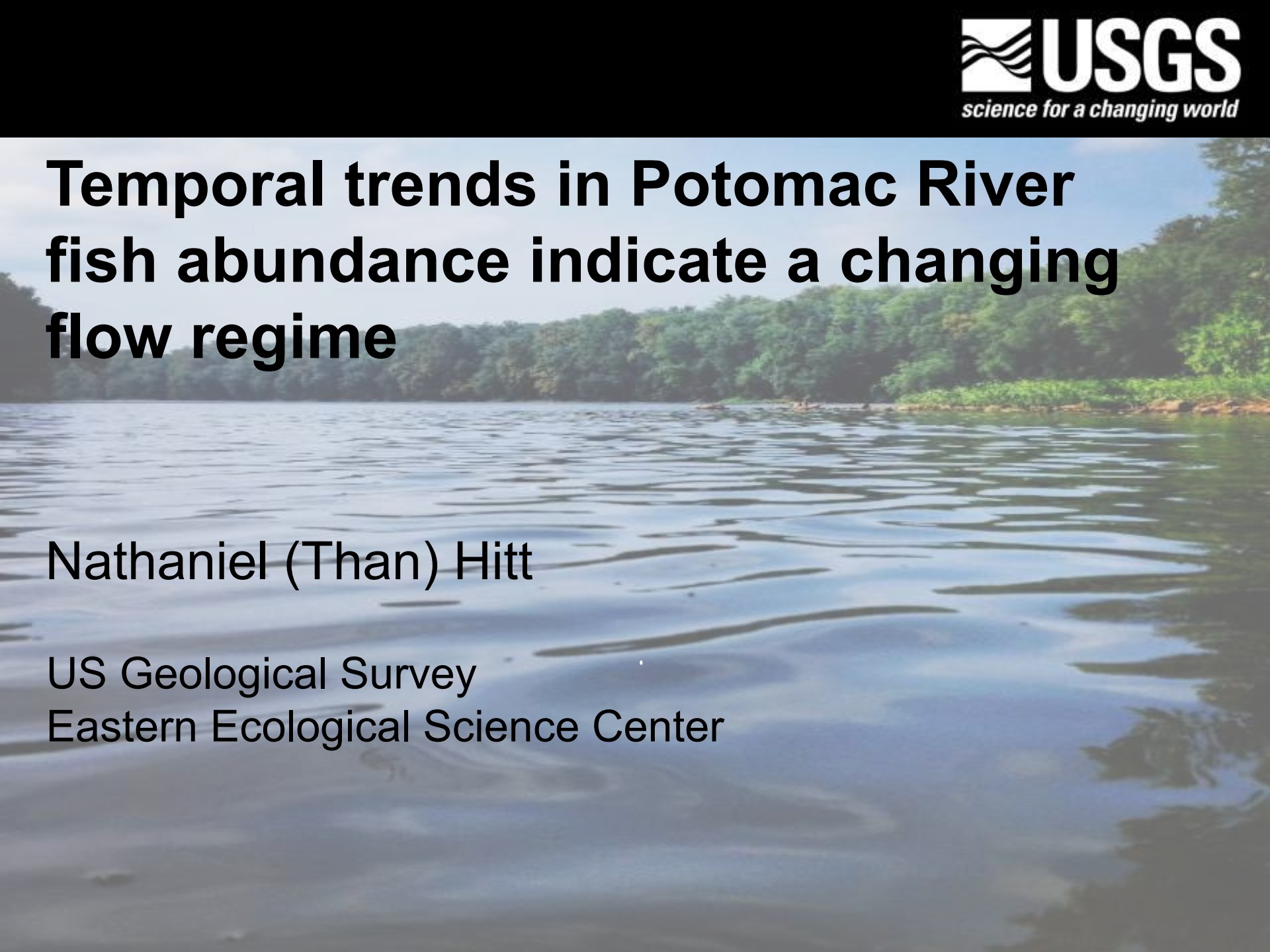

Temporal trends in Potomac River fish abundance indicate a changing flow regime

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Eastern Ecological Science Center

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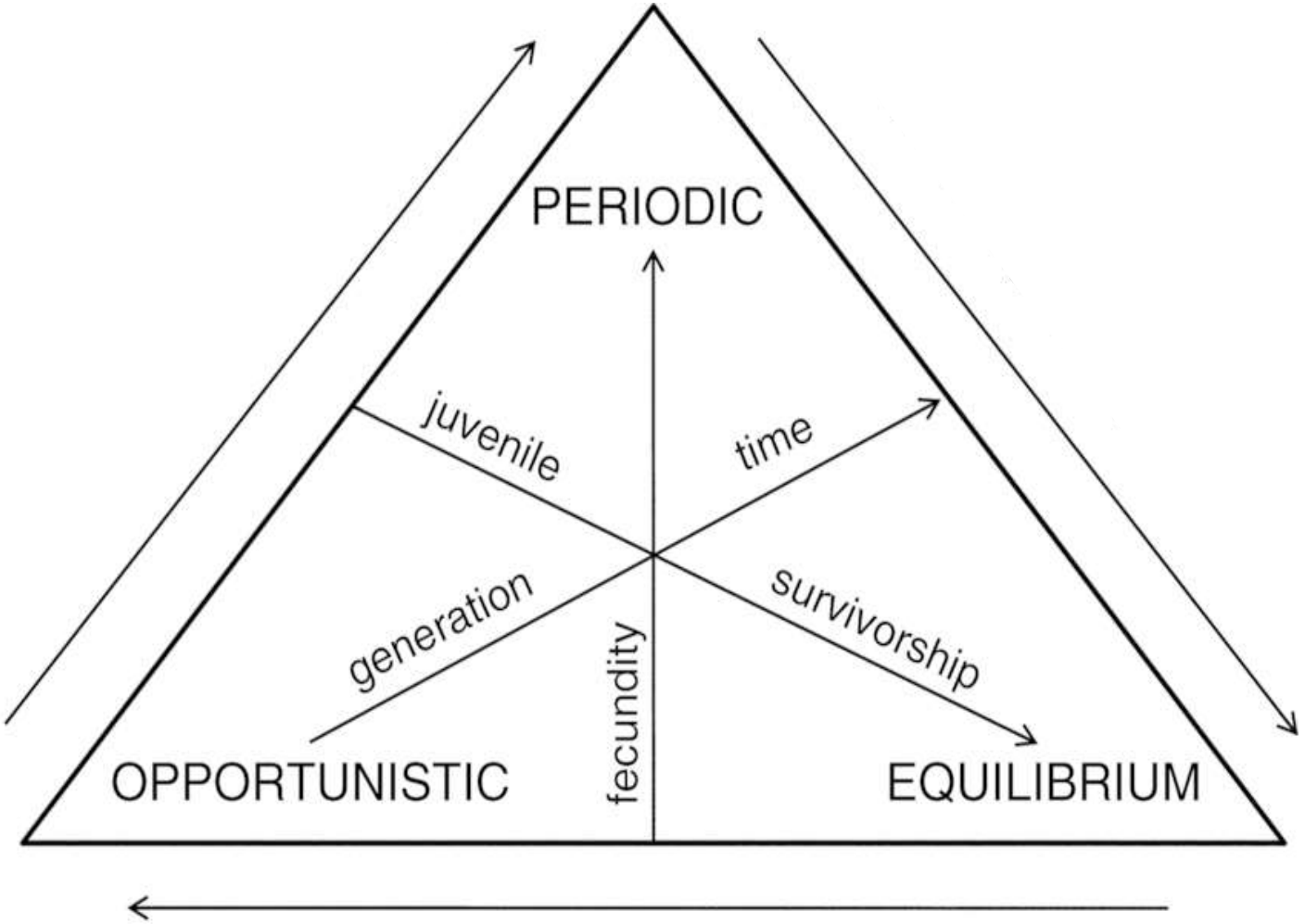
USGS Eastern Ecological Science Center
Kearneysville, WV
nhitt@usgs.gov

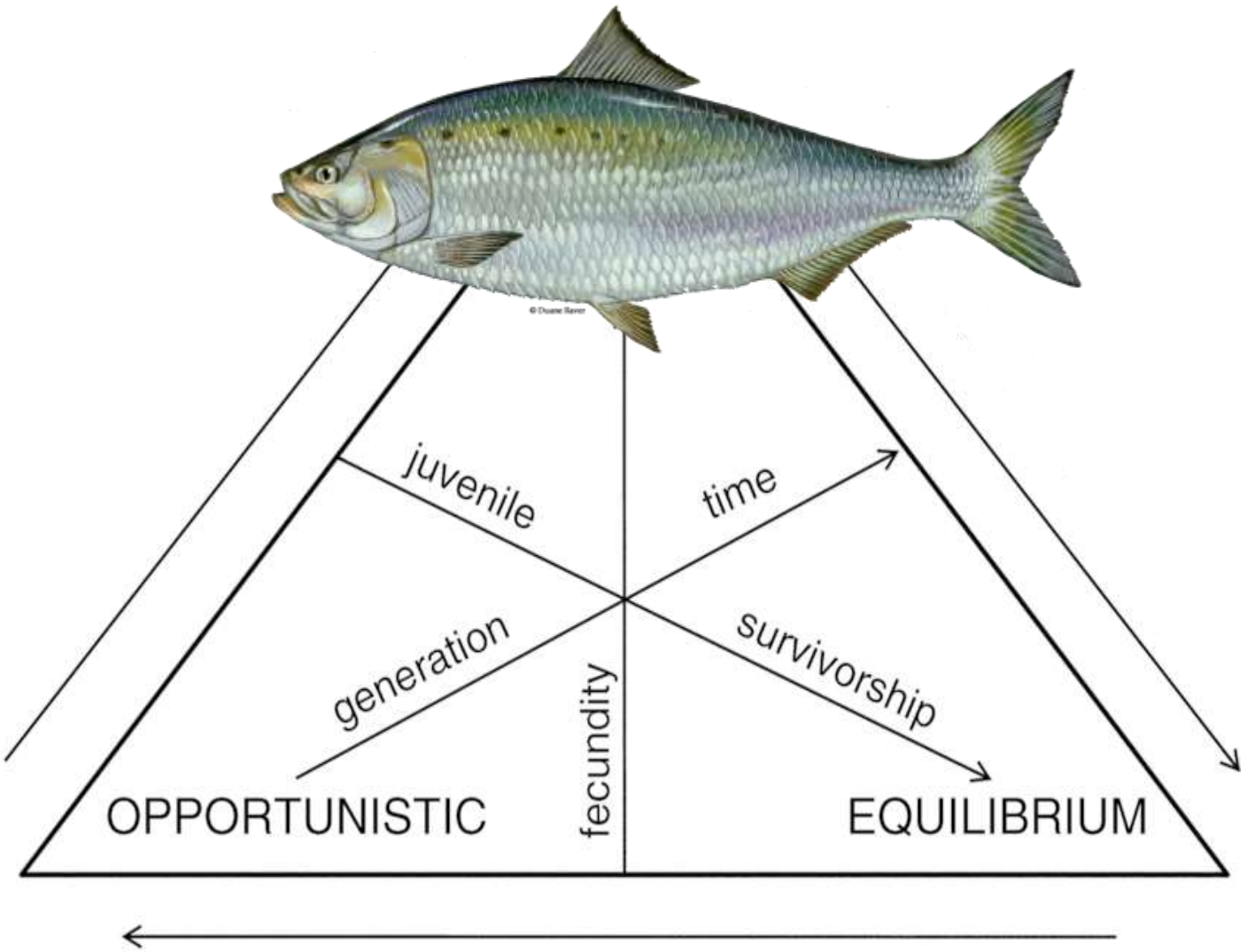
Population and community ecology of stream fishes

Life history theory



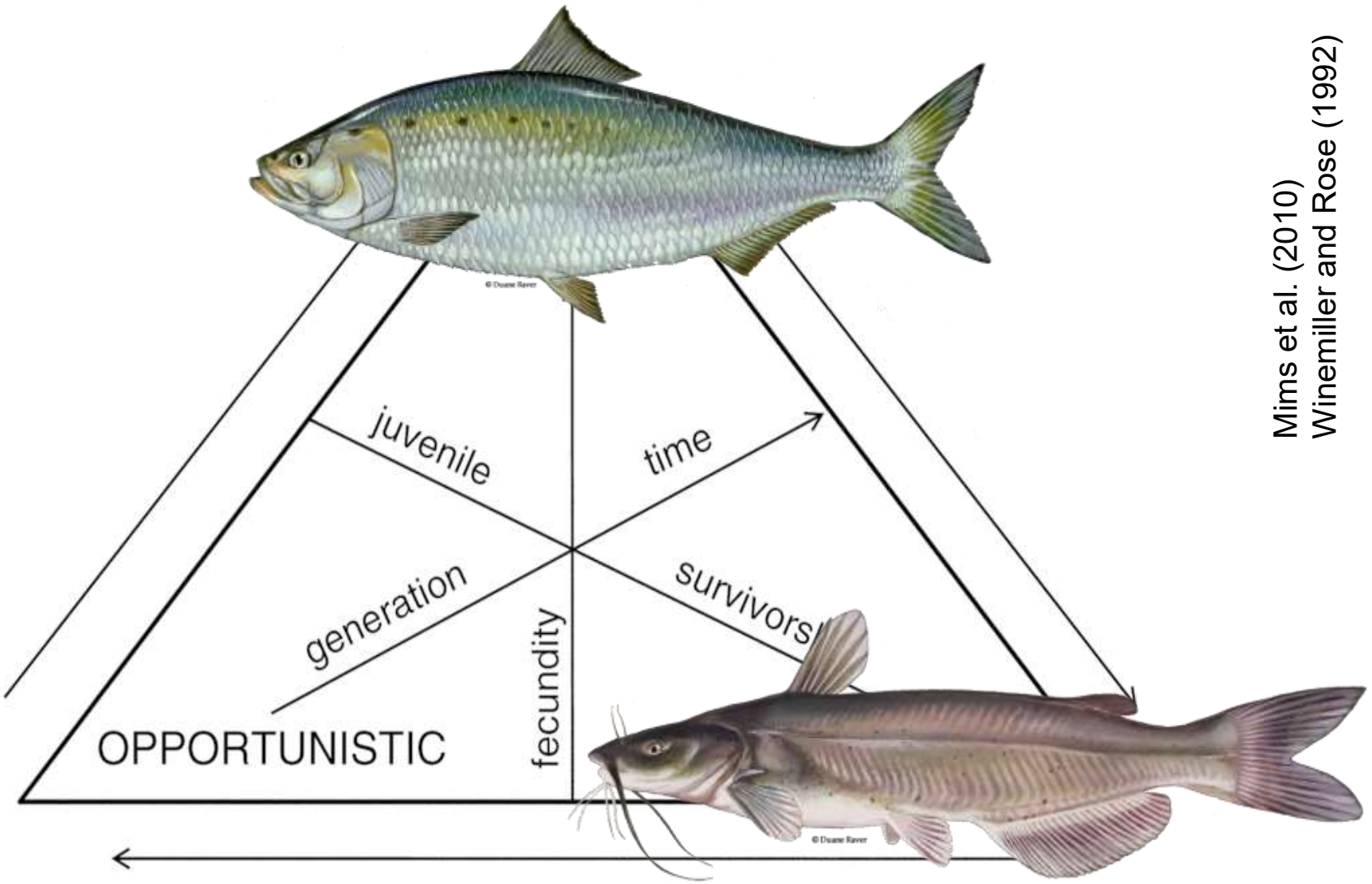
Mims et al. (2010)
Winemiller and Rose (1992)

