A case study on the Santa Cruz River: Can Treated Wastewater Support Desert Fishes?

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The Santa Cruz River


Google

Santa Cruz River Basin

N

Arizona Remote Sensing Center

Photo Credit: Jeff Smith

Photo Credit: Hamdhani

Photo Credit: Hamdhani

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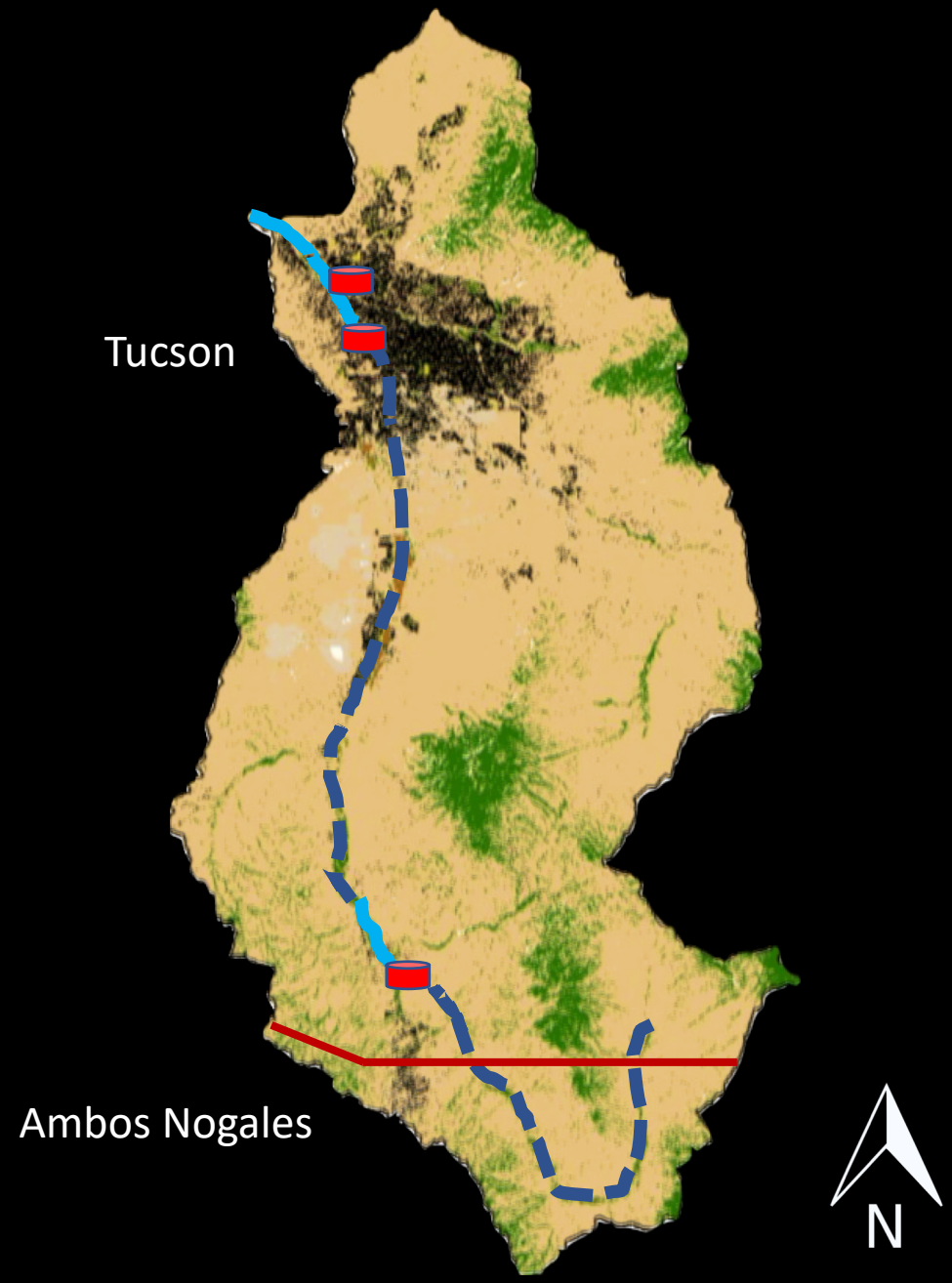
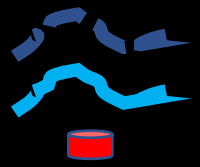
Santa Cruz River Basin





Legend

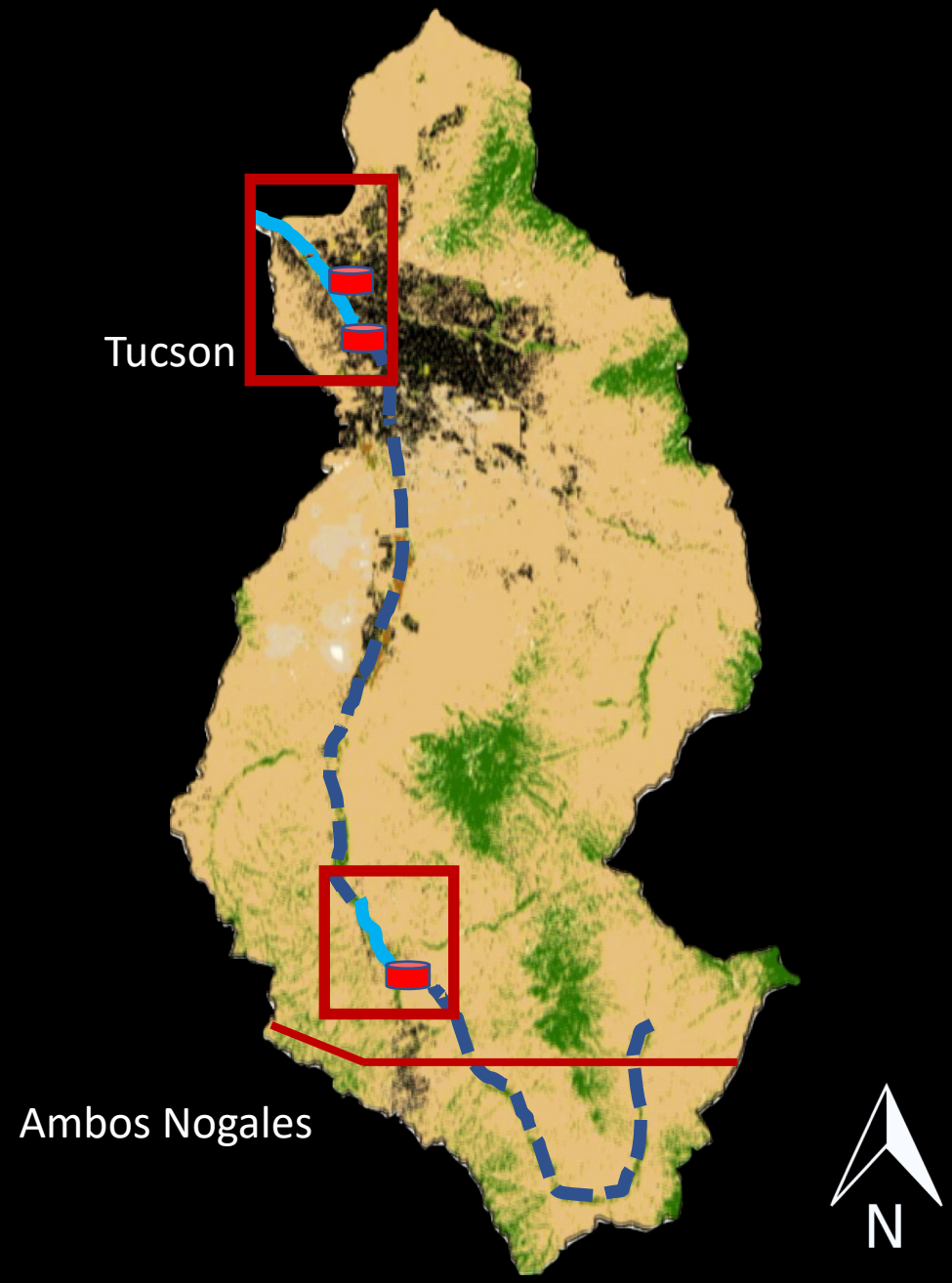
Ephemeral Flow

Perennial Effluent Flow

Wastewater Treatment Plant

Arizona Remote Sensing Center

Santa Cruz River Basin



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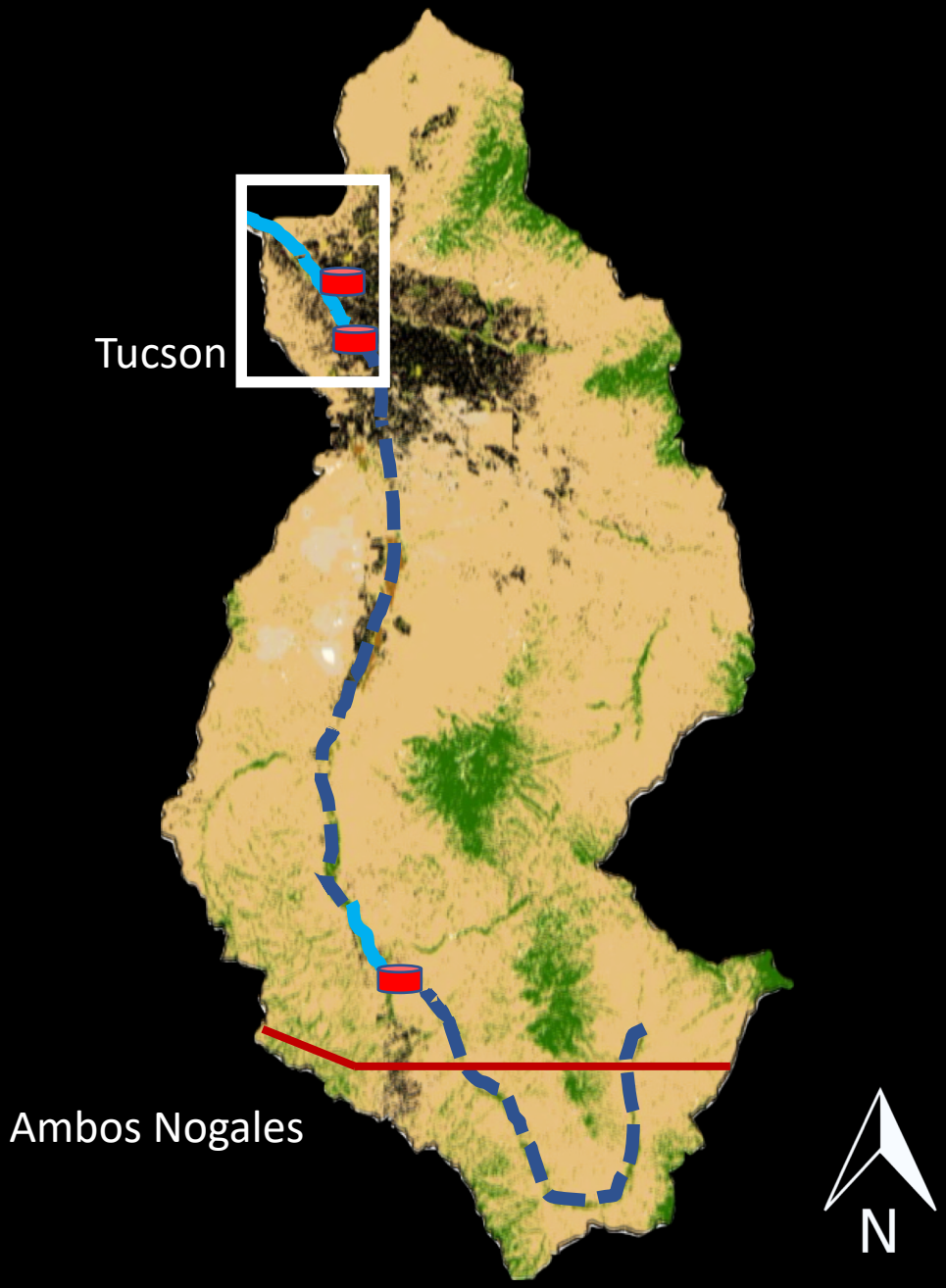
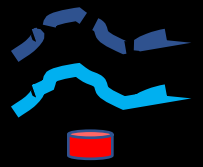
Santa Cruz River Basin





Legend

Ephemeral Flow

Perennial Effluent Flow

Wastewater Treatment Plant

Arizona Remote Sensing Center

Photo Credit: Michael Bogan

Photo Credit: Michael Bogan

Photo Credit: Hamdhani

Poeciliopsis occidentalis

Photo Credit: Joel Sartore

What are the implications of using treated wastewater as habitat for desert fishes?

What are the implications of using treated wastewater as habitat for desert fishes?

