Meeting Summary
HAT 3 Meeting
March 31, 2021
9:00 am to 11:30 am
Conference Call

Participants:
Leslie Allen – Balch and Bingham
Angie Anderegg – Alabama Power Company (Alabama Power)
Dave Anderson – Alabama Power
Jeff Baker – Alabama Power
Jason Carlee – Alabama Power
Keith Chandler – Alabama Power
Evan Collins – United States Fish and Wildlife Service (USFWS)
Allan Creamer – Federal Energy Regulatory Commission (FERC)
Jim Crew – Alabama Power
Dennis Devries – Auburn University
Colin Dinken – Kleinschmidt Associates (Kleinschmidt)
Amanda Fleming – Alabama Power
Todd Fobian – Alabama Department of Conservation and Natural Resources (ADCNR)
Chris Goodman – Alabama Power
Jim Hancock – Balch and Bingham
Martha Hunter – Alabama Rivers Alliance (ARA)
Elijah Lamb – Auburn University
Donna Matthews – Downstream Property Owner
Lydia Mayo – Environmental Protection Agency (EPA)
Tina Mills – Alabama Power
Jason Moak – Kleinschmidt
Erin Padgett –USFWS
Sarah Salazar – FERC
Kelly Schaeffer – Kleinschmidt
Ehlana Stell – Auburn University
Jimmy Traylor – Downstream Property Owner
Sandra Wash – Kleinschmidt
Jack West – ARA
Rusty Wright – Auburn University

Meeting Summary:
Angie Anderegg (Alabama Power) opened the meeting and reviewed phone etiquette and explained that the purpose of the meeting was to review results of Auburn University's study, which will be filed as an appendix to Final Aquatic Resources Study Report on April 12, 2021.

Jason Moak (Kleinschmidt Associates) reviewed the background and purpose of the Aquatic Resources Study. Jason described the components of the study, which include the desktop assessment, the temperature assessment of the Tallapoosa River conducted by Kleinschmidt and Alabama Power, and Auburn University's study.

Dr. Dennis Devries (Auburn University) reviewed the four target species and discussed the results of the literature review of temperature preferences and thresholds.

Ehlana Stell (Auburn University) reviewed the temperature analysis of downstream sites and at Heflin. Sarah Salazar (Federal Energy Regulatory Commission (FERC)) asked if a connection would be made between the temperature tolerances of the target species and the temperature regime of the river. Ehlana said that both variables were used to conduct growth simulations using a bioenergetics model. Jimmy Traylor (Downstream Property Owner) asked if it is correct that a 6 °C change is equivalent to a 42 °F change. Ehlana said that a temperature of 6 °C converts to 42 °F, but an increase or decrease in temperature of 6 °C in magnitude is about 11 °F. Dr. Rusty Wright (Auburn University) noted that the effect of temperature fluctuations on fish varies depending on whether the fluctuation is an increase or a decrease. Temperature fluctuations downstream of Harris Dam are greatest in the summer when water released from Harris Dam is cooler than ambient temperatures. Fish are typically more tolerant of sudden temperature decreases compared to sudden increases. Donna Matthews (Downstream Property Owner) asked if it was correct that 6 °C fluctuations never happened at the Heflin site. Ehlana stated that those fluctuations are very rare and noted that the Heflin site is more turbid and more insulated to changes in temperature. Donna asked if all this information was in the report, and Dr. Devries confirmed. Allan Creamer (FERC) stated that his understanding was that the Green Plan consisted of generation releases with pulse releases in between. Angie confirmed, stating that under the Green Plan, peaking occurs during peak generation demand and short pulses occur in between generation releases. Jimmy Traylor asked, regarding target species, which categories or families the Flathead Catfish (*Pylodictis olivaris*), Bowfin (*Amia calva*), carps, and suckers fall into. Dr. Wright stated that there are other kinds of catfish in the river, such as bullhead species, but Channel Catfish (*Ictalurus punctatus*) were chosen as a target species because they are very common. Flathead Catfish are in the family Icatluridae along with other species of catfish; Bowfin are the only living species in the family Amiidae; carps belong in the family Cyprinidae along with minnows; and suckers belong in the family Catostomidae. Elijah Lamb noted that Flathead Catfish seemed common in the river.

Elijah Lamb (Auburn University) reviewed the fish community assessment. Jimmy stated that there were more crayfish in the river before construction of Harris Dam and asked about the variation in crayfish quantity. Dr. Devries said the diet data indicated that fish were eating them and they are therefore available, but pre-dam conditions cannot be used for quantity or density comparison because the data do not exist. Dr. Wright said the two species of black bass (Alabama Bass (*Micropterus henshalli*) and Tallapoosa Bass (*Micropterus tallapoosae*)) often consume crayfish if they are available. Jimmy stated he spent a lot of summers wading in No Business Creek, Cornhouse Creek, and others and said the difference in the ecosystem once you move away from the backflow of the river is noticeable and likely characteristic of what the river looked like before the dam. Dr. Wright said there were limitations on the number of areas they could sample, but creeks are not typically good control sites for mainstem rivers. They are definitely less influenced by the dam but not necessarily less influenced by other factors such as upstream watershed conditions. Sarah asked if Auburn University was able to distinguish between insect orders within the diet data (e.g., Diptera, Ephemeroptera, Plecoptera, and

Tricoptera). Elijah stated they have those data but reported all insects as one diet item in the report to reduce complexity of the figures and that those data could be used in the future for publications; however, order data was used for inputs in the bioenergetics model. Donna stated that maintaining the granularity of those data could be important for future work. Elijah stated that the more detailed diet data is archived at Auburn University. Donna asked what accounts for variation in sample size by location, noting that Auburn had very little control over sample size of fish and that fish movement over large distances of river was seemingly insignificant. She stated that one would assume that in a 40-mile stretch of river that the species would be fairly evenly distributed. Donna asked if there was a statistical procedure that spread the data out over the river so that inferences could be made about the entire system. Elijah stated that catch rates are usually used as indicators of abundance. Lower catch rates of a species indicate lower abundance of that species. Almost half of the species captured were found at all four study sites. Dr. Wright noted that no sampling gear is without bias. The equipment is going to be more efficient in some habitats over others, but sampling is standardized as much as possible to reduce that bias. Dr. Devries noted it would not be accurate to apply data from one site to the entire system as habitat availability could vary by site and river stretch. Jason Moak (Kleinschmidt Associates) asked what the strangest diet item found was, and Elijah stated maybe a seven or eight inch snake. Jimmy asked what the major difference was between Auburn University's study and Elise Irwin's (United States Geological Survey) previous studies. Elijah said Elise's studies used pre-positioned electrofishing grids that sampled shallow water areas roughly the size of a tabletop. The Auburn University study used boat and barge electrofishing to cover various habitats over a greater area. The Auburn University study also included the bioenergetics component.

Ehlana reviewed the respirometry trials and stated that Auburn University wanted to test the more extreme fluctuations seen downstream of Harris Dam, so 5 °C decreases in temperature were used to simulate releases. Evan Collins (United States Fish and Wildlife Service (USFWS)) asked if it was reasonable to conclude that physical refuge and habitat could possibly be more of a limiting factor or be a more important consideration than temperature and water velocity alone. Dr. Wright said that the species of this study could not maintain position in the water column during generation in areas near the dam. Having refuges where fish can get out of high flow events is important, but it would be important to know where fish go on a fine-scale tracking approach (e.g., behind a rock, tree). That information would be needed before refuge availability could be determined. It is evident that fish are not being completely washed downstream because Auburn University found them in the tailrace. Dr. Devries summarized that temperature and velocity are as important as refuge, and while it is not evident where fish are going during high flow events, they appear to be taking refuge. Sarah asked if these studies cover the full range of temperature and dissolved oxygen (DO) seen downstream of Harris Dam based on varying positions of the weir. Ehlana stated that DO was not measured as an independent variable. Angie stated that the skimmer weir has been in the topmost position for years, so it is always releasing from as high as possible in the water column. Ehlana stated that a specific temperature (5 °C) needed to be chosen for trials because the entire range seen downstream of Harris Dam could not be covered in the study. The number of temperatures that could be tested was limited by the sample size and the amount of time available to conduct the study. Jason M. stated that based on what Auburn did test, some inferences could possibly be made about the temperatures in between. Dr. Wright said the effect of temperature on growth is not linear, so the ability to make those inferences is somewhat limited. He also stated that the effects of a temperature decrease on fish are typically not as negative or harmful as the effects of a temperature increase and that acclimation plays a large role in the temperature tolerances of fish.

Dr. Wright reviewed the bioenergetics modeling and growth simulations and stated that a Bluegill model was used to simulate growth rates of Redbreast Sunfish (*Lepomis auritis*). Jimmy asked how the fish per square mile or acre would vary. Dr. Wright said that they calculated catch-per-effort (CPE). Calculating fish per area is difficult and very intensive, but CPE could possibly be correlated to abundance. Jimmy stated he has fished the river from Harris Dam to below Horseshoe Bend, and that Auburn's data is good, but it does not include the habitat or availability of fish in these areas. Jimmy said the number of species encountered from Harris Dam to Malone is a lot less than around Horseshoe Bend. The water flow is less volatile around Horseshoe Bend, and snakes, bugs, and crayfish are more abundant, there is less bank erosion, and the environment in general is better. Jimmy said the fishing is bad near Malone, that things start to improve further downstream of Harris Dam, and that Auburn University's study is missing a habitat component. Ehlana stated that a habitat analysis was not a component of this study, and Angie stated that there is a robust downstream habitat study that will be released April 12, 2021. Dr. Devries said CPE can provide a picture of fish abundance, but to determine fish per area is extremely intensive. In pond systems for example, ponds are usually drained. In river systems, rotenone can be applied to an area, but the movement of water and habitat variability limits efficacy. Jimmy said the issue is that he is trying to compare the river to the way it was in the 1970s but only getting pieces of the puzzle. Dr. Devries replied that those comparisons could be made if Auburn University had similar data from the 1970s, but those data just don't exist. The data from the Auburn University study and the experience of downstream landowners does not necessarily disagree or differ in value, but making direct comparisons is not possible. Donna asked if data and anecdotes of angler experience could be used to make comparisons to today. Dr. Wright said there have been many studies on the Tallapoosa River downstream of Harris Dam over the years but many of them have taken very different approaches, so direct comparisons between them may not be entirely accurate. Auburn University took an approach that would incorporate the open channel habitats more than previous studies, which mostly sampled shallow water habitat. Dr. Devries said that community data from the pre-positioned electrofishing grids in other studies were representative of shallow water habitats. Colin Dinken (Kleinschmidt Associates) noted that the desktop assessment, which is being revised for the Final *Aquatic Resources Study Report*, contains findings from previous studies on the Tallapoosa River downstream of Harris Dam and reference sites. Some of the fish community findings in the Auburn University study were compared to findings from studies in the desktop assessment, and Auburn University has discussed the limitations of comparing their results to previous studies. Kelly Schaeffer (Kleinschmidt Associates) added that Appendix E of the Final *Recreation Evaluation Study Report* includes information on fishing effort, catch, and harvest by anglers in the Tallapoosa River downstream of Harris Dam. Sarah asked if it was possible to compare the bioenergetics results to those of similar rivers. Ehlana said different rivers could possibly be compared if there are a lot of similarities between the two systems. Dr. Devries said that studies used in the literature review of temperature requirements of the target species came from many different systems and regions (e.g., from ponds versus rivers or northern versus southern regions). Comparisons cannot be reliably made between systems or regions. A bioenergetics model from the northern United States could not be used in the southern United States. Only growth rates can be reliably compared using von Bertalannfy growth curves. Having growth records below Harris Dam would have been very helpful. Allan stated that the outcomes of the inter-related studies being conducted for relicensing will need to be integrated to draw conclusions about different operating scenarios for Harris Dam. Allan noted the importance of understanding that only data and information from the record can be used for relicensing. If data does not exist for a certain time period, the best that can be done is to qualitatively describe what things may have been like at that time and try to draw some conclusions. Allan expressed concern about models that do not have good data going into them. He acknowledged that anecdotal information can contain inherent biases, and it is not necessarily information that should be used in a model. Angie stated that the pieces are starting to come together and that the purpose of the meeting today was only to present results of the Auburn University study.

Angie thanked everyone for attending the meeting and reiterated that the Auburn University report was sent to HAT 3 about a week prior to the HAT 3 meeting.

Using Bioenergetics to Address the Effects of Temperature and Flow on Fishes in the Harris Dam Tailrace

Dennis DeVries, Russell Wright, Ehlana Stell, Eli Lamb
School of Fisheries, Aquaculture and Aquatic Sciences
Auburn University
HAT 3 Fish and Wildlife

5 March 2021

Project Objectives

1. Summarize the data that are available in the literature concerning temperature requirements for target species, including spawning and hatching temperatures, lethal limits, and thermal optima

2. Summarize the data that are available in reports and from relevant agencies for water temperatures across a gradient downstream from the Harris Dam tailrace and compare those data with similar data from reference sites upstream of Harris Reservoir

Project Objectives

3. Quantify the fish community across a gradient downstream from the Harris Dam tailrace and in a reference site upstream of Harris Reservoir

4. Quantify effects of temperature and flow variation on target fish species energy budgets using bioenergetics modeling

Study Species

Channel Catfish

Ictalurus punctatus

- Benthic specialist
- Omnivore

Redbreast Sunfish

Lepomis auritus

- Lentic Specialist
- Invertivore

Alabama Bass

Micropterus henshalli

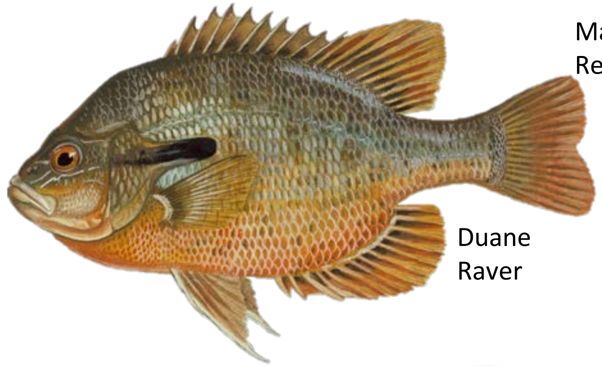
- Habitat generalist
- Omnivore

Tallapoosa Bass

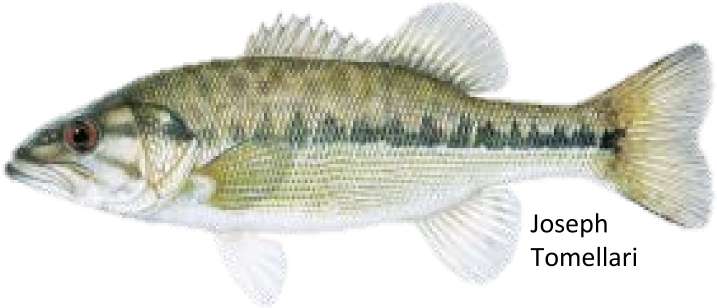
Micropterus tallapoosae

- Lotic Specialist
- Omnivore

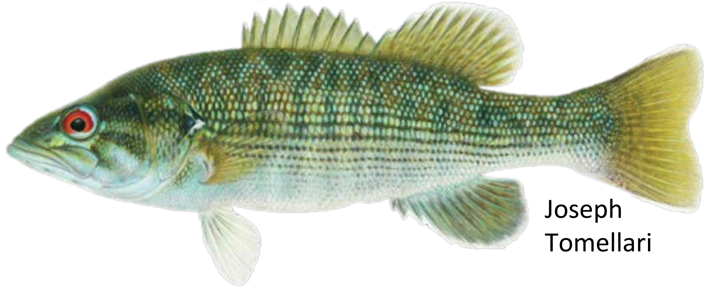
Maynard Reece



Duane Raver



Joseph Tomellari



Joseph Tomellari

Objective 1: Temperature Requirements

- researched via Web of Science and Google Scholar
- data pulled from more than 70 papers

Channel Catfish

- minima: 0.0-9.8 C
  - depending on acclimation, fluctuating vs. stable
- distribution: 10-32C
- optimal 24-30C
- preferred 18-31C with acclimation,
- preferred 25.2-30.5C w/out acclimation
- spawning: 20-30C
- maxima: 30.9-42.1C, depend on acclimation

Redbreast Sunfish

- minima: ??<15C??
- distribution: 4-22C
- optimal 25-30C
- preferred 18-32C with acclimation
- preferred 27-29C w/out acclimation
- spawning: 16.8-27.8C
- maxima: 33-41C

Alabama Bass/Spotted Bass

- minima: <10C
- preferred w/out acclimation: 22.5-32.5C
  - preferred w/acclimation to falling temps: 16.9-32.1C
  - preferred w/acclimation to rising temps: 24.8-31.4C
- distribution: ??
- spawning:
  - 13-20.6C for Alabama Bass
  - 13-23.3C for Spotted Bass
- maxima: 30.76-36C

Tallapoosa Bass/Redeye Bass/Shoal Bass

- minima: ??
- distribution: ??
- spawning:
  - 16.6-22.8C for Redeye Bass
  - 15-24C for Shoal Bass
- maxima: ??

Objective 1: Temperature Requirements

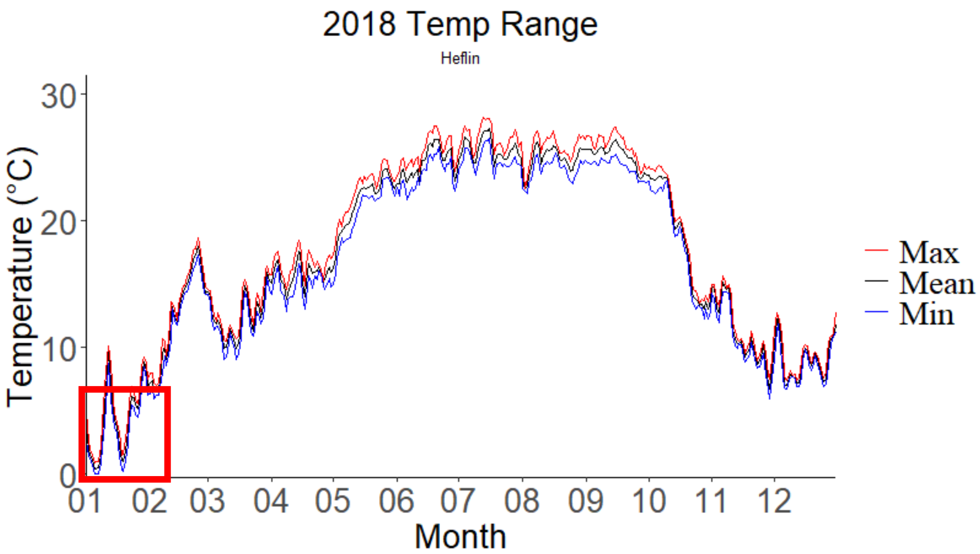
- substantial variation across studies
- acclimation is important (latitudinal variation?)
- diel variation is important
- variation in methods and approaches hampers conclusions

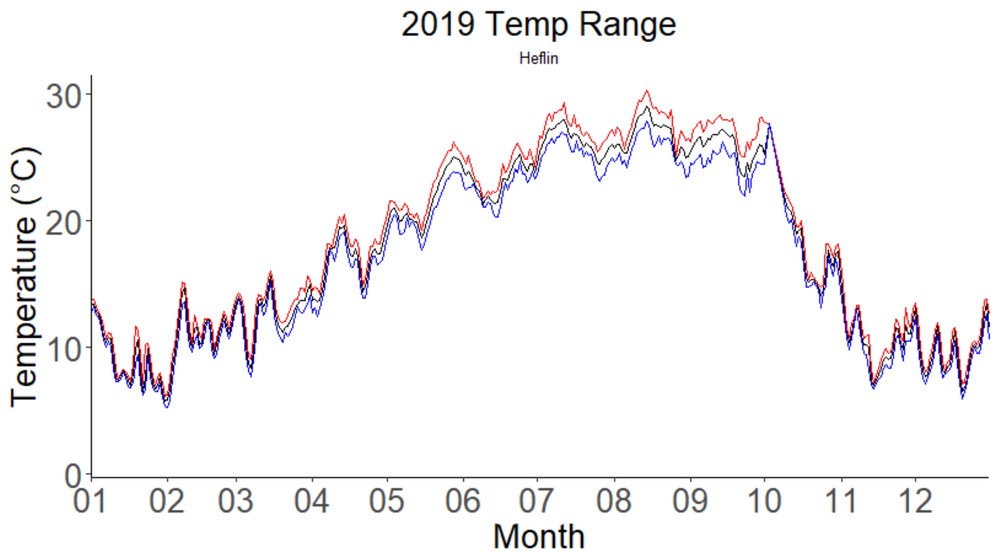
Objective 2: Summarize the data that are available in reports and from relevant agencies for water temperatures across a gradient downstream from the Harris Dam tailrace and compare those data with similar data from reference sites upstream of Harris Reservoir

