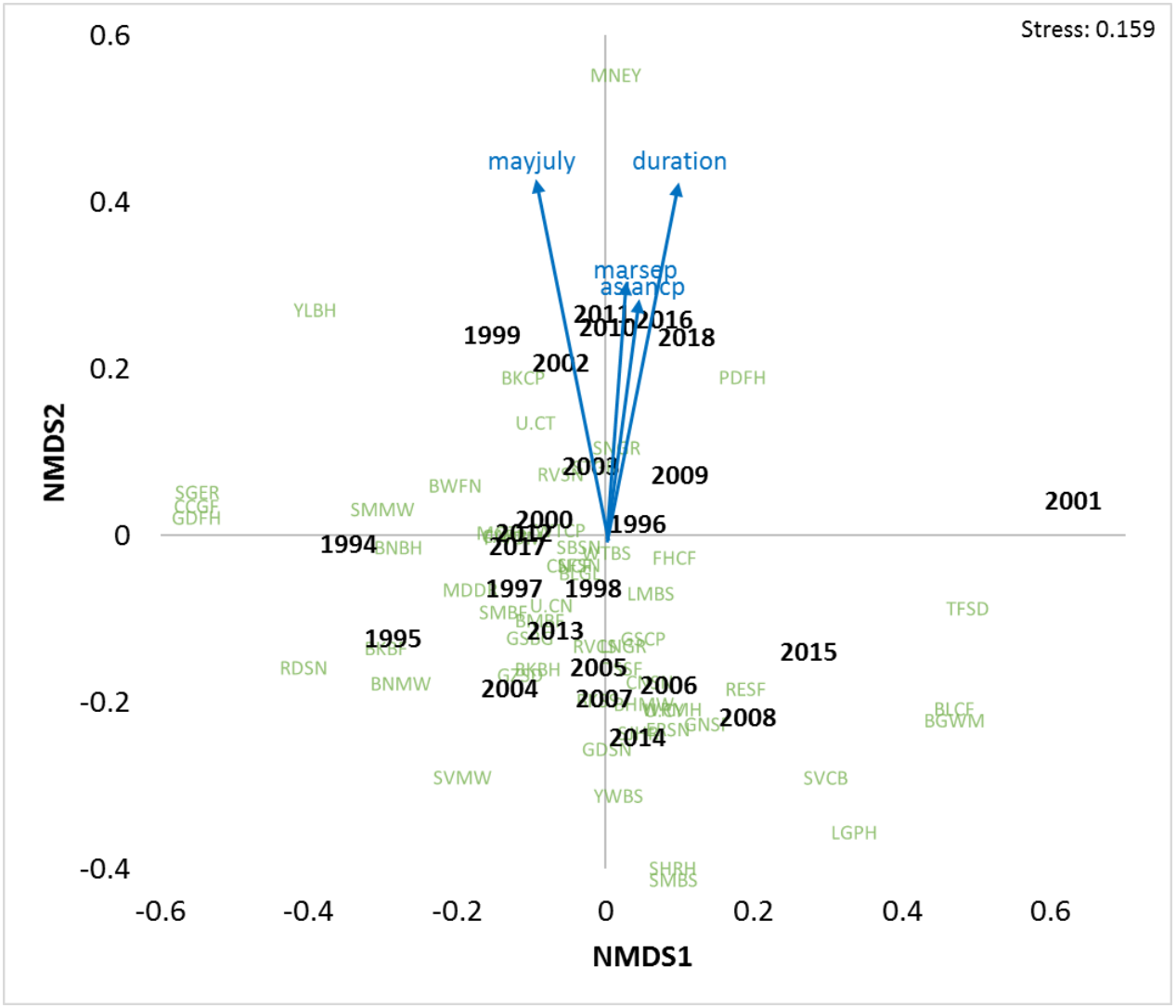
- **Ellis Bay**, all individuals SSM

- P-values
  - Mayjuly – 0.902
  - Marsept – 0.971
  - Duration – 0.667
  - Asiancp – 0.562



- **Powerplant**, all individuals SSM

- P-values
  - Mayjuly – 0.329
  - Marsept – 0.588
  - Duration – 0.327
  - Asiancp – 0.609