Potential issues

1. Impacts from artificial flow regime?
2. CECs changing sex morphology?
3. Altered diets?

Poeciliopsis occidentalis

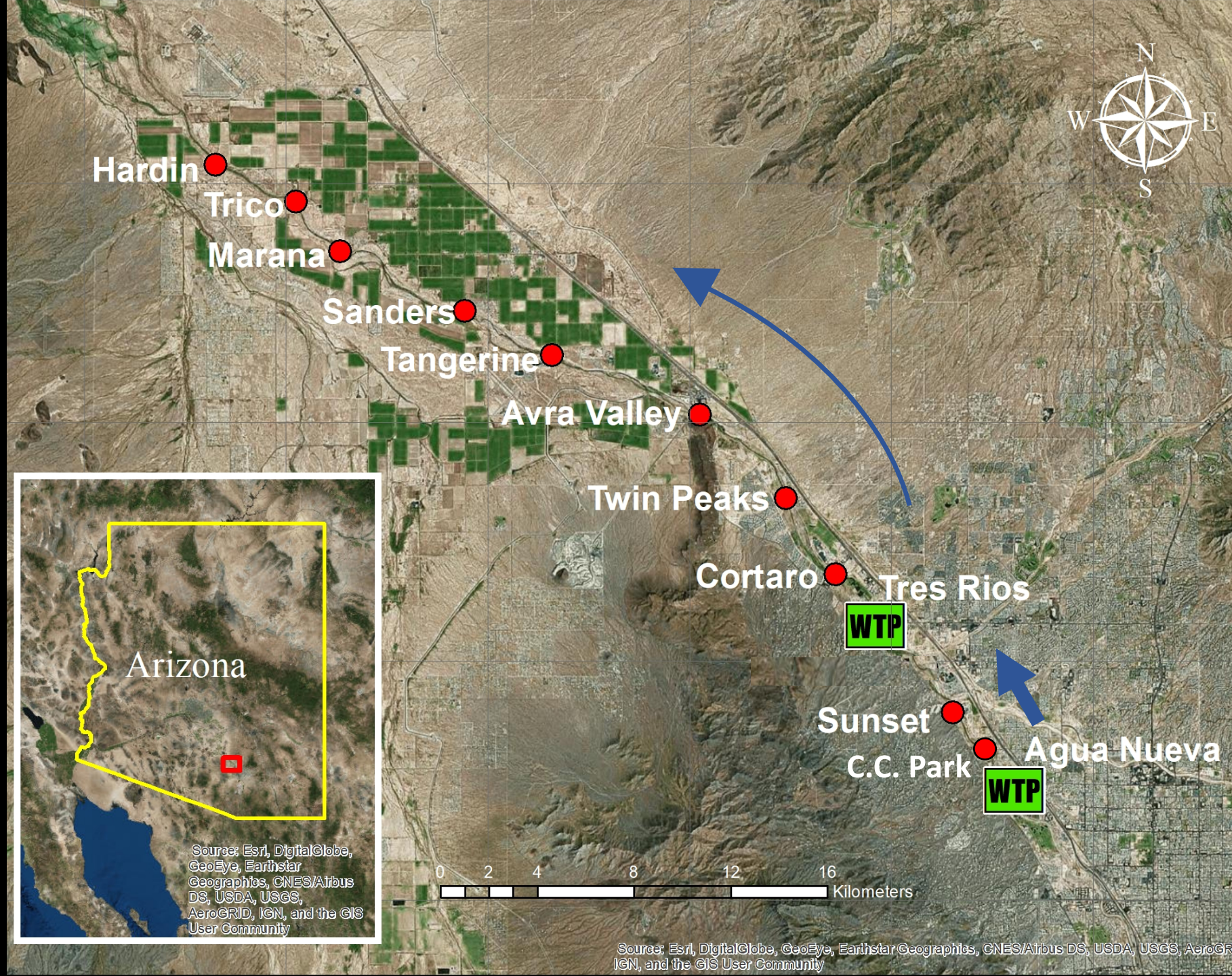
Photo Credit: Joel Sartore

Poeciliopsis occidentalis

Gambusia affinis

Photo Credit: Joel Sartore

Sampling


Hardin
Trico
Marana
Sanders
Tangerine
Avra Valley
Twin Peaks
Cortaro
Tres Rios
WTP
Sunset
C.C. Park
Agua Nueva
WTP
N
W
E
S
Arizona
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 2 4 8 12 16
Kilometers
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGR
IGN, and the GIS User Community