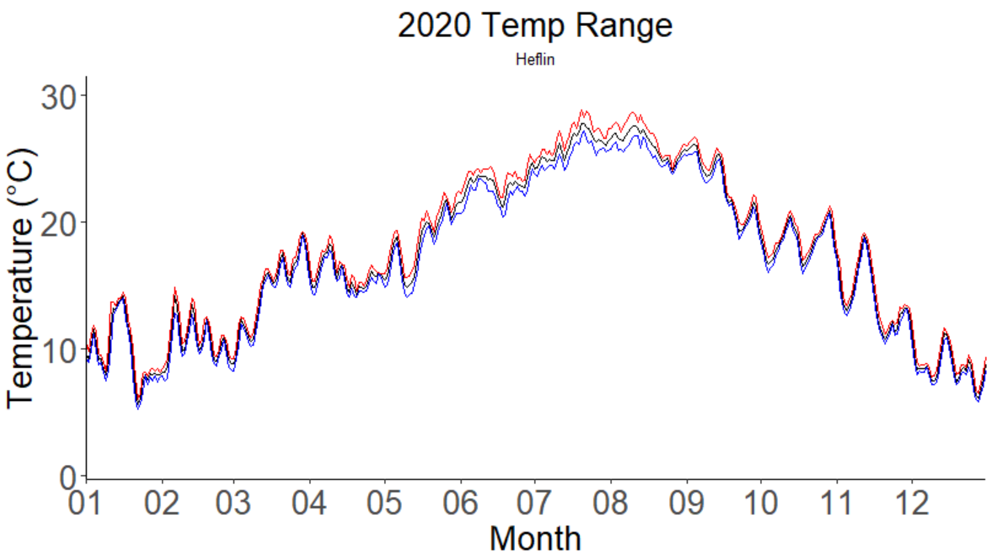
Tailrace, Malone, and Wadley temperature data (2000-2018) presented previously

Reminder:

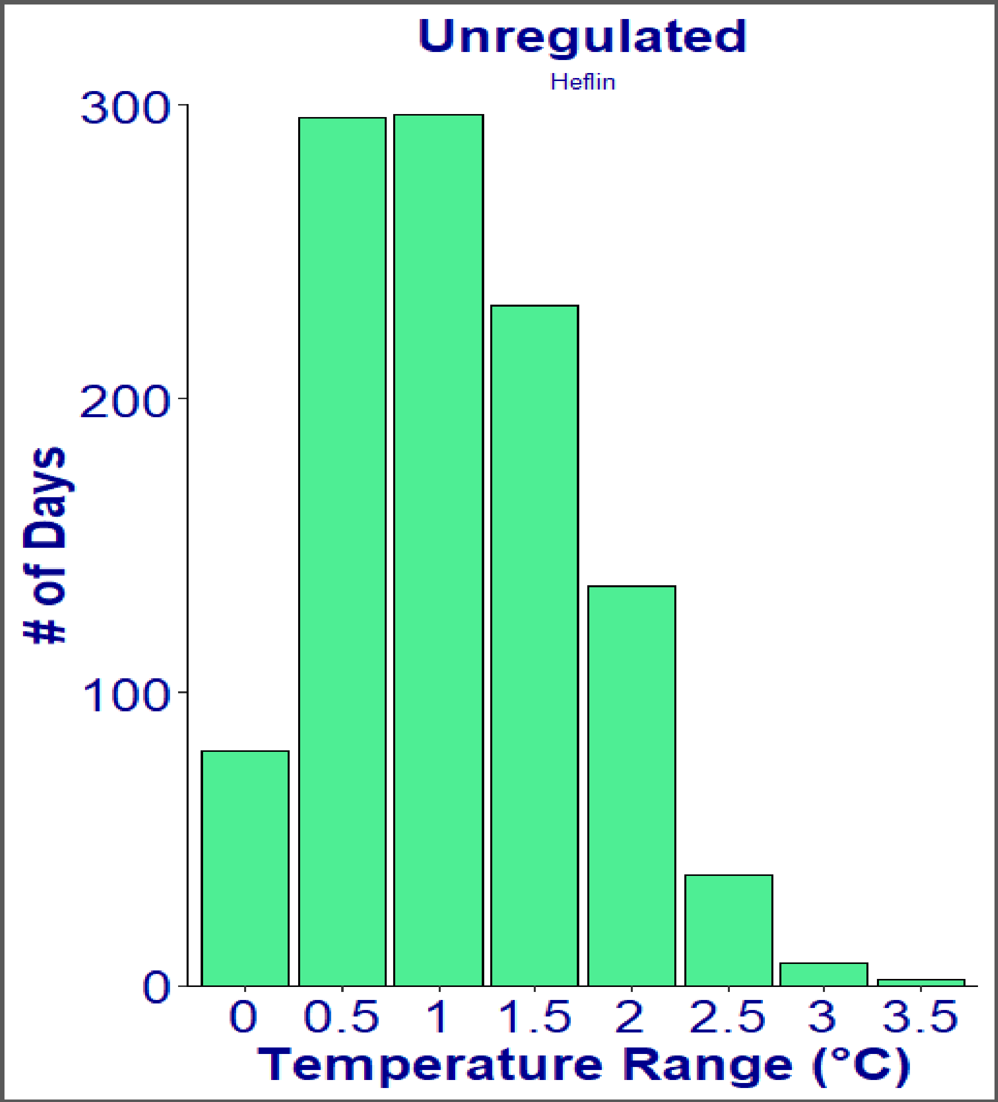
- No significant difference in temperatures before/after green plan
- Large variation in temperature during certain times
- Discharge changes temperature over small-time scales
- Rarely large daily temperature ranges





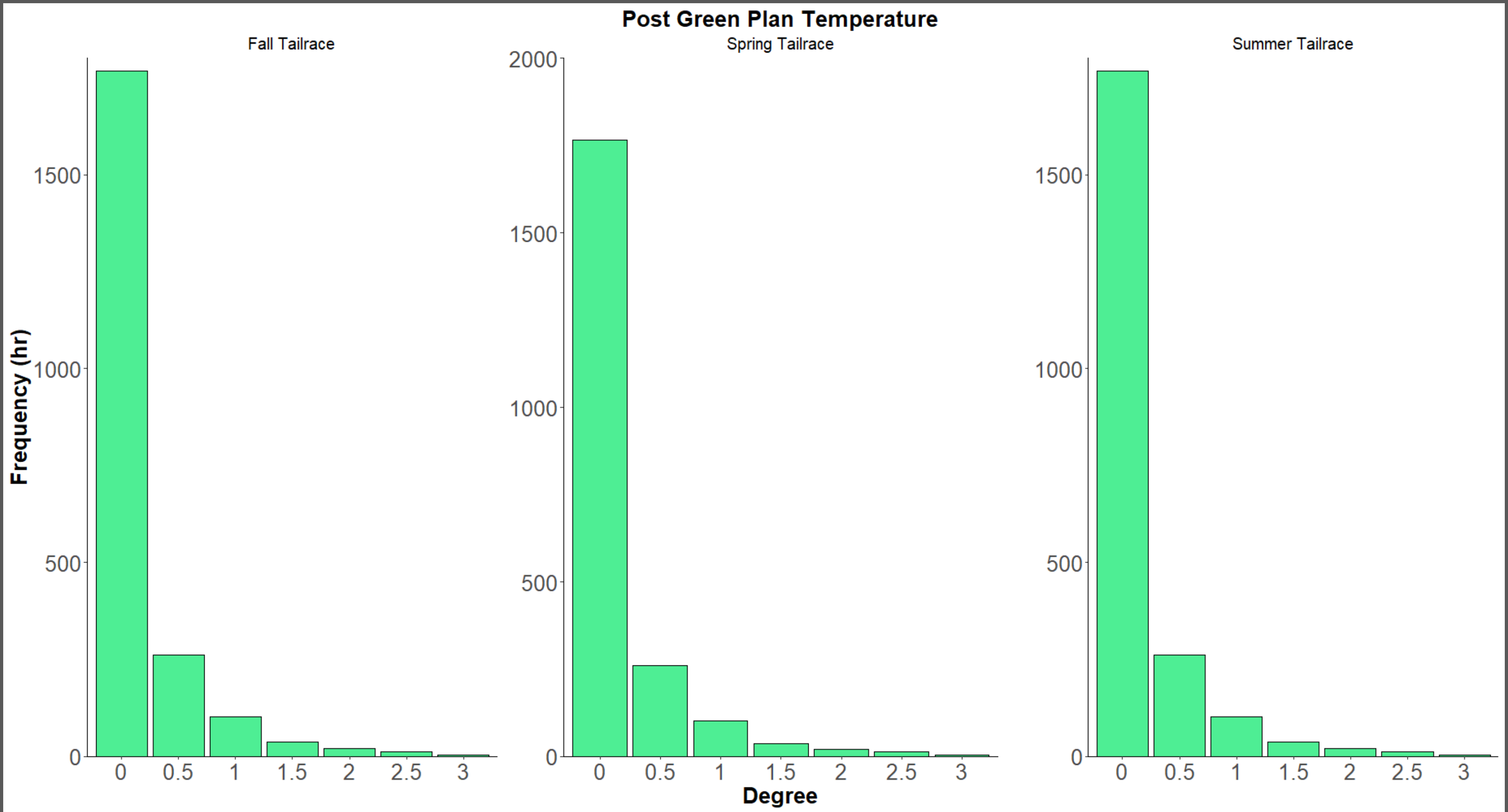


- Very little daily temperature variation
- Water warms and cools quickly between seasons