Life history theory



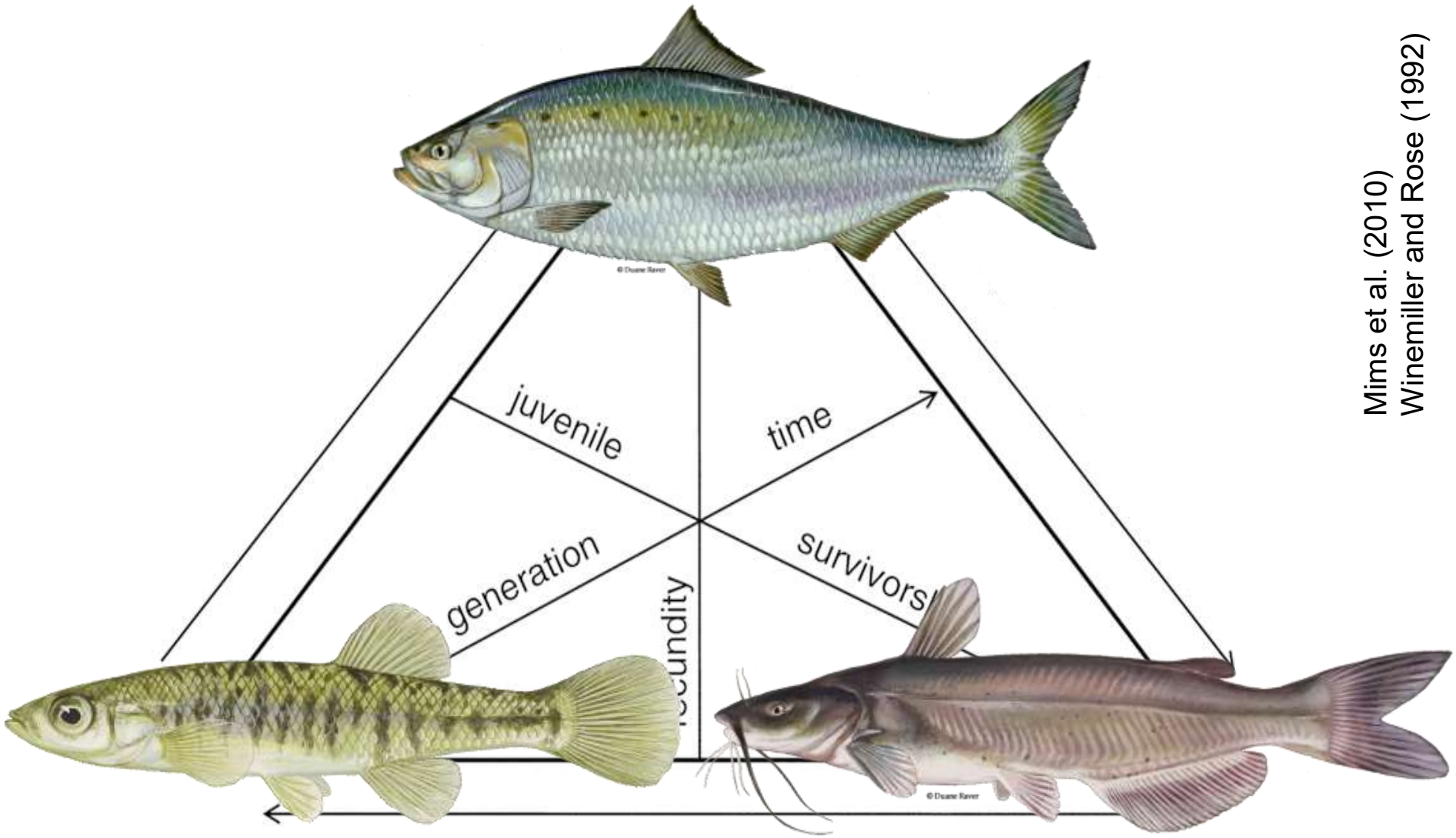
Mims et al. (2010)
Winemiller and Rose (1992)

Life history theory



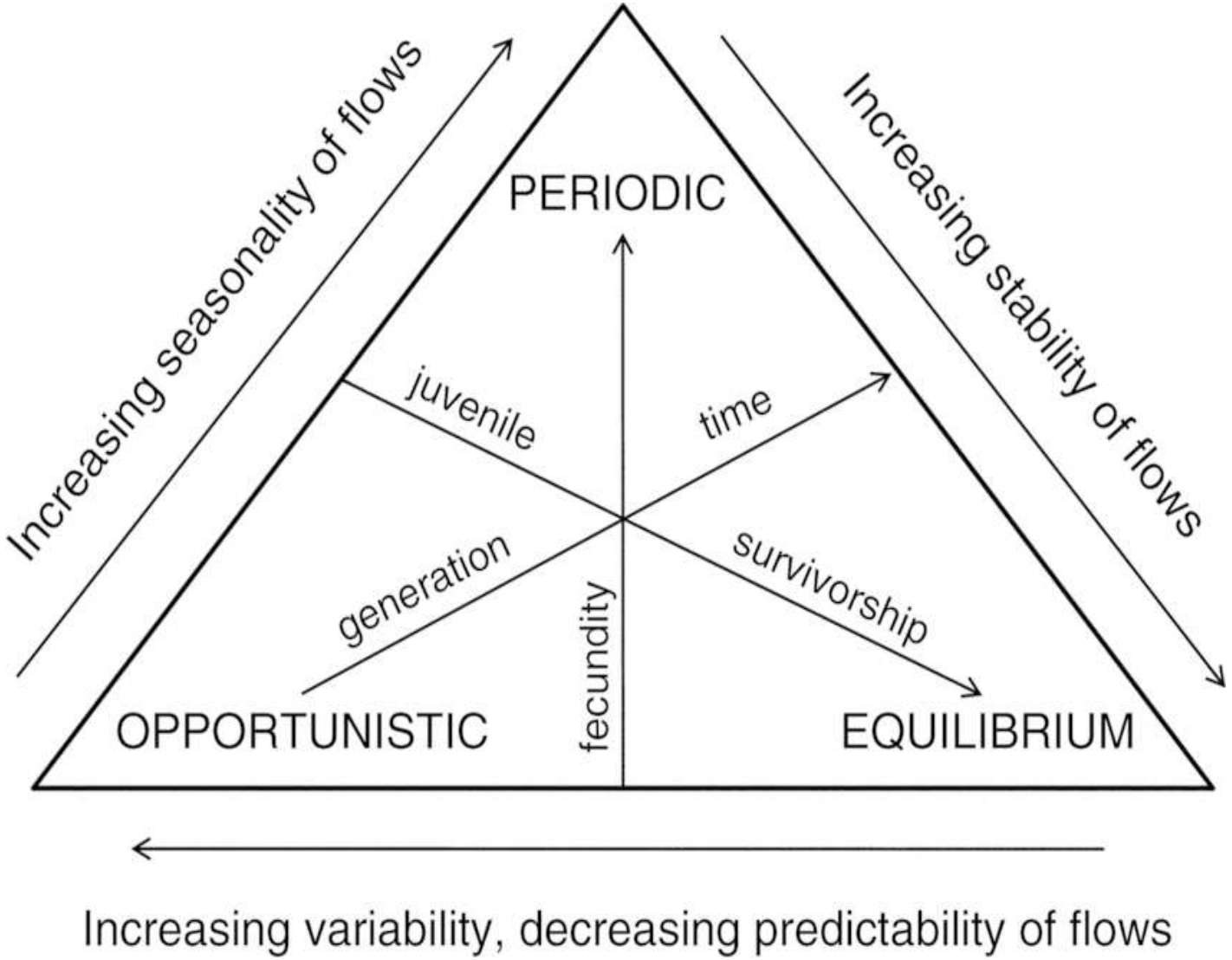
Mims et al. (2010)
Winemiller and Rose (1992)

Life history theory



Mims et al. (2010)
Winemiller and Rose (1992)

Life history theory linked to flow



Mims et al. (2010)
Winemiller and Rose (1992)

Life history theory explains fish community response to flow stabilization

Climate and land use prediction: more extreme flows

Climate and land use prediction: more extreme flows

The Potomac River

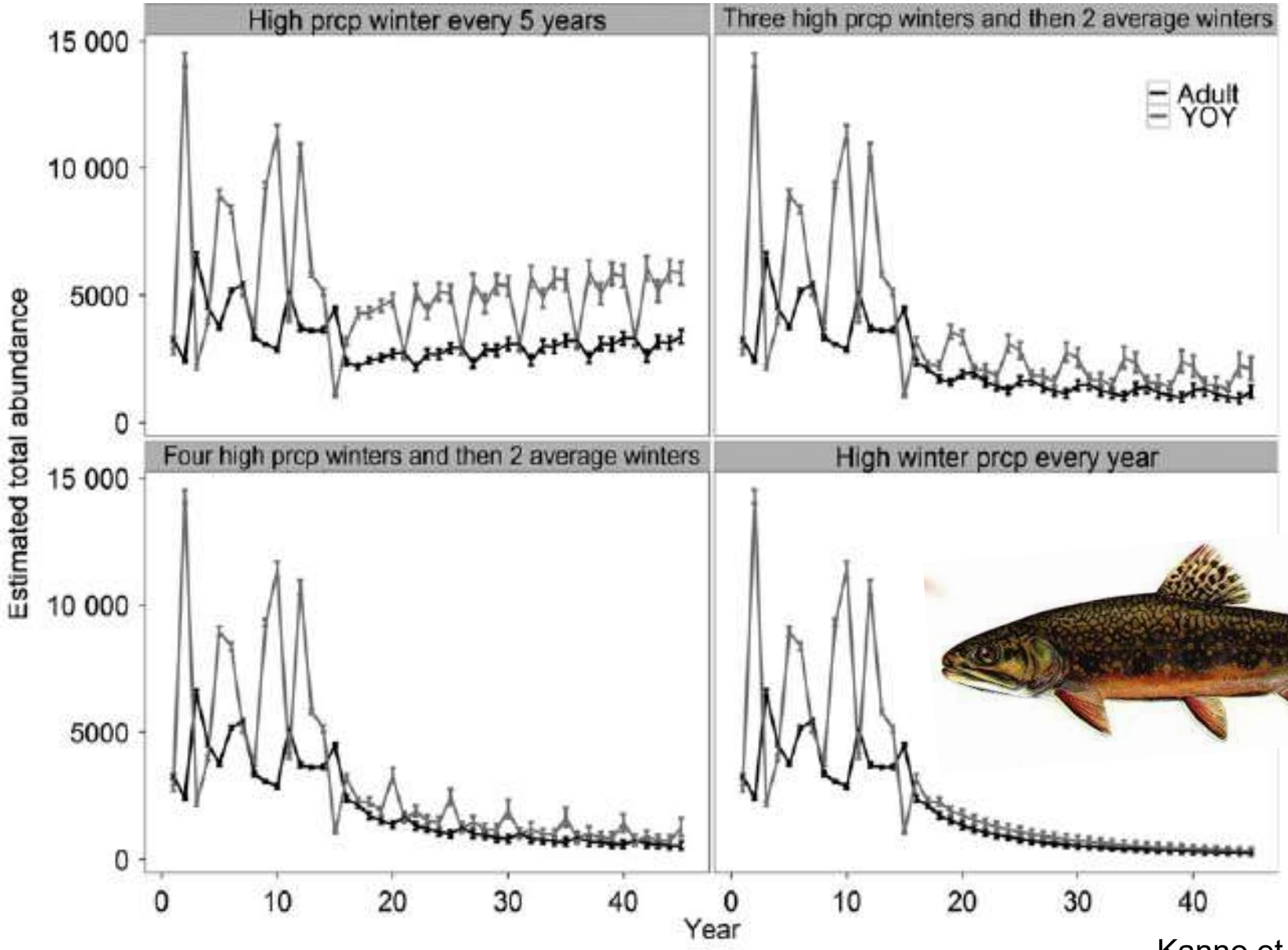
- Relatively little storage
- One of the most natural flow regimes of large rivers in the US
- Important for understanding changes in flow via climate and land use

The Potomac River: natural flow regime

The Potomac River: natural flow regime

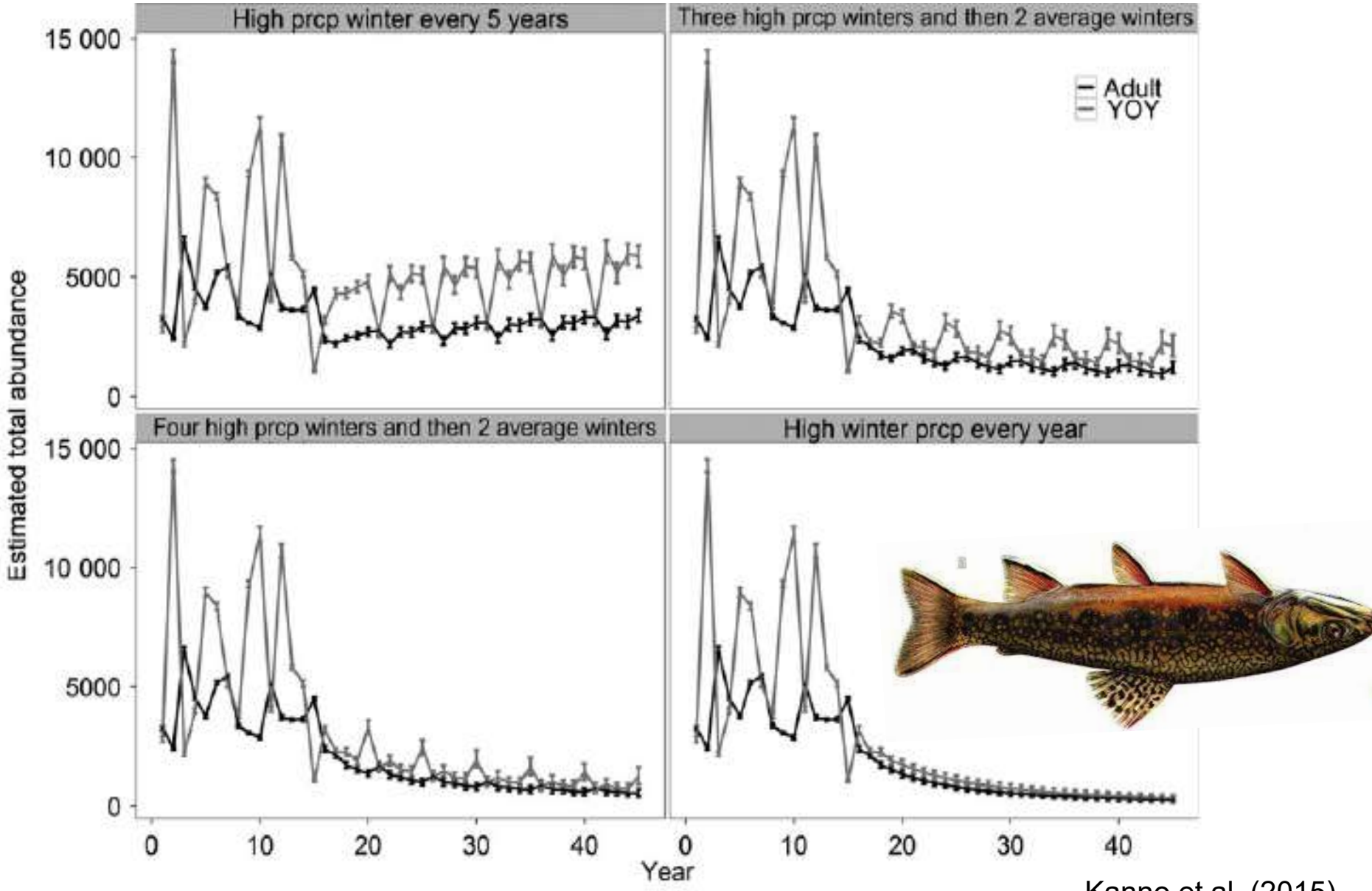
Photos: Irene Owsley

High flows can limit fish recruitment



Kanno et al. (2015)

High flows can limit fish recruitment



Kanno et al. (2015)

Are fish communities changing over time in the Potomac River?