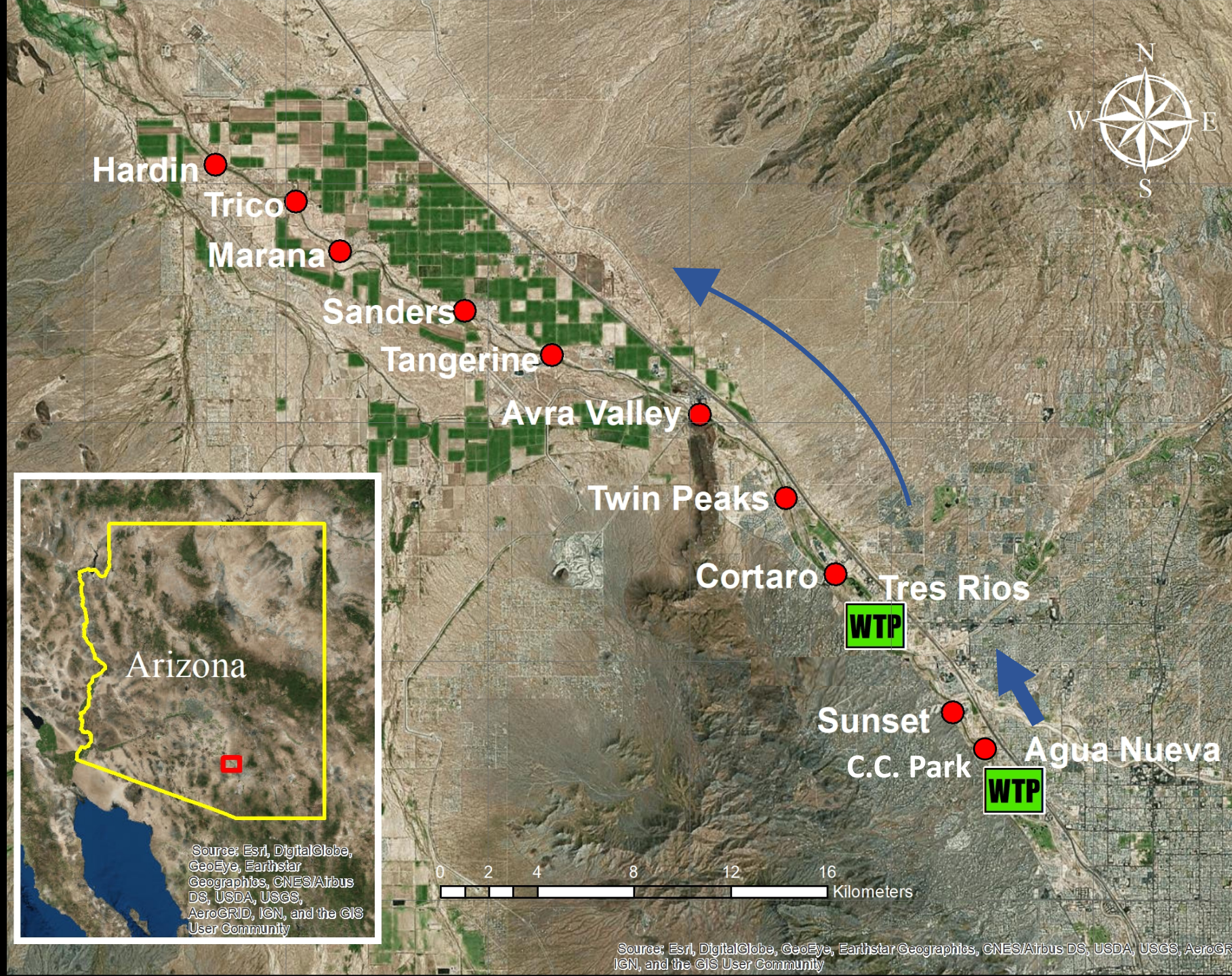
Sampling

10 sites

~4km apart

2 WRFs

150m transect



Sampling

10 sites

~4km apart

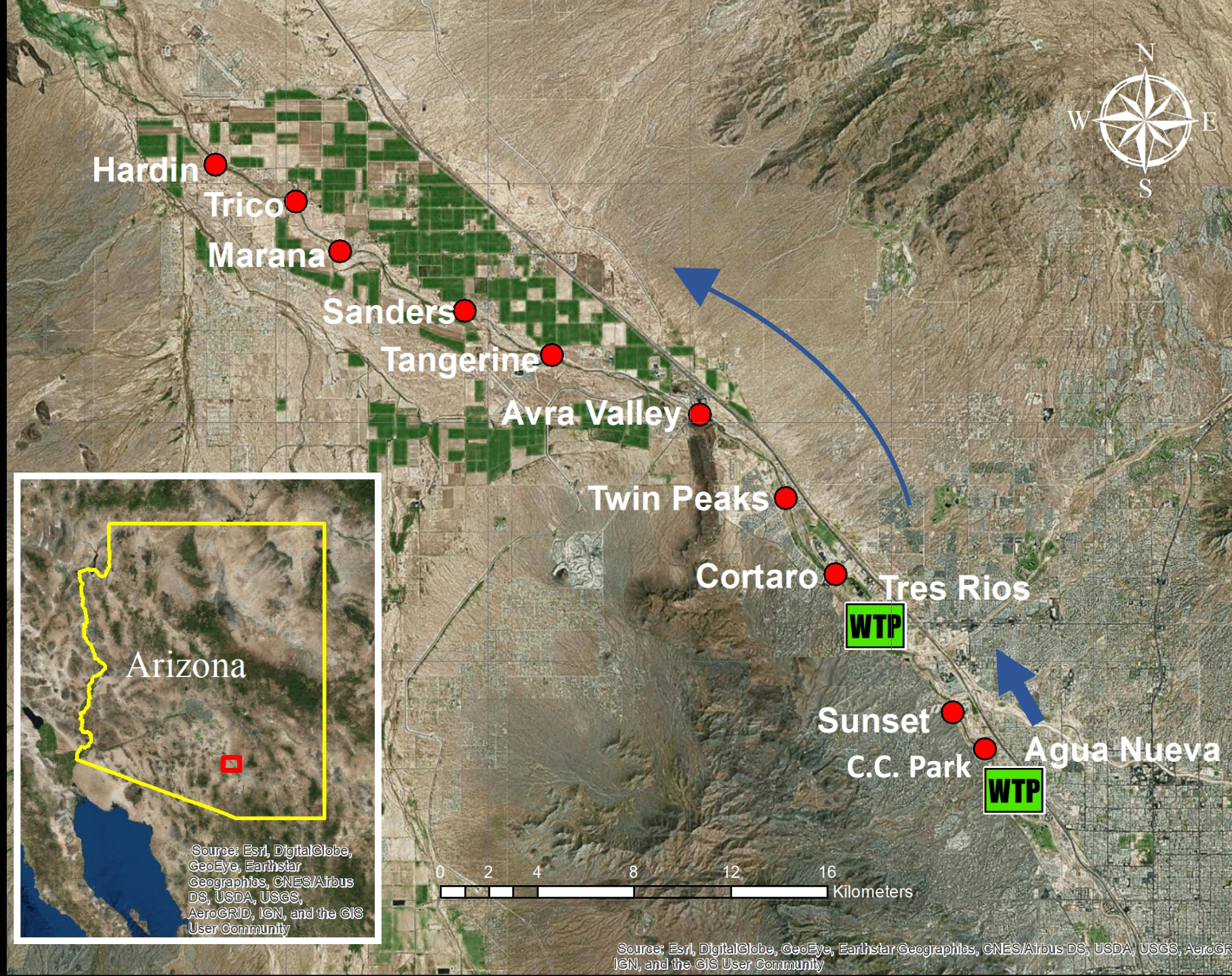
2 WRFs

150m transect

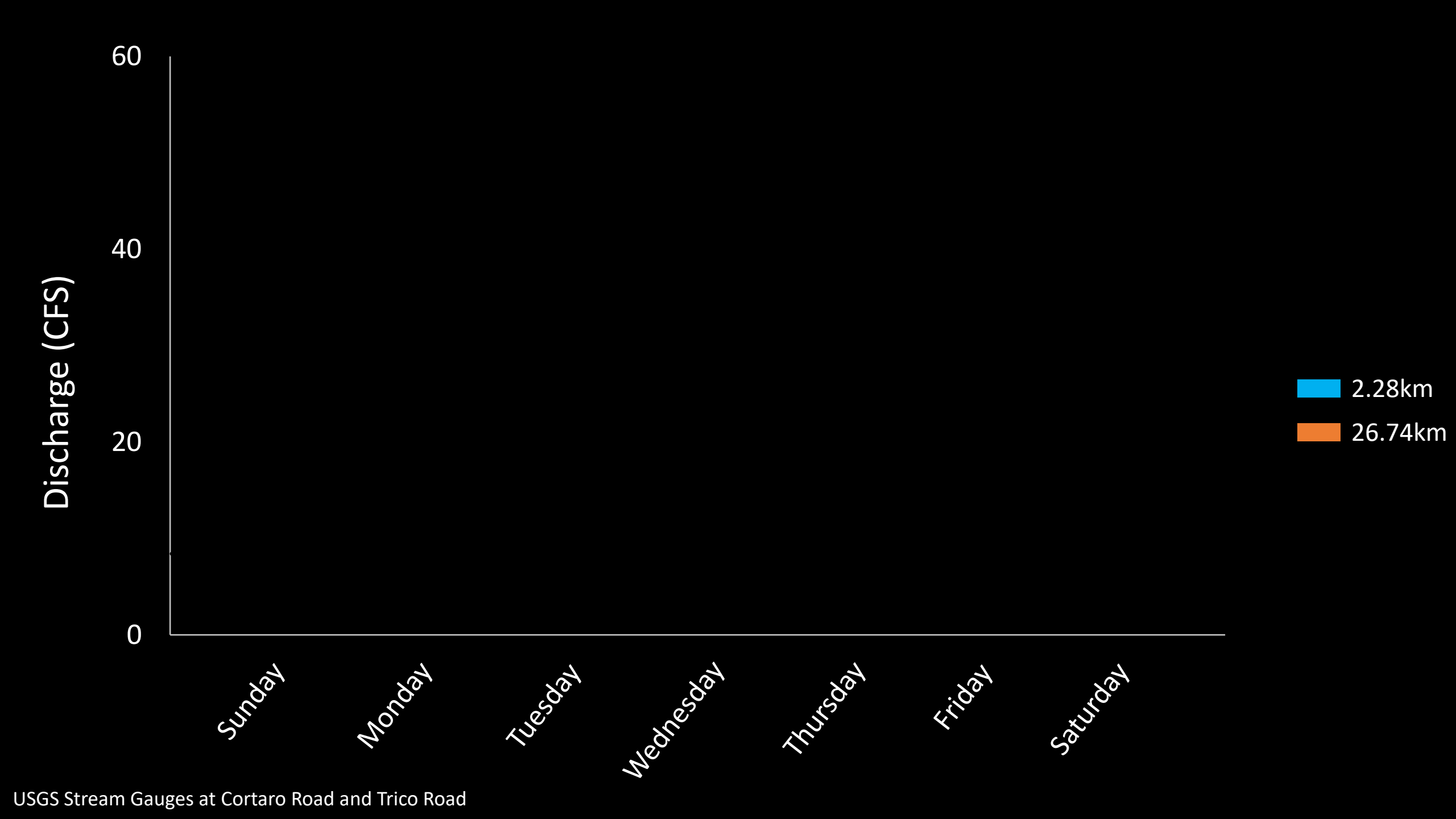
Water quality

Invertebrates

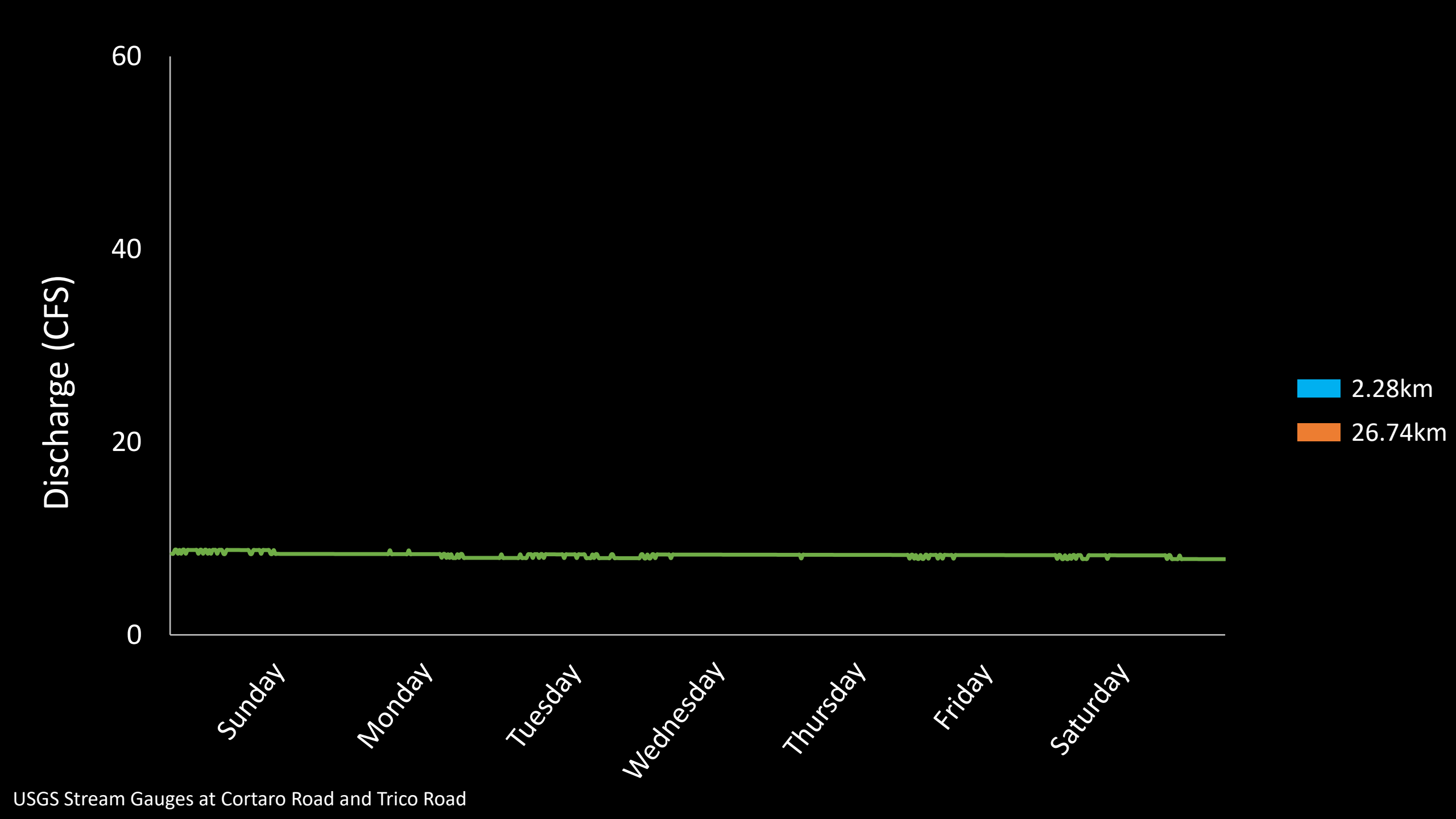
Mosquitofish



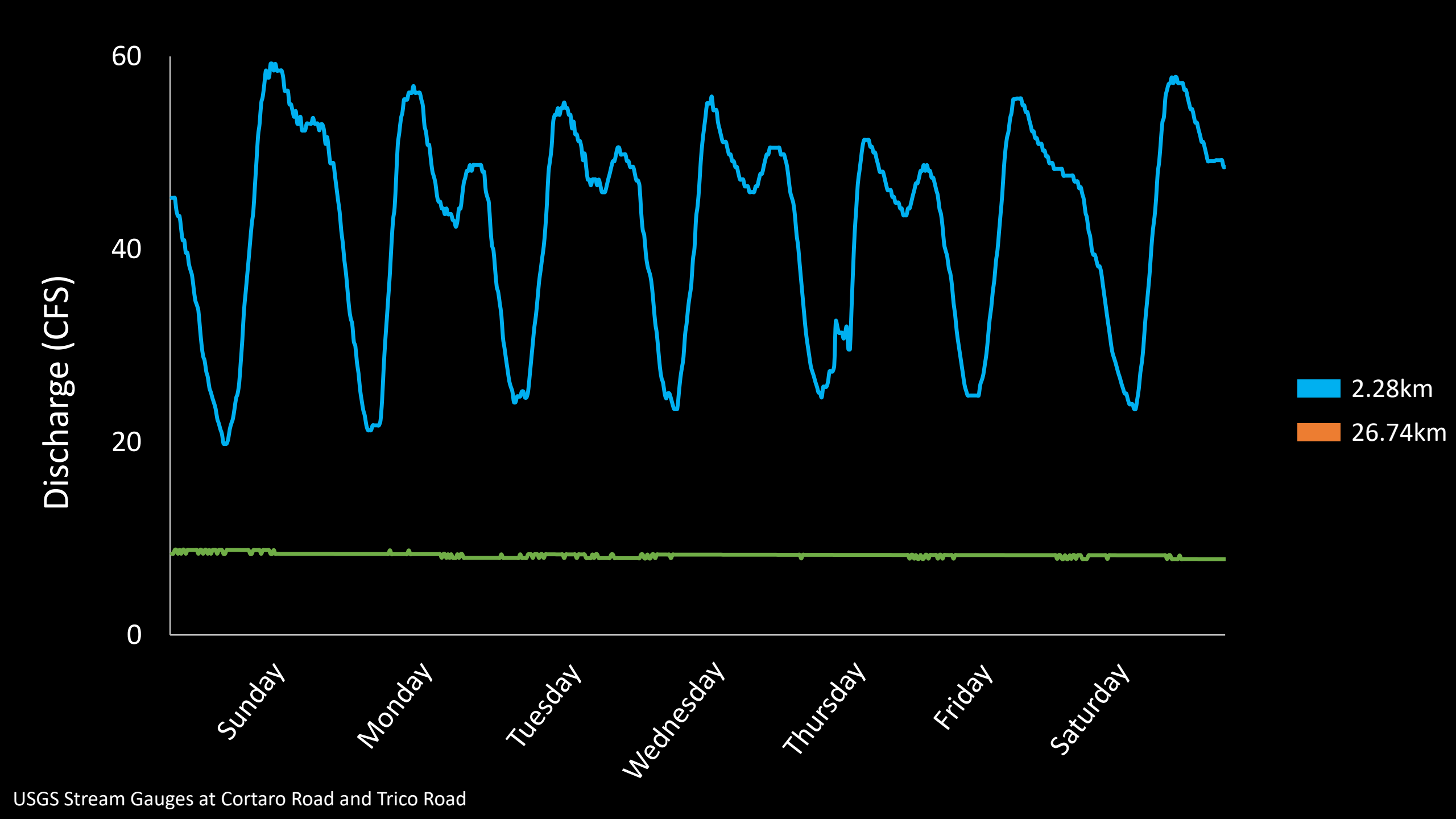
Impacts from an Artificial Flow Regime?



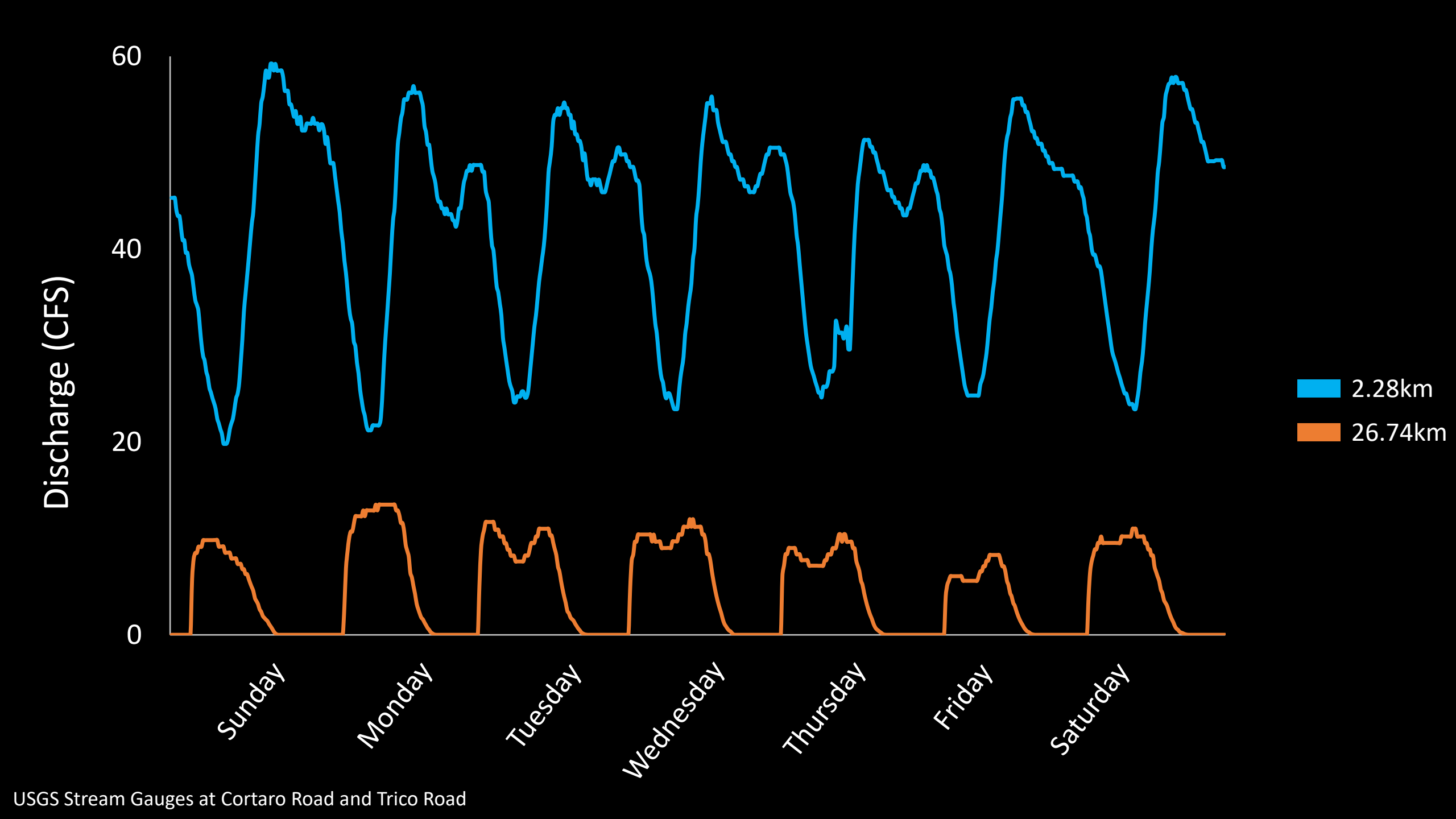
USGS Stream Gauges at Cortaro Road and Trico Road