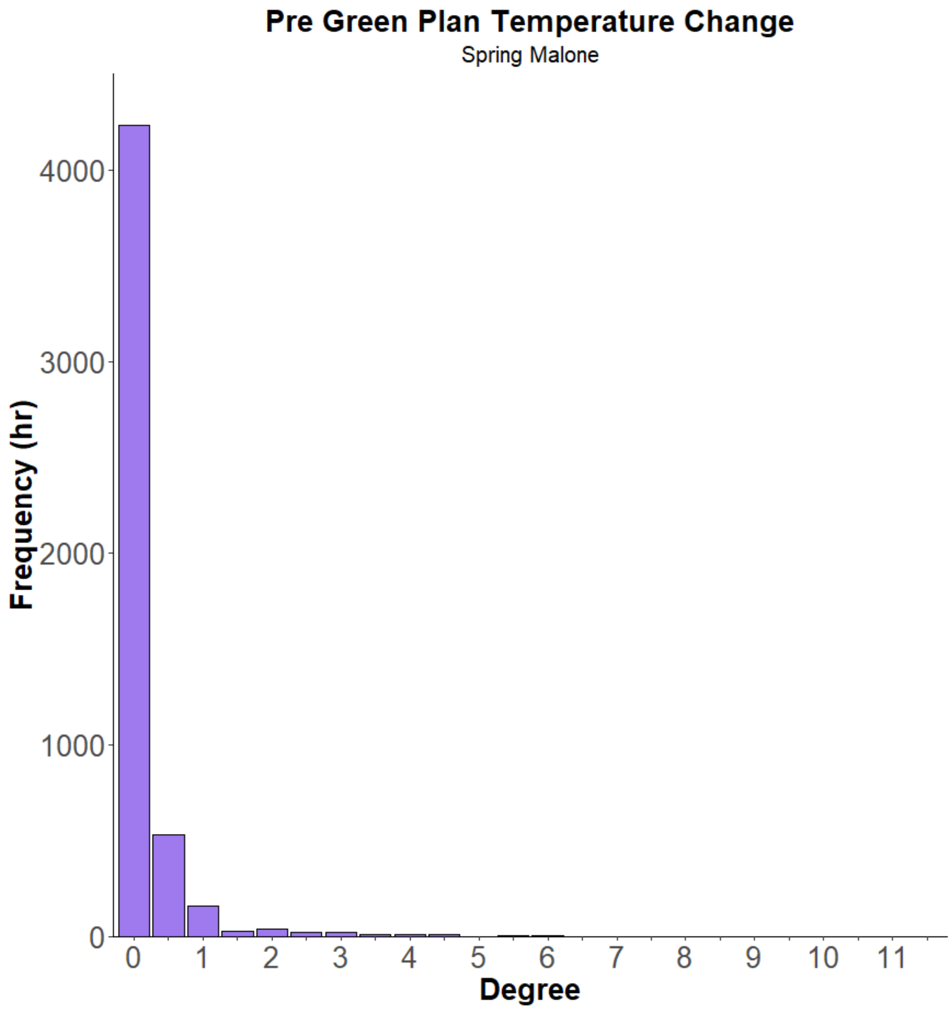


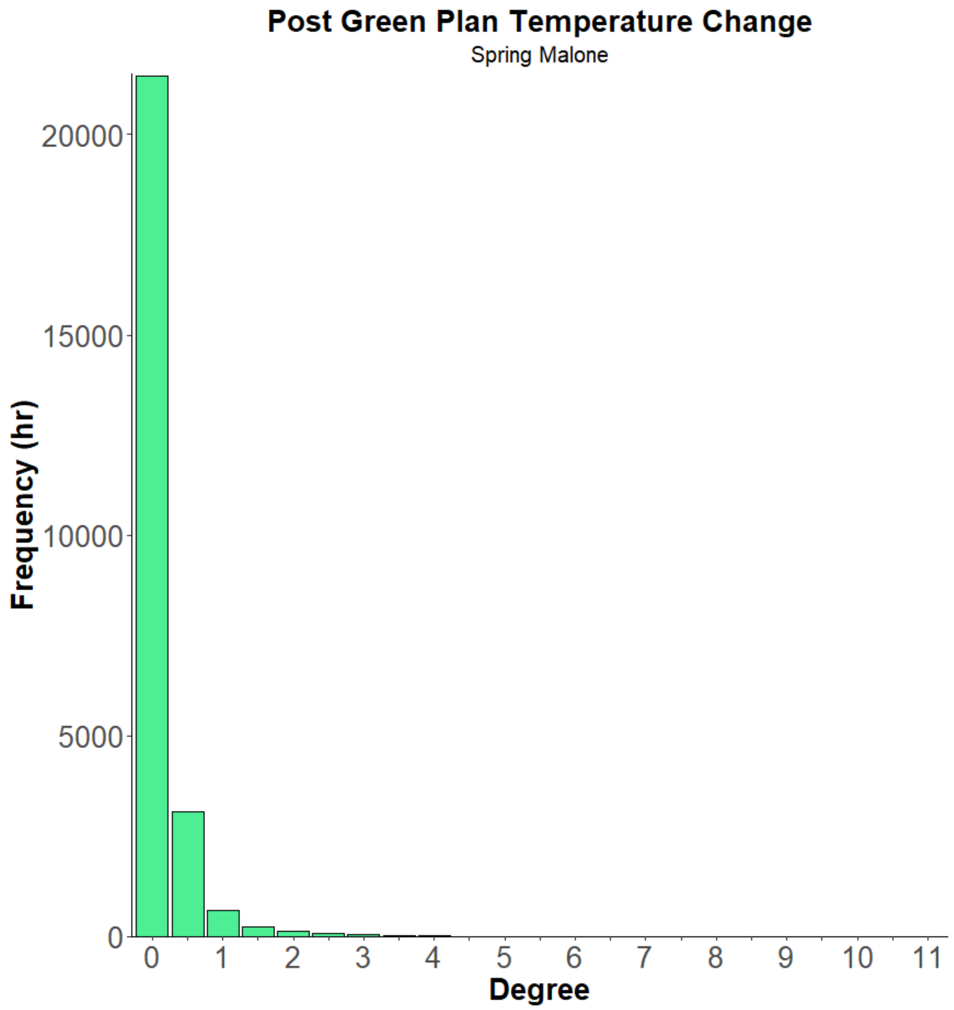
Most days see less than 3 C fluctuation

Hourly temperature fluctuations

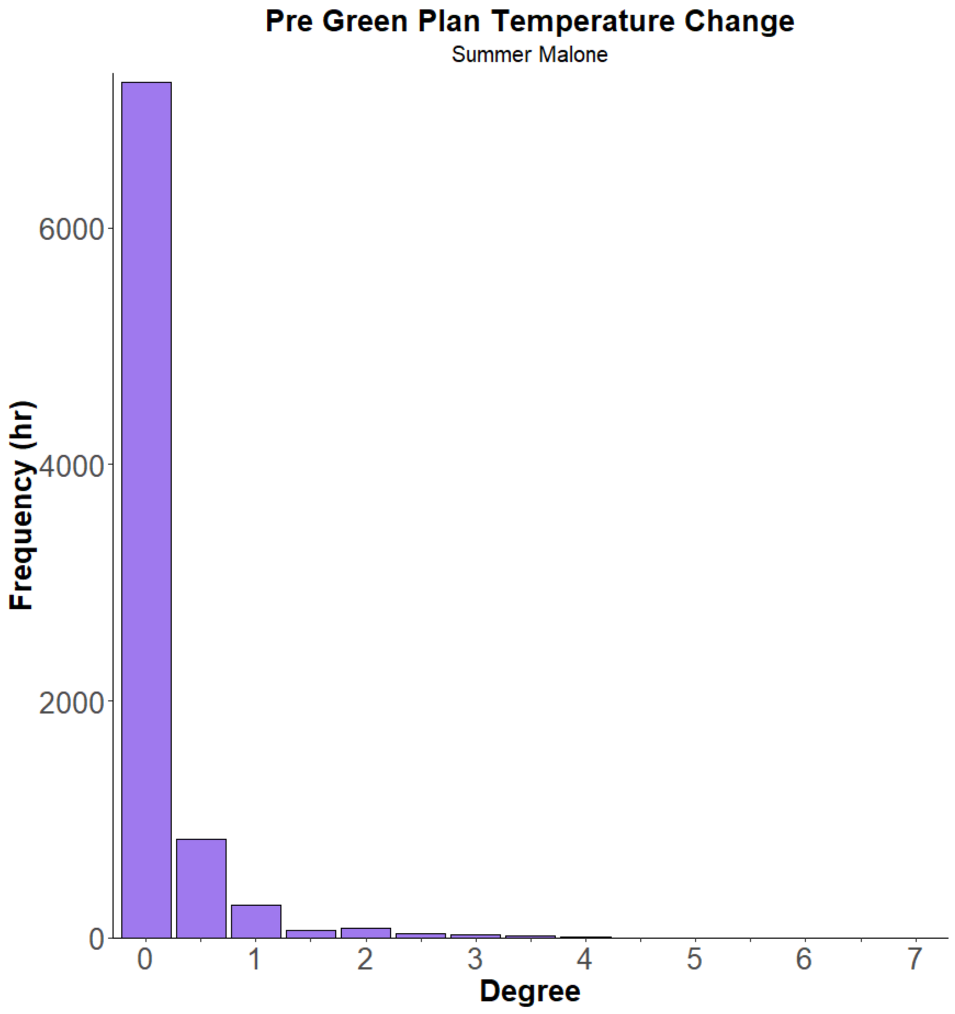


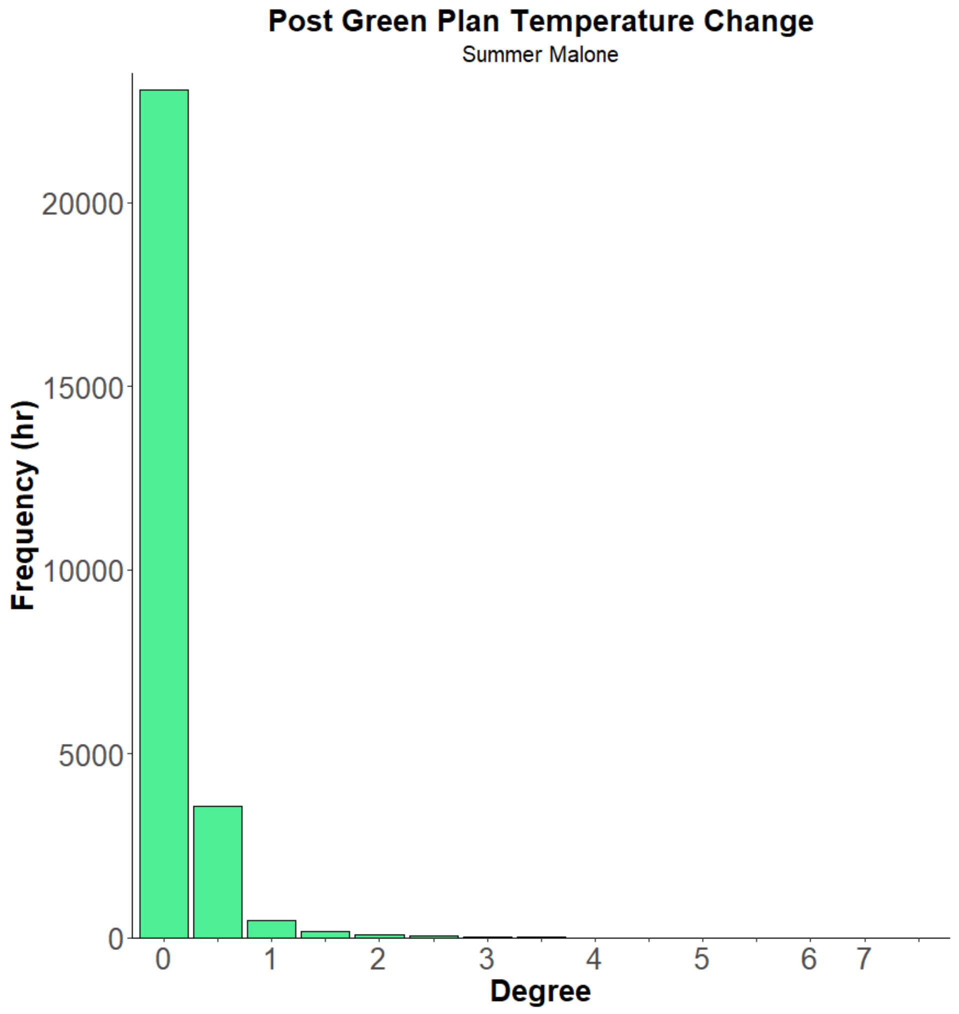
Average hourly temperature fluctuations



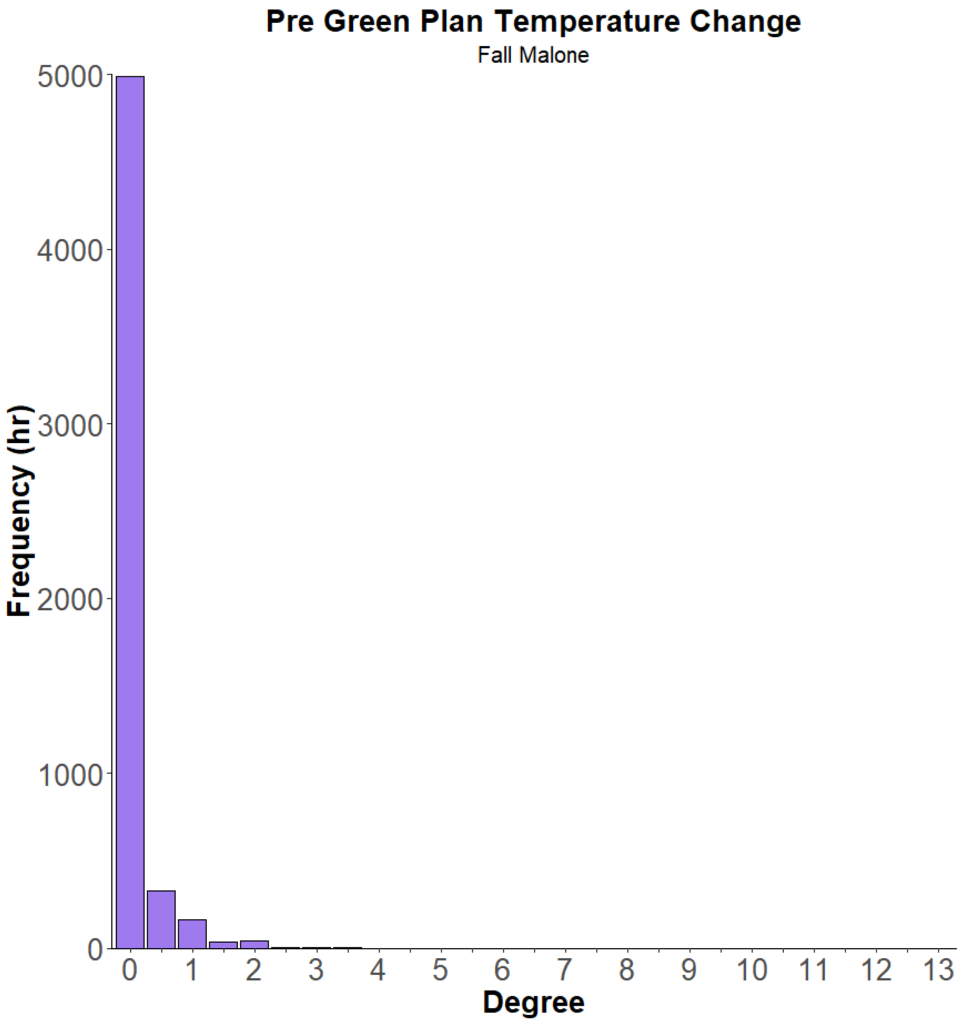


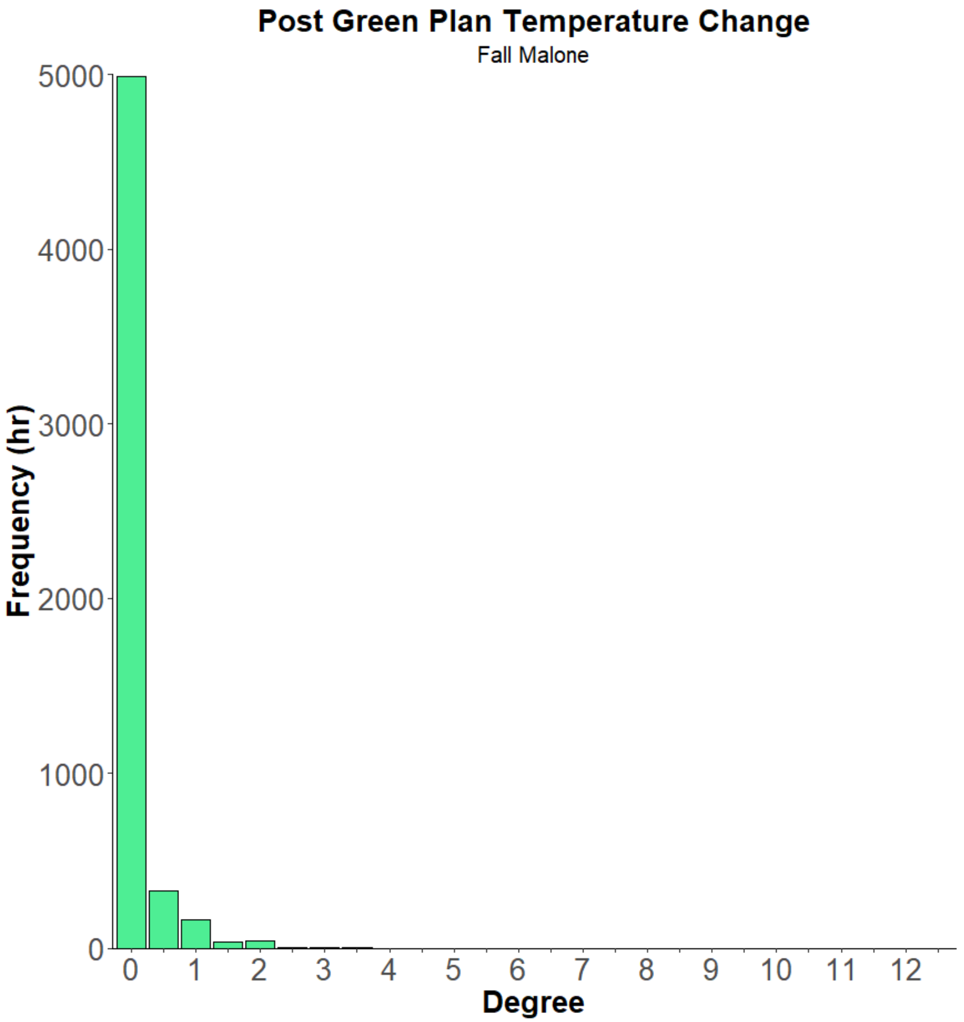
Average hourly temperature fluctuations



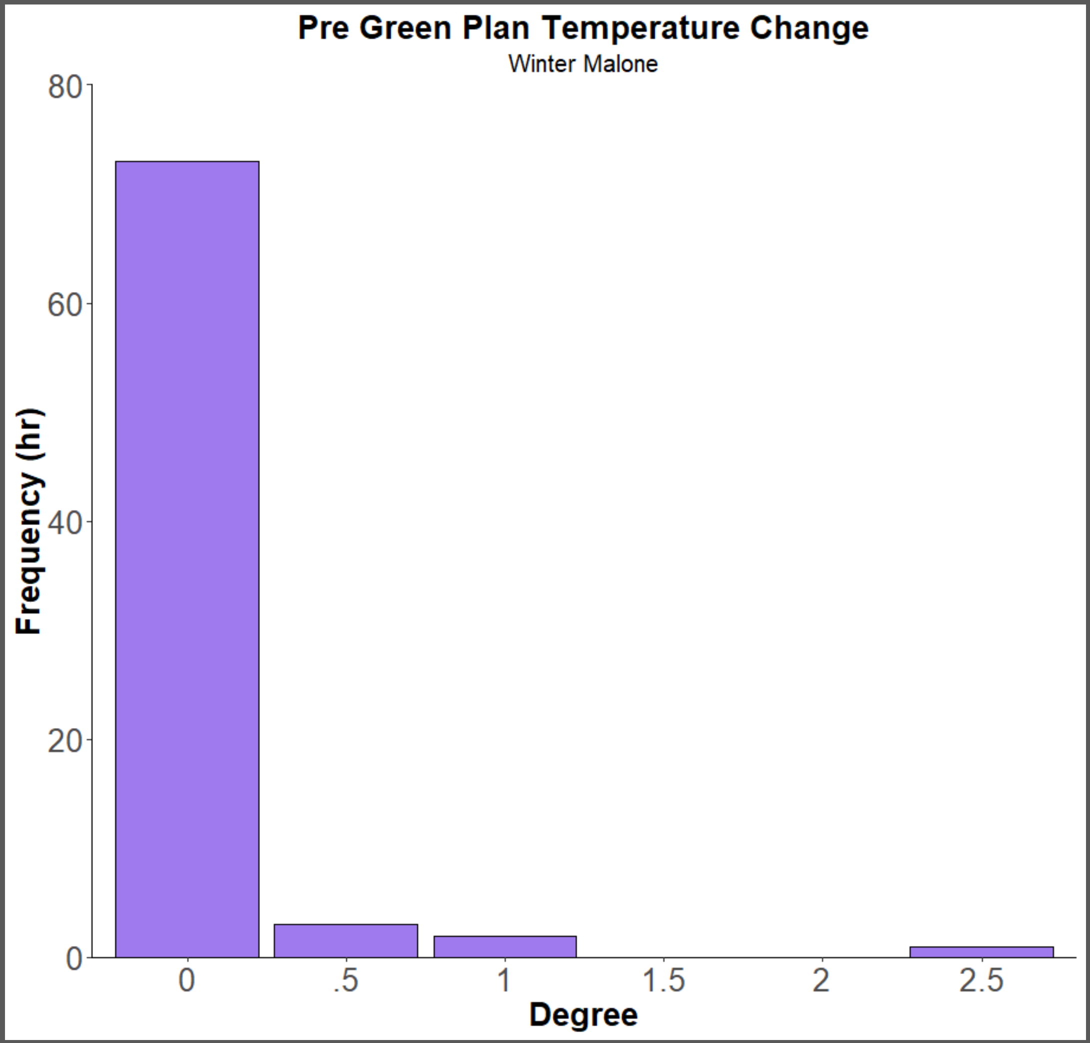


Average hourly temperature fluctuations

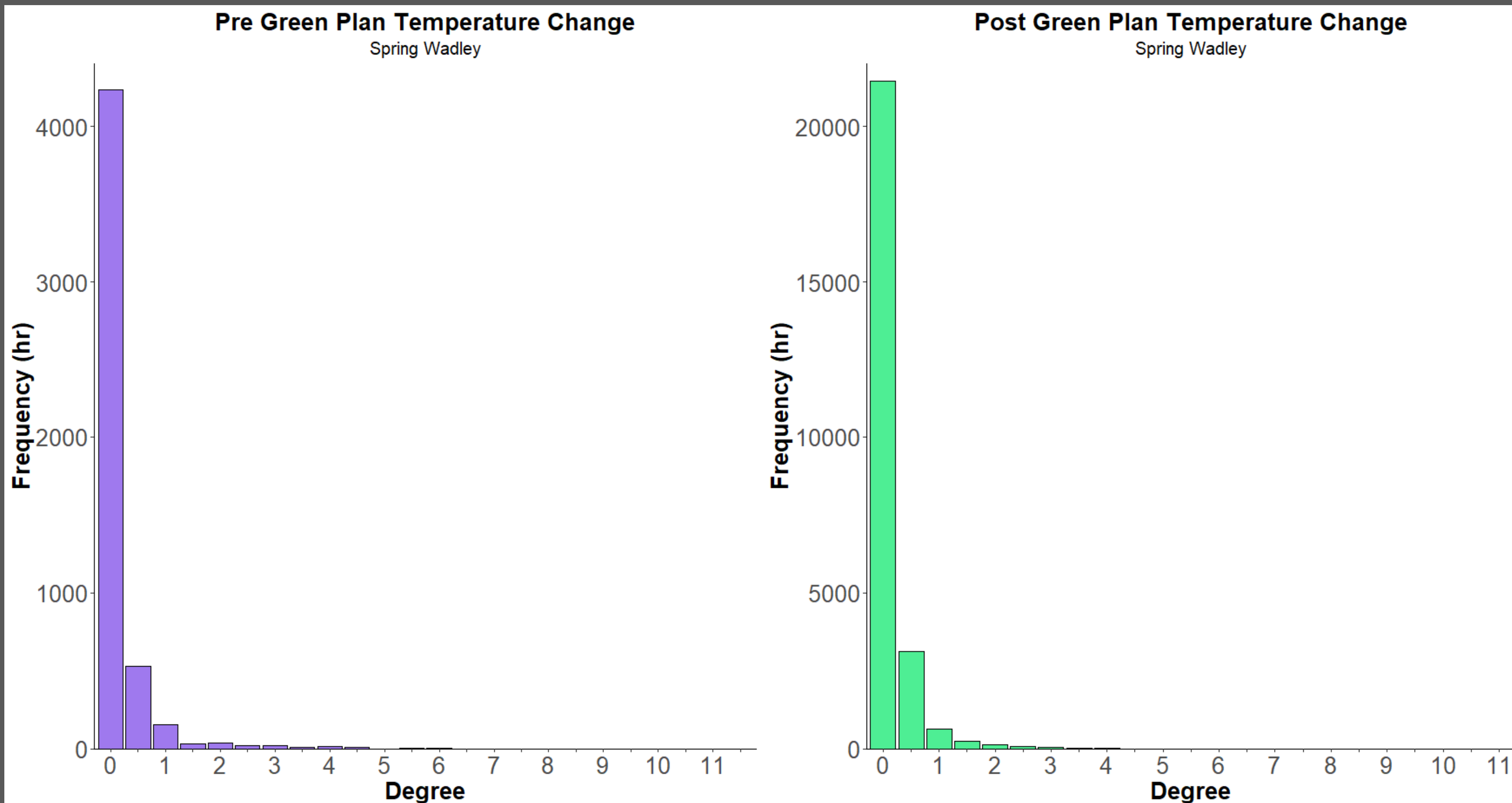




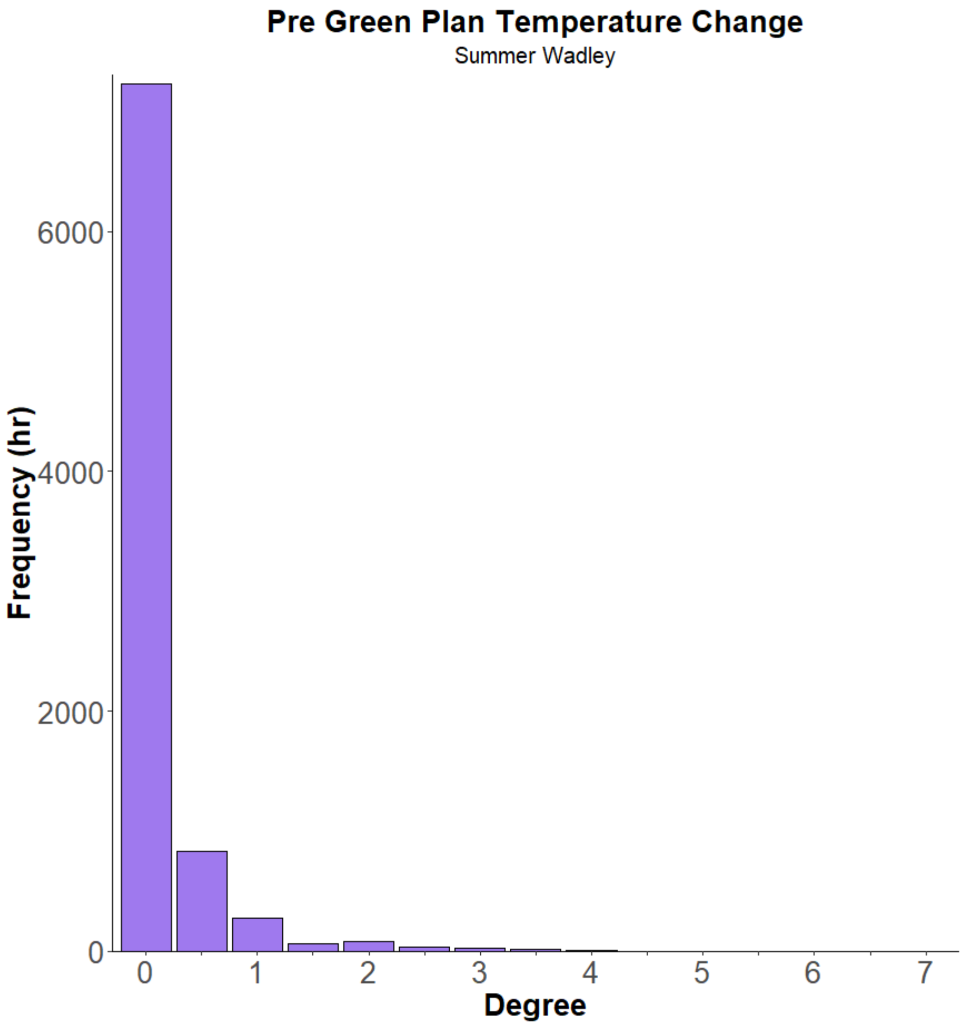
Average hourly temperature fluctuations

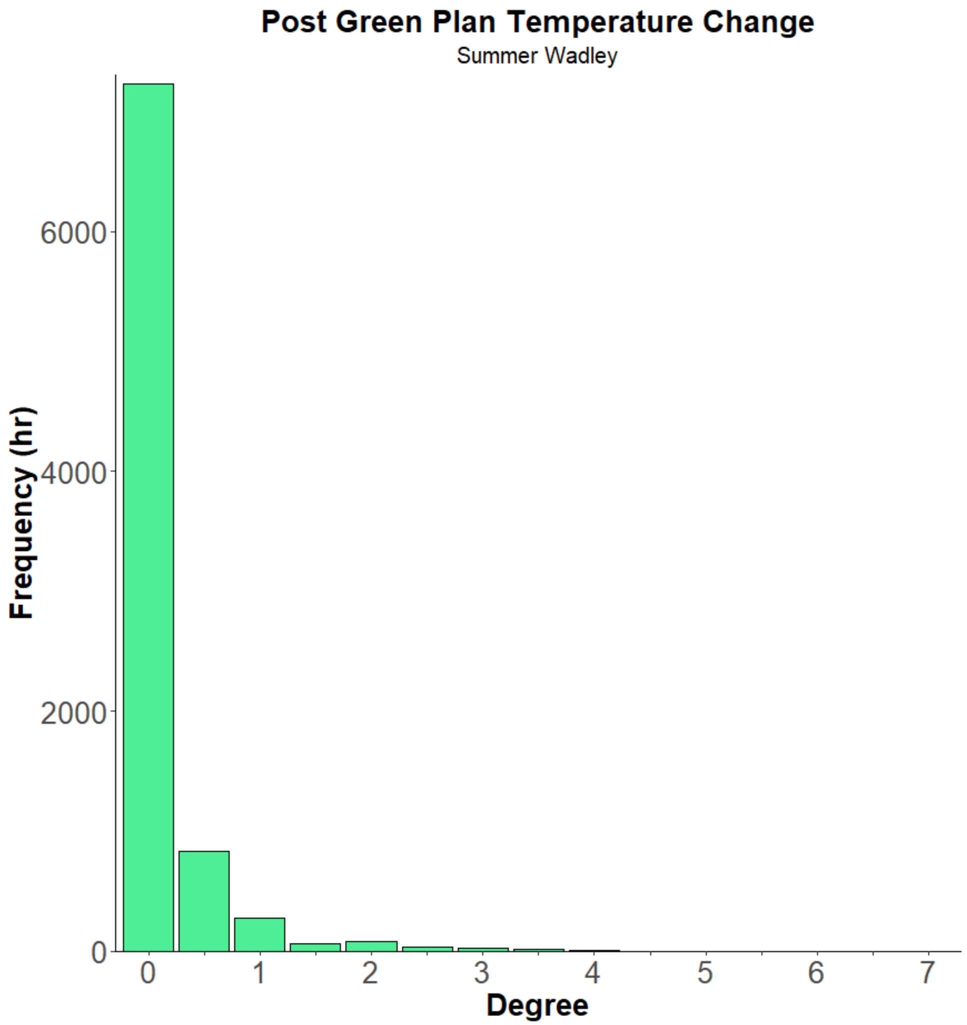


Average hourly temperature fluctuations

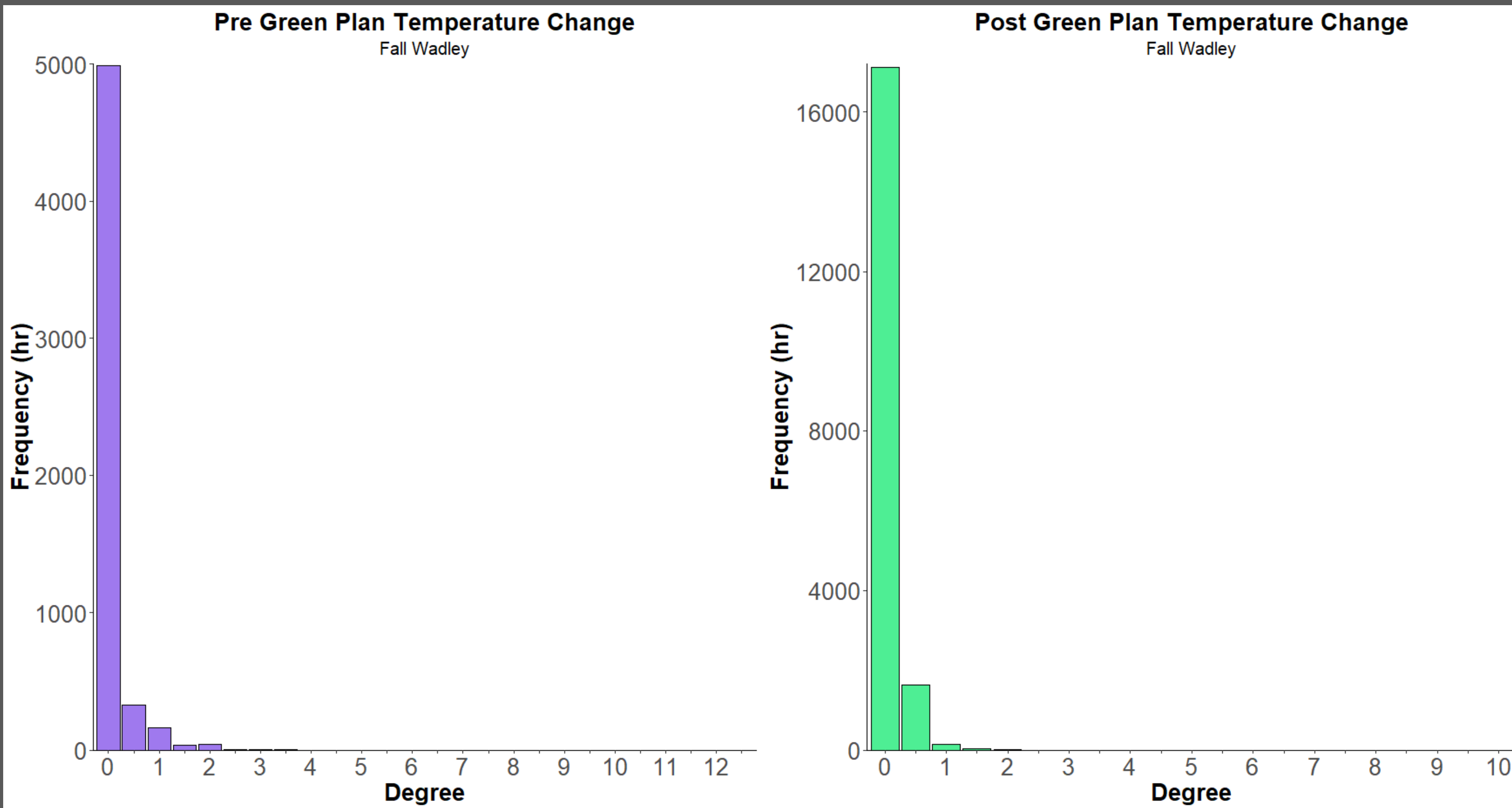


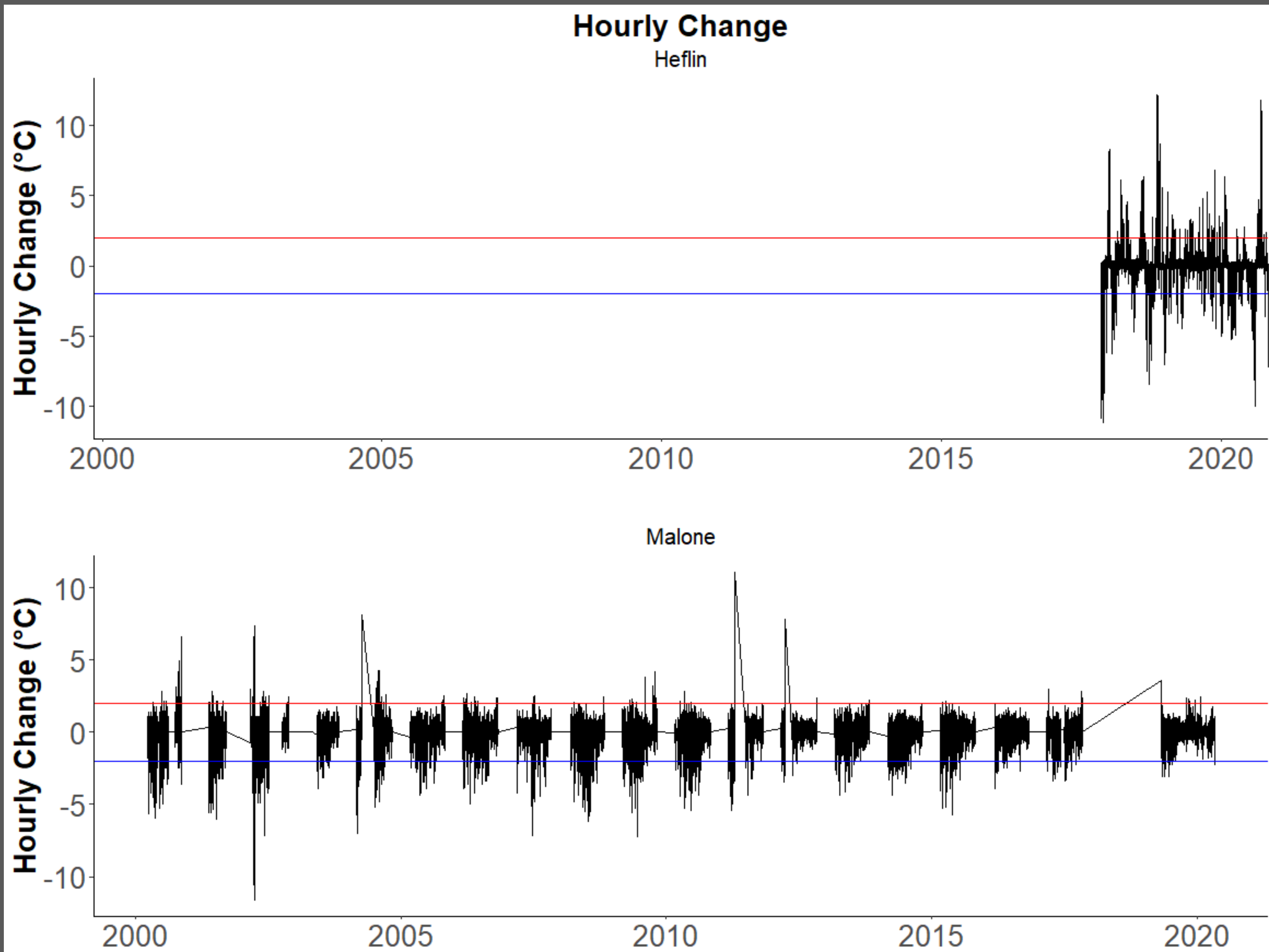
Average hourly temperature fluctuations



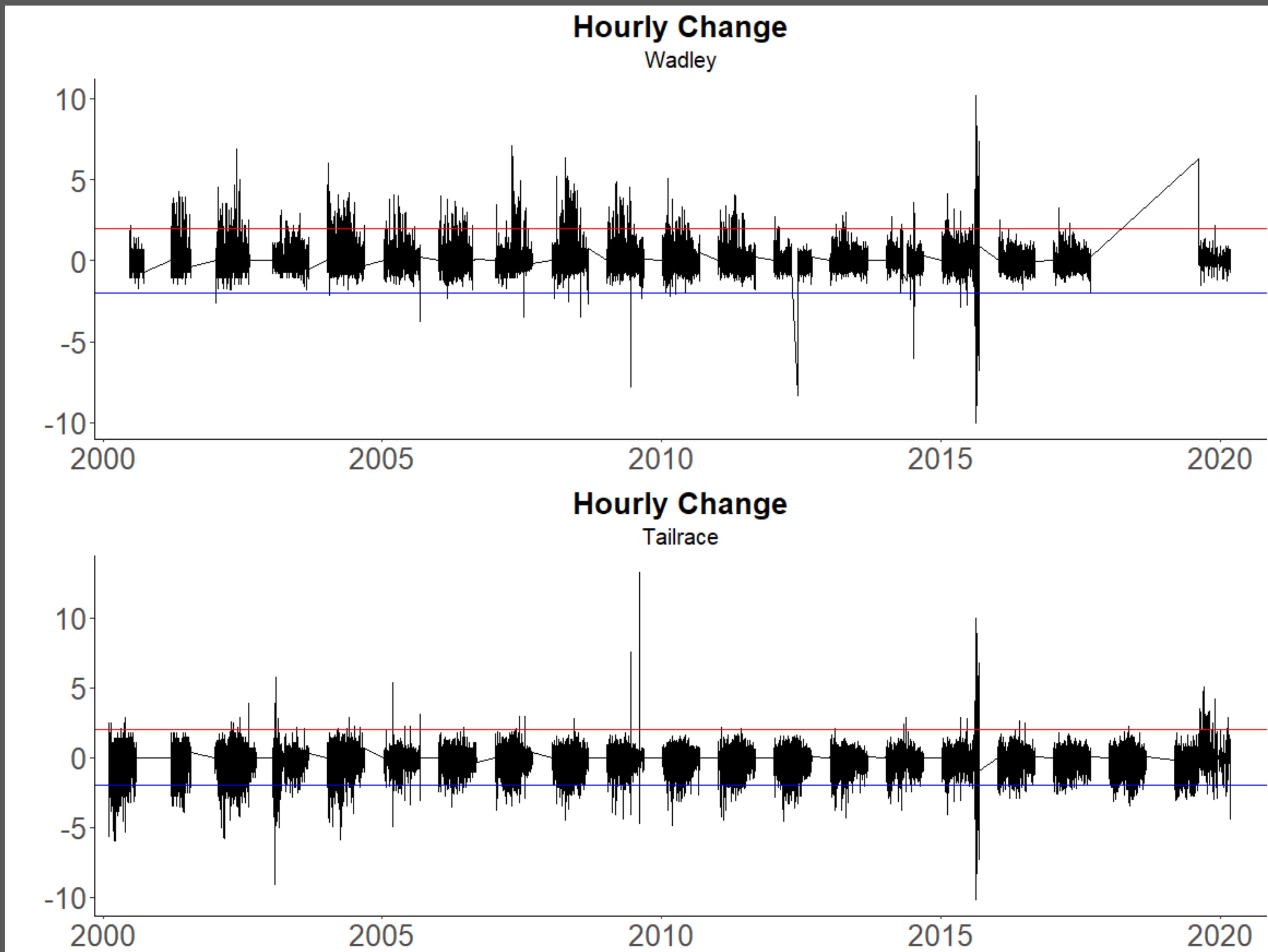


Average hourly temperature fluctuations





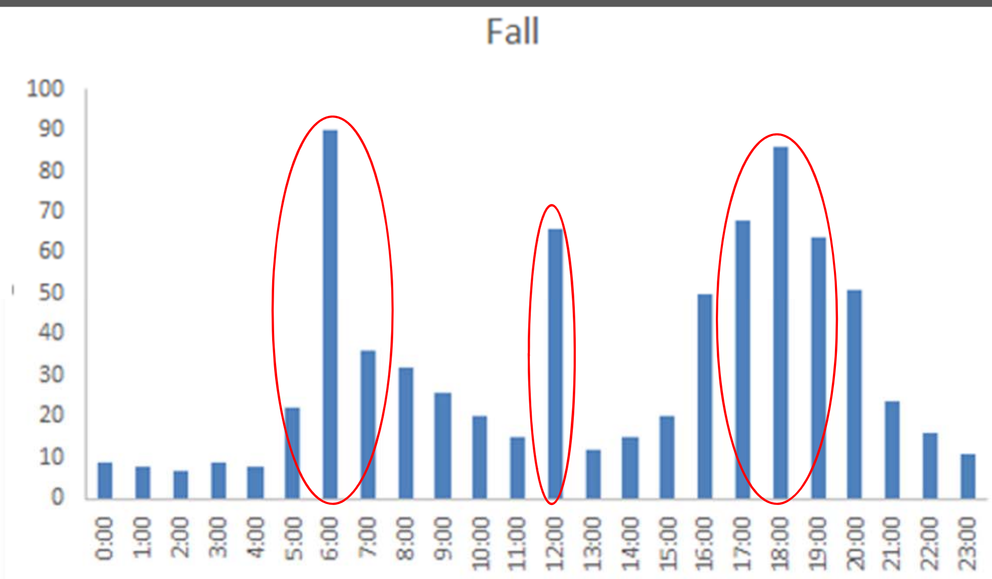
- No data for Heflin available before 2018
- More fluctuations within an hour at Heflin
  - Logger air exposure
- Majority of hourly variation occurs with ± 2 C (red and blue lines)

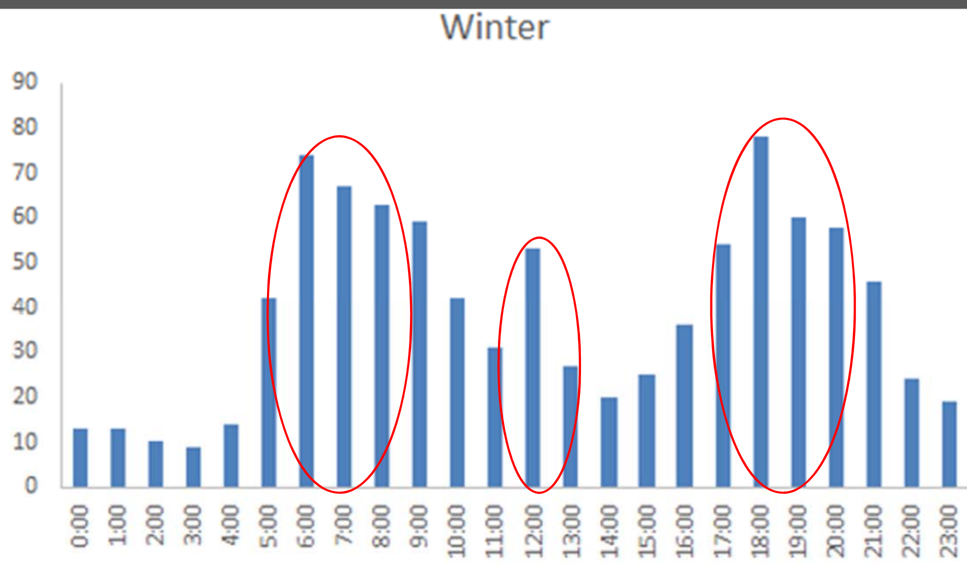


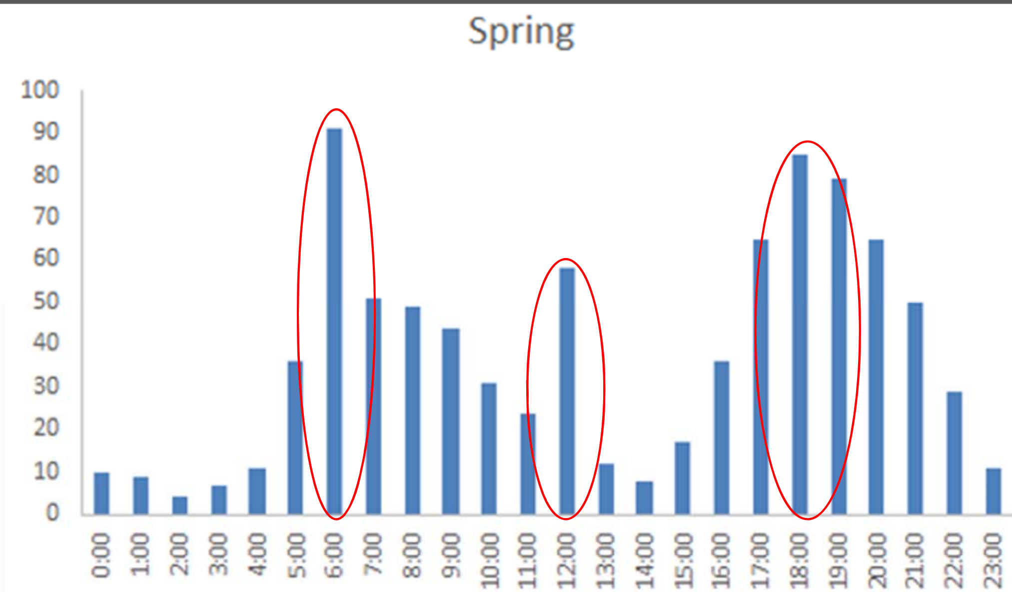
- No data for Wadley 2018 - 2019