Are fish communities changing over time in the Potomac River?

If so, are these changes random with respect to ecological flow requirements?

Are fish communities changing over time in the Potomac River?

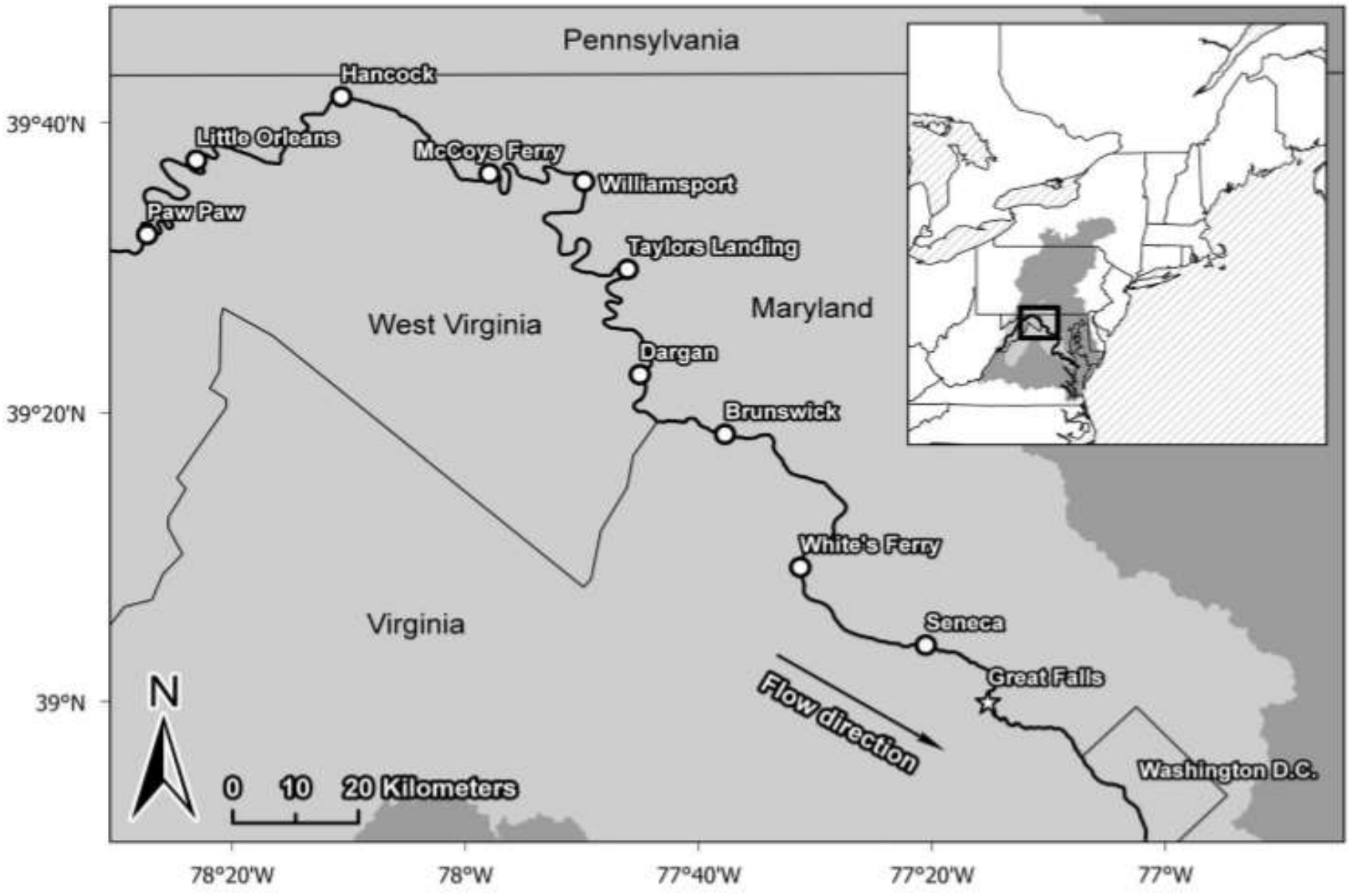
If so, are these changes random with respect to ecological flow requirements?

Or is there a non-random trend regarding flow stability and predictability?

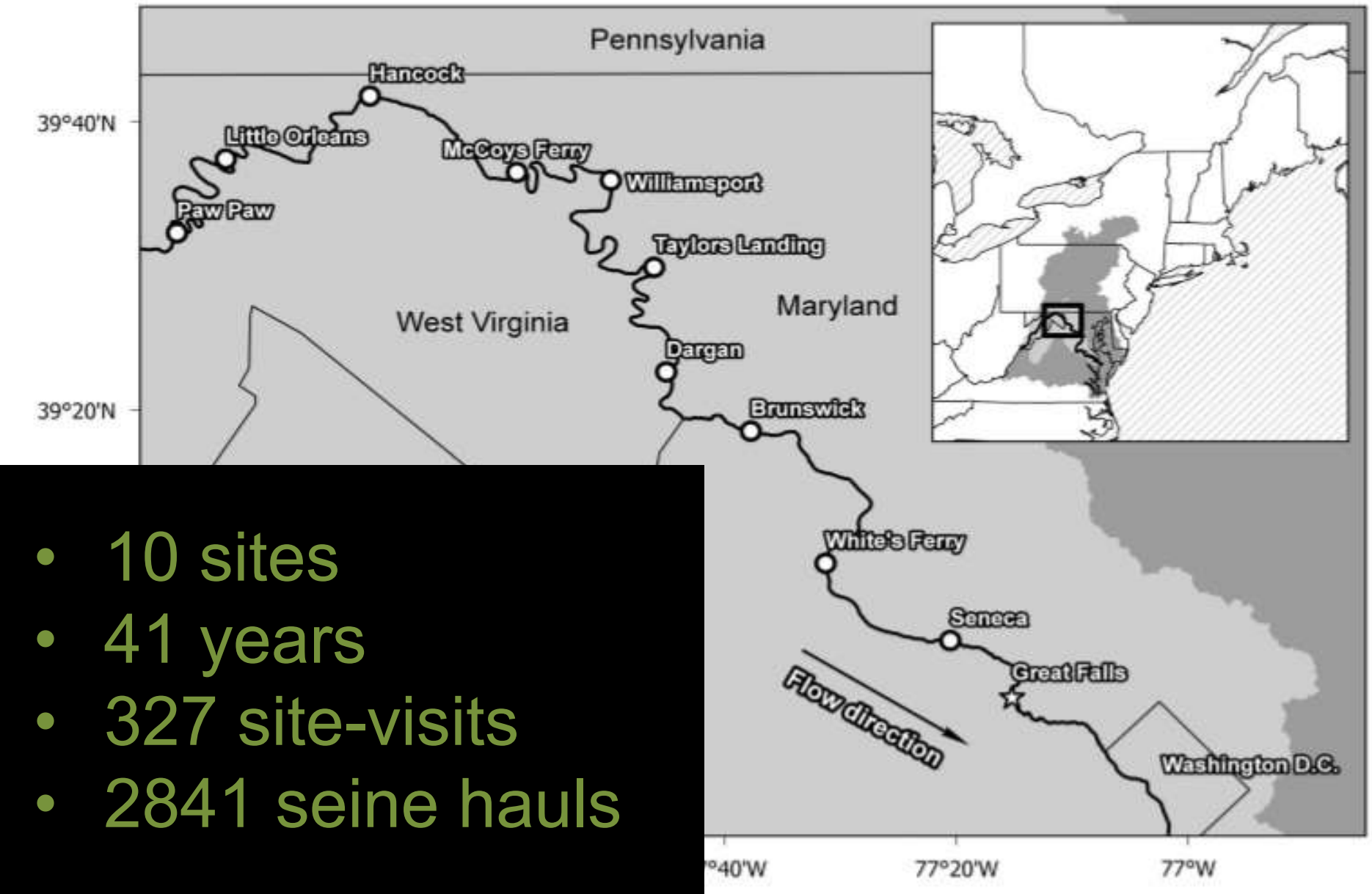
Methods

- MD-DNR juvenile index surveys
- Model temporal change in abundance
- Multivariate species traits analysis
- Temporal change ~ life history variation

MD-DNR juvenile index surveys: 1975-2017



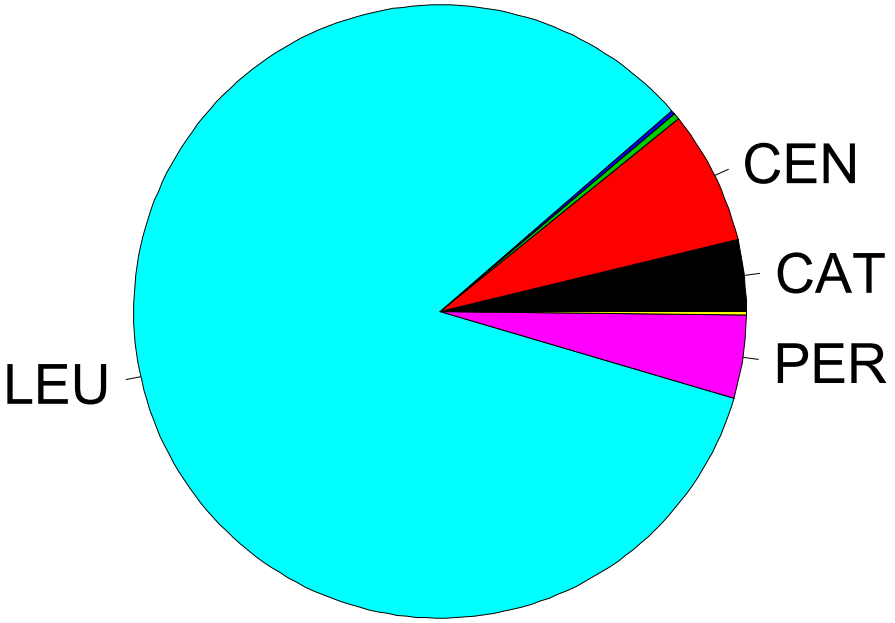
MD-DNR juvenile index surveys: 1975-2017



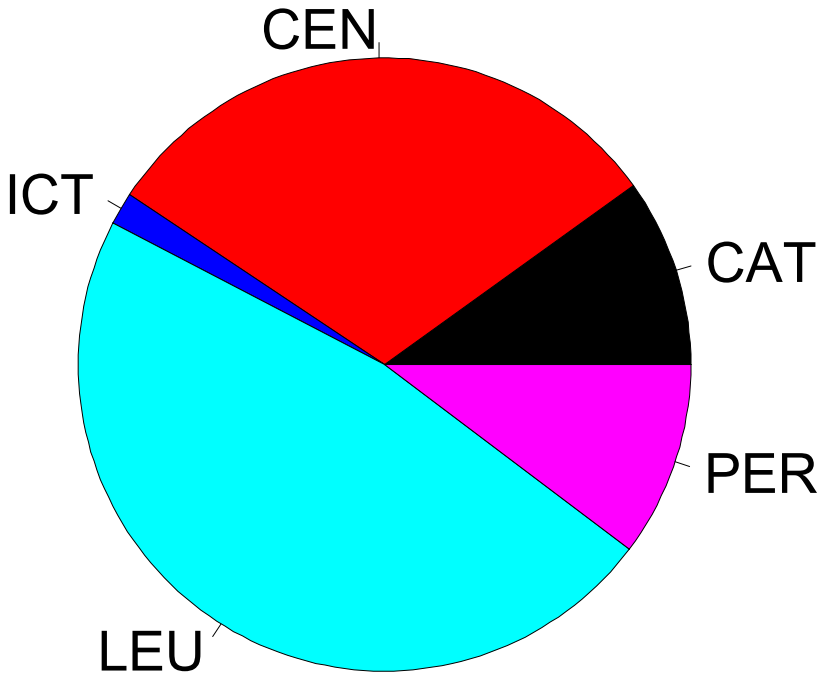
- 10 sites
- 41 years
- 327 site-visits
- 2841 seine hauls