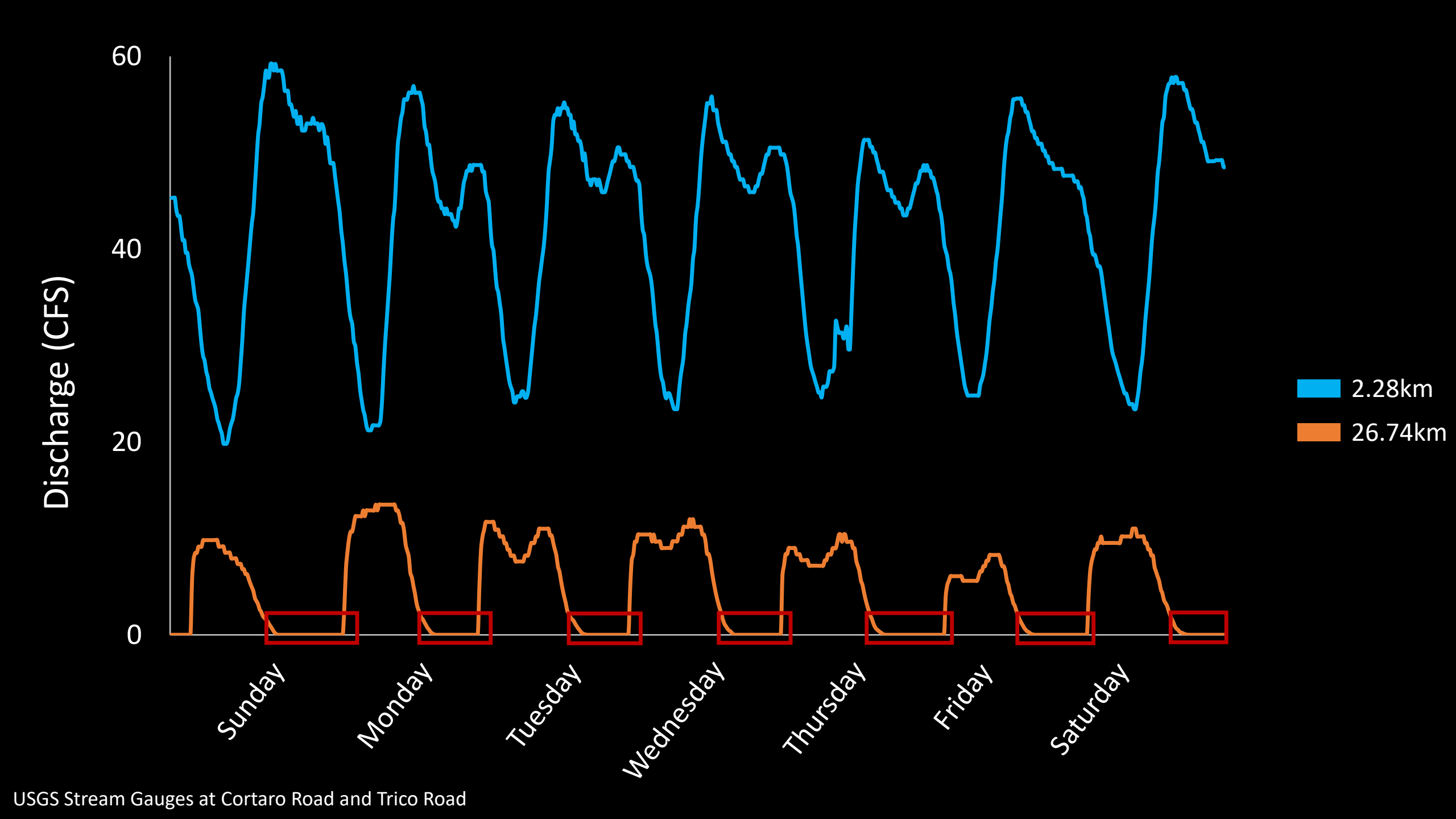
USGS Stream Gauges at Cortaro Road and Trico Road



USGS Stream Gauges at Cortaro Road and Trico Road

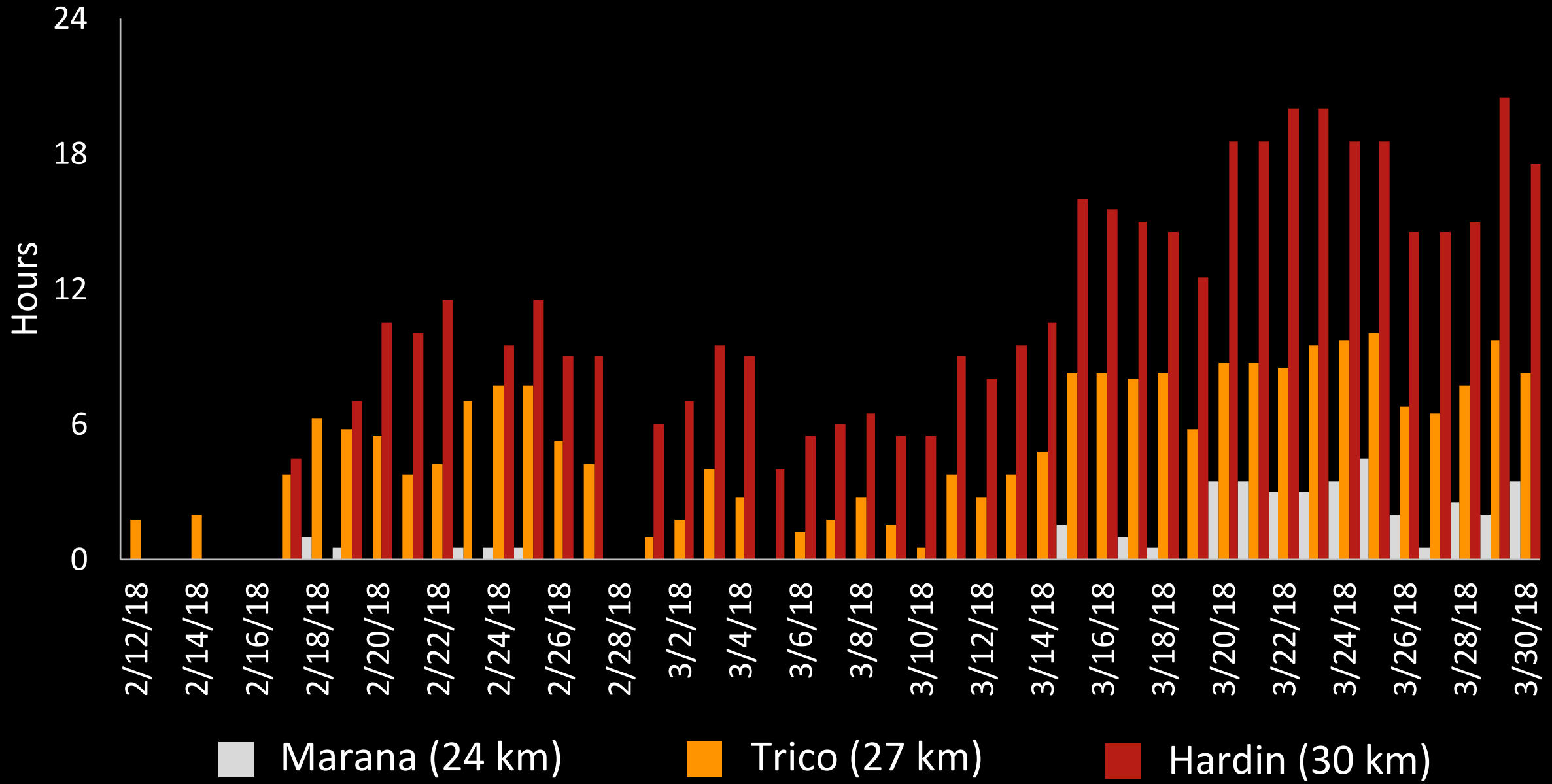


USGS Stream Gauges at Cortaro Road and Trico Road



USGS Stream Gauges at Cortaro Road and Trico Road

Spring 2018 Daily Drying




MOULTRIE
84°F
Marana
09 JUL 2017 05:49 am


MOULTRIE
95°F
Marana
08 JUL 2017 07:19 pm

Photo Credit: Kelsey Hollien

Photo Credit: Michael Bogan

Artificial Flow Regime

Quantification of a single drying event, Spring 2019: 7.5km

Artificial Flow Regime

Quantification of a single drying event, Spring 2019: 7.5km

Mosquitofish- 0

Artificial Flow Regime

Quantification of a single drying event, Spring 2019: 7.5km

Mosquitofish- 0
Common Carp- 1

Photo Credit: Hamdhani

Artificial Flow Regime

Low number of mortalities

- Declining fish densities in general

Ecological impacts of effluent discharge patterns (Halaburka et al. 2013)

CECs Changing Sex Morphology?