- Majority of hourly variation occurs with ± 2 C (red and blue lines)

		2 C		4 C		6 C		8 C		10 C		12+ C	
	Site	**Pre GP**	**Post GP**	**Pre GP**	**Post GP**	**Pre GP**	**Post GP**	**Pre GP**	**Post GP**	**Pre GP**	**Post GP**	**Pre GP**	**Post GP**
Spring	Heflin		0.97		0.005		0.0006						
	Tailrace		0.99		0.01								
	Malone	0.99	0.98	0.0052	0.011	0.00048	0.0013	0.000097	0.000038	0	0	0.00019	0.000038
	Wadley	0.97	0.99	0.019	0.011	0.0061	0.0013	0.0014	0.000039	0.00019	0	0.00039	0.000039
Summer	Heflin		0.99		0.0057		0.0006						
	Tailrace		0.98		0.019								
	Malone	0.97	0.99	0.018	0.0066	0.0021	0.00087	0.00023	0.00011				
	Wadley	0.98	0.99	0.019	0.0066	0.0021	0.00087	0.00023	0.00011				
Fall	Heflin		0.97		0.0058		0.0035		0.0018		0.004		
	Tailrace		0.99		0.0034								
	Malone	0.98	0.98	0.011	0.011	0.0011	0.0011	0.00036	0.00036	0	0	0.00053	0.00053
	Wadley	0.97	0.99	0.02	0.019	0.0061	0.0013	0.0014	0.00049	0.00019	0.00022	0.00039	0.000055
Winter	Heflin		0.97		0.01		0.004		0.002		0.0024		0.001
	Tailrace												
	Malone	0.98		0.013									
	Wadley												

Generation Frequency



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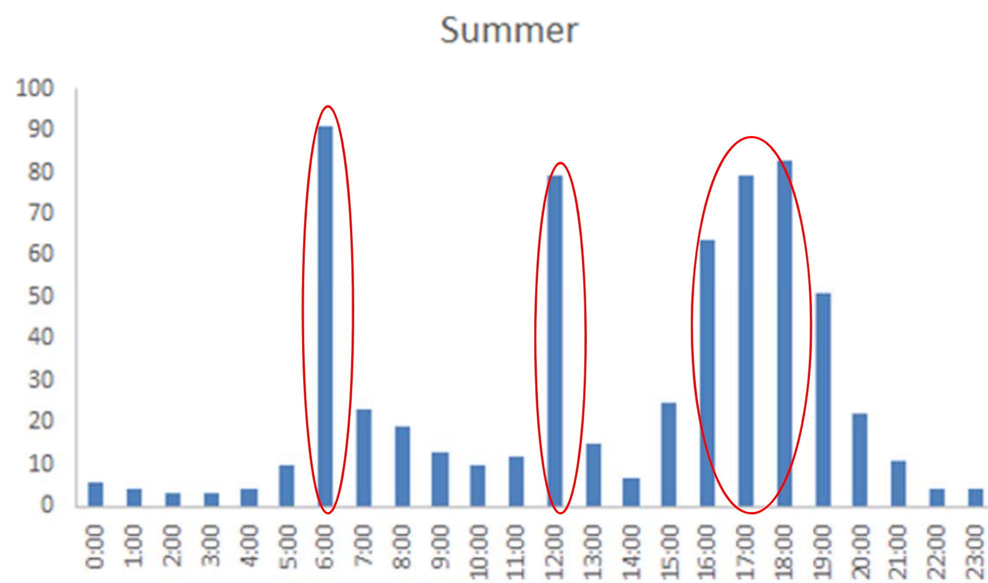
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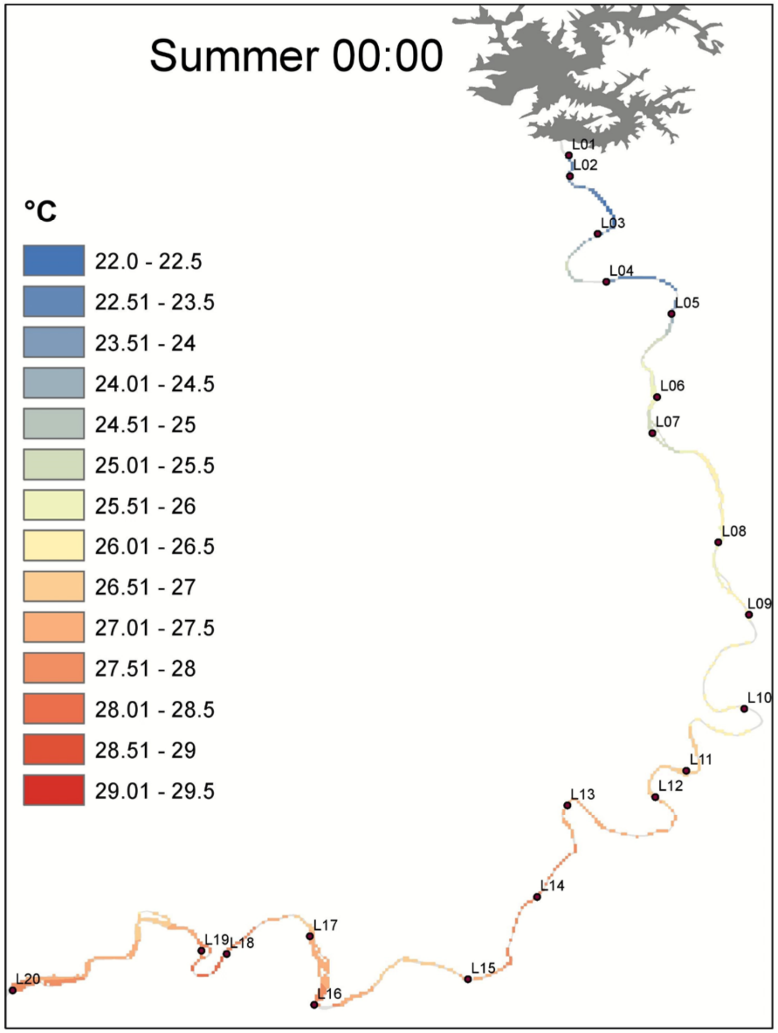