Replicate seine hauls per survey

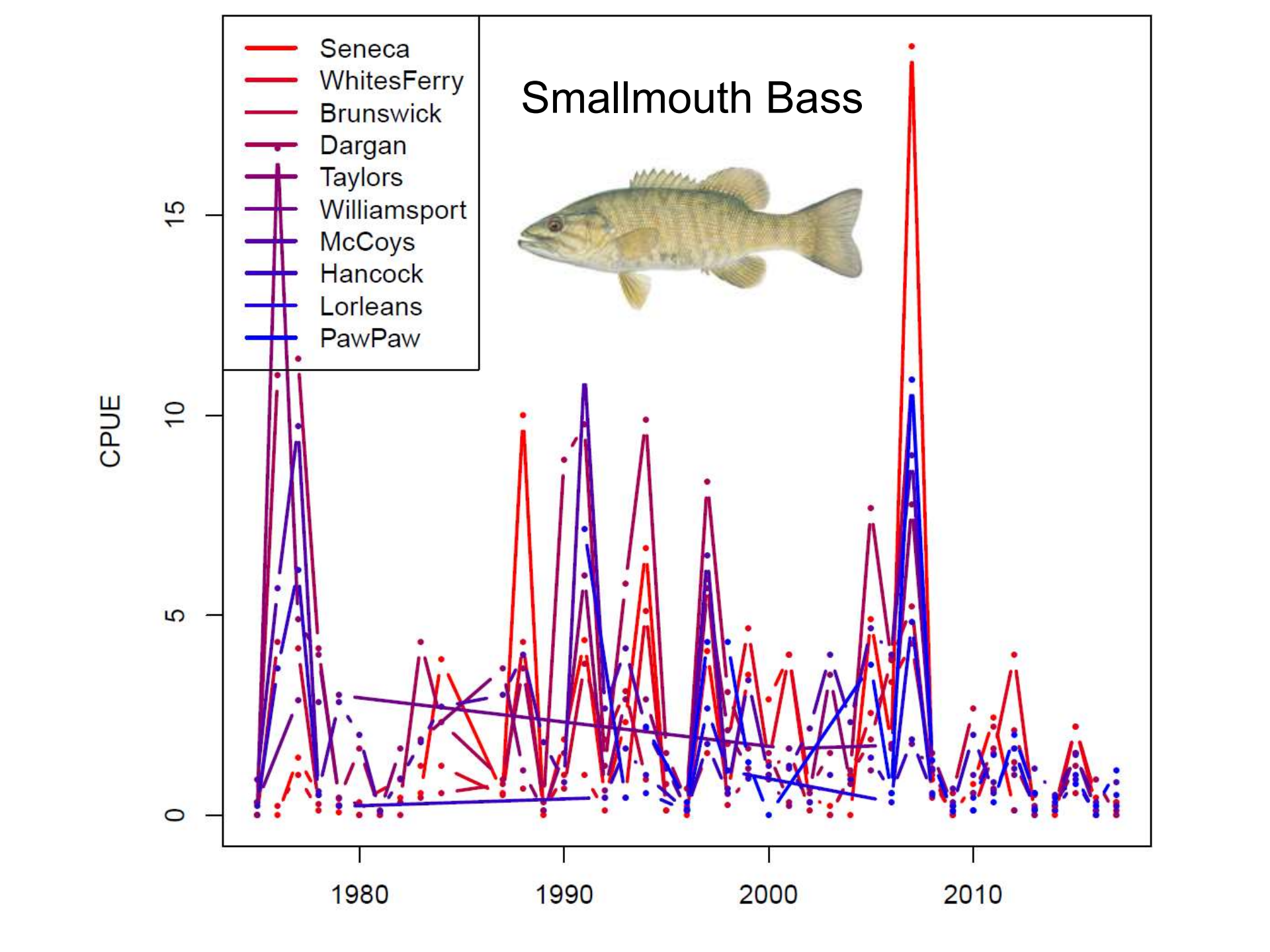
28 species, 7 families, > 250K fish

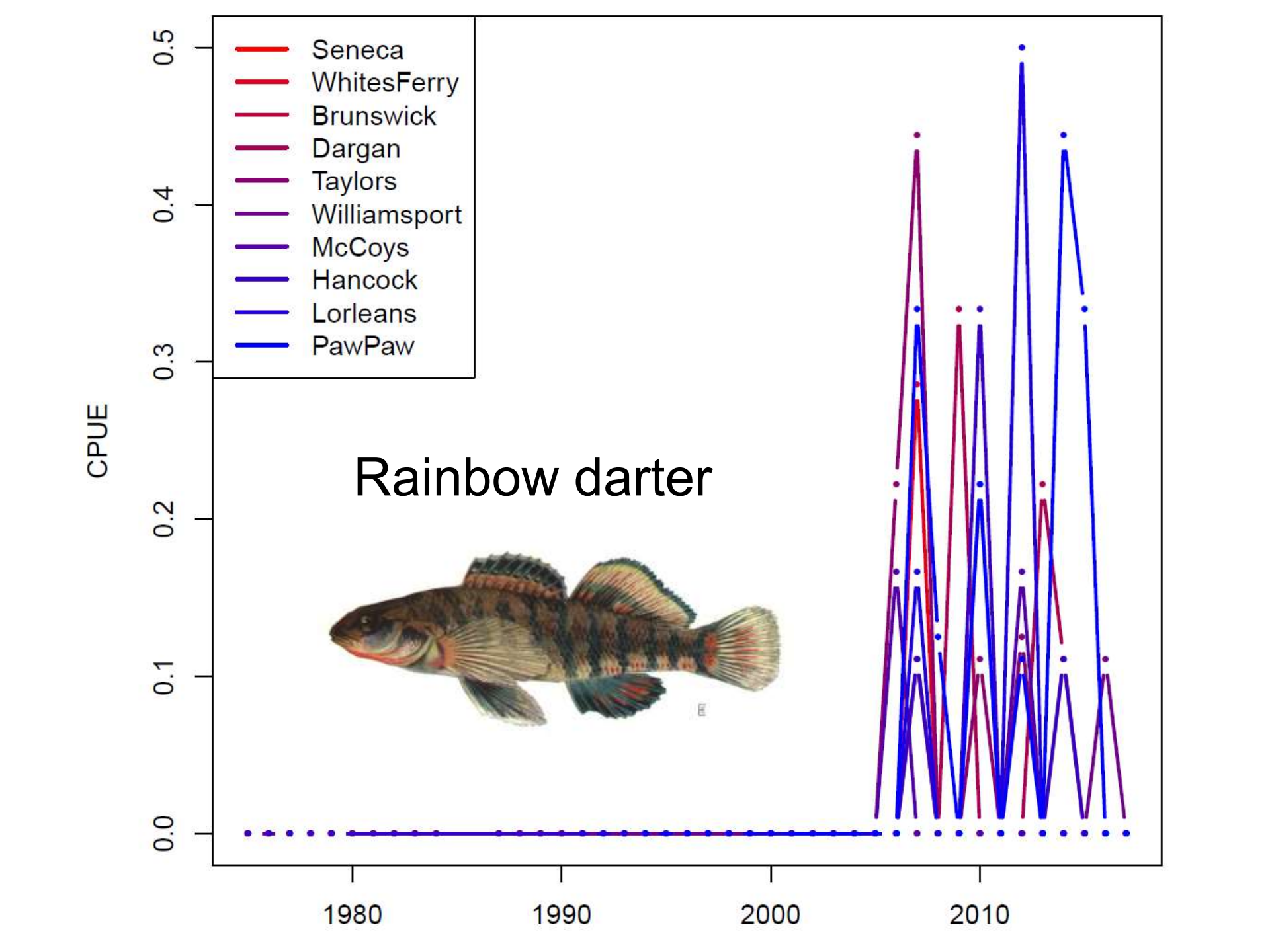


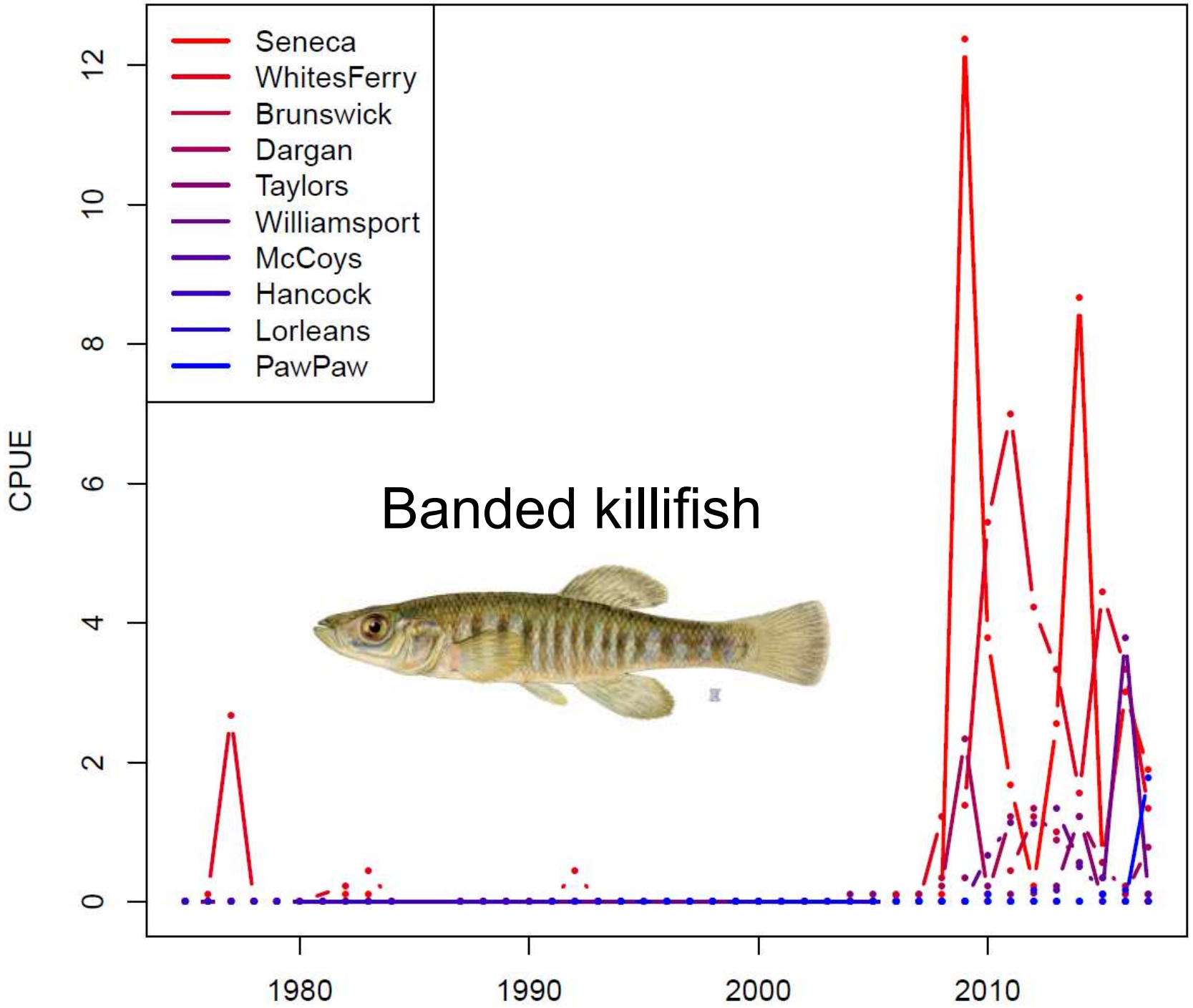
Abundance

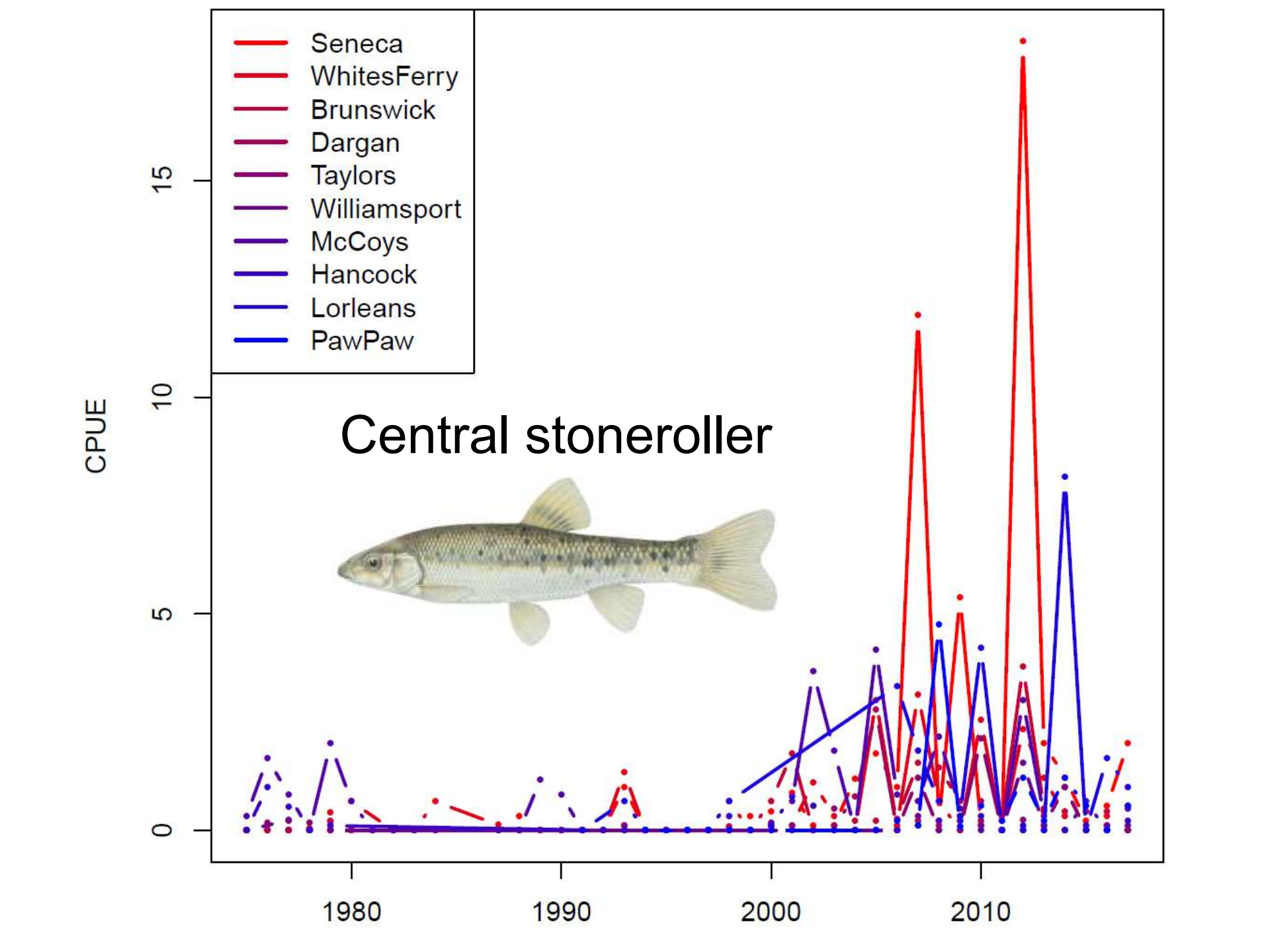


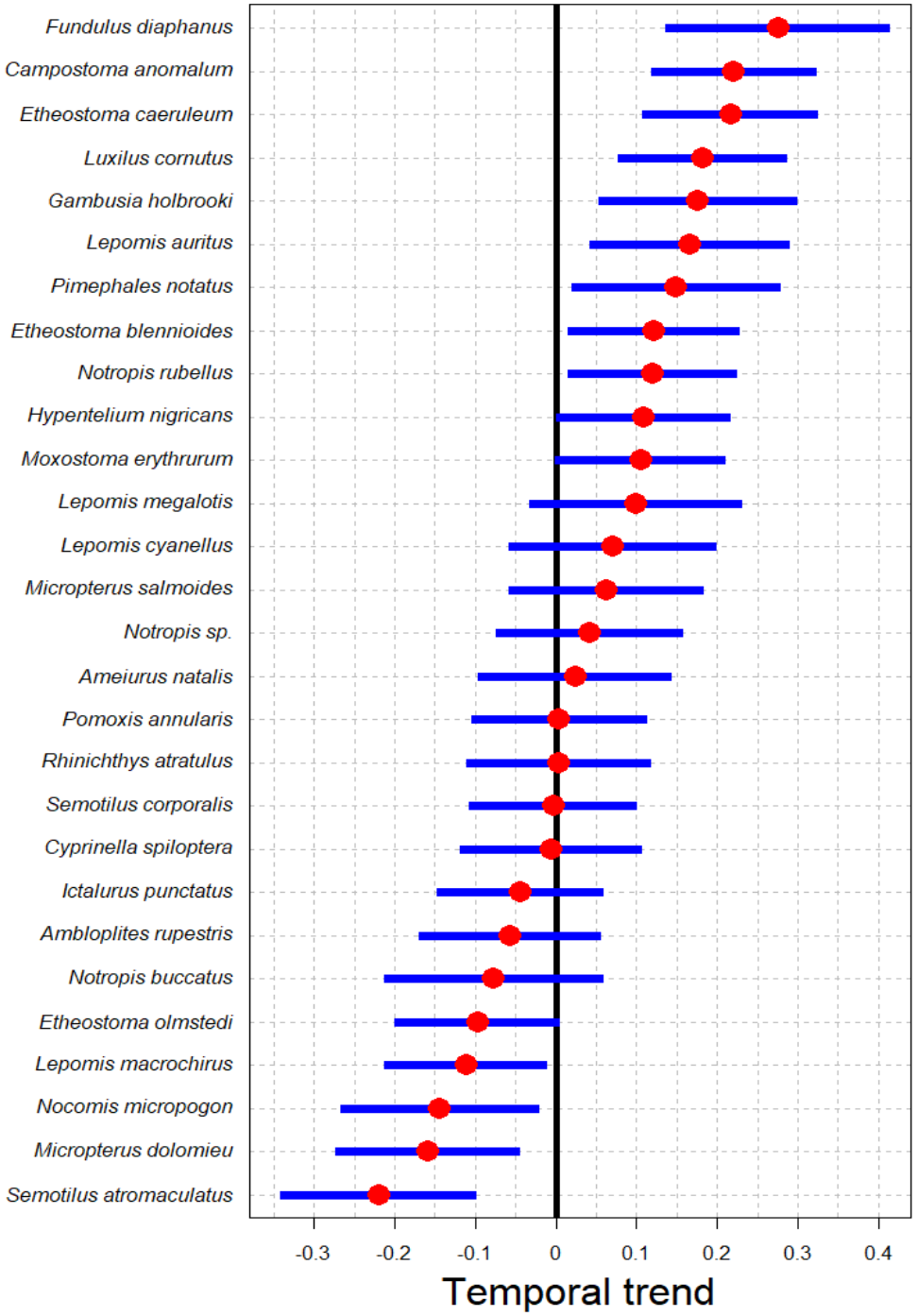
Species richness


Seneca
WhitesFerry
Brunswick
Dargan
Taylors
Williamsport
McCoys
Hancock
Lorleans
PawPaw
Smallmouth Bass
CPUE
0
5
10
15
1980
1990
2000
2010