CECs and Sexual Morphology

Hormone dependent sexual dimorphism

Male

Female

Photo Credit: Joel Sartore

CECs and Sexual Morphology

Hormone dependent sexual dimorphism

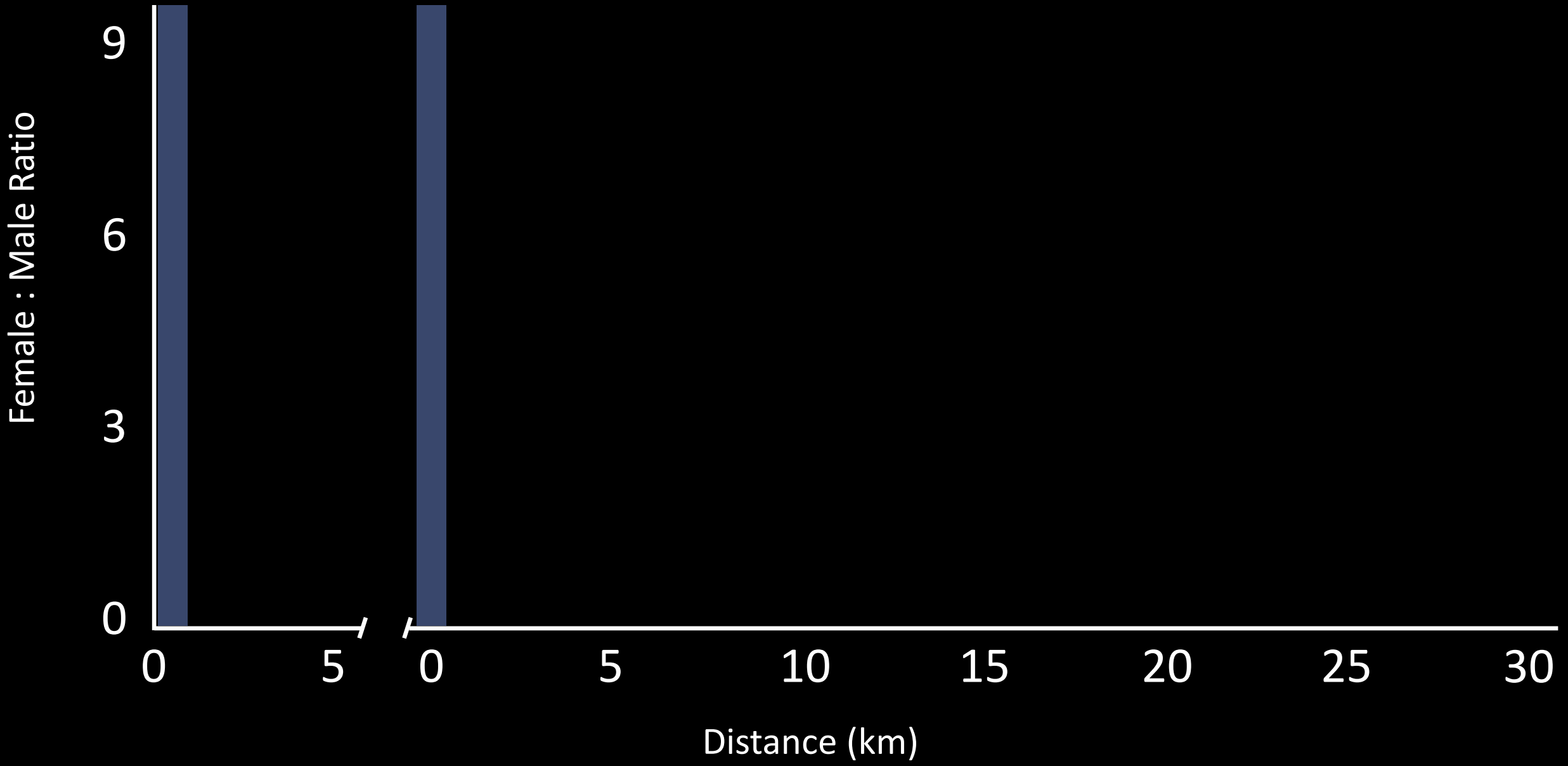
Gonopodium

Male

Female

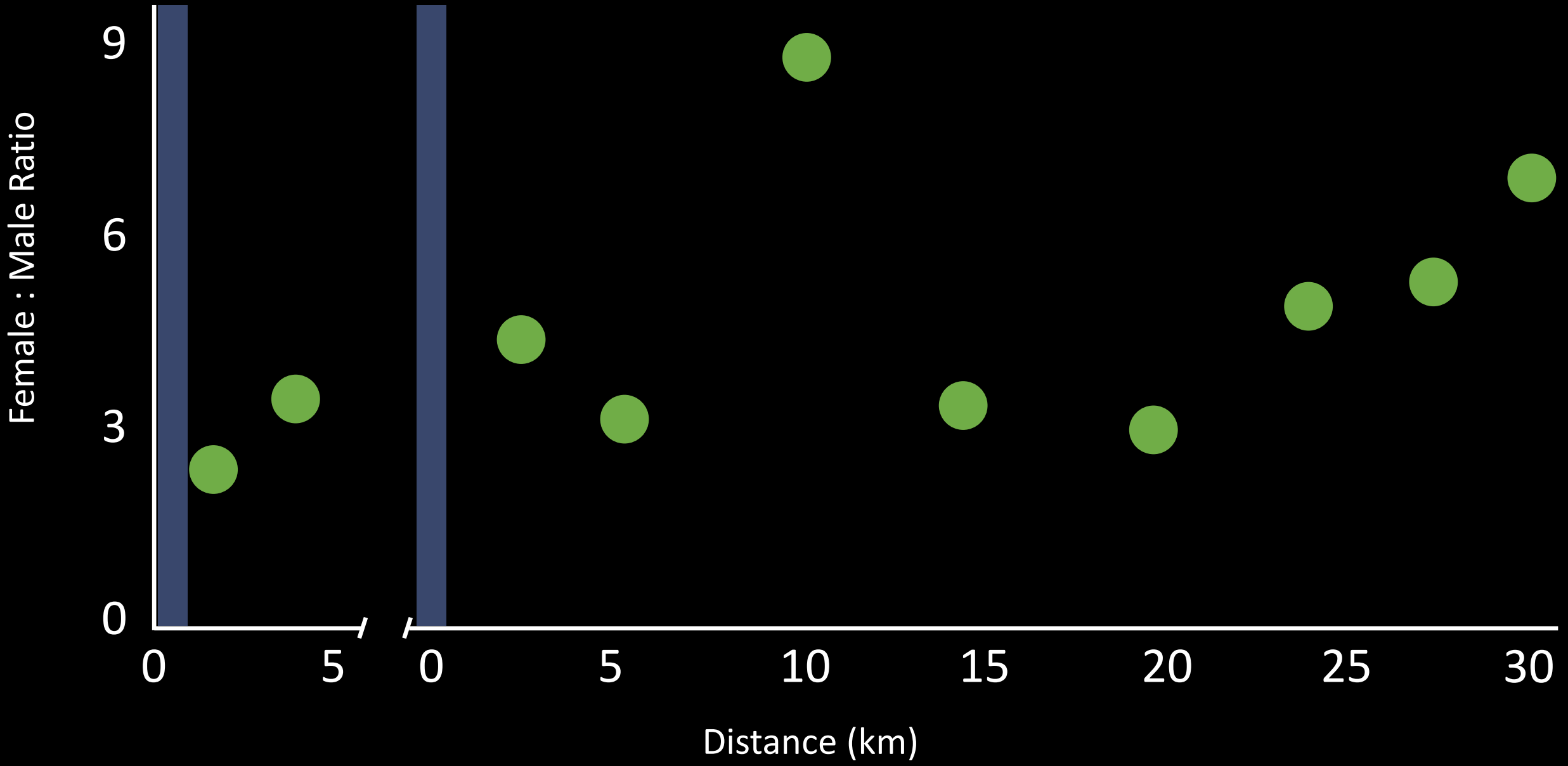
Photo Credit: Joel Sartore

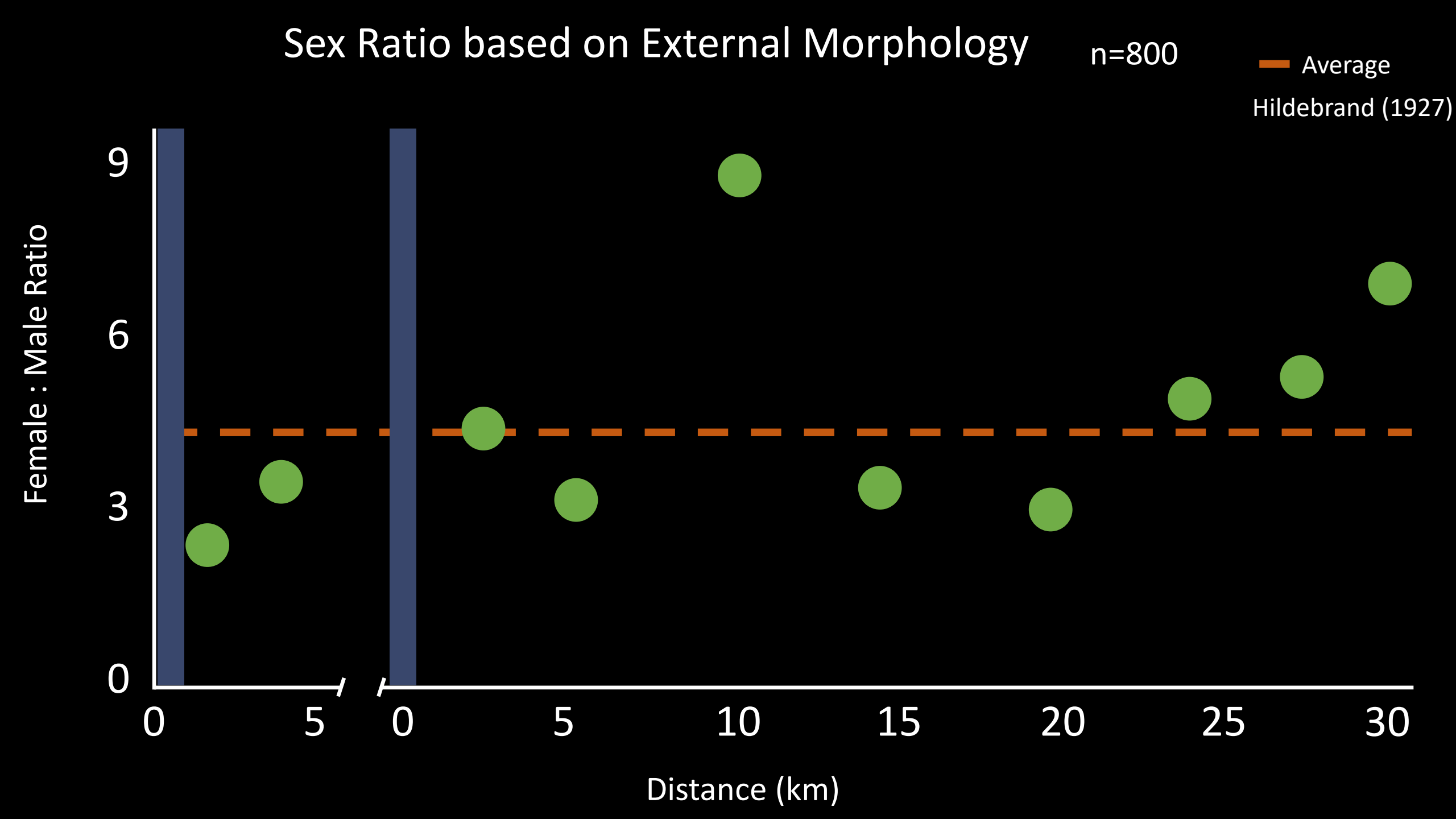
Sex Ratio based on External Morphology



Sex Ratio based on External Morphology

n=800




Sex Ratio based on External Morphology
n=800
Average
Hildebrand (1927)
Female : Male Ratio
9
6
3
0
0
5
0
5
10
15
20
25
30
Distance (km)