Summer 00:00
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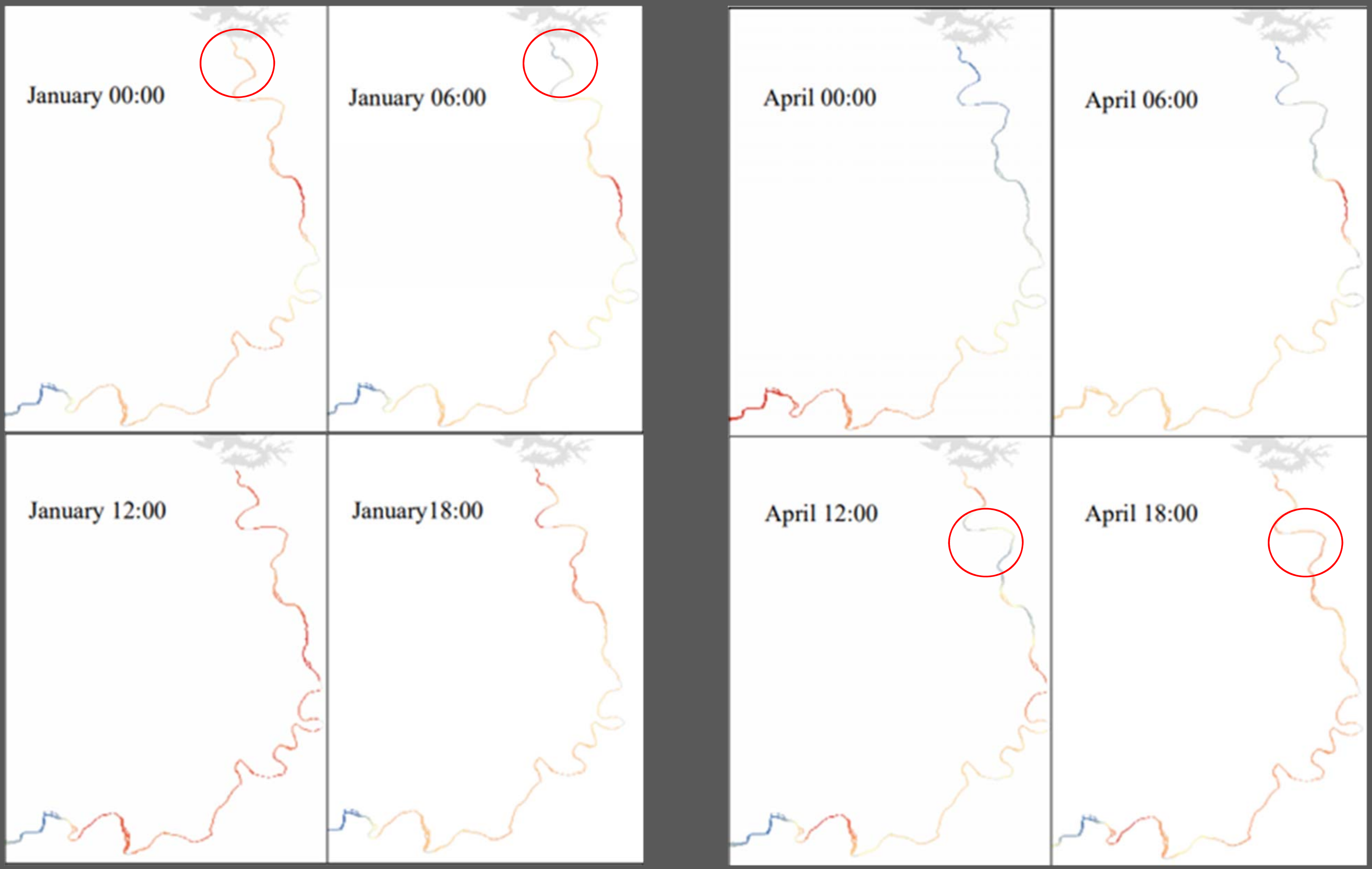
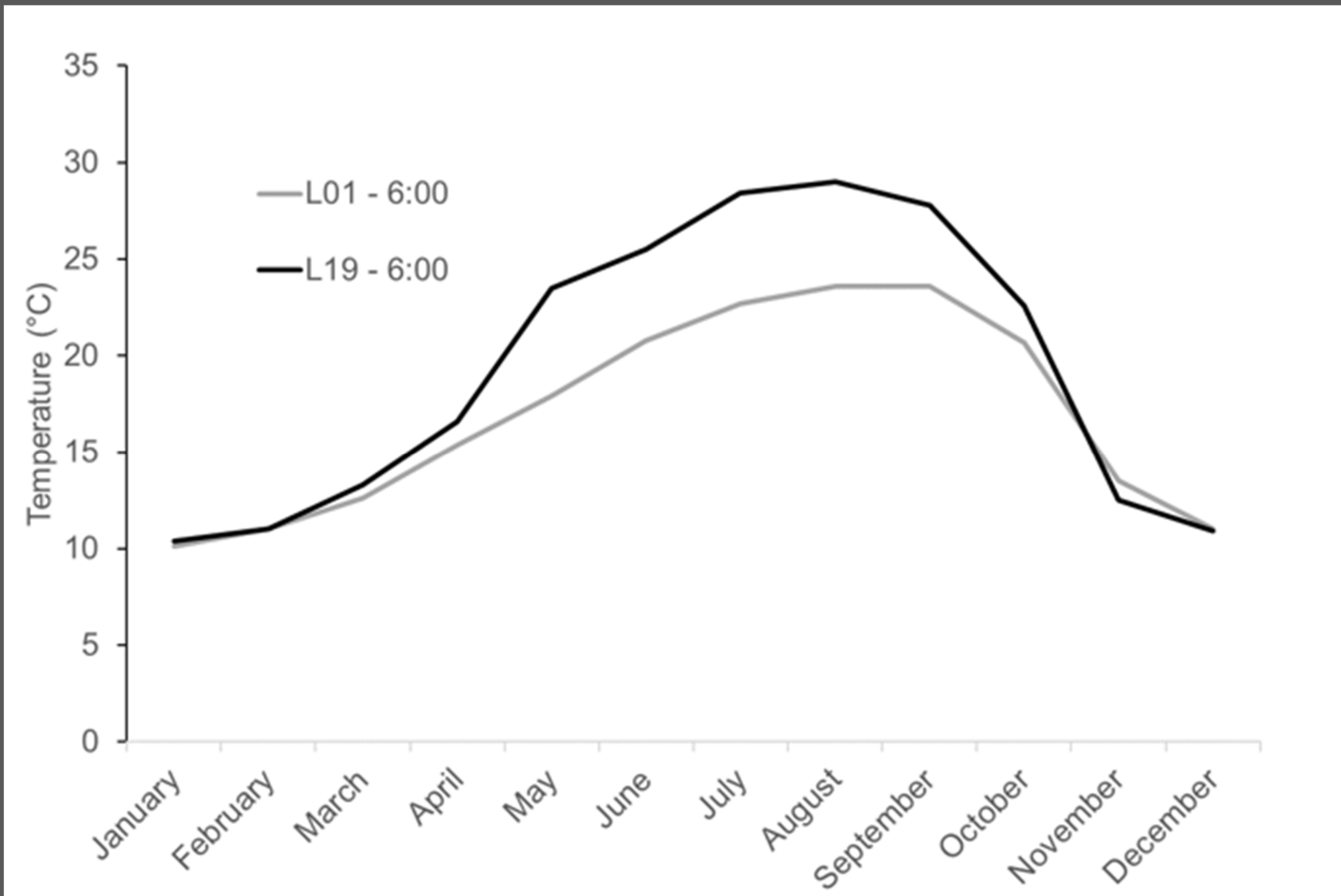
L19
L20


January 00:00
January 06:00
January 12:00
January18:00
April 00:00
April 06:00
April 12:00
April 18:00



L01 - 6:00
L19 - 6:00
Temperature (°C)
35
30
25
20
15
10
5
0
January
February
March
April
May
June
July
August
September
October
November
December

Conclusions Objective 2

- No significant differences downstream before and after Green Plan
- Temperature fluctuates the most in summer
  - Differences seen downstream
  - Pulses identifiable in temperature data
- Little fluctuation in winter above and below dam
- Hourly temperature fluctuations overwhelmingly less than 2 C on average
  - Can be up to 6 C (12 C changes recorded, but this is likely equipment failures)
  - Most extreme in summer
  - No large hourly fluctuations recorded upstream of dam

Objective 3: Quantify the fish community across a gradient downstream from the Harris Dam tailrace and in a reference site upstream of Harris Reservoir

Objective 3: Community, Age/Growth, Telemetry

- Community
  - Summary
  - Frequency and CPE
    - By site, season, site x season
- Age and Growth
  - Body condition
  - Age frequency
  - von Bertalanffy curves
- Diet
  - Percent by weight by season
  - Percent by weight by site
- Telemetry
  - Manual tracking
  - Stationary acoustic receivers

Field Methods

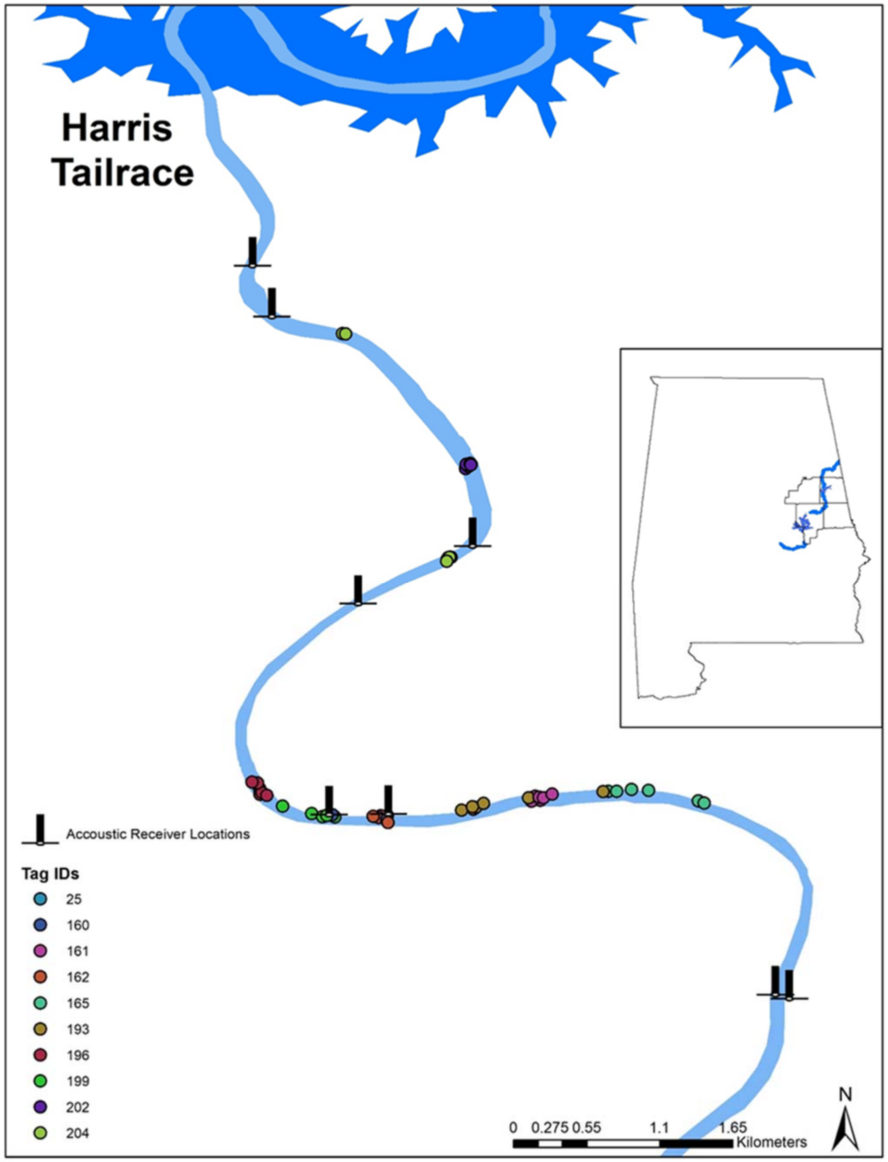
- All sites sampled every-other month
- Standardized boat/barge electrofishing
  - 6, 10-minute transects
  - Barge used in the tailrace
  - All non-target individuals identified, weighed, and measured (and returned to capture site starting July 2020)

Fish Work-up Methods

- All fish identified to species
- Non-target species
  - 10 of each non-target species weighed/measured
  - Remaining individuals weighed as a group
- Target species
  - Otoliths, gonads, and diets extracted
  - Fin clips collected from Alabama Bass and Tallapoosa Bass
  - Ages estimated, annuli measured

Telemetry Methods

- 10 stationary acoustic receivers
  - 8 between tailrace and CR 15 in Malone, 2 at AL 77 in Wadley
  - Concrete anchors, cabled to bank
- 16 CART tags deployed
- Manual tracking
  - Tailrace to CR 15 in Malone



Data Analysis: Community

- Diversity
  - Shannon's H
  - Species richness
  - Family richness
- Abundance
  - CPE by site
  - CPE by season
  - CPE by site x season

Data Analysis: Age-and-Growth

- Body condition
  - W_r calculated for CCAT, ALAB, TPBA
  - K_n calculated for RBSF
  - ANOVA of body condition by site for each species
- Age and Growth
  - Length standardized to last measured annulus
  - von Bertalanffy parameters estimated using neg. log likelihood

Data Analysis: Diet

- Weight of each diet item estimated
  - Published length – weight regressions
- Percent-by-weight
  - Percent-by-weight in individual, averaged across individuals in each site x season combination

Data Analysis: Telemetry

- Data filtering
  - False detections removed
  - Detections of other receivers removed
- Visual assessment
  - Graphs of each detected fish's location
  - Mapped each fish's location during manual tracking
  - Maximum total movement quantified

Results: Community

Site	Total Species	Total Families	Shannon's H
Lee’s Bridge	39	9	2.80
Tailrace	39	7	2.60
Wadley	37	7	2.90
Horseshoe Bend	35	7	2.56
All	57	9	3.07

CPE by site

	CPE	LB CPE	TR CPE	WD CPE	HB CPE
Amiidae	0.15	0.78	0.00	0.00	0.00
Clupeidae	2.80	6.44	0.00	2.57	3.50
Cyprinidae/Leuciscidae	29.20	22.44	21.81	40.48	32.92
Catostomidae	16.32	21.00	2.09	32.67	14.92
Ictaluridae	7.06	11.56	9.39	2.29	5.17
Fundulidae	0.49	0.11	0.51	0.48	0.75
Moronidae	0.24	1.11	0.07	0.00	0.00
Centrarchidae	49.17	35.00	56.32	51.52	49.50
Percidae	14.51	2.22	28.45	20.95	2.00

Lee's Bridge CPE by season

	Spring CPE	Summer CPE	Fall CPE	CPE
Amiidae	1.33	0.50	0.50	0.78
Clupeidae	6.33	5.50	7.00	6.44
Cyprinidae/Leuciscidae	21.33	19.00	25.00	22.44
Catastomidae	9.00	15.50	32.75	21.00
Ictaluridae	10.33	15.50	10.50	11.56
Fundulidae	0.33	0.00	0.00	0.11
Moronidae	3.33	0.00	0.00	1.11
Centrarchidae	23.67	33.50	44.25	35.00
Percidae	0.33	1.00	4.25	2.22

Tailrace CPE by season

	Winter CPE	Spring CPE	Summer CPE	Fall CPE	CPE
Cyprinidae/Leuciscidae	$\boxed{68.50}$	13.50	4.00	19.50	21.81
Catastomidae	$\boxed{7.00}$	1.54	0.50	1.25	2.09
Ictaluridae	8.00	5.13	9.50	$\boxed{16.25}$	9.39
Fundulidae	2.00	0.17	0.00	0.50	0.51
Moronidae	0.00	0.00	0.00	0.25	0.07
Centrarchidae	49.00	$\boxed{61.37}$	29.50	$\boxed{66.00}$	56.32
Percidae	21.50	26.50	$\boxed{46.00}$	26.00	28.45

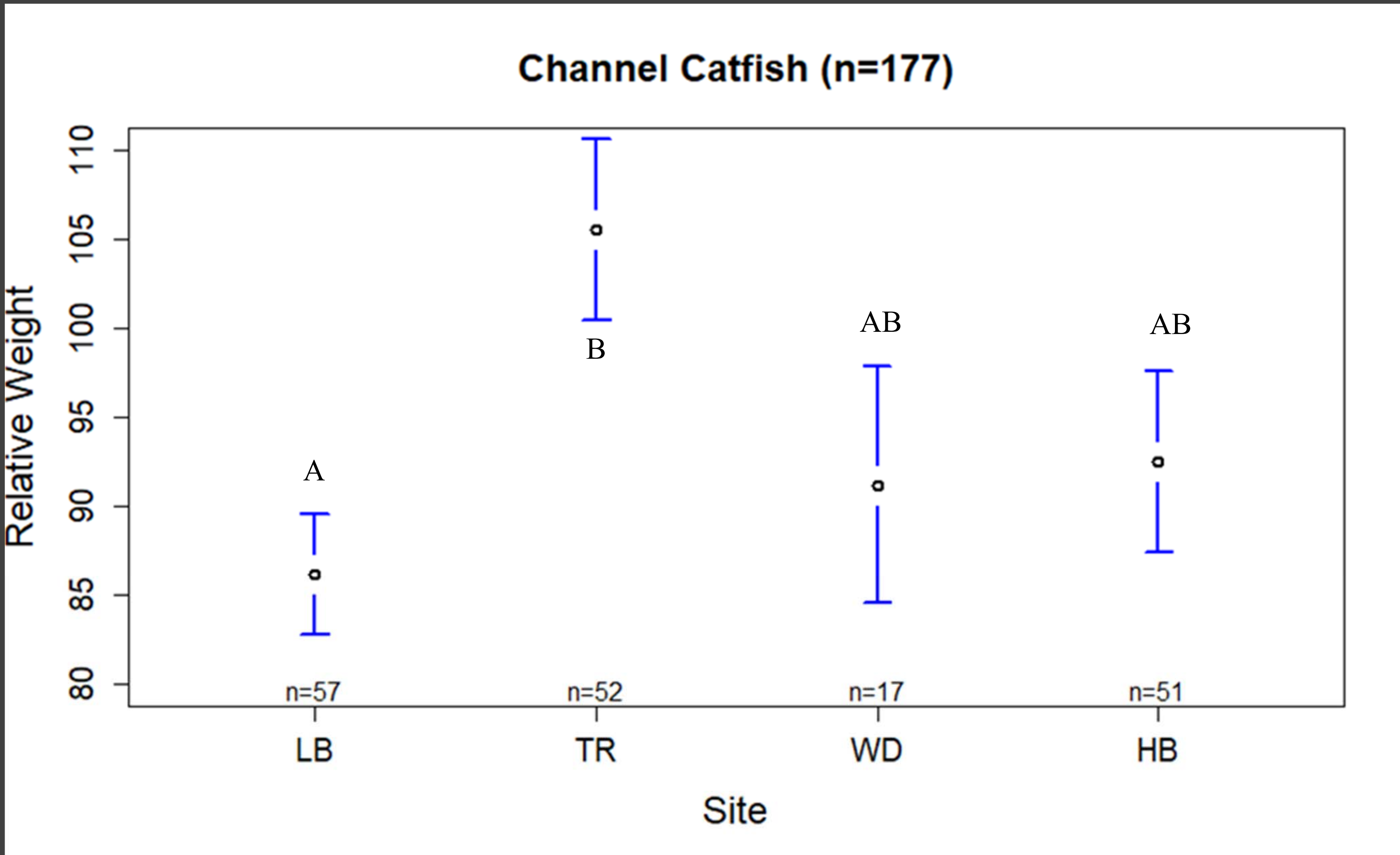
Wadley CPE by season

	Winter CPE	Spring CPE	Summer CPE	Fall CPE	CPE
Clupeidae	8.50	3.60	0.50	0.00	2.57
Cyprinidae/Leuciscidae	35.00	50.00	46.00	34.50	40.48
Catastomidae	29.50	28.40	31.00	37.75	32.67
Ictaluridae	0.50	0.00	3.00	4.25	2.29
Fundulidae	0.50	0.40	1.50	0.00	0.48
Centrarchidae	17.50	38.80	93.50	55.50	51.52
Percidae	0.50	13.20	25.00	34.00	20.95