Seneca
WhitesFerry
Brunswick
Dargan
Taylors
Williamsport
McCoys
Hancock
Lorleans
PawPaw
Rainbow darter
CPUE
0.0
0.1
0.2
0.3
0.4
0.5
1980
1990
2000
2010

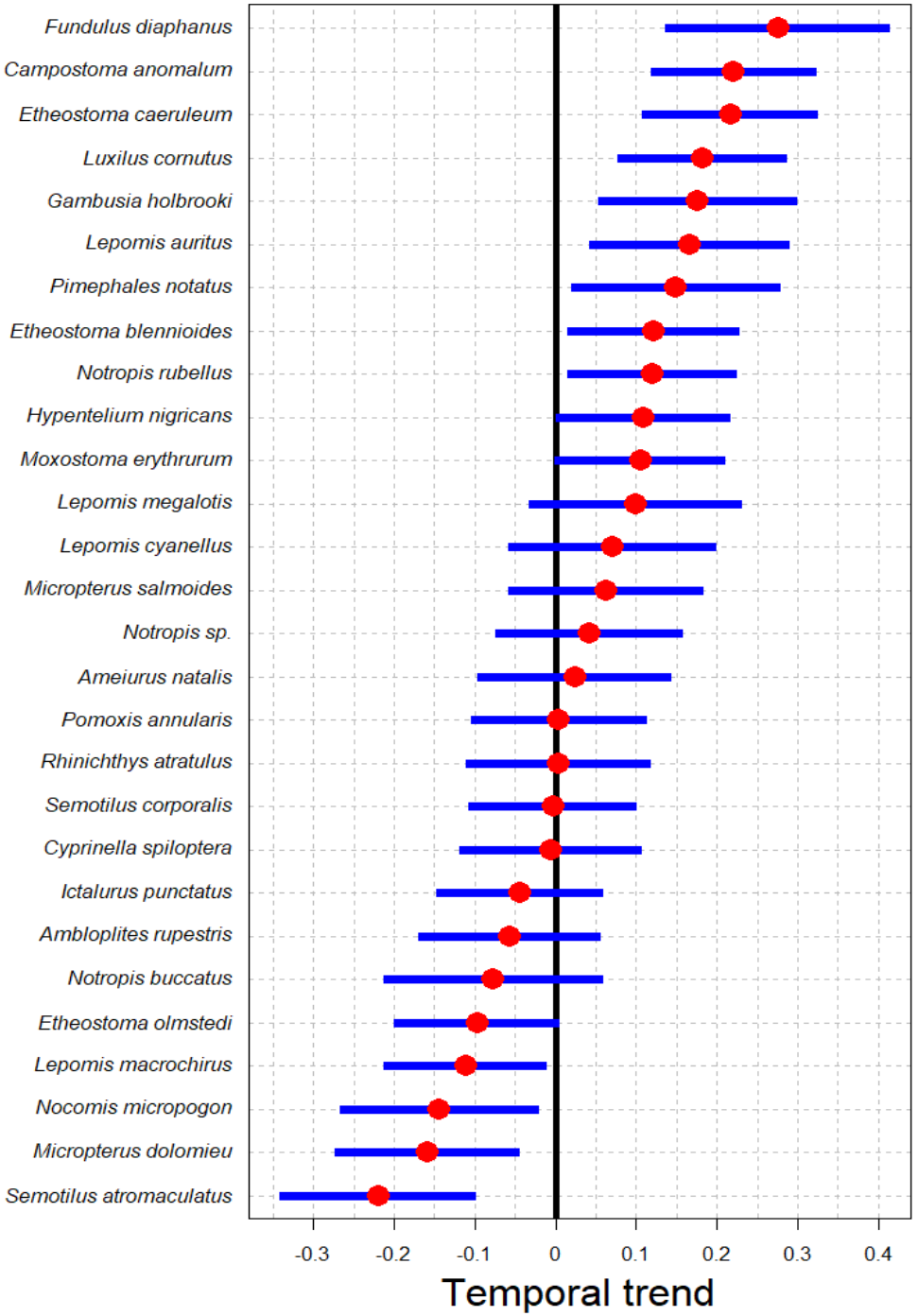

Seneca
WhitesFerry
Brunswick
Dargan
Taylors
Williamsport
McCoys
Hancock
Lorleans
PawPaw
CPUE
0
2
4
6
8
10
12
1980
1990
2000
2010
Banded killifish


Seneca
WhitesFerry
Brunswick
Dargan
Taylors
Williamsport
McCoys
Hancock
Lorleans
PawPaw
Central stoneroller
CPUE
0
5
10
15
1980
1990
2000
2010

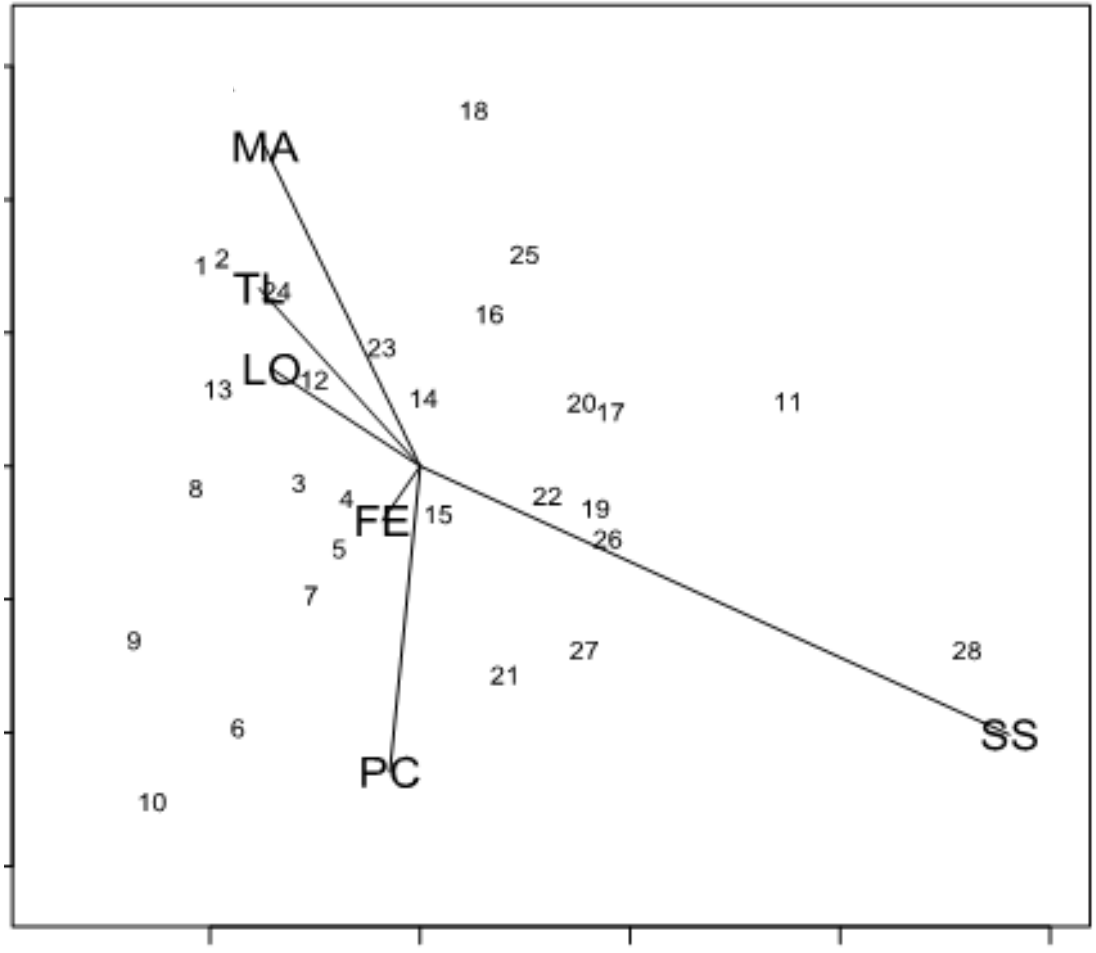

Fundulus diaphanus
Campostoma anomalum
Etheostoma caeruleum
Luxilus cornutus
Gambusia holbrooki
Lepomis auritus
Pimephales notatus
Etheostoma blennioides
Notropis rubellus
Hypentelium nigricans
Moxostoma erythrurum
Lepomis megalotis
Lepomis cyanellus
Micropterus salmoides
Notropis sp.
Ameiurus natalis
Pomoxis annularis
Rhinichthys atratulus
Semotilus corporalis
Cyprinella spiloptera
Ictalurus punctatus
Ambloplites rupestris
Notropis buccatus
Etheostoma olmstedi
Lepomis macrochirus
Nocomis micropogon
Micropterus dolomieu
Semotilus atromaculatus
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
Temporal trend

Banded killifish
Central stoneroller
Rainbow darter
Common shiner
Mosquitofish

Tessellated darter
Bluegill
River chub
Smallmouth bass
Creek chub



Life history diversity in the Potomac River



MA = maturation age

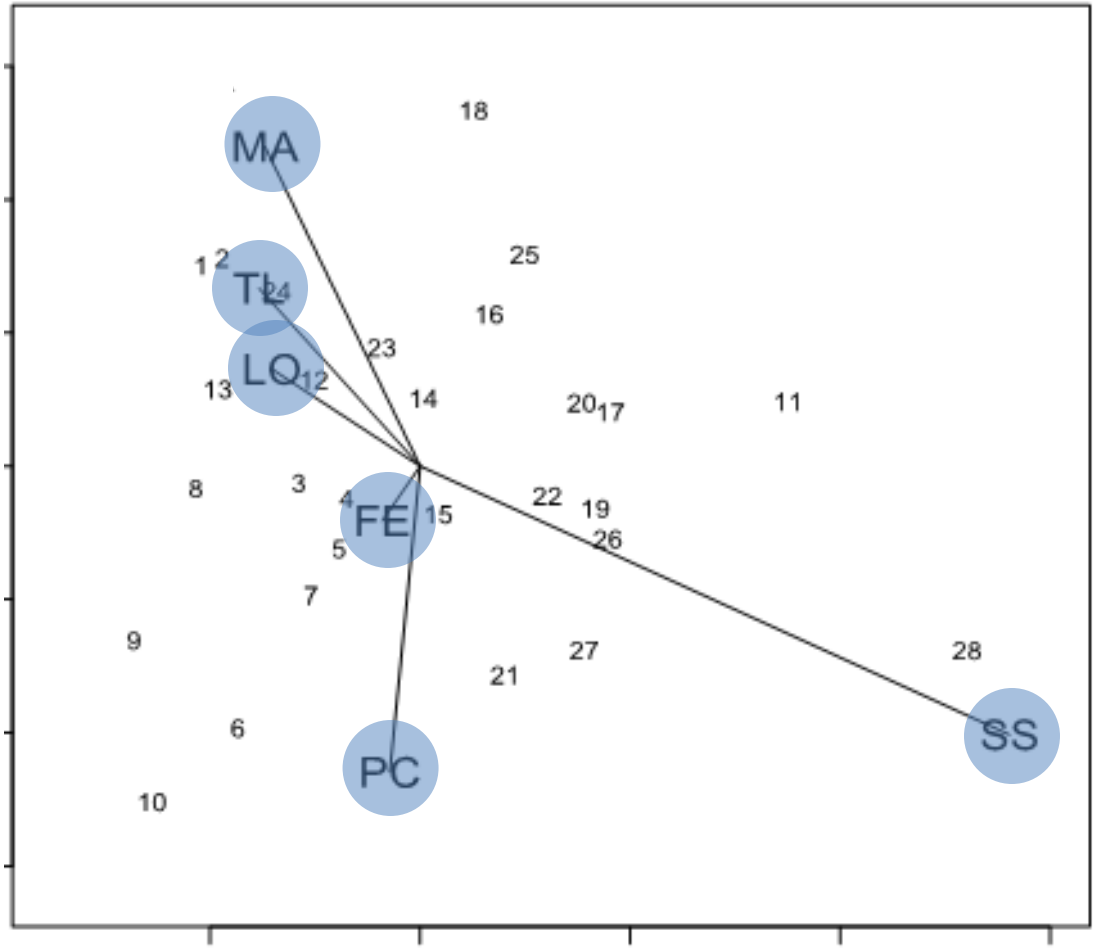
TL = total length

LO = longevity

FE = fecundity

SS = spawning season length

Life history diversity in the Potomac River



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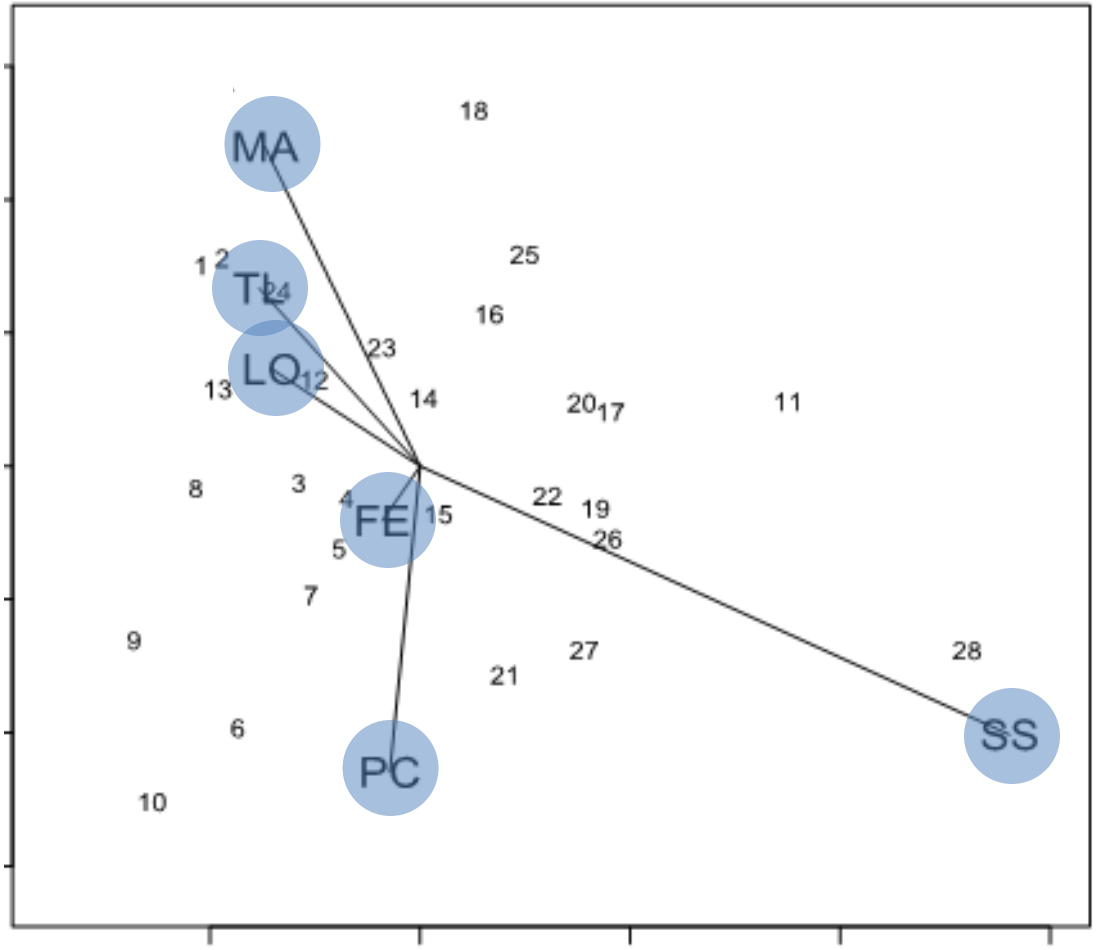
Life history diversity in the Potomac River