STANDARDIZED BY SPECIES MAX			OFFSET STANDARDIZED BY SPECIES MAX			JUVENILE STANDARDIZED BY SPECIES MAX			OFFSET JUVENILE STANDARDIZED BY SPECIES MAX		
BACKWATER	IV	P-VALUE	BACKWATER	IV	P-VALUE	BACKWATER	IV	P-VALUE	BACKWATER	IV	P-VALUE
ALL	May July	0.010	ALL	May July	0.375	ALL	May July	0.277	ALL	May July	0.274
	March Sept	0.003		March Sept	0.058		March Sept	0.518		March Sept	0.386
	Duration	0.011		Duration	0.086		Duration	0.647		Duration	0.055
	Asian Carp	0.331		Asian Carp	0.098		Asian Carp	0.494		Asian Carp	0.174
BRICKHOUSE	May July	0.001	BRICKHOUSE	May July	0.490	BRICKHOUSE	May July	0.008	BRICKHOUSE	May July	0.638
	March Sept	0.001		March Sept	0.173		March Sept	0.064		March Sept	0.354
	Duration	0.001		Duration	0.392		Duration	0.033		Duration	0.955
	Asian Carp	0.218		Asian Carp	0.118		Asian Carp	0.490		Asian Carp	0.242
ELLIS BAY	May July	0.920	ELLIS BAY	May July	0.847	ELLIS BAY	May July	0.824	ELLIS BAY	May July	0.952
	March Sept	0.971		March Sept	0.840		March Sept	0.569		March Sept	0.875
	Duration	0.667		Duration	0.871		Duration	0.656		Duration	0.777
	Asian Carp	0.562		Asian Carp	0.703		Asian Carp	0.812		Asian Carp	0.617
POWERPLANT	May July	0.329	POWERPLANT	May July	0.920	POWERPLANT	May July	0.016	POWERPLANT	May July	0.770
	March Sept	0.588		March Sept	0.985		March Sept	0.044		March Sept	0.587
	Duration	0.327		Duration	0.962		Duration	0.007		Duration	0.792
	Asian Carp	0.609		Asian Carp	0.455		Asian Carp	0.427		Asian Carp	0.524
WEST ALTON	May July	0.025	WEST ALTON	May July	0.677	WEST ALTON	May July	0.056	WEST ALTON	May July	0.220
	March Sept	0.013		March Sept	0.177		March Sept	0.315		March Sept	0.091
	Duration	0.004		Duration	0.208		Duration	0.152		Duration	0.308
	Asian Carp	0.279		Asian Carp	0.494		Asian Carp	0.572		Asian Carp	0.909

STANDARDIZED BY COMMUNITY TOTAL			OFFSET STANDARDIZED BY COMMUNITY TOTAL			JUVENILE STANDARDIZED BY COMMUNITY TOTAL			OFFSET JUVENILE STANDARDIZED BY COMMUNITY TOTAL		
BACKWATER	IV	P-VALUE	BACKWATER	IV	P-VALUE	BACKWATER	IV	P-VALUE	BACKWATER	IV	P-VALUE
ALL	May July	0.929	ALL	May July	0.482	ALL	May July	0.544	ALL	May July	0.672
	March Sept	0.946		March Sept	0.598		March Sept	0.855		March Sept	0.534
	Duration	0.906		Duration	0.784		Duration	0.933		Duration	0.686
	Asian Carp	0.104		Asian Carp	0.826		Asian Carp	0.291		Asian Carp	0.750
BRICKHOUSE	May July	0.155	BRICKHOUSE	May July	0.435	BRICKHOUSE	May July	0.162	BRICKHOUSE	May July	0.450
	March Sept	0.427		March Sept	0.480		March Sept	0.345		March Sept	0.477
	Duration	0.682		Duration	0.412		Duration	0.426		Duration	0.412
	Asian Carp	0.003		Asian Carp	0.240		Asian Carp	0.199		Asian Carp	0.247
ELLIS BAY	May July	0.409	ELLIS BAY	May July	0.759	ELLIS BAY	May July	0.752	ELLIS BAY	May July	0.683
	March Sept	0.493		March Sept	0.424		March Sept	0.471		March Sept	0.657
	Duration	0.118		Duration	0.814		Duration	0.217		Duration	0.733
	Asian Carp	0.232		Asian Carp	0.670		Asian Carp	0.406		Asian Carp	0.709
POWERPLANT	May July	0.174	POWERPLANT	May July	0.901	POWERPLANT	May July	0.291	POWERPLANT	May July	0.897
	March Sept	0.528		March Sept	0.956		March Sept	0.731		March Sept	0.822
	Duration	0.162		Duration	0.509		Duration	0.251		Duration	0.494
	Asian Carp	0.040		Asian Carp	0.874		Asian Carp	0.022		Asian Carp	0.872
WEST ALTON	May July	0.234	WEST ALTON	May July	0.353	WEST ALTON	May July	0.393	WEST ALTON	May July	0.372
	March Sept	0.346		March Sept	0.454		March Sept	0.688		March Sept	0.877
	Duration	0.186		Duration	0.606		Duration	0.314		Duration	0.926
	Asian Carp	0.364		Asian Carp	0.095		Asian Carp	0.479		Asian Carp	0.678

- No significant correlations in Ellis Bay or Powerplant

- Ellis Bay is deep, and more than half the shoreline is lined with cobble rock, making vegetation growth there near impossible. Shallow areas affected by EPM are too shallow to sample and sites are alternated
- Powerplant is located the farthest upstream, where EPM would have the smallest effect, exposing little shoreline for emergent vegetation

- No offset analysis showed significant correlation for any environmental variable
  - Unexpected – if a drawdown was successful, vegetation should increase recruitment, which would show the following year
  - Vegetation dies over winter and during spring floods – perhaps fish only utilize EPM vegetation during current year