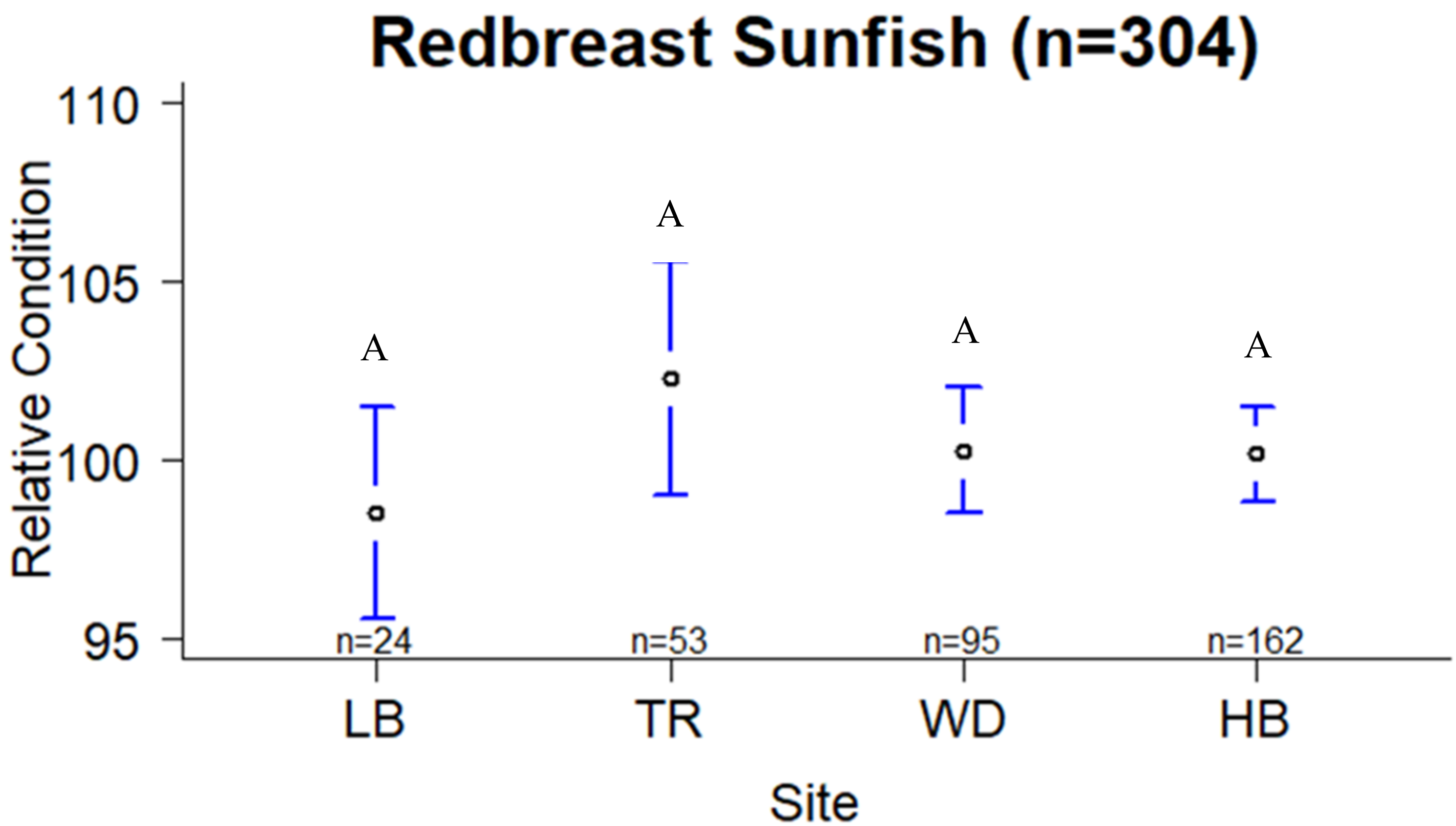
Horseshoe Bend CPE by season

	Winter CPE	Spring CPE	Summer CPE	Fall CPE	CPE
Clupeidae	16.00	0.75	0.00	1.75	3.50
Cyprinidae/Leuciscidae	49.50	51.75	6.00	19.25	32.92
Catastomidae	13.00	15.25	13.00	16.50	14.92
Ictaluridae	1.00	3.00	8.50	7.75	5.17
Fundulidae	1.00	1.50	0.00	0.25	0.75
Centrarchidae	28.50	55.75	49.50	53.75	49.50
Percidae	0.00	5.00	1.50	0.25	2.00

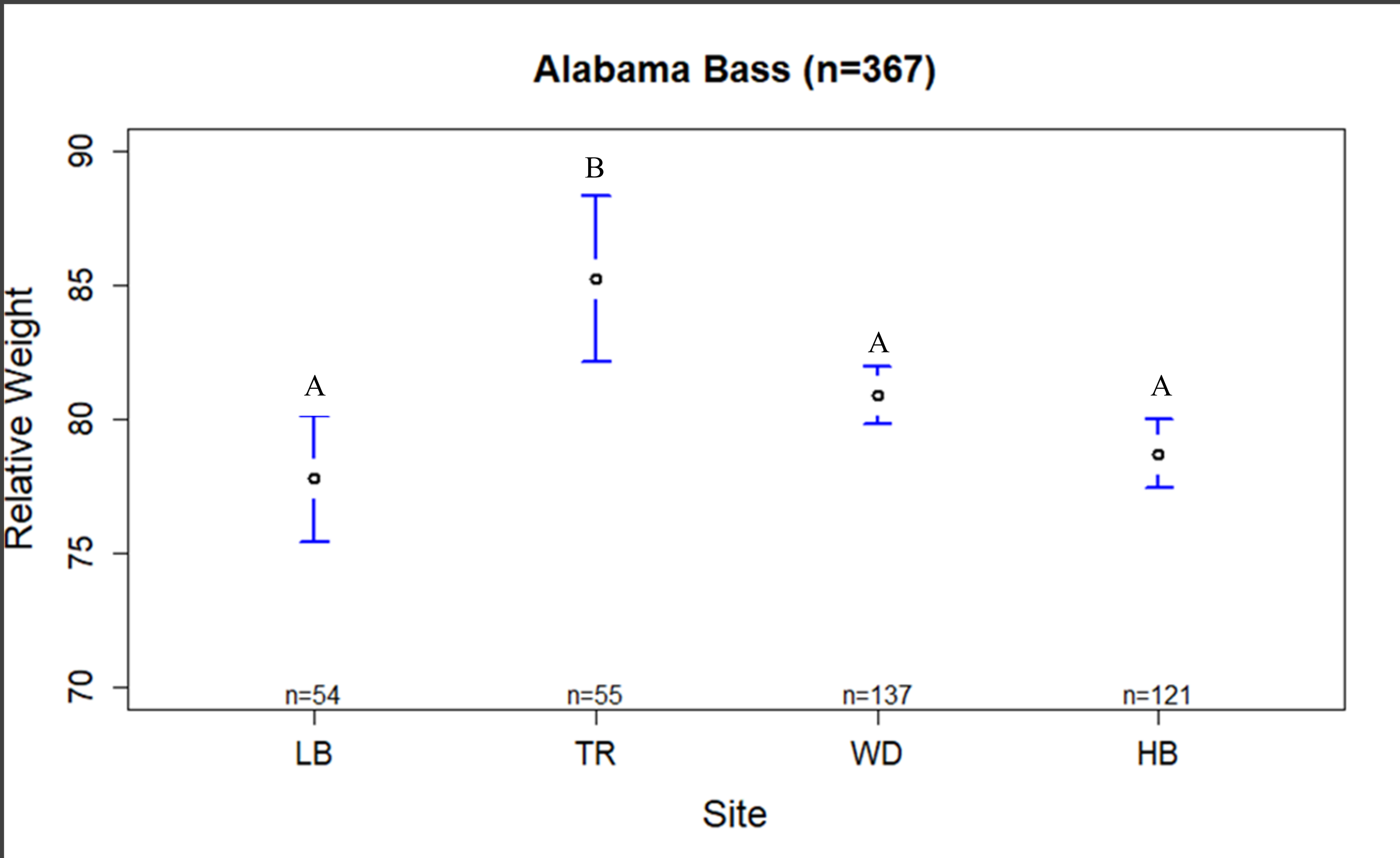
Results: age-and-growth



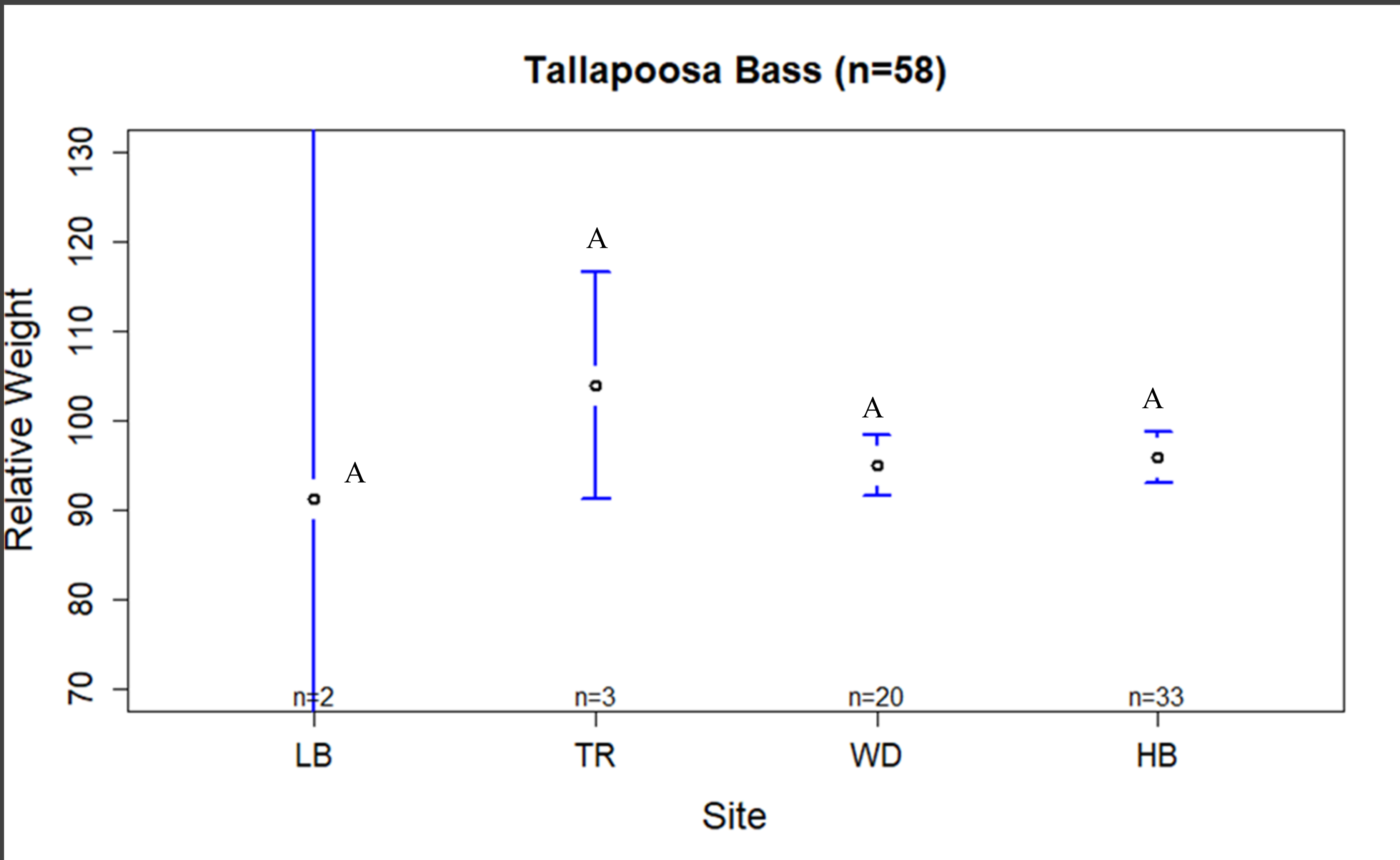
Channel Catfish (n=177)
Relative Weight
110
105
100
95
90
85
80
A
B
AB
AB
n=57
n=52
n=17
n=51
LB
TR
WD
HB
Site



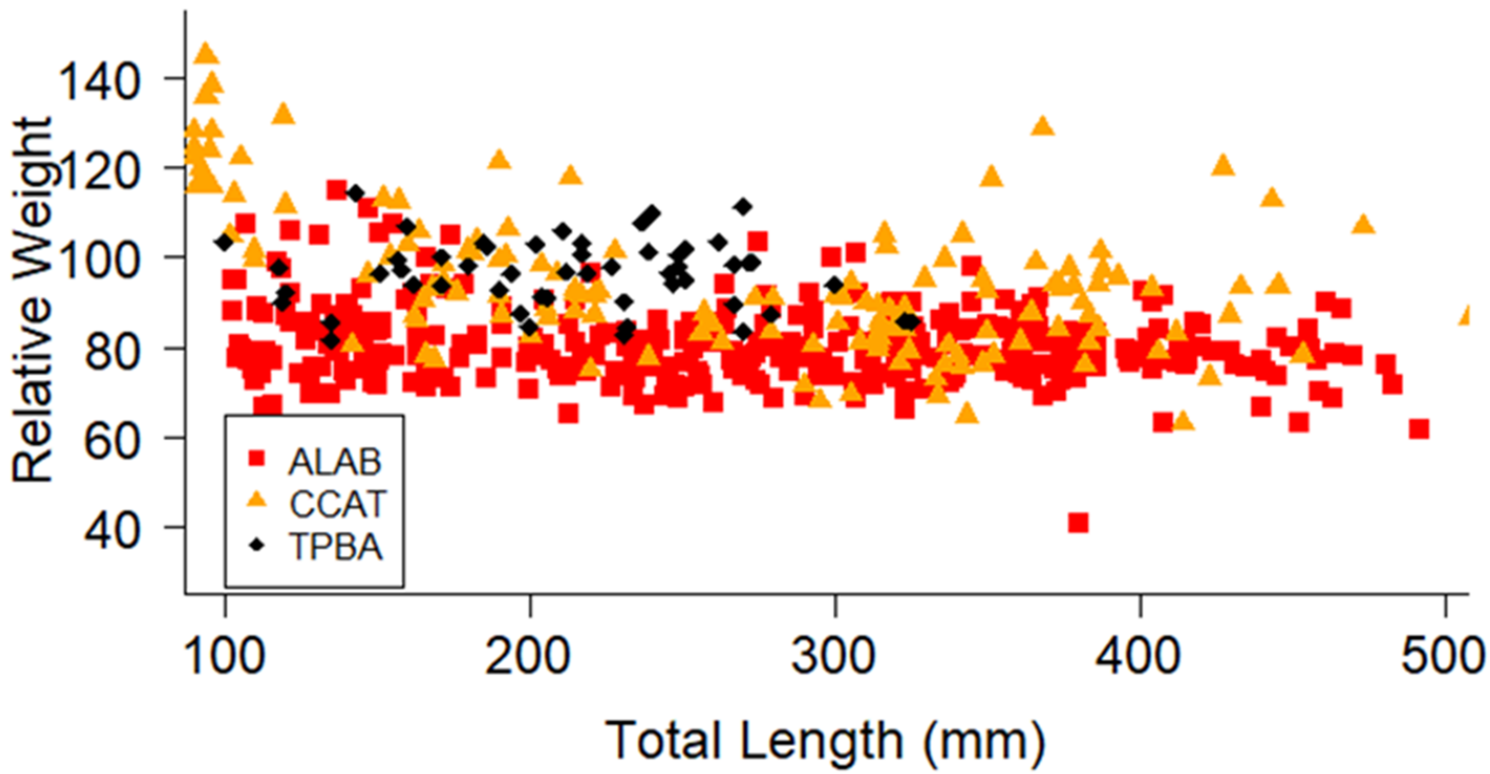
Redbreast Sunfish (n=304)
Relative Condition
110
105
100
95
A
A
A
A
n=24
n=53
n=95
n=162
LB
TR
WD
HB
Site



Alabama Bass (n=367)
Relative Weight
Site
90
85
80
75
70
B
A
A
A
n=54
n=55
n=137
n=121
LB
TR
WD
HB

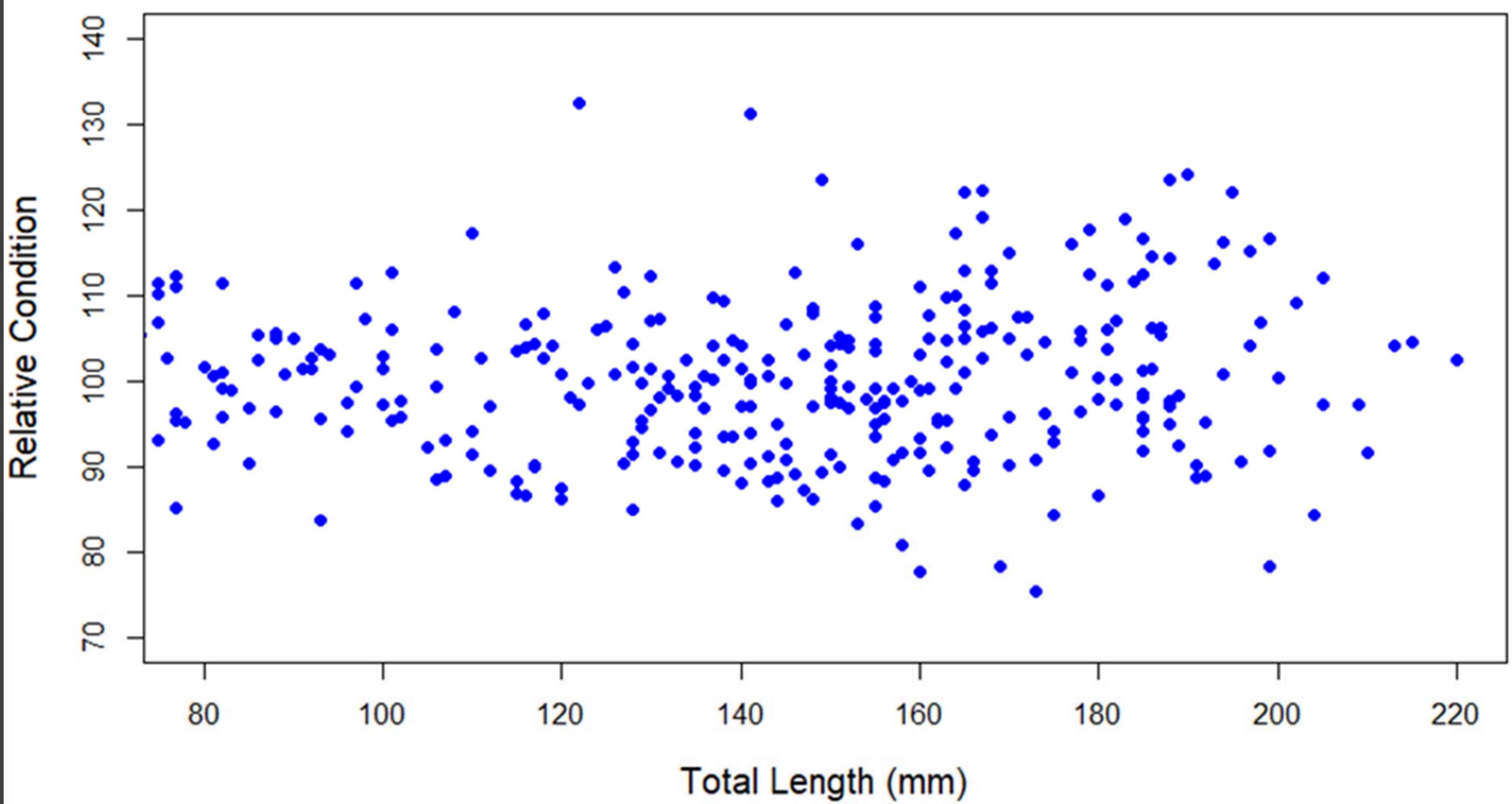


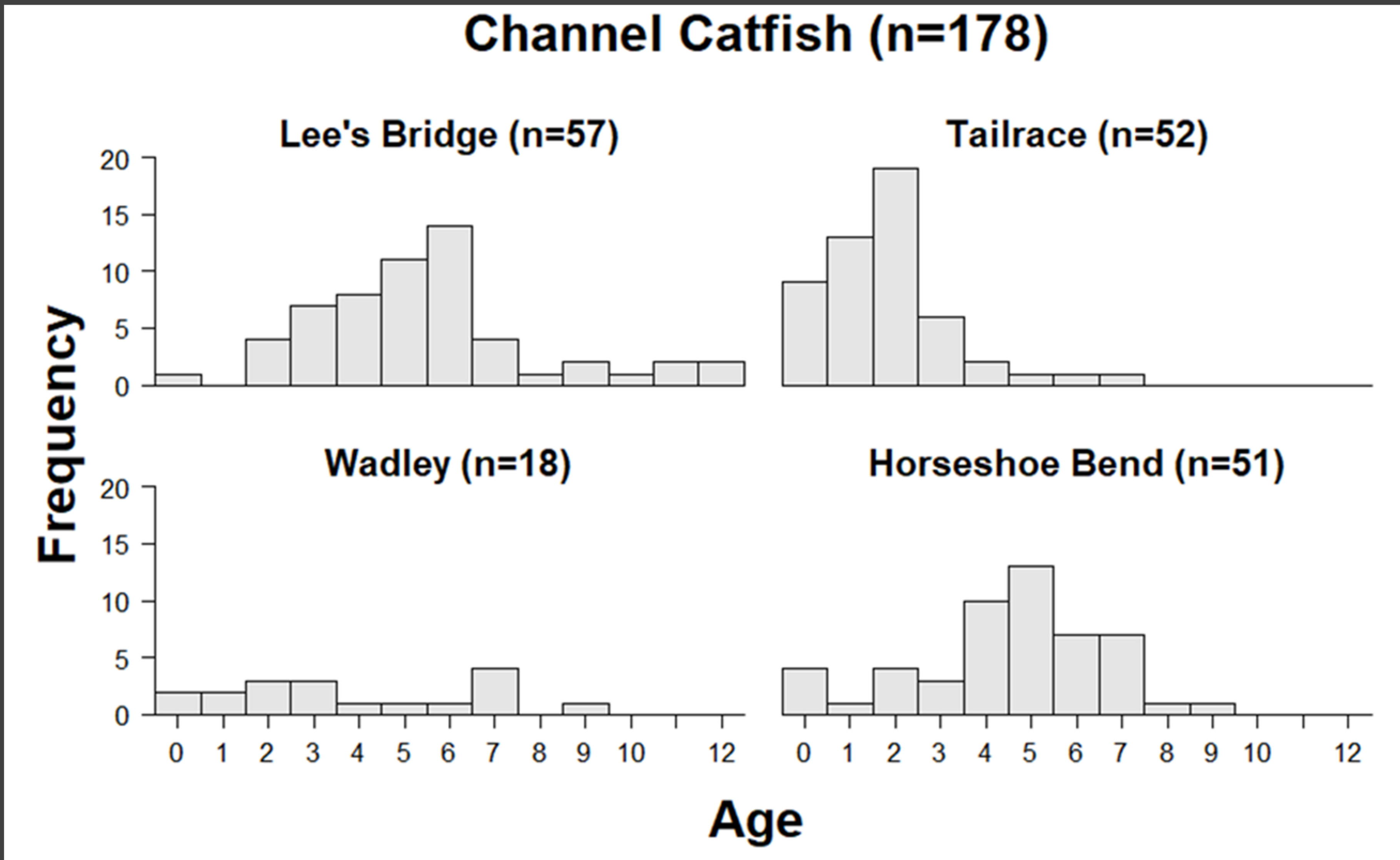
Tallapoosa Bass (n=58)
Relative Weight
130
120
110
100
90
80
70
A
A
A
A
n=2
n=3
n=20
n=33
LB
TR
WD
HB
Site