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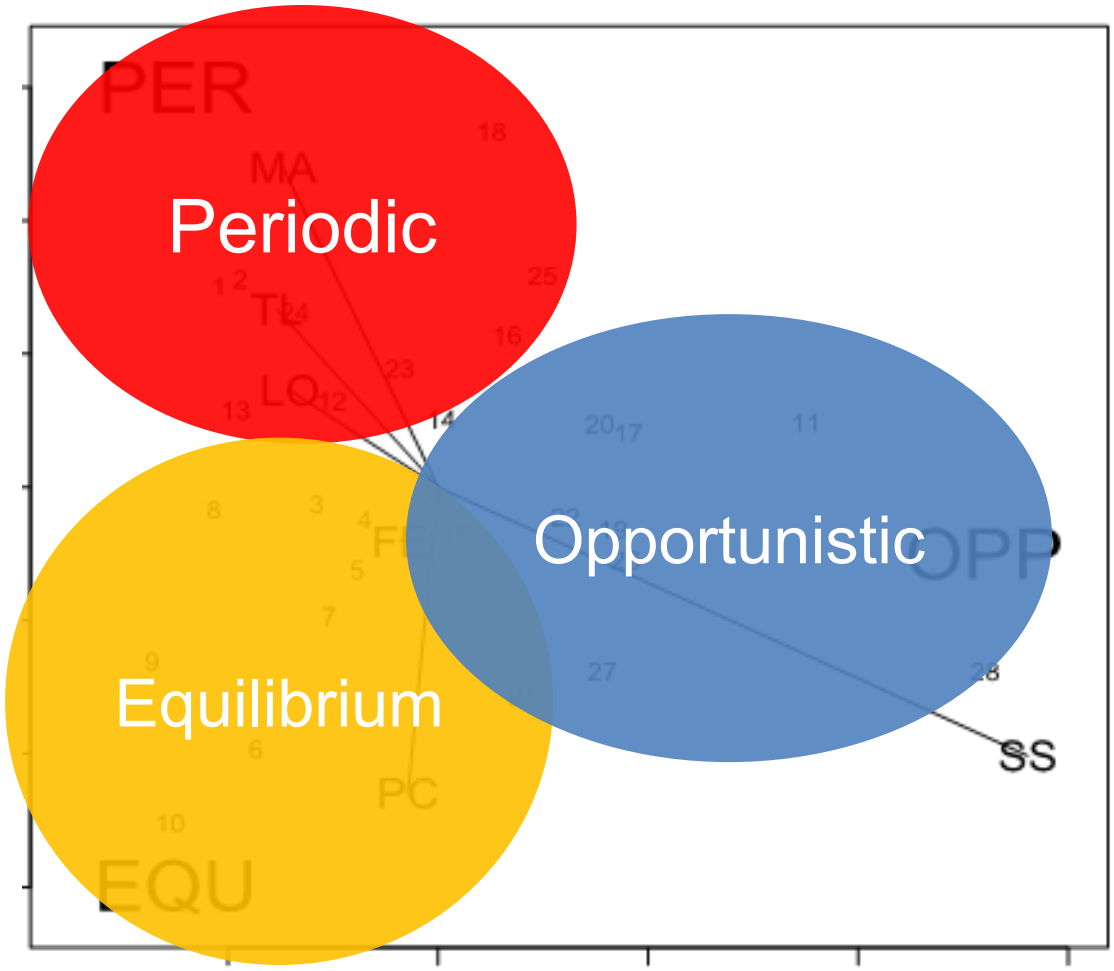

MA = maturation age

TL = total length

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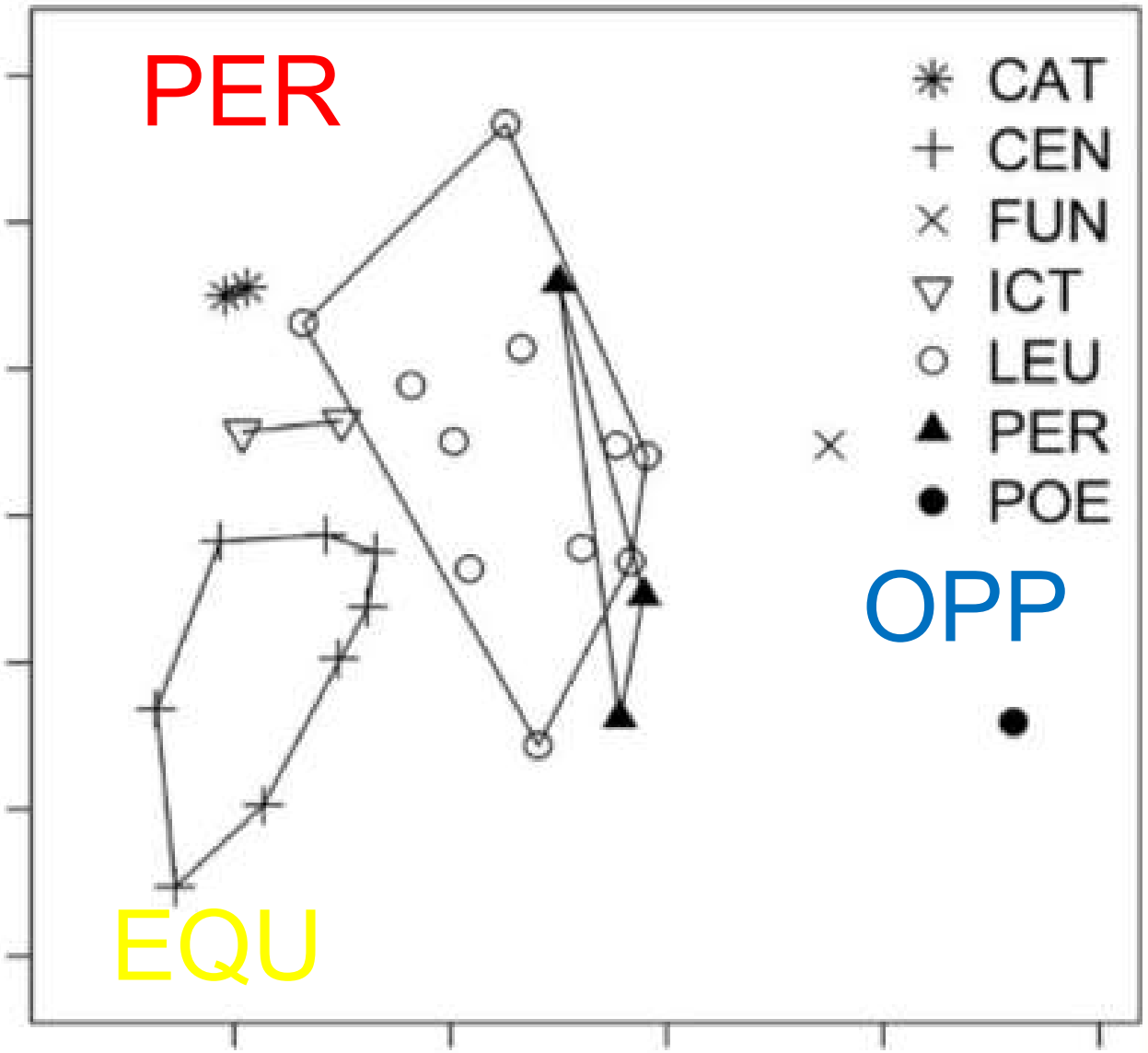
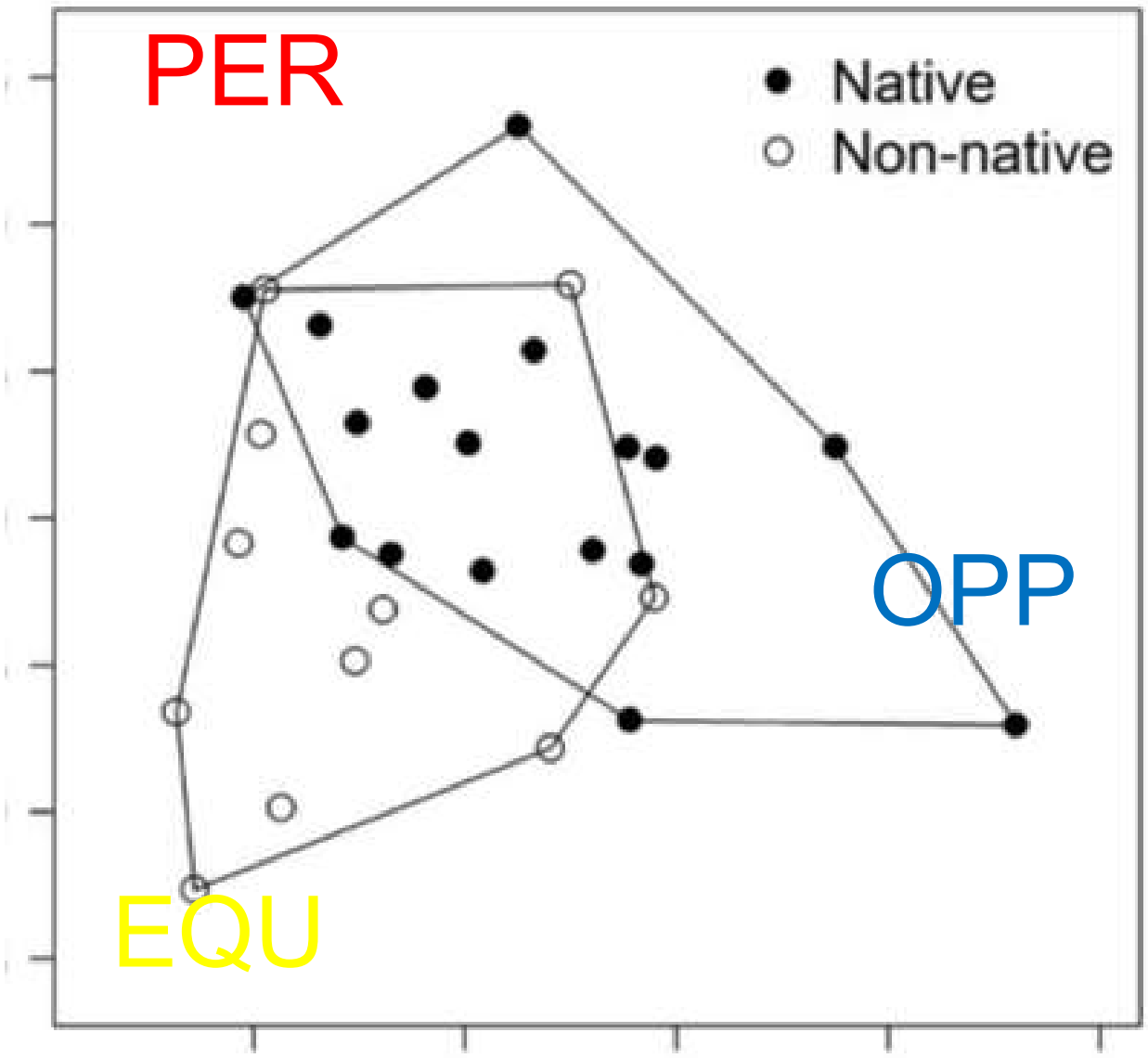
FE = fecundity