- Juvenile analyses only showed mild significant correlation
  - Only in Brickhouse Slough and Powerplant, when SSM
  - Powerplant used as a cooler refuge
    - West Alton Bay too shallow/warm/anoxic

- Multivariate correlations between fish community structure and Asian carp abundance were not significant for any backwater
  - Unexpected since Asian carp have significant overlap in diet with native filter feeders and are shown to be detrimental to native sport fish
  - May be attributed to low catch rates
    - Hard to catch – they leap from the water and scatter when shocked
      - Other fish are drawn to electrical pulse
    - Years with high abundance were attributed to juvenile swarms in mini fykes
      - 2016 had 6291 total Asian carp - 5992 silver carp <29-mm length caught in one mini fyke (95%)

- Not significant when using raw abundance, ranked abundance in backwaters, ranked abundance of Pool 26, or ranked abundance in all LTRM reaches

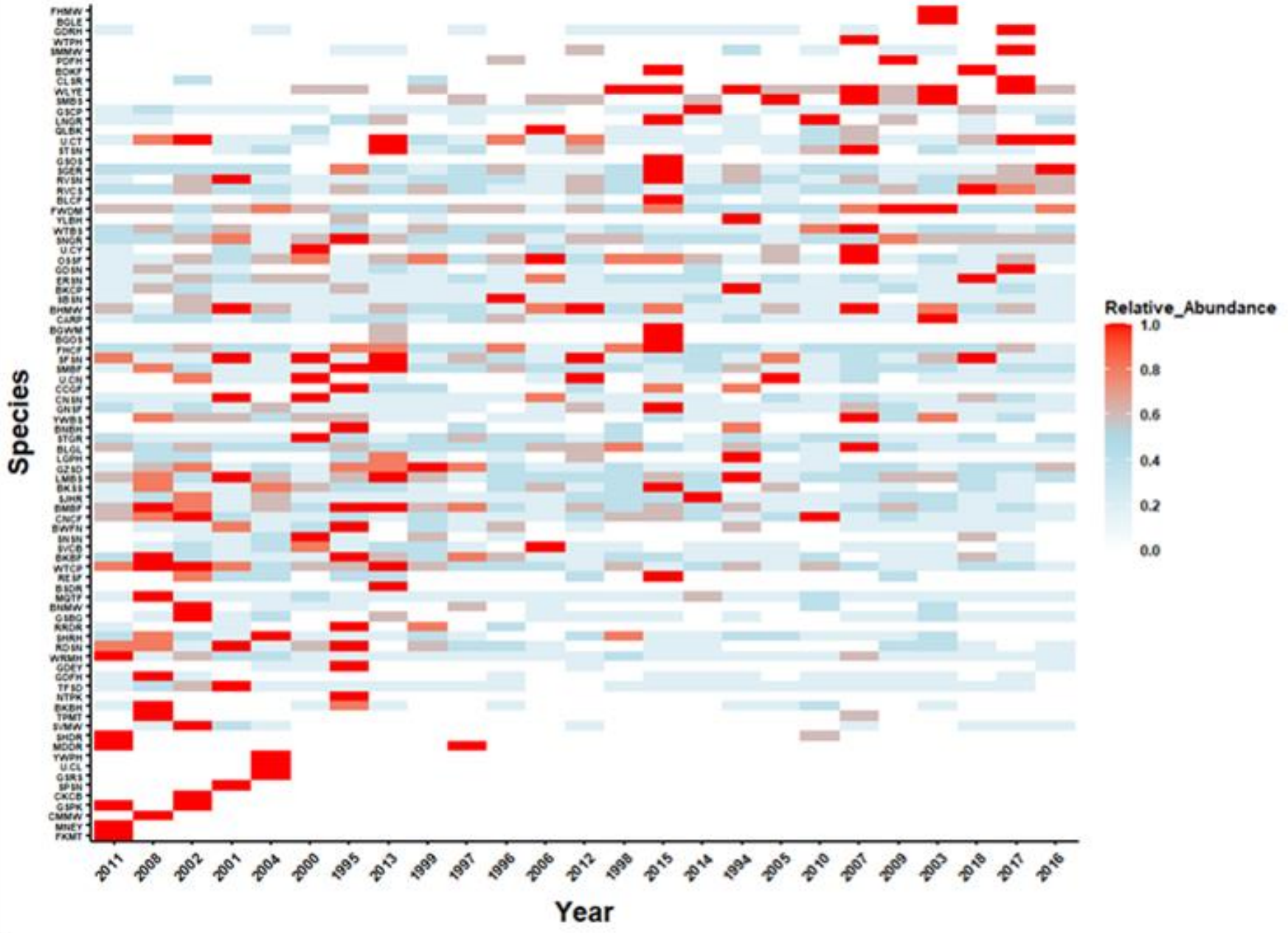


Figure 13. Heatmap including all 84 taxa in all backwaters combined. High relative abundance colored red, low abundance colored white.