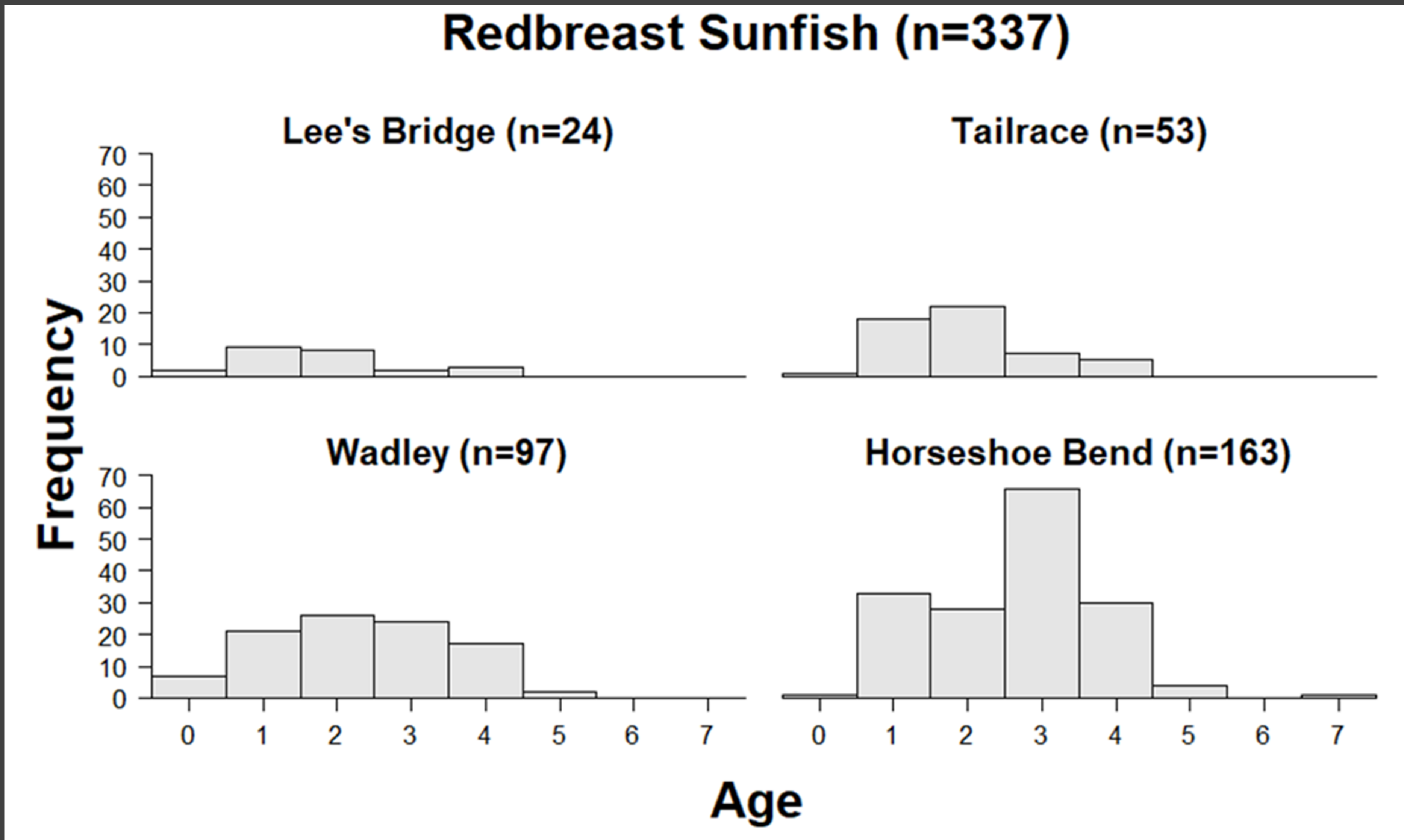


Relative Weight
140
120
100
80
60
40
100
200
300
400
500
Total Length (mm)
ALAB
CCAT
TPBA

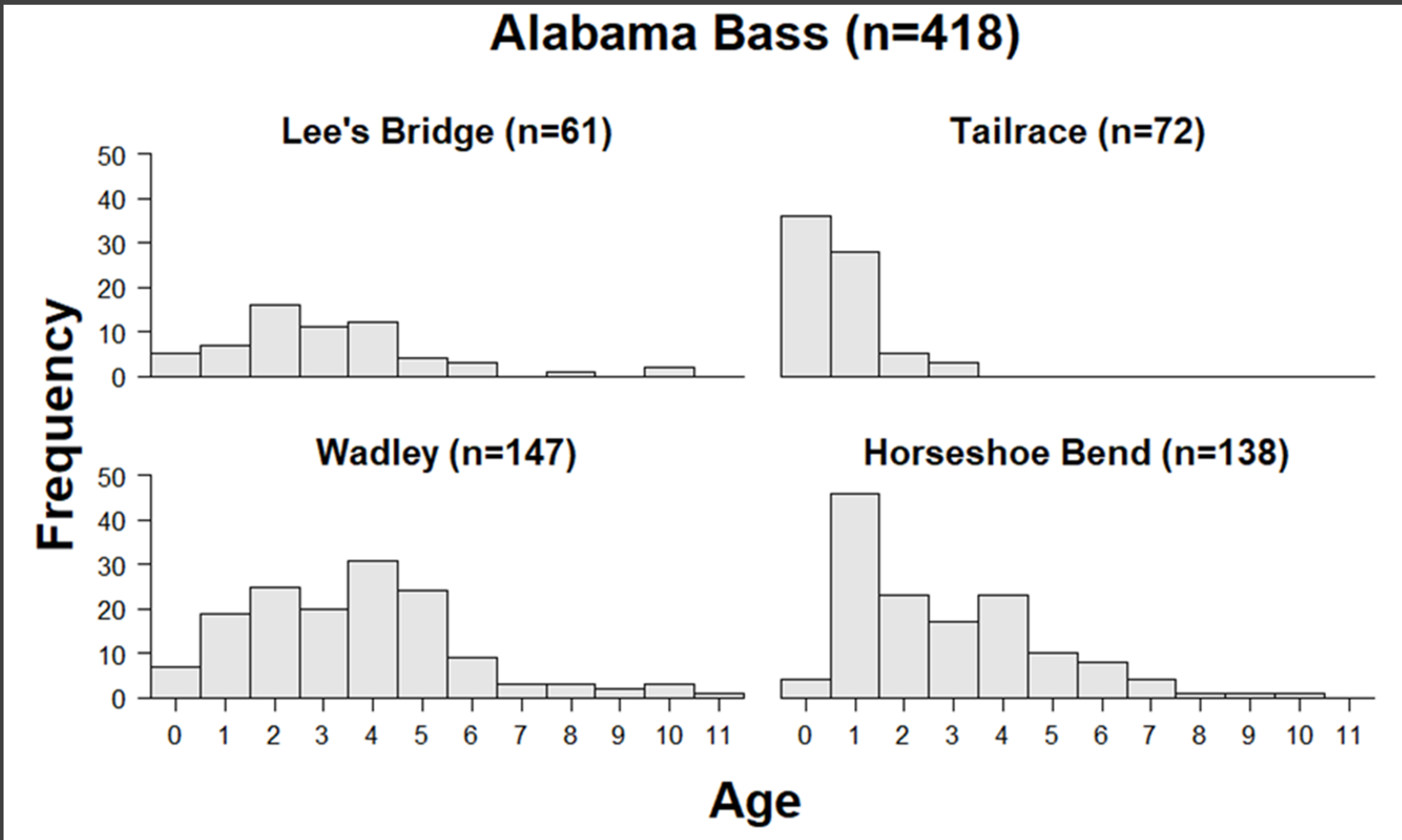
Redbreast Sunfish (n=304)

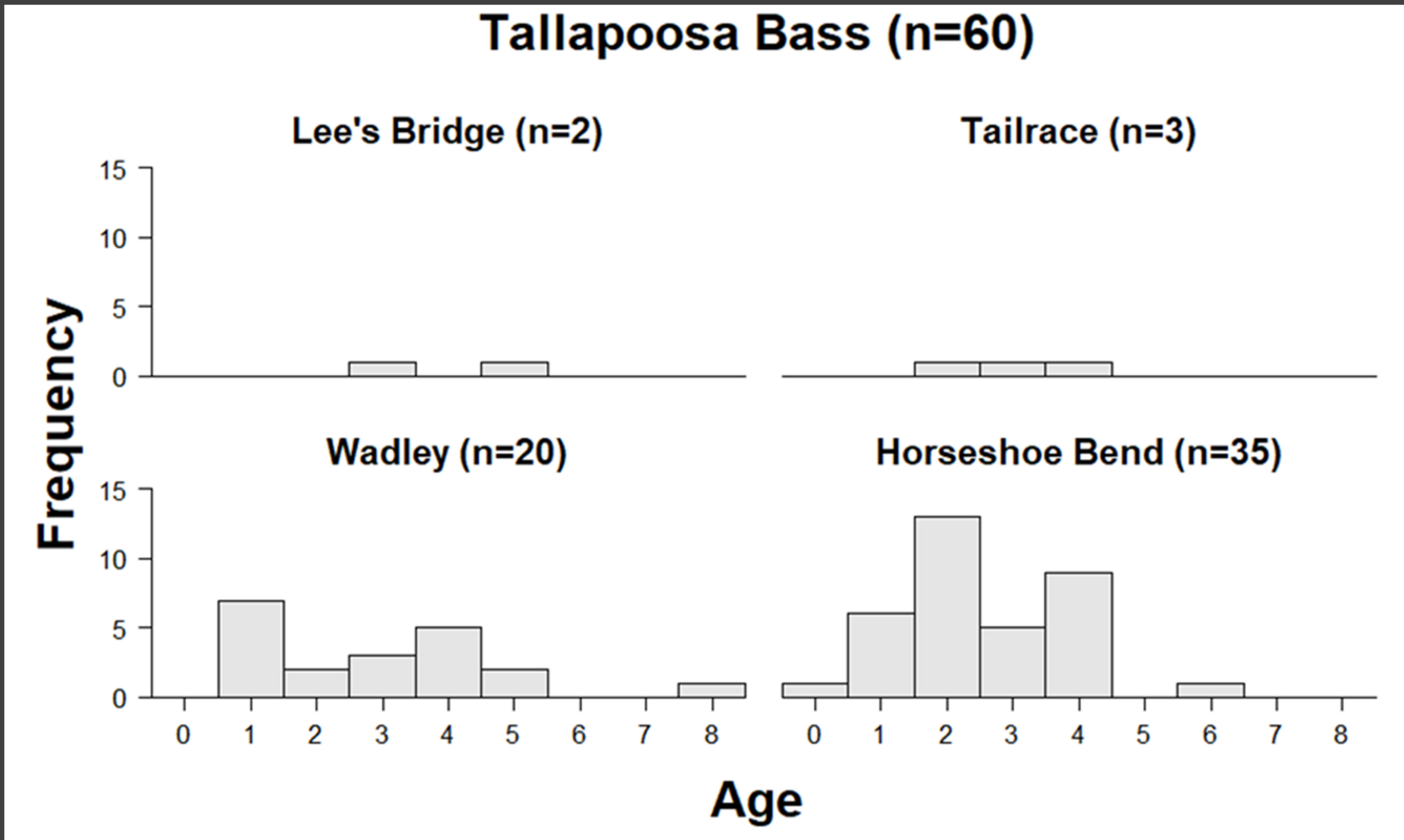


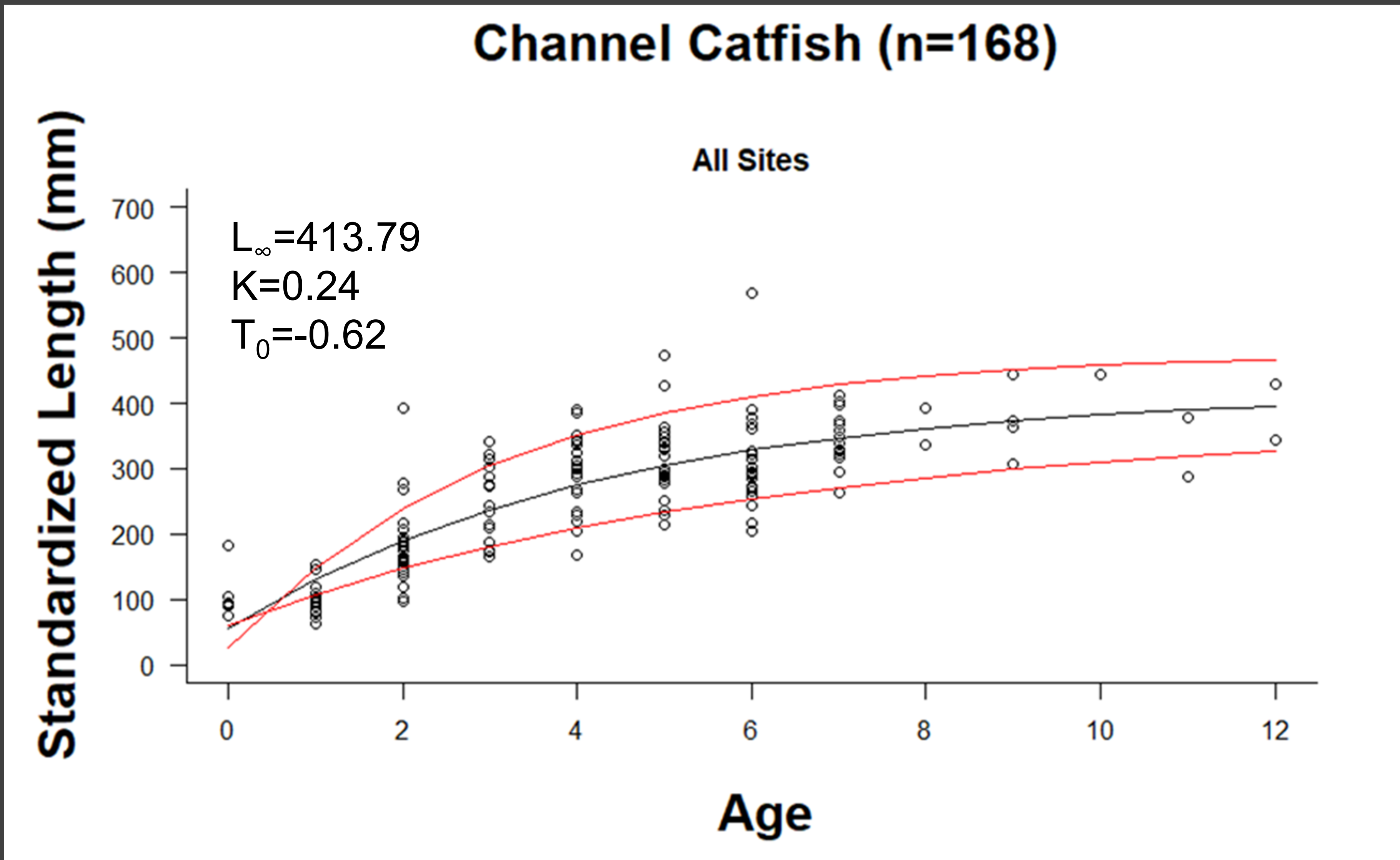

Channel Catfish (n=178)
Lee's Bridge (n=57)
Tailrace (n=52)
Wadley (n=18)
Horseshoe Bend (n=51)
Frequency
0
5
10
15
20
0 1 2 3 4 5 6 7 8 9 10 12
Age