SS = spawning season length

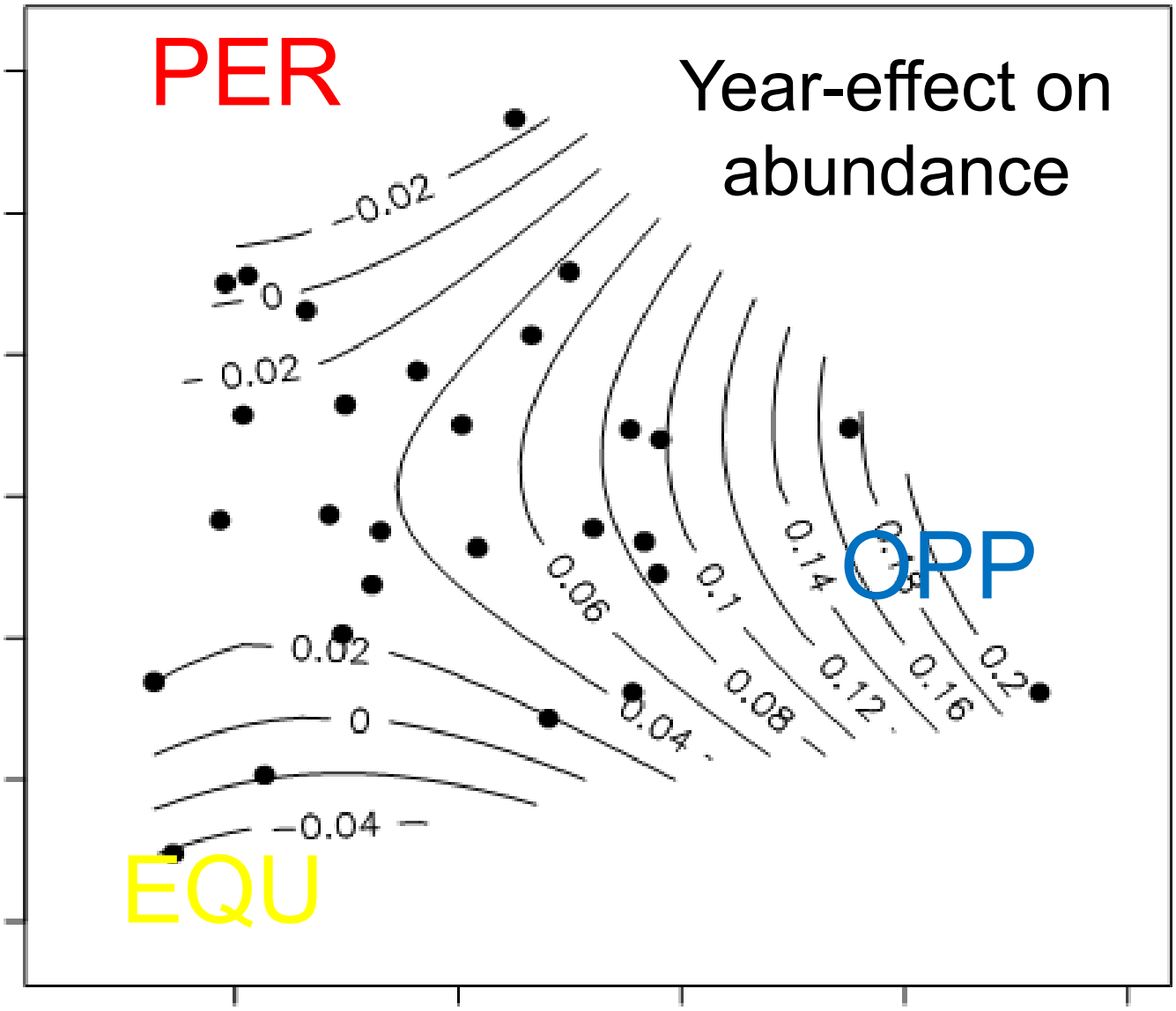
Taxonomic family structure



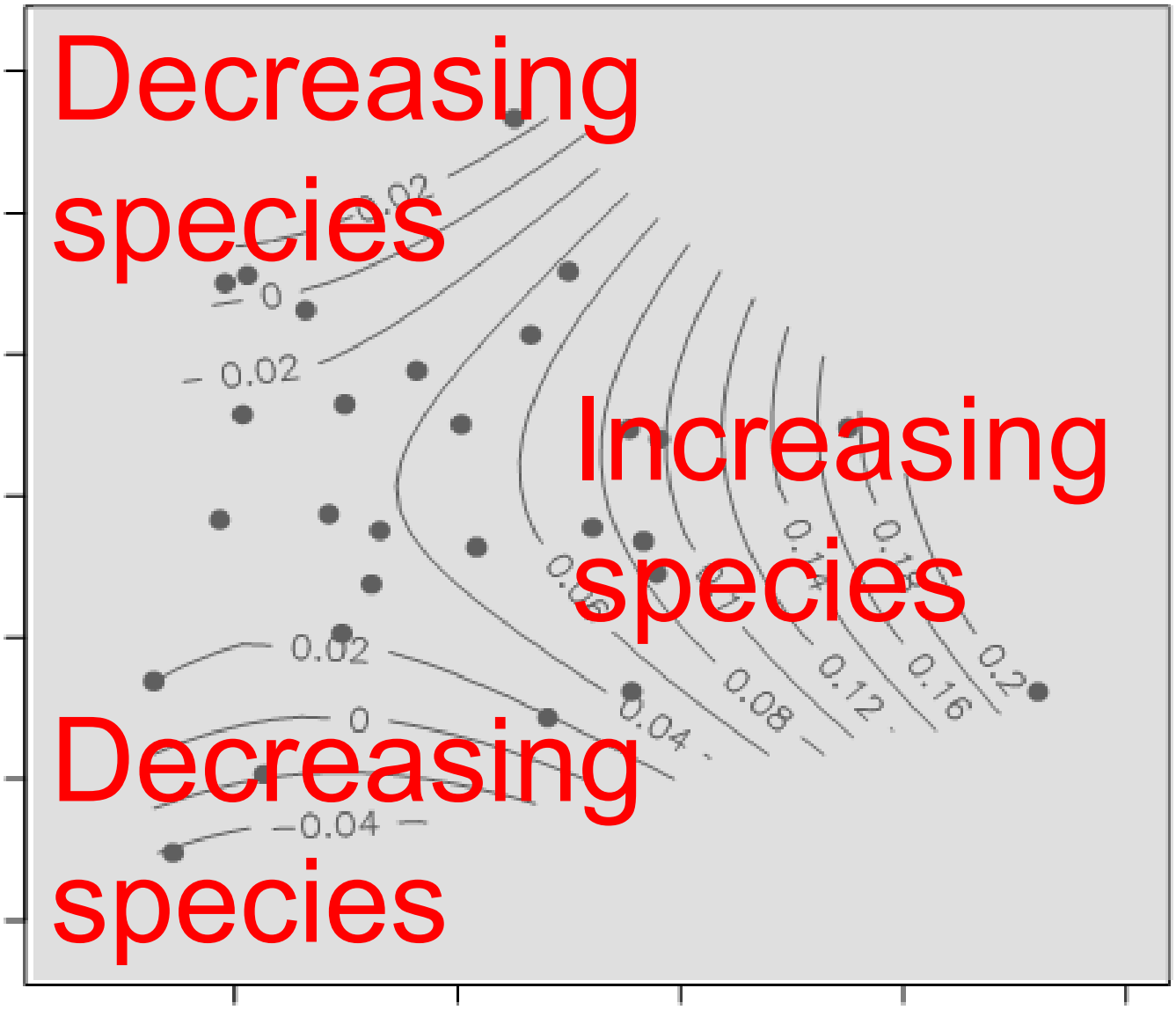
Native status



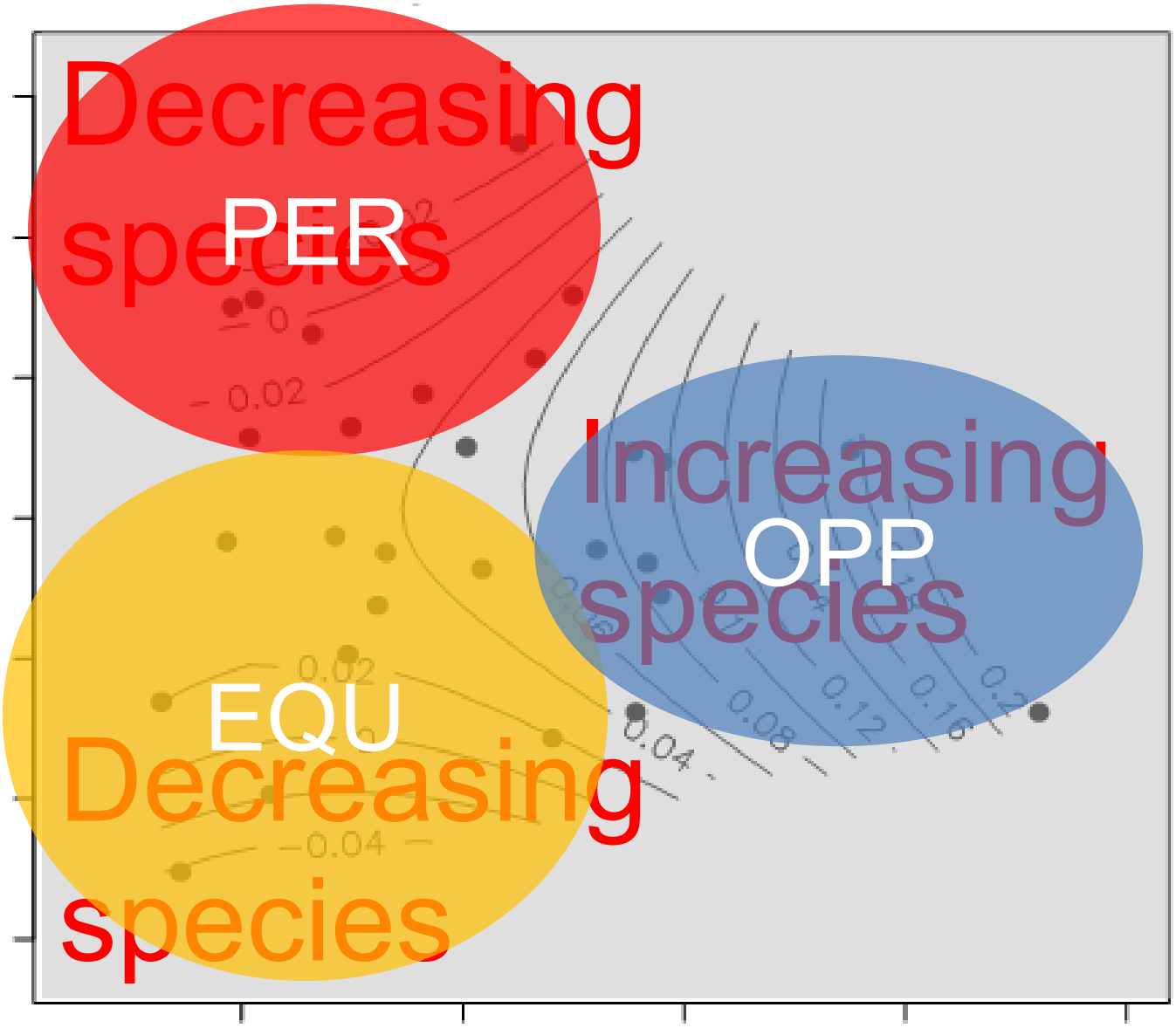
Temporal trends + life history strategies



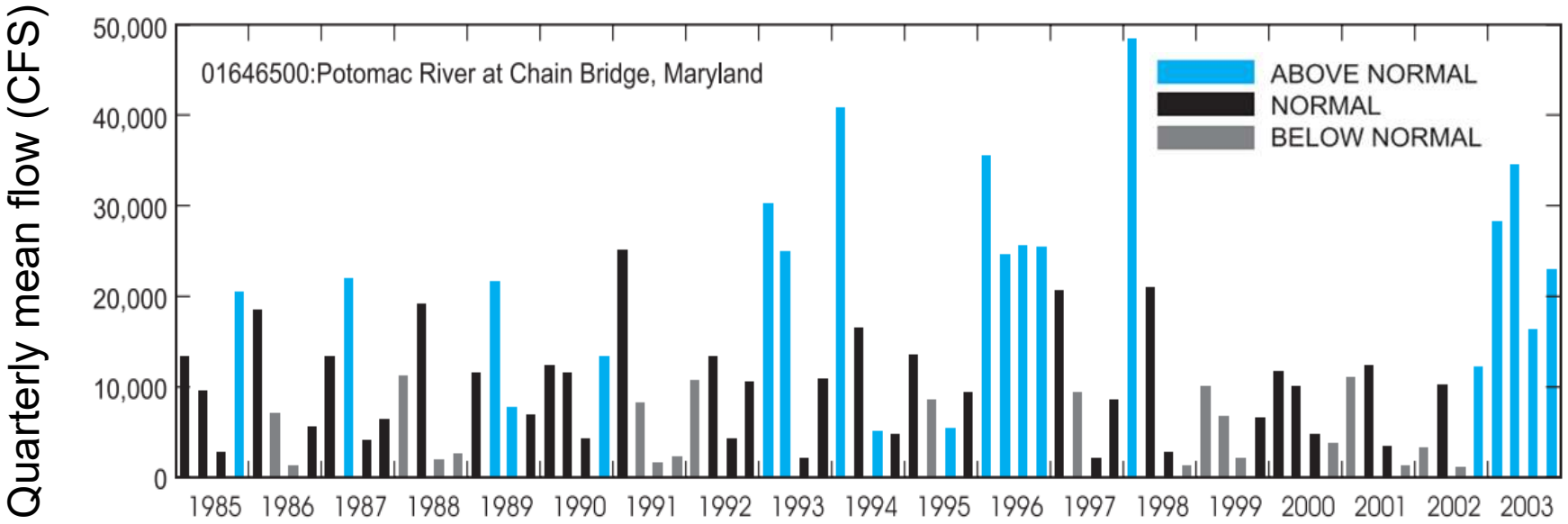
Temporal trends + life history strategies



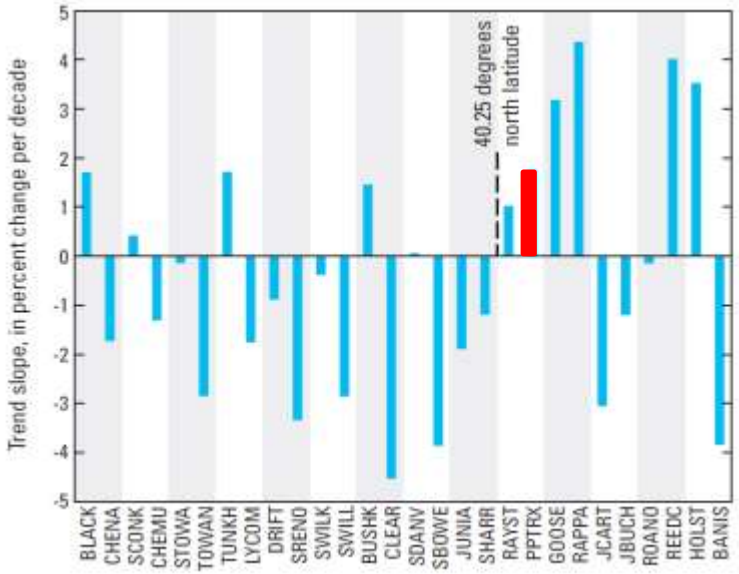
Temporal trends + life history strategies



Increasing spring peak-flows in the Potomac River



Langland et al. (2004)



Spring peak flows:
Increasing ~ 2% per decade

Rice and Hirsch (2012)

esa

ECOSPHERE

FRESHWATER ECOLOGY

Fish life history trends indicate increasing flow stochasticity in an unregulated river

NATHANIEL P. HITT,[1,†] KARLI M. ROGERS,[1] ZACHARY A. KELLY,[1] JOSH HENESY,[2] AND JOHN E. MULLICAN[2]

[1]*U.S. Geological Survey, Leetown Science Center, 11649 Leetown Road, Kearneysville, West Virginia 25430 USA*
[2]*Freshwater Fisheries Program, Maryland Department of Natural Resources, 20901 Fish Hatchery Road, Hagerstown, Maryland 21740 USA*

Citation: Hitt, N. P., K. M. Rogers, Z. A. Kelly, J. Henesy, and J. E. Mullican. 2020. Fish life history trends indicate increasing flow stochasticity in an unregulated river. Ecosphere 11(2):e03026. 10.1002/ecs2.3026

Ecosphere 2020

ORIGINAL RESEARCH

Ecology of FRESHWATER FISH WILEY

Stabilising effects of karstic groundwater on stream fish communities

Nathaniel P. Hitt[1] | Karli M. Rogers[1] | Karmann G. Kessler[1] | Martin A. Briggs[2] | Jennifer H. Fair[3]

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[2]Observing Systems Division, U.S. Geological Survey, Hydrologic Remote Sensing Branch, Storrs, Connecticut, USA

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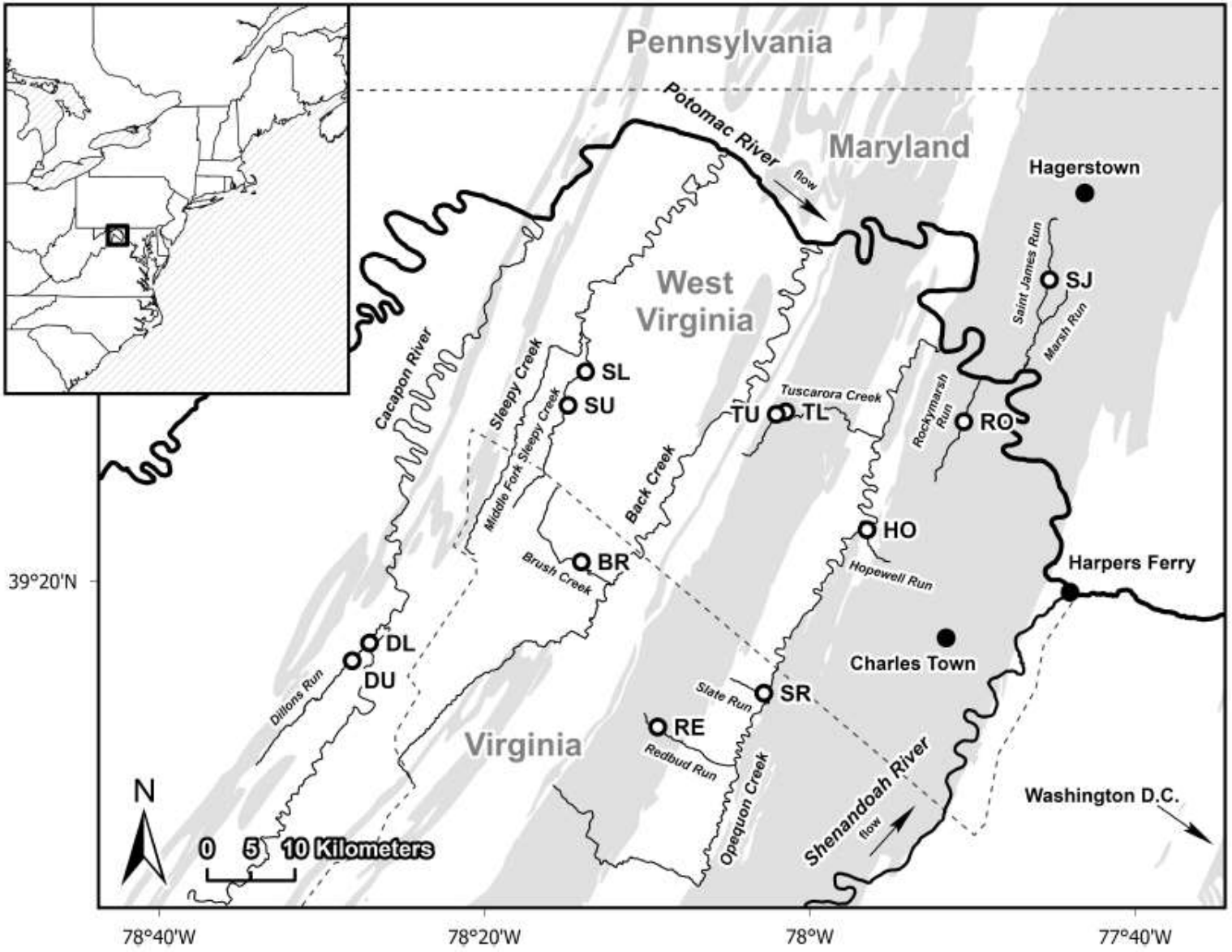
Nathaniel P. Hitt, U.S. Geological Survey, Eastern Ecological Science Center, Kearneysville, West Virginia, USA.
Email: nhitt@usgs.gov