CECs and Sexual Morphology

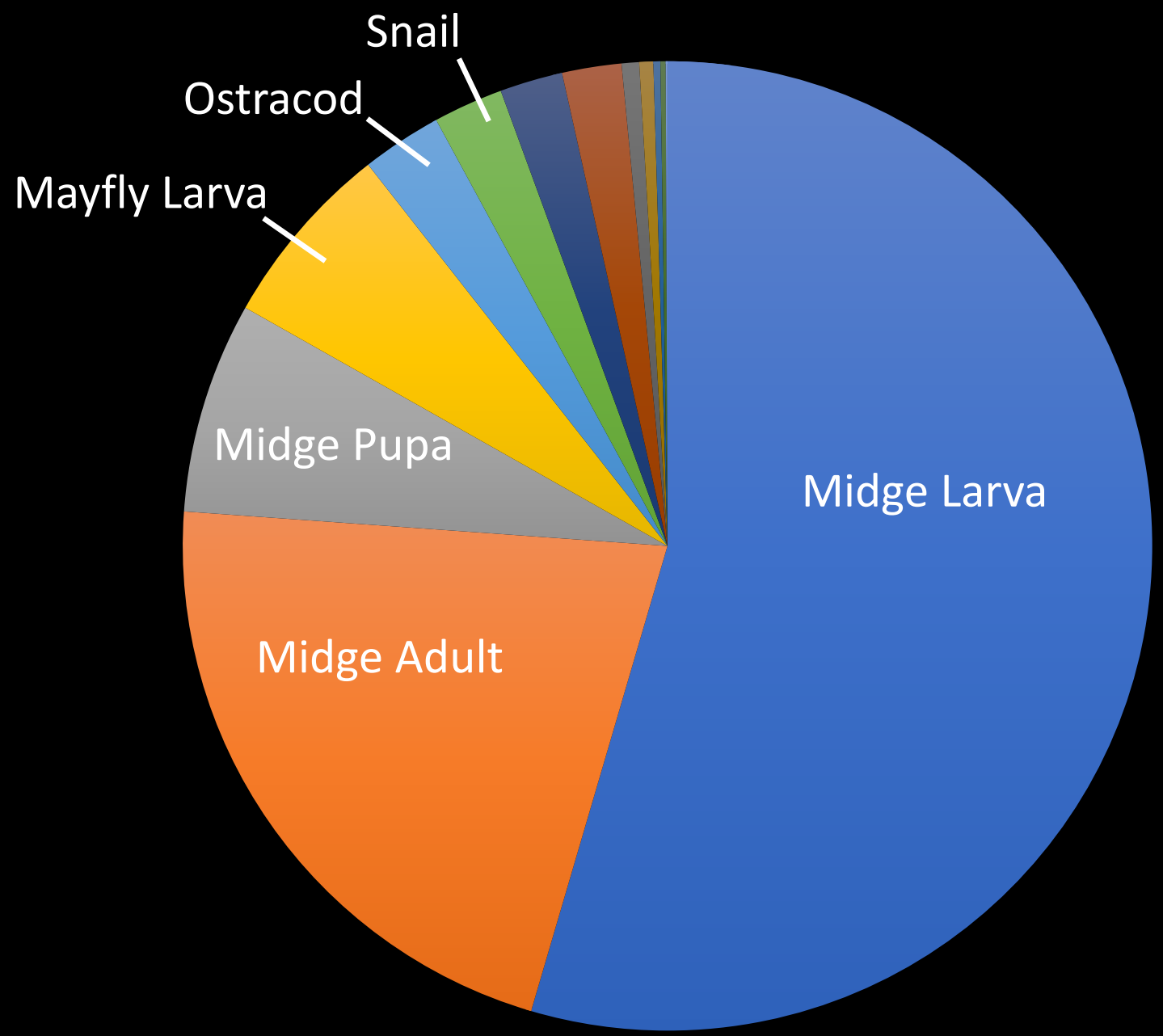
No evidence of unusual sex ratios

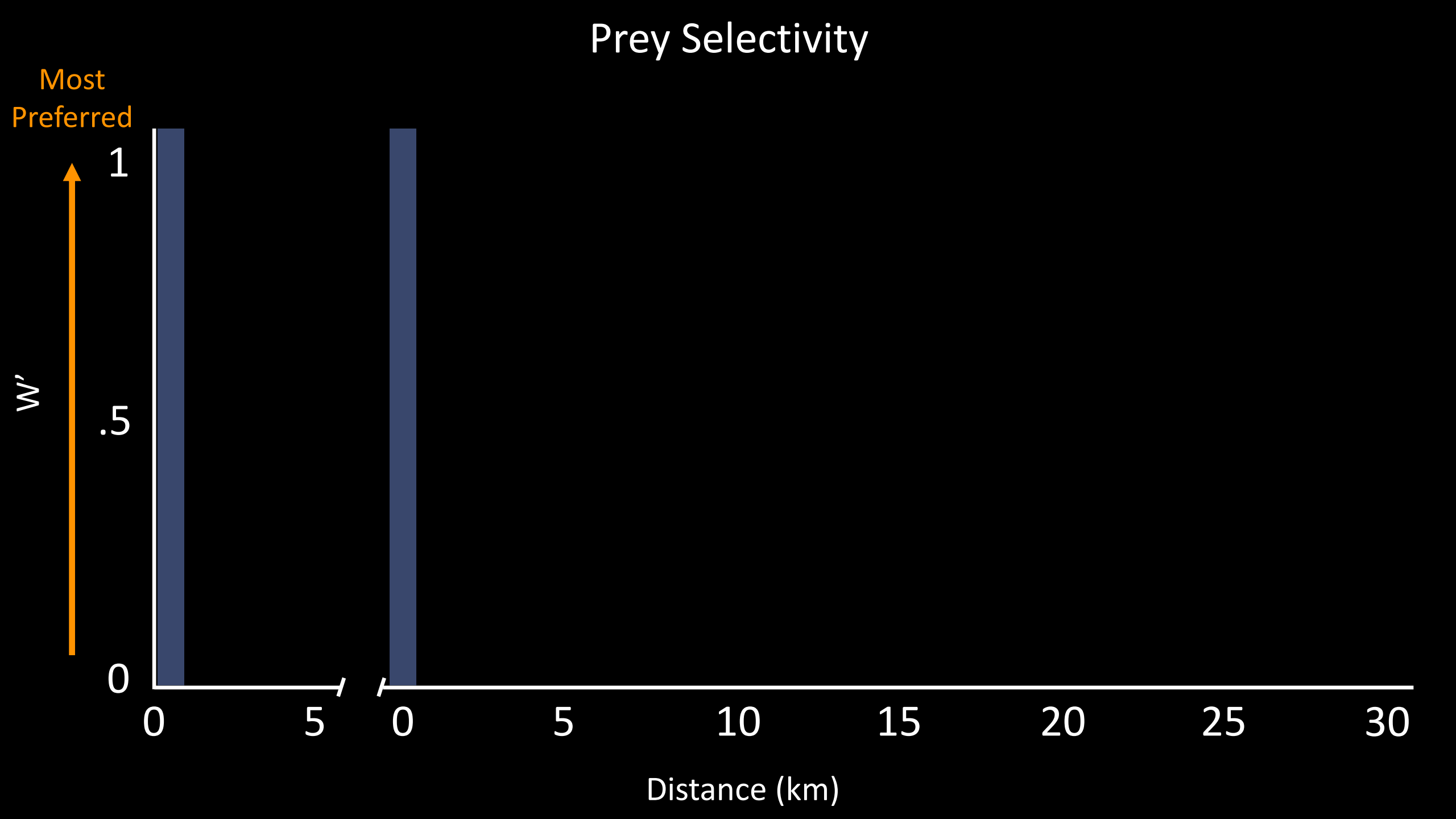
No longitudinal trends in relation to WRF proximity

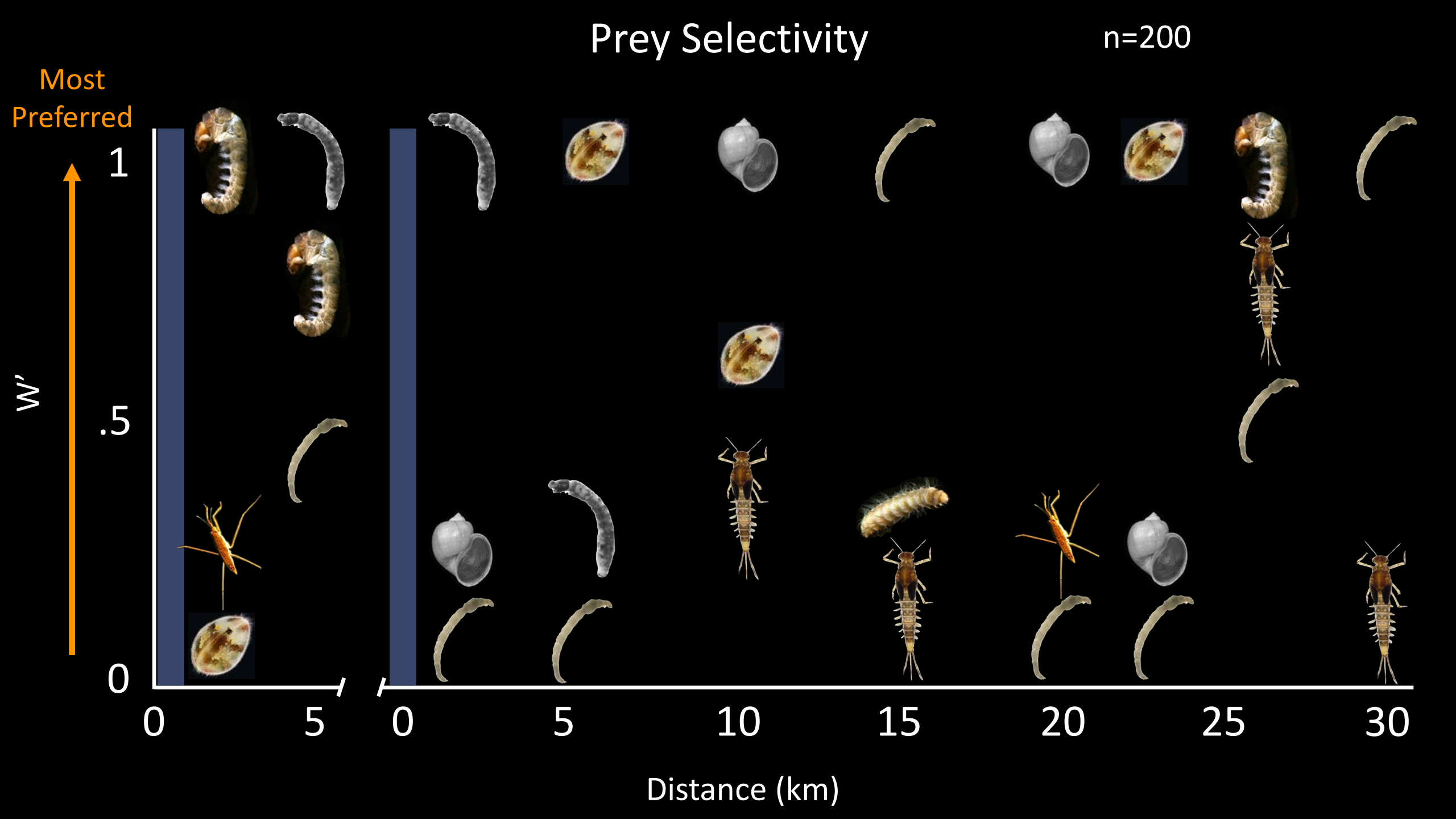
Altered Diets?

Diet Composition

n=200




Prey Selectivity
Most Preferred
1
.5
0
w'
0
5
0
5
10
15
20
25
30
Distance (km)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Most Preferred
W'
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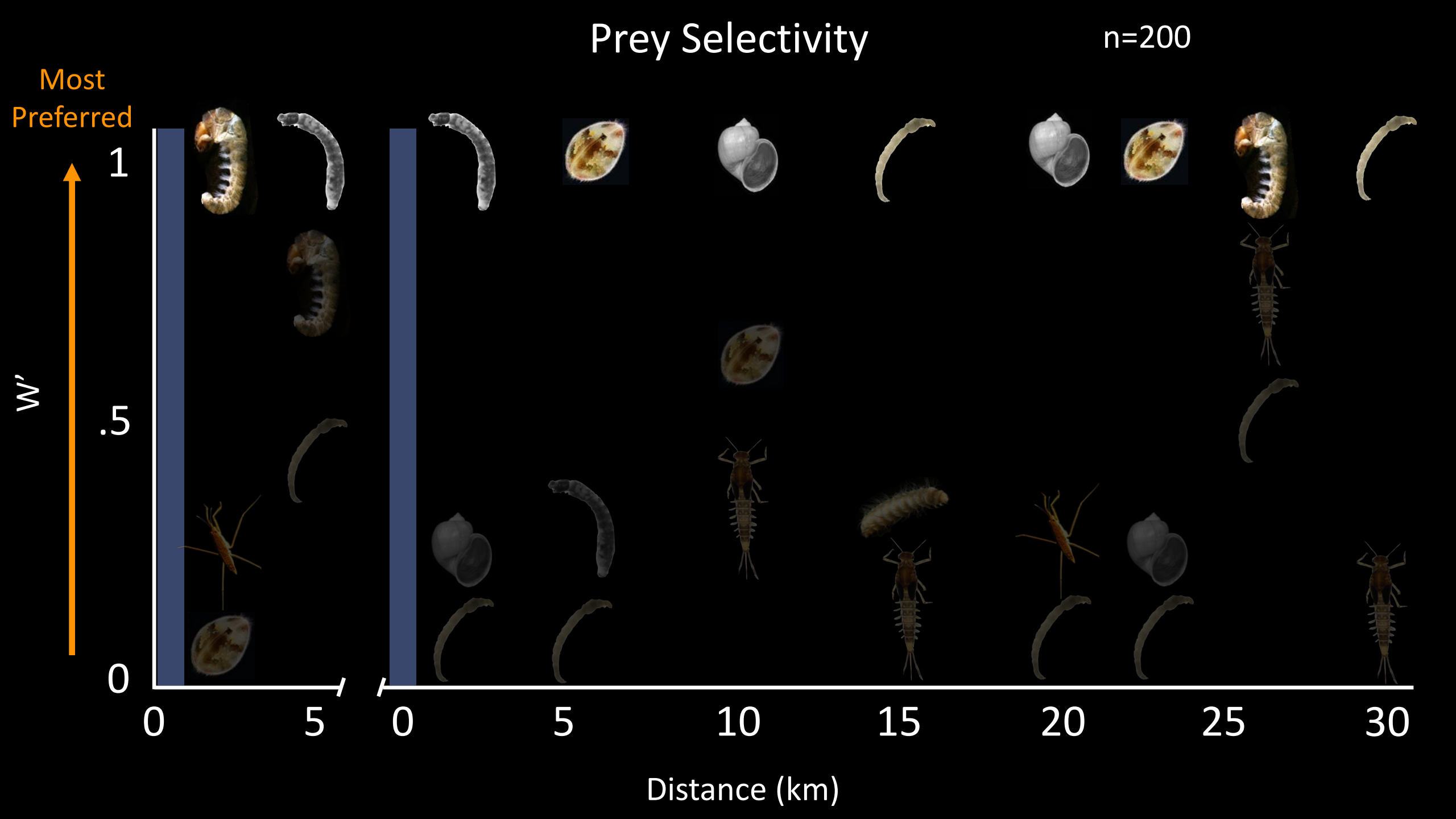
.5
0
0
5
0
5
10
15
20
25
30
Distance (km)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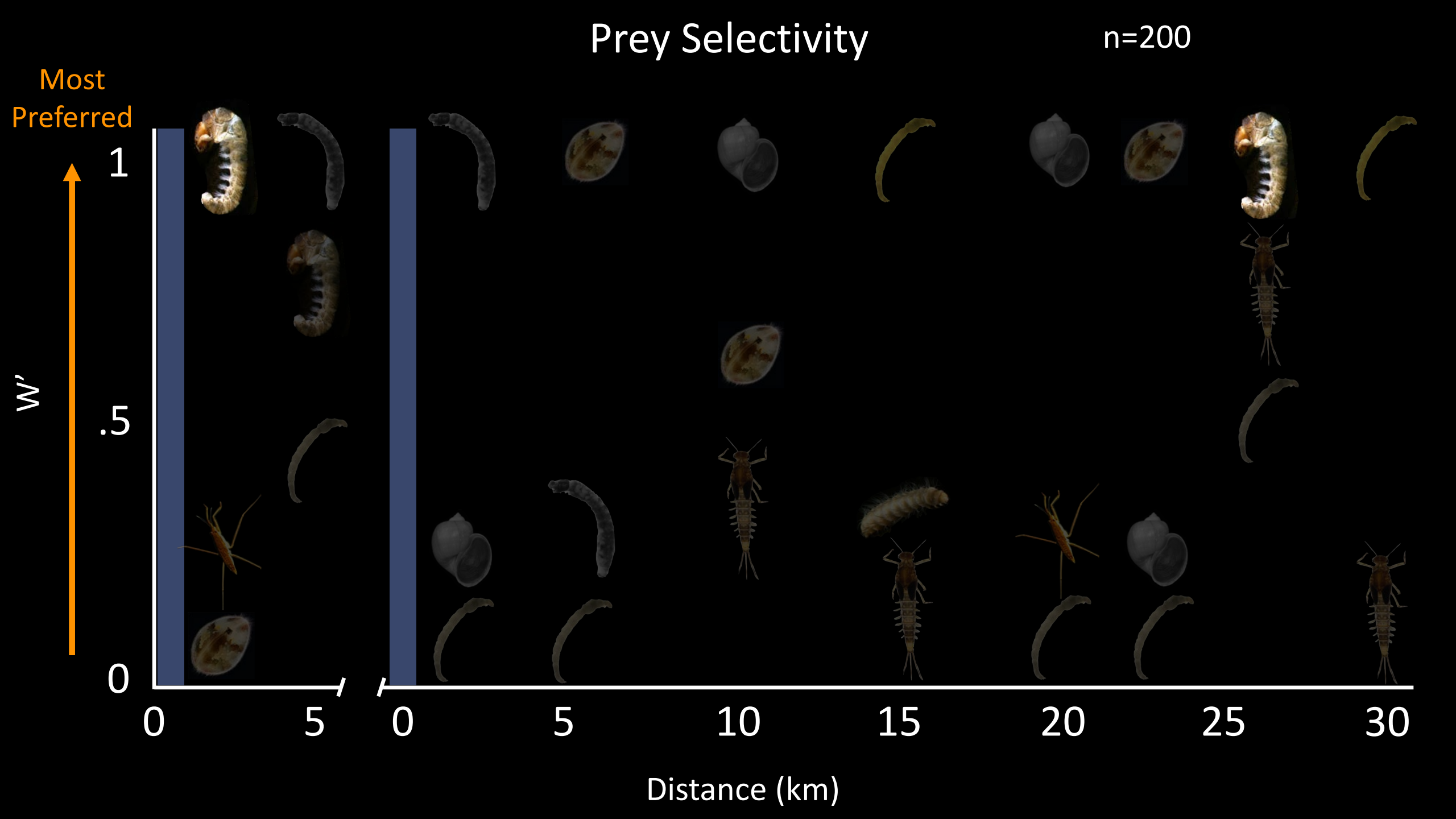
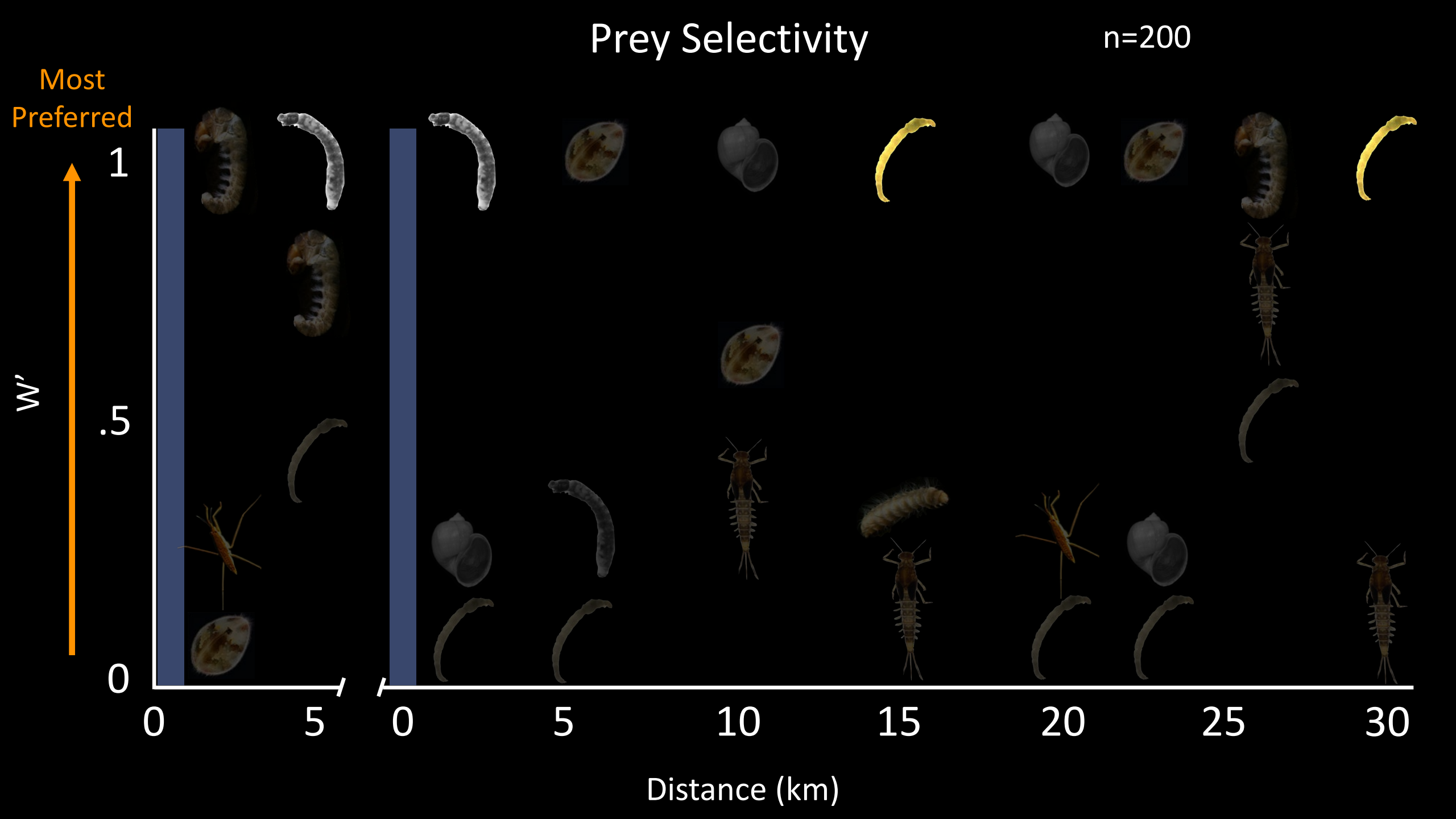
W'
1
.5
0
0
5
0
5
10
15
20
25
30
Distance (km)