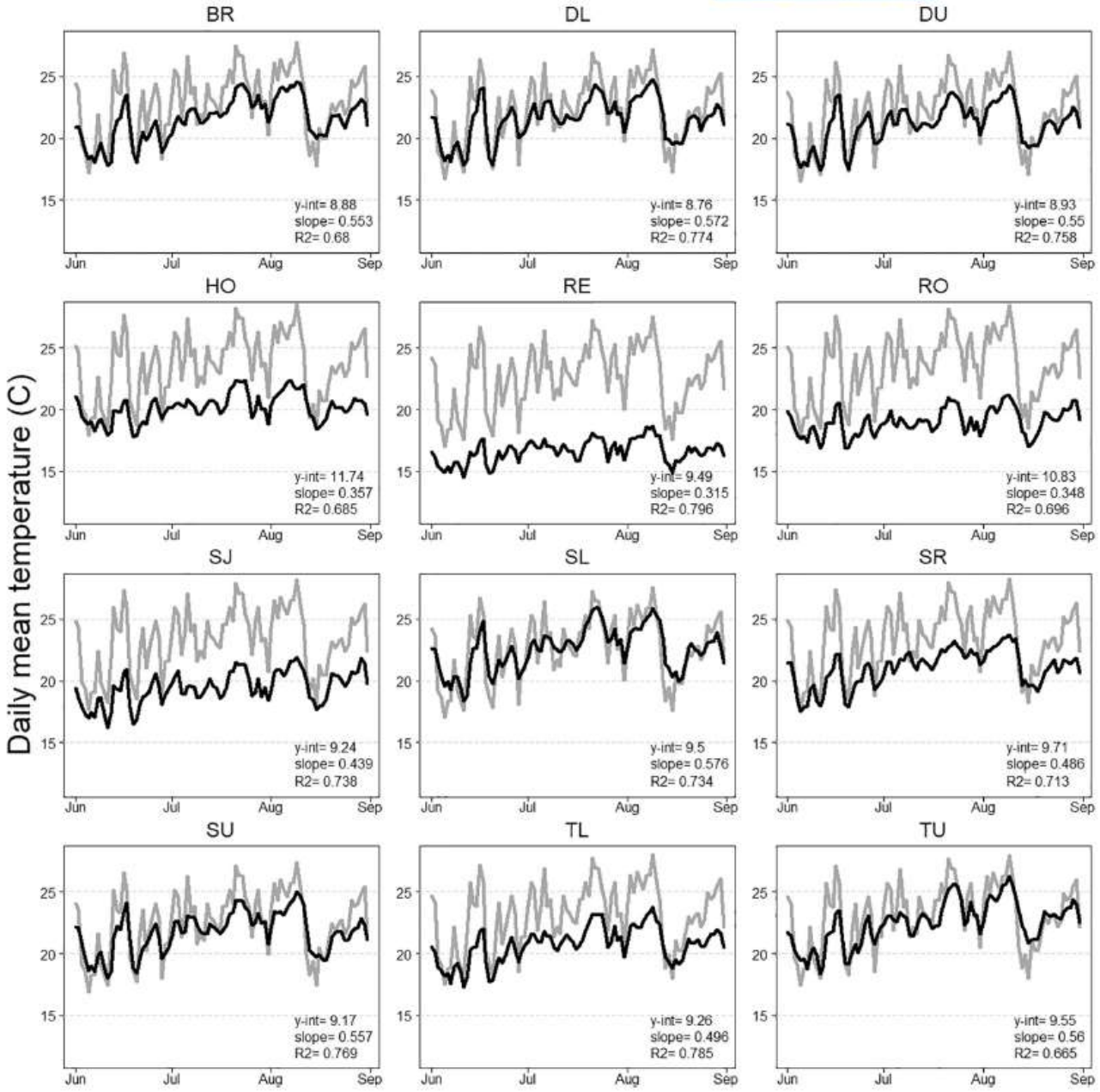
Funding information
U.S. Geological Survey

Abstract

Although groundwater exchange processes are known to modulate atmospheric influences on stream temperature and flow, the implications for ecological stability are poorly understood. Here, we evaluated temporal change in stream fish communities across a gradient of groundwater influence defined by karst terrain (carbonate parent materials) within the Potomac River basin of eastern North America. We surveyed 12 sites in 2022 that had been sampled 29–30 years previously with similar methods. We also collected stream temperature data from each site and used the regression slope of the air-water temperature relationship to index stream thermal sensitivity and groundwater exchange processes. Sites in karst terrain exhibited strong groundwater controls on stream temperature, and fish communities were more stable over time in these locations than elsewhere. However, stream thermal sensitivity was a stronger predictor of species persistence than the spatial distribution of karst terrain in contributing areas,

Ecology of Freshwater Fish 2023


Pennsylvania
Maryland
West Virginia
Virginia
Potomac River
flow
Hagerstown
Saint James Run
Marsh Run
SJ
Cacapon River
Sleepy Creek
Middle Fork Sleepy Creek
SL
SU
Tuscarora Creek
TU
TL
Rockymarsh Run
RO
Back Creek
HO
Hopewell Run
Harpers Ferry
Brush Creek
BR
39°20'N
DL
DU
Dillons Run
Charles Town
Slate Run
SR
RE
Redbud Run
Opequon Creek
Shenandoah River
flow
Washington D.C.
N
0 5 10 Kilometers
78°40'W
78°20'W
78°W
77°40'W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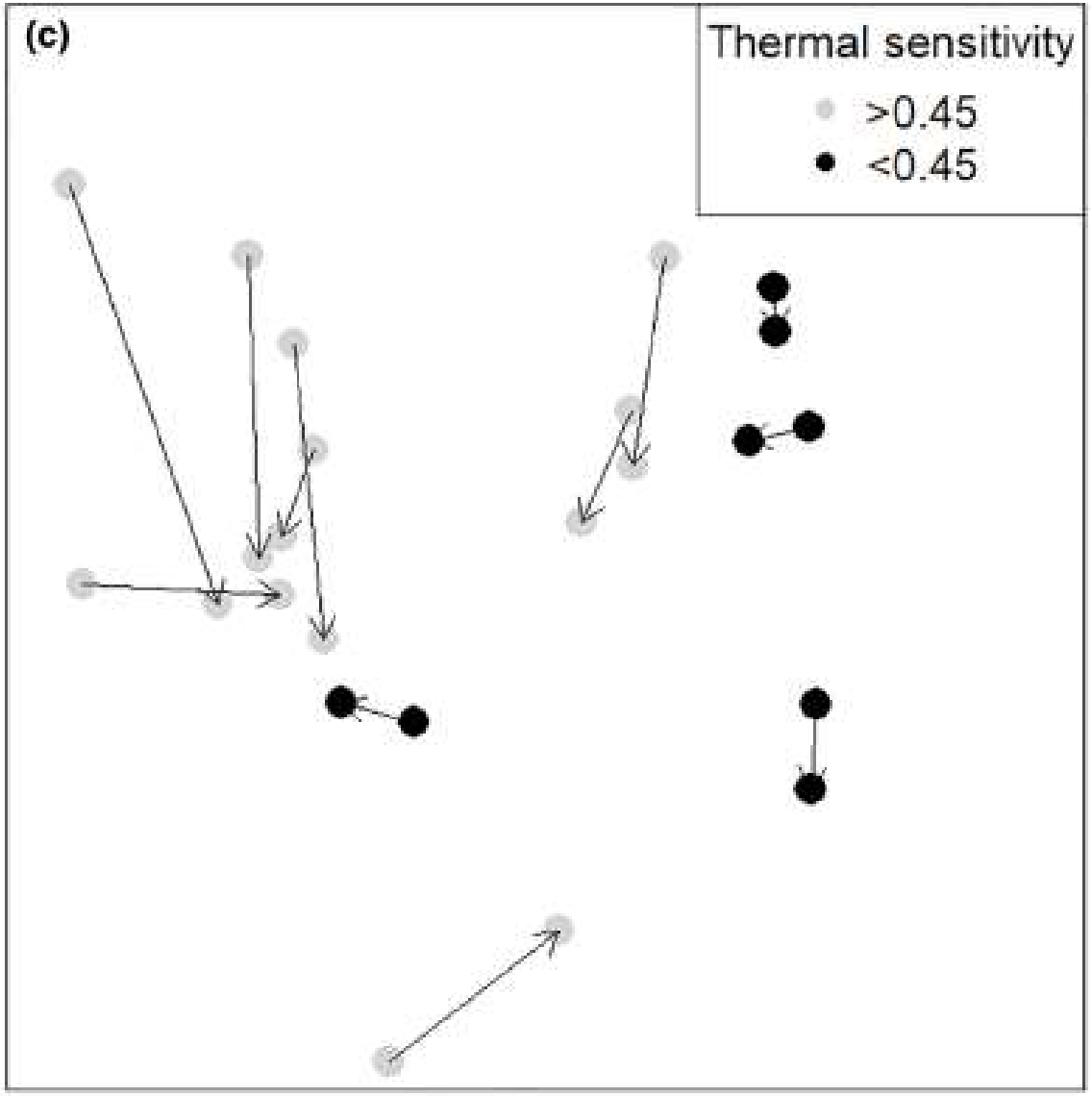
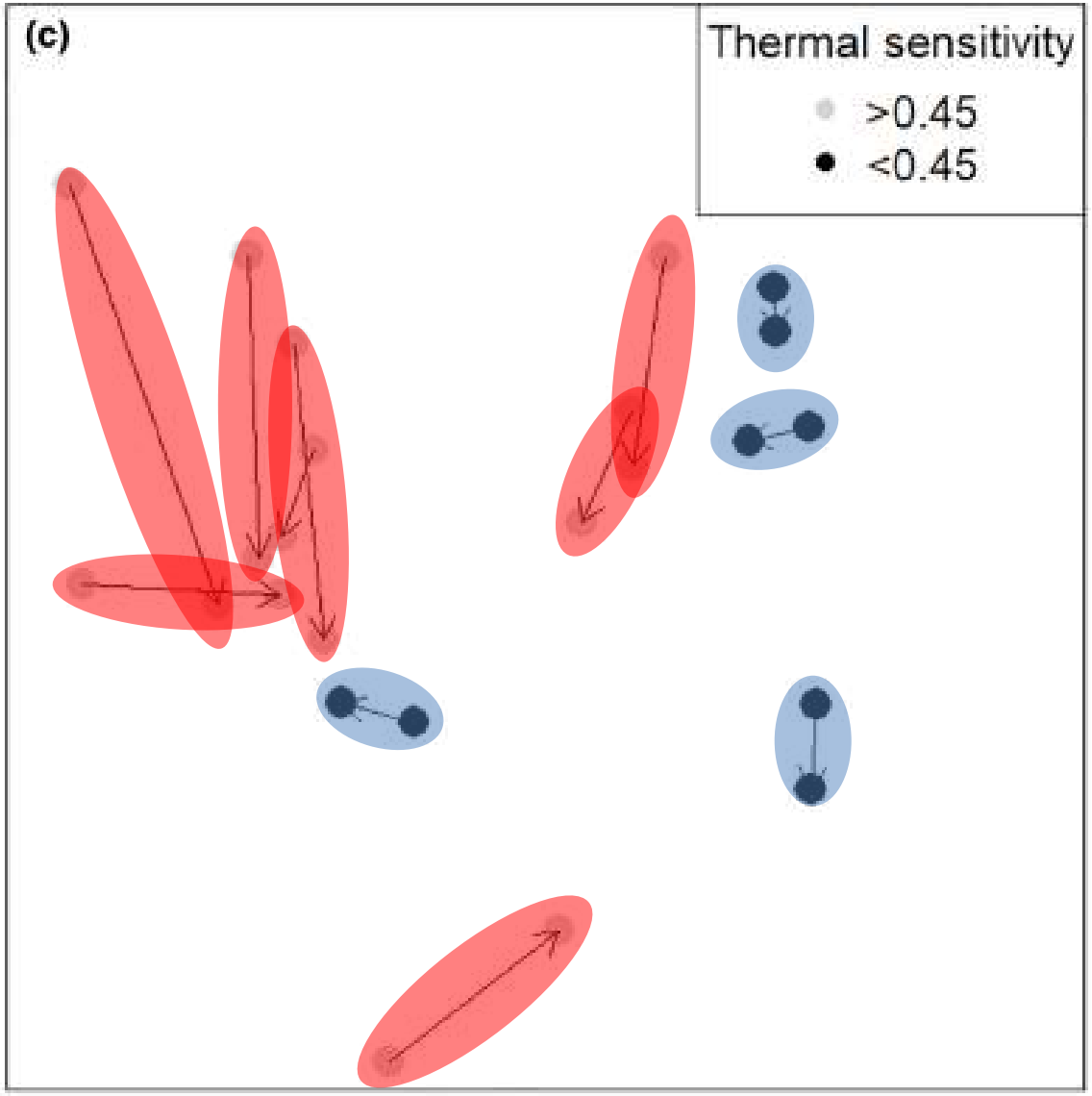
slope= 0.553
R2= 0.68
DL
y-int= 8.76
slope= 0.572
R2= 0.774
DU
y-int= 8.93
slope= 0.55
R2= 0.758
HO
y-int= 11.74
slope= 0.357
R2= 0.685
RE
y-int= 9.49
slope= 0.315
R2= 0.796
RO
y-int= 10.83
slope= 0.348
R2= 0.696
SJ
y-int= 9.24
slope= 0.439
R2= 0.738
SL
y-int= 9.5
slope= 0.576
R2= 0.734
SR
y-int= 9.71
slope= 0.486
R2= 0.713
SU
y-int= 9.17
slope= 0.557
R2= 0.769
TL
y-int= 9.26
slope= 0.496
R2= 0.785
TU
y-int= 9.55
slope= 0.56
R2= 0.665
Daily mean temperature (C)
15
20
25
Jun
Jul
Aug
Sep

Stable flows and temperature = stable fish communities



29-30 year time span

Stable flows and temperature = stable fish communities



29-30 year time span

Stable flow and temp (strong GW controls)

Variable flow and temp (weak GW controls)

Main ideas

- **Fish communities are changing** in the Potomac basin
- Several species that require stable or predictable flows are **decreasing** over time
- Several species that capitalize on unpredictable flows are **increasing** over time
- Fish community trends support predictions for **flow de-stabilization** under climate and land use change

Ecological evidence for climate and land use predictions

Washington DC
July 8, 2019

For more information

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