Prey Selectivity
n=200
Most Preferred
W'
1
.5
0
0
5
0
5
10
15
20
25
30
Distance (km)


Prey Selectivity
n=200
Most Preferred
W'
1
.5
0
0
5
0
5
10
15
20
25
30
Distance (km)

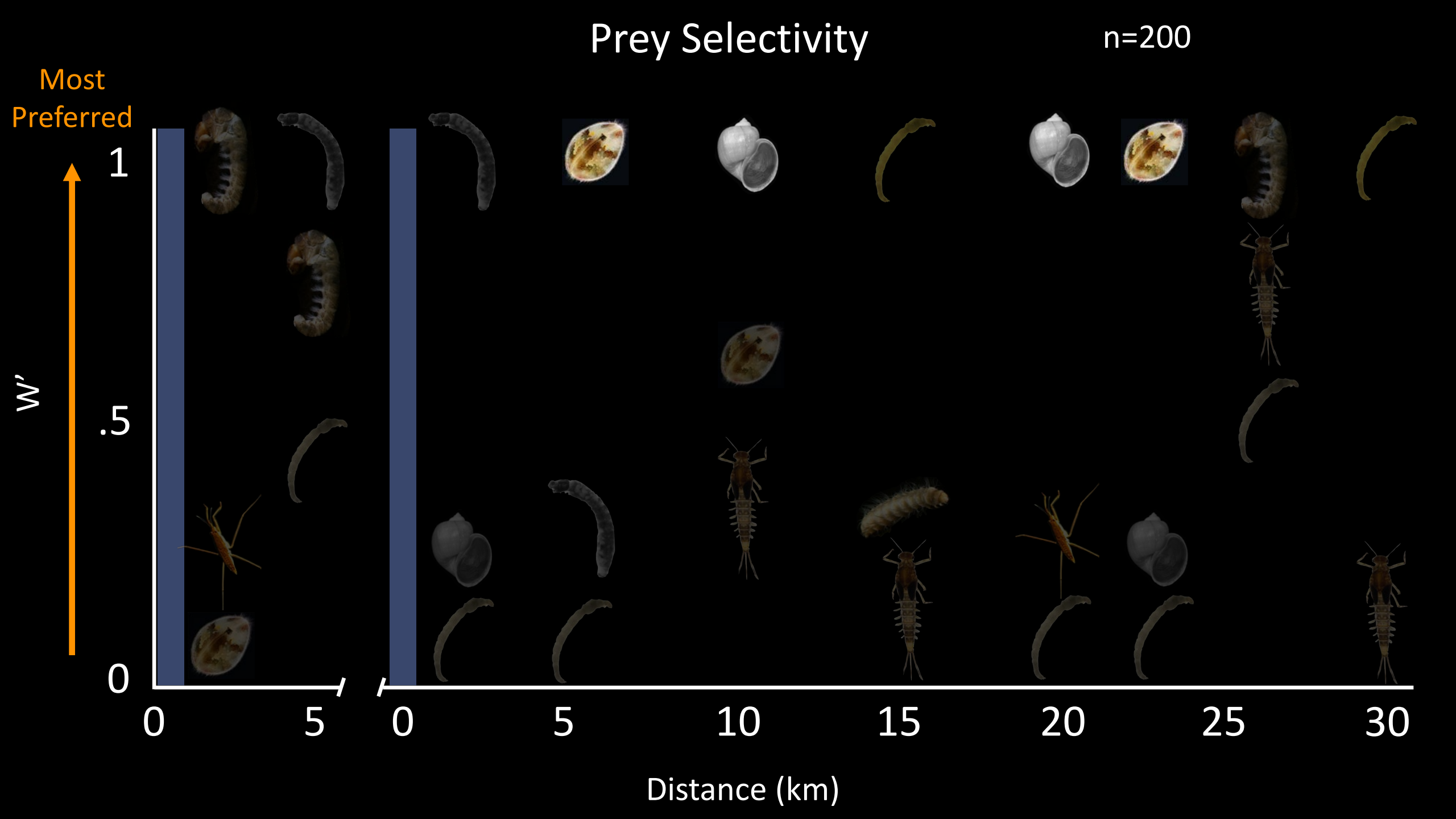

Prey Selectivity
n=200
Most Preferred
W'
1
.5
0
0
5
0
5
10
15
20
25
30
Distance (km)



Photo Credit: Kelsey Hollien

Photo Credit: Kelsey Hollien

Microplastics

Photo Credit: Michael Bogan

Microplastics

Where do they come from?

-WRFs
-Runoff

Photo Credit: Michael Bogan

Microplastics

Found as far as 30 km downstream from outfall

Photo Credit: Michael Bogan

Microplastics

Found as far as 30 km downstream from outfall

0.21 fragments/m^3
5.56 beads/m^3
12,000 fibers/m^3

Photo Credit: Michael Bogan

Microplastics

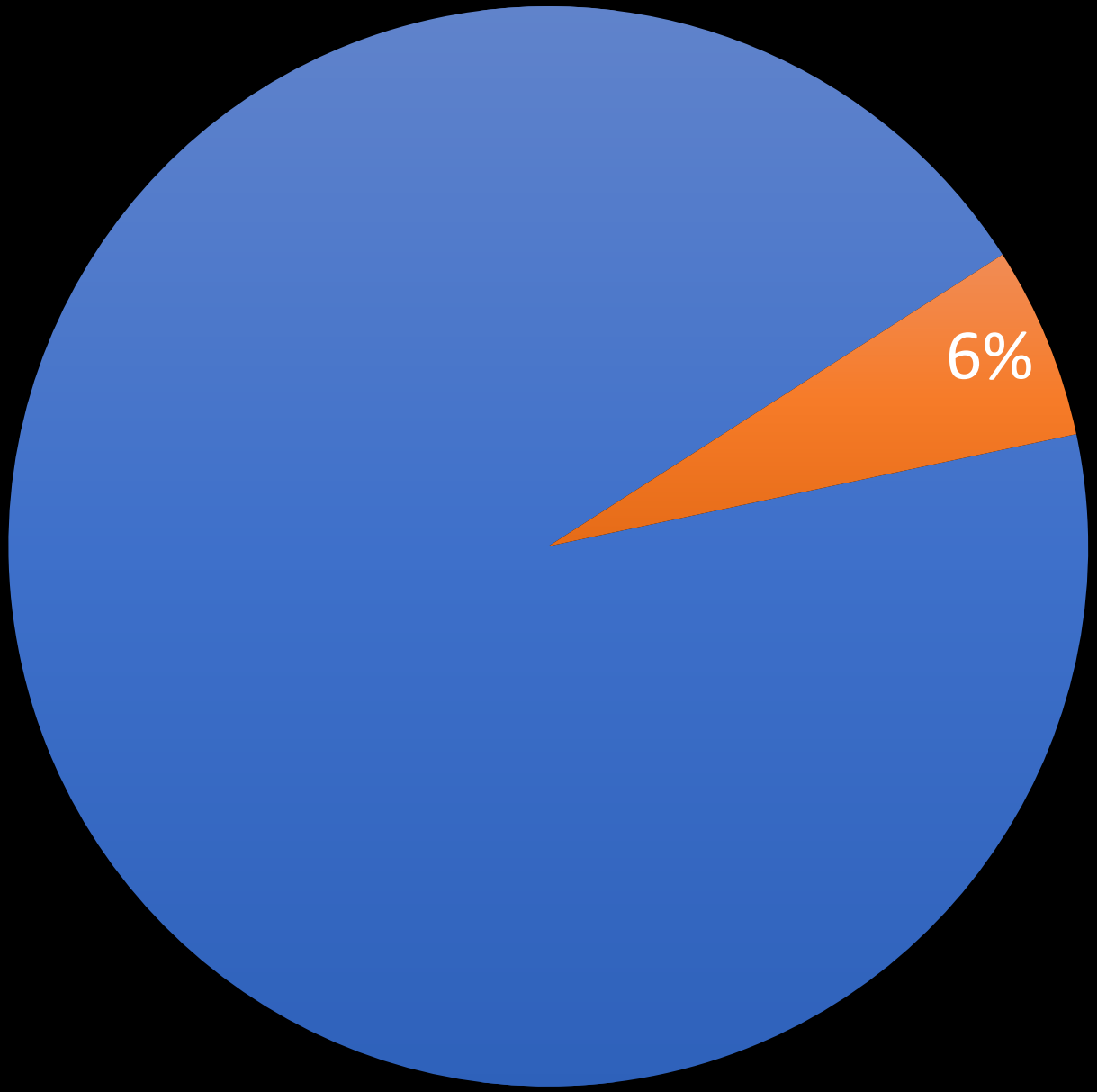
Found as far as 30 km downstream from outfall

0.21 fragments/m^3
5.56 beads/m^3
12,000 fibers/m^3

4 - 160,000 fibers/m^3
(Gasperi et al 2015; Talvitie et al 2015)

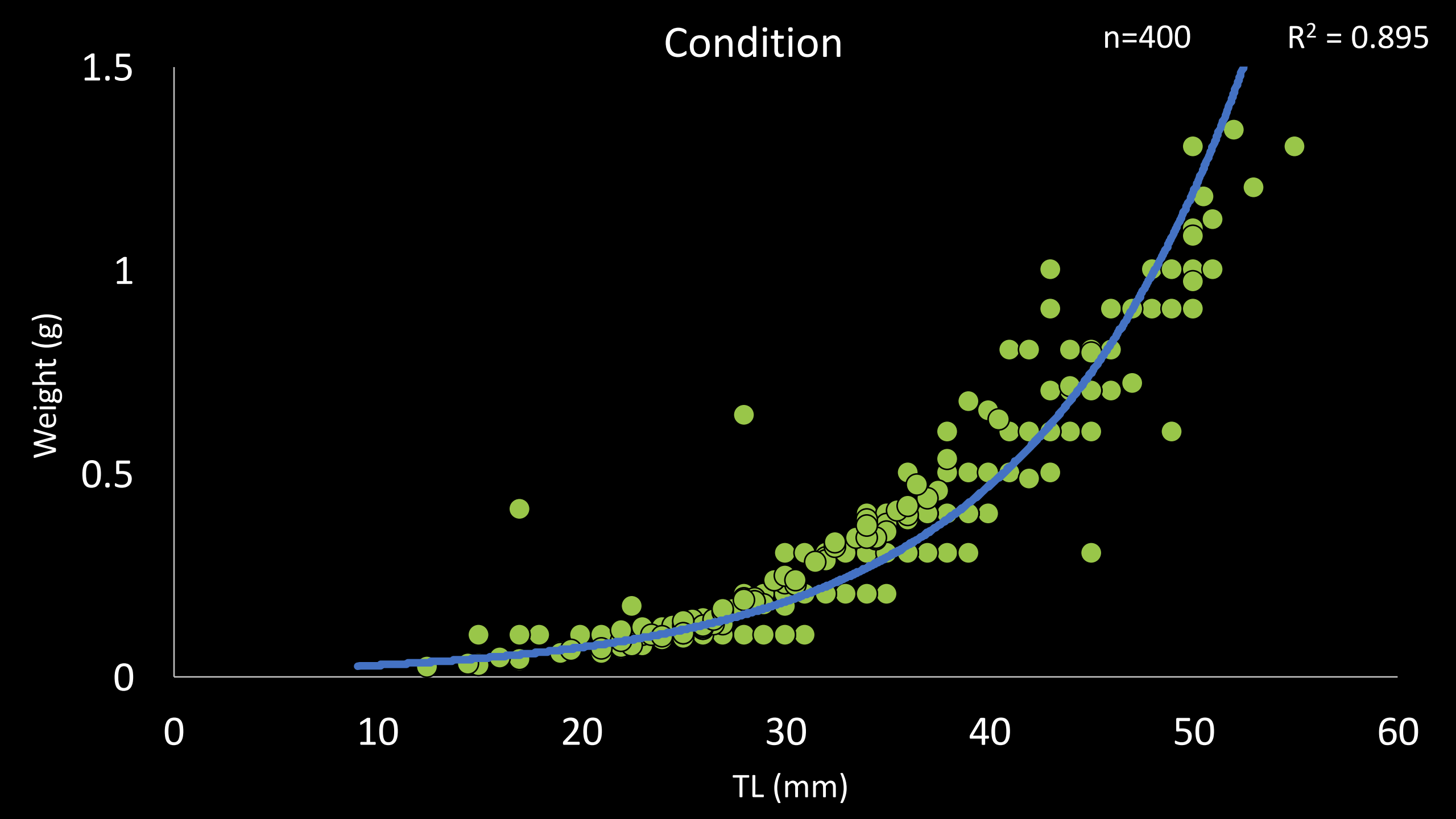
Photo Credit: Michael Bogan

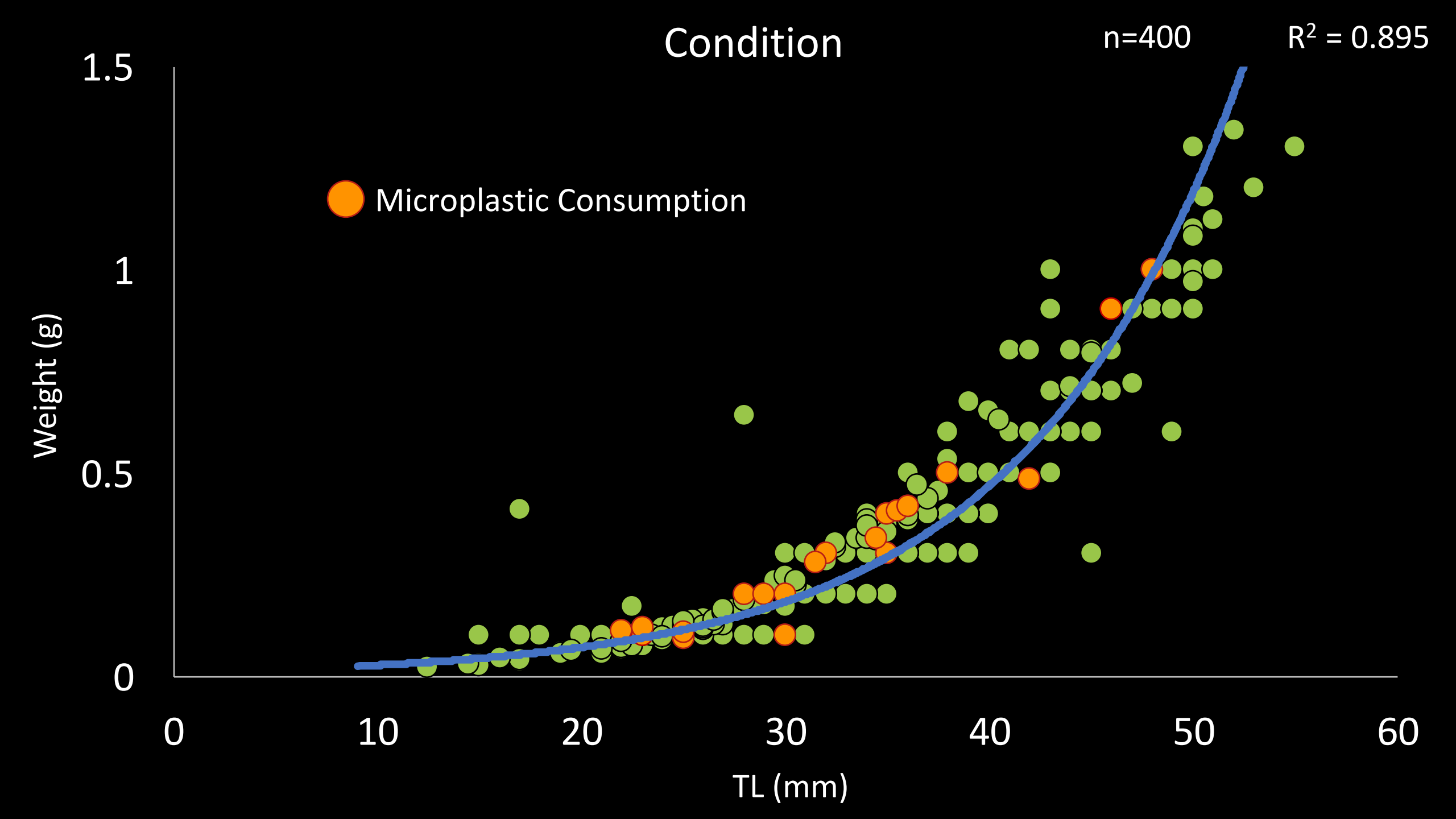
Microplastic Consumption



n=400

Photo Credit: Joel Sartore


Condition
n=400
R² = 0.895
1.5
1
0.5
0
Weight (g)
0
10
20
30
40
50
60
TL (mm)


Condition
n=400
R^2 = 0.895
Microplastic Consumption
Weight (g)
1.5
1
0.5
0
0
10
20
30
40
50
60
TL (mm)

Altered Diets: Microplastics

Microplastic consumption rates were lower than anticipated

Based on fish condition, no apparent health impacts

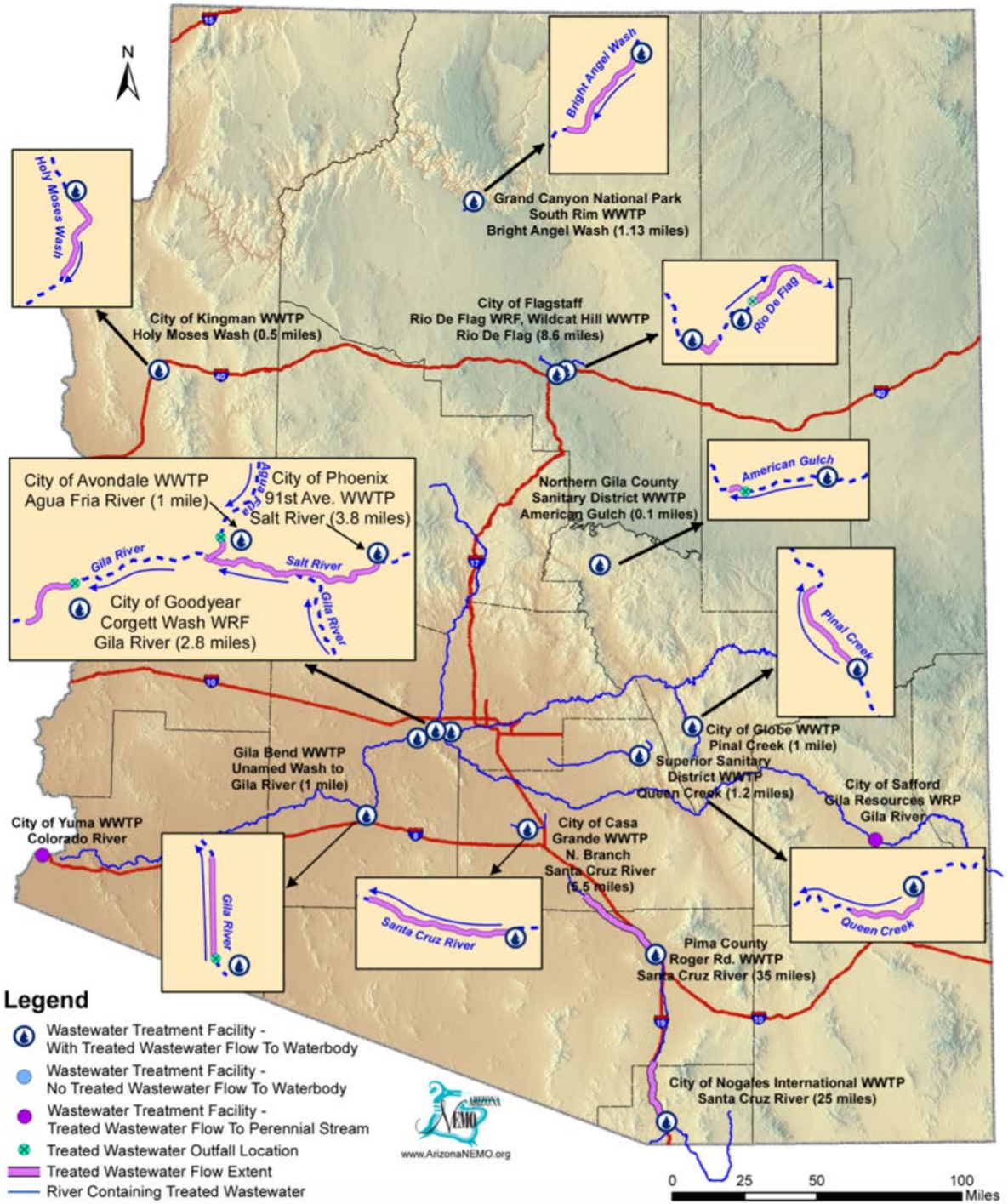
Conclusions

Conclusions

Living in treated wastewater does present challenges to fish

Some negative impacts were not as prominent as initially expected

Effluent systems should not be overlooked as refuge habitat for desert fishes



Uhlman et al. (2012)

The Santa Cruz River is one of many effluent dominated systems in AZ.

~100 miles of effluent dominated flow in AZ

Uhlman et al. (2012)

Next Steps

- Increase sub sample size

- Continue processing microplastic samples
  - -Spatial and temporal dynamics
  - -Sediment deposition rates

Photo Credit: Margarethe Brummermann

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1913

1981

Webb and Leake (2007)

Prey Selectivity

$$W' = (r_i/p_i)/(r_i/p_i)_{preferred}$$

(Vanderploeg and Scavia 1979; Pothoven and Vanderploeg 2004)