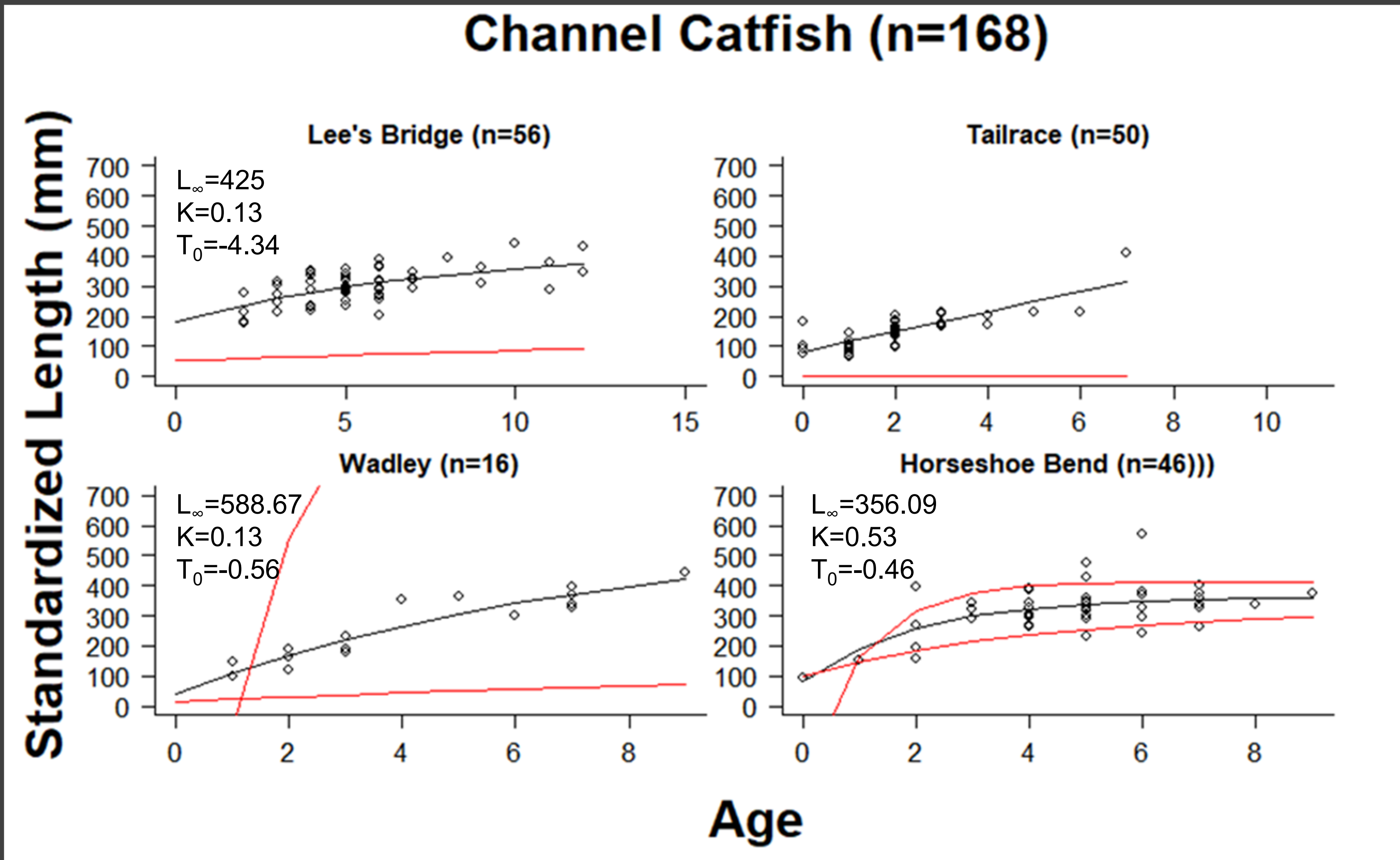


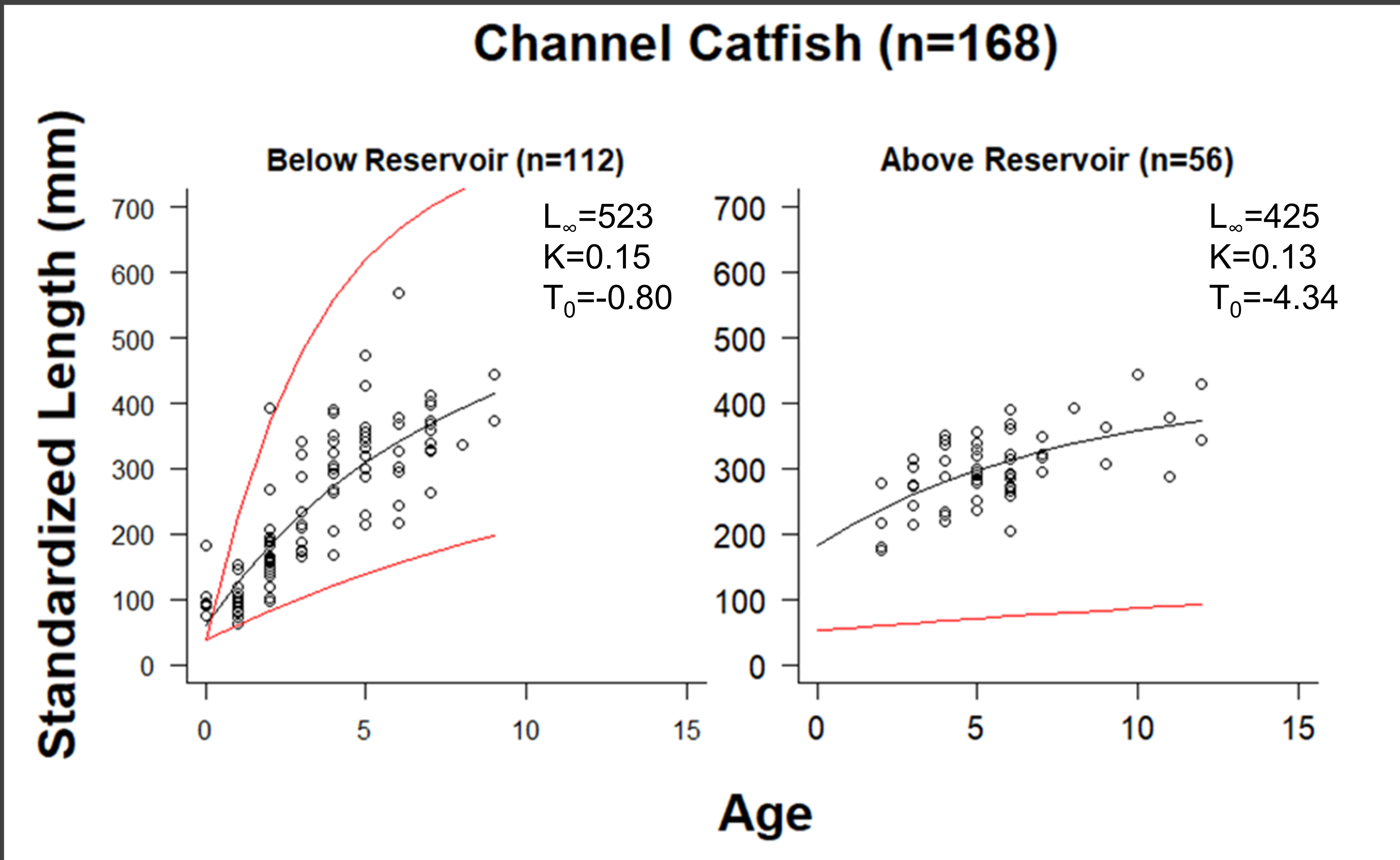
Redbreast Sunfish (n=337)
Lee's Bridge (n=24)
Tailrace (n=53)
Wadley (n=97)
Horseshoe Bend (n=163)
Frequency
Age
0
10
20
30
40
50
60
70
0
1
2
3
4
5
6
7


Alabama Bass (n=418)
Lee's Bridge (n=61)
Tailrace (n=72)
Wadley (n=147)
Horseshoe Bend (n=138)
Frequency
Age
0
10
20
30
40
50
0
1
2
3
4
5
6
7
8
9
10
11

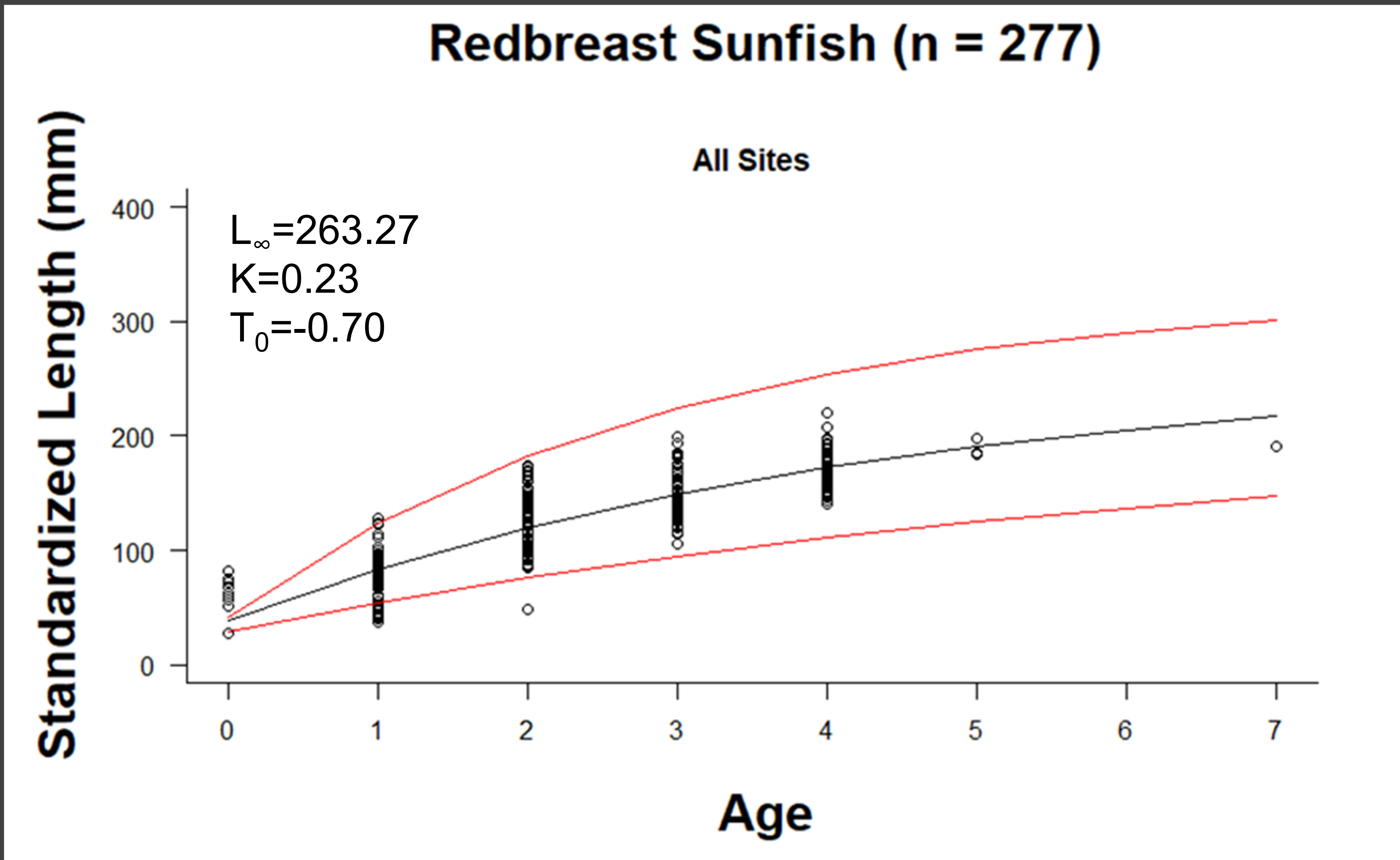

Tallapoosa Bass (n=60)
Lee's Bridge (n=2)
Tailrace (n=3)
Wadley (n=20)
Horseshoe Bend (n=35)
Frequency
0
5
10
15
0 1 2 3 4 5 6 7 8
Age

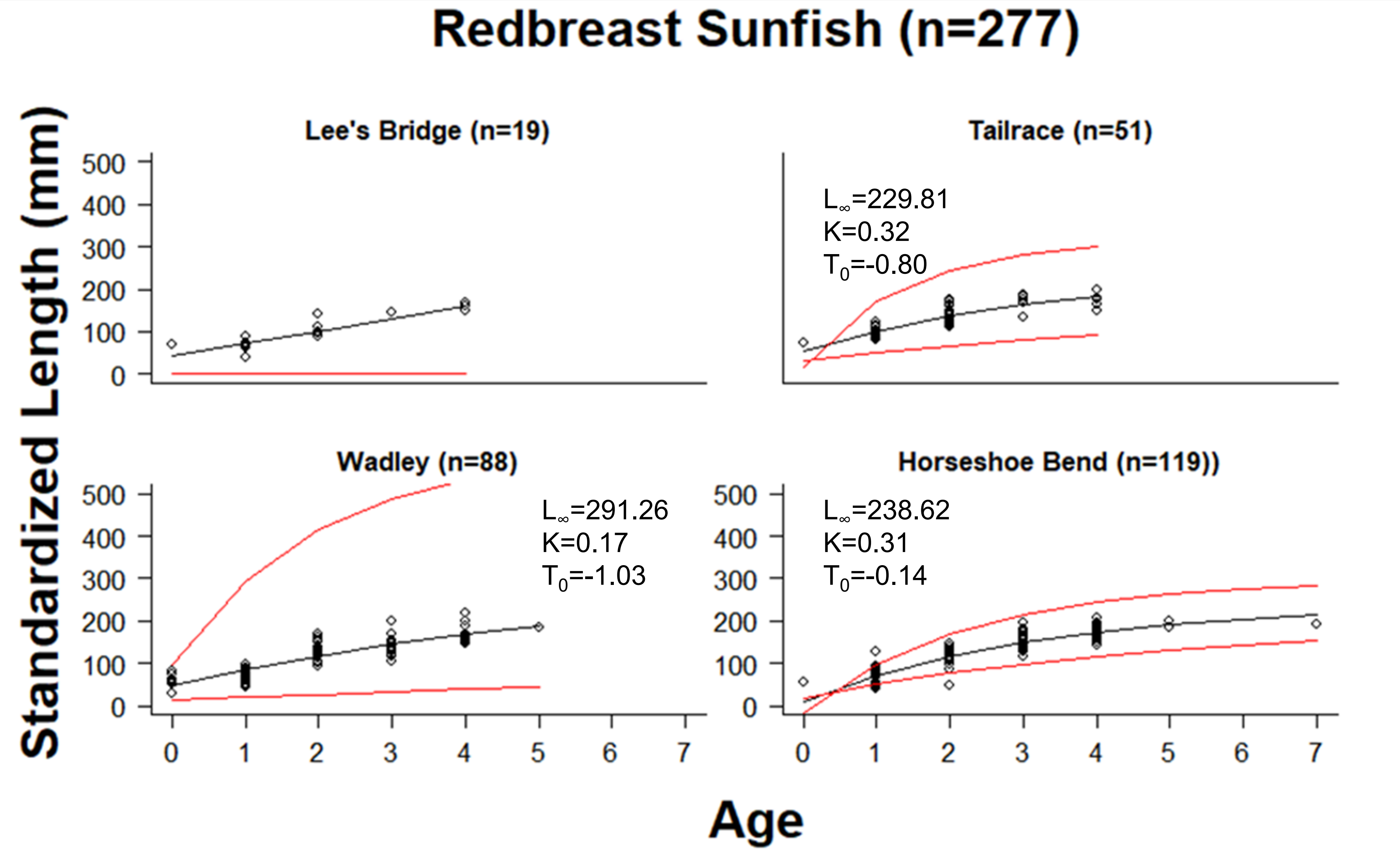

Channel Catfish (n=168)
All Sites
L_∞=413.79
K=0.24
T_0=-0.62
Standardized Length (mm)
0
100
200
300
400
500
600
700
0
2
4
6
8
10
12
Age

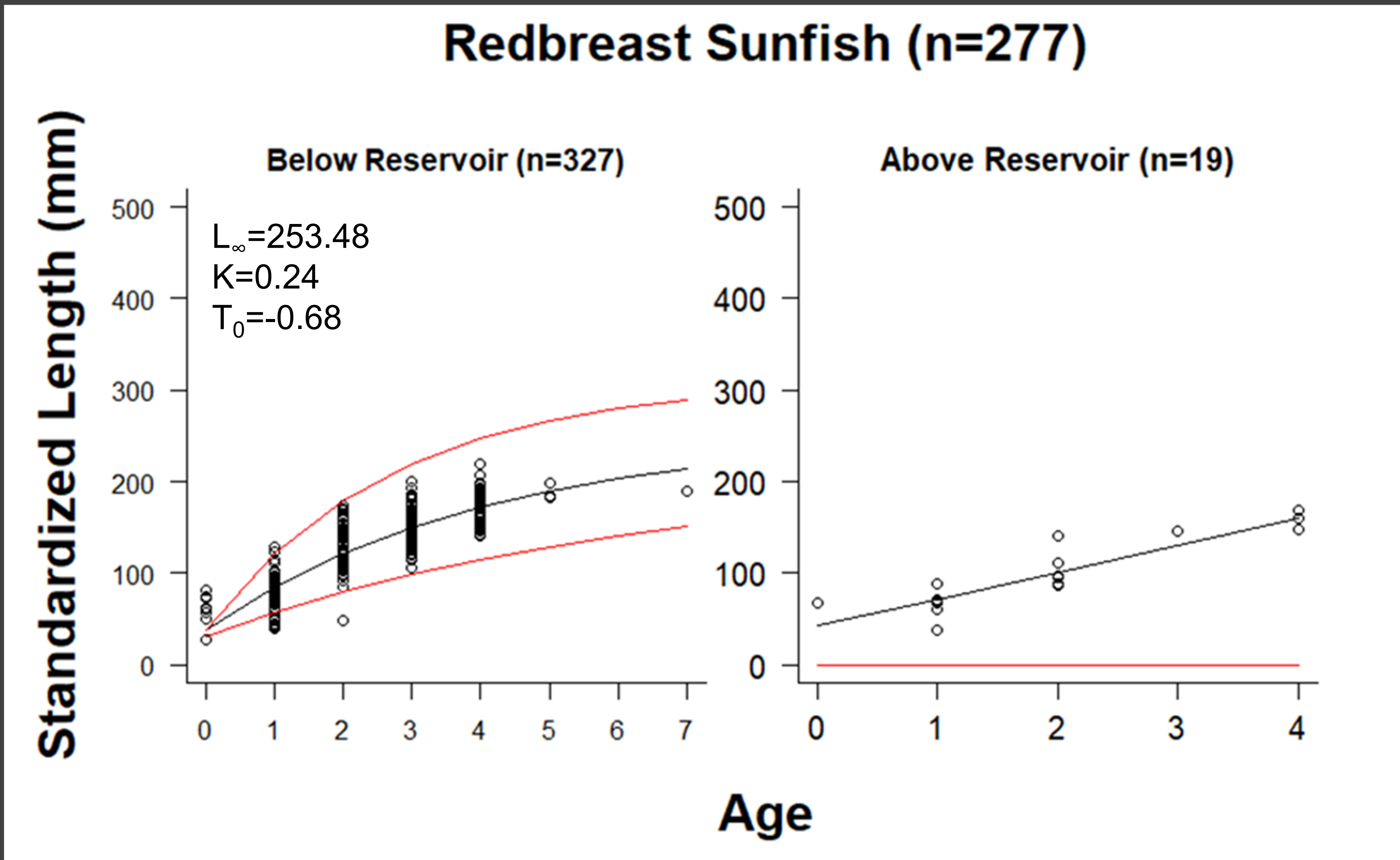

Channel Catfish (n=168)
Lee's Bridge (n=56)
L∞=425
K=0.13
T0=-4.34
Tailrace (n=50)
Wadley (n=16)
L∞=588.67
K=0.13
T0=-0.56
Horseshoe Bend (n=46)))
L∞=356.09
K=0.53
T0=-0.46
Standardized Length (mm)
Age



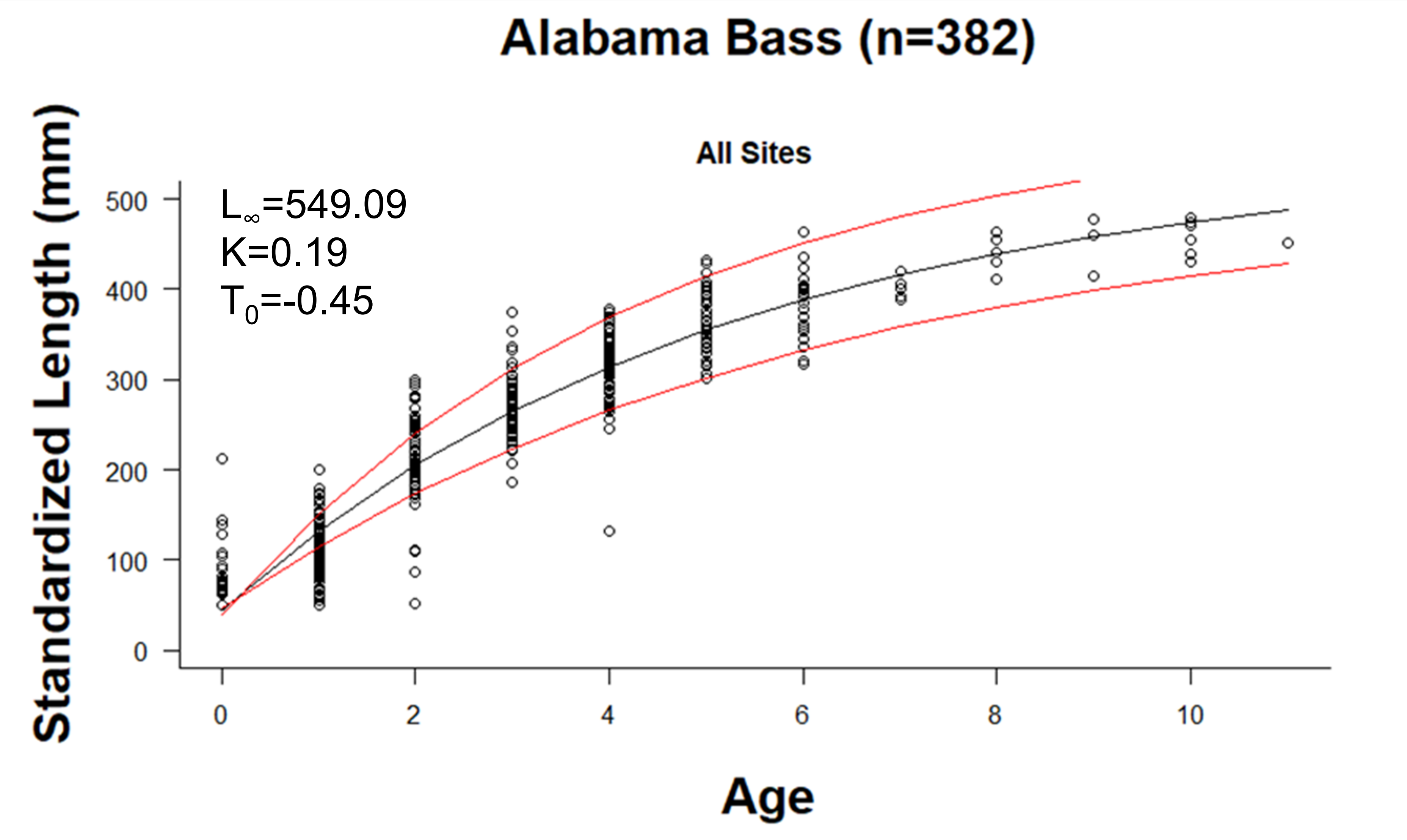
Channel Catfish (n=168)
Below Reservoir (n=112)
Above Reservoir (n=56)
L_∞=523
K=0.15
T_0=-0.80
L_∞=425
K=0.13
T_0=-4.34
Standardized Length (mm)
0
100
200
300
400
500
600
700
0
5
10
15
Age


Redbreast Sunfish (n = 277)
All Sites
L_∞=263.27
K=0.23
T_0=-0.70
Standardized Length (mm)
400
300
200
100
0
0
1
2
3
4
5
6
7
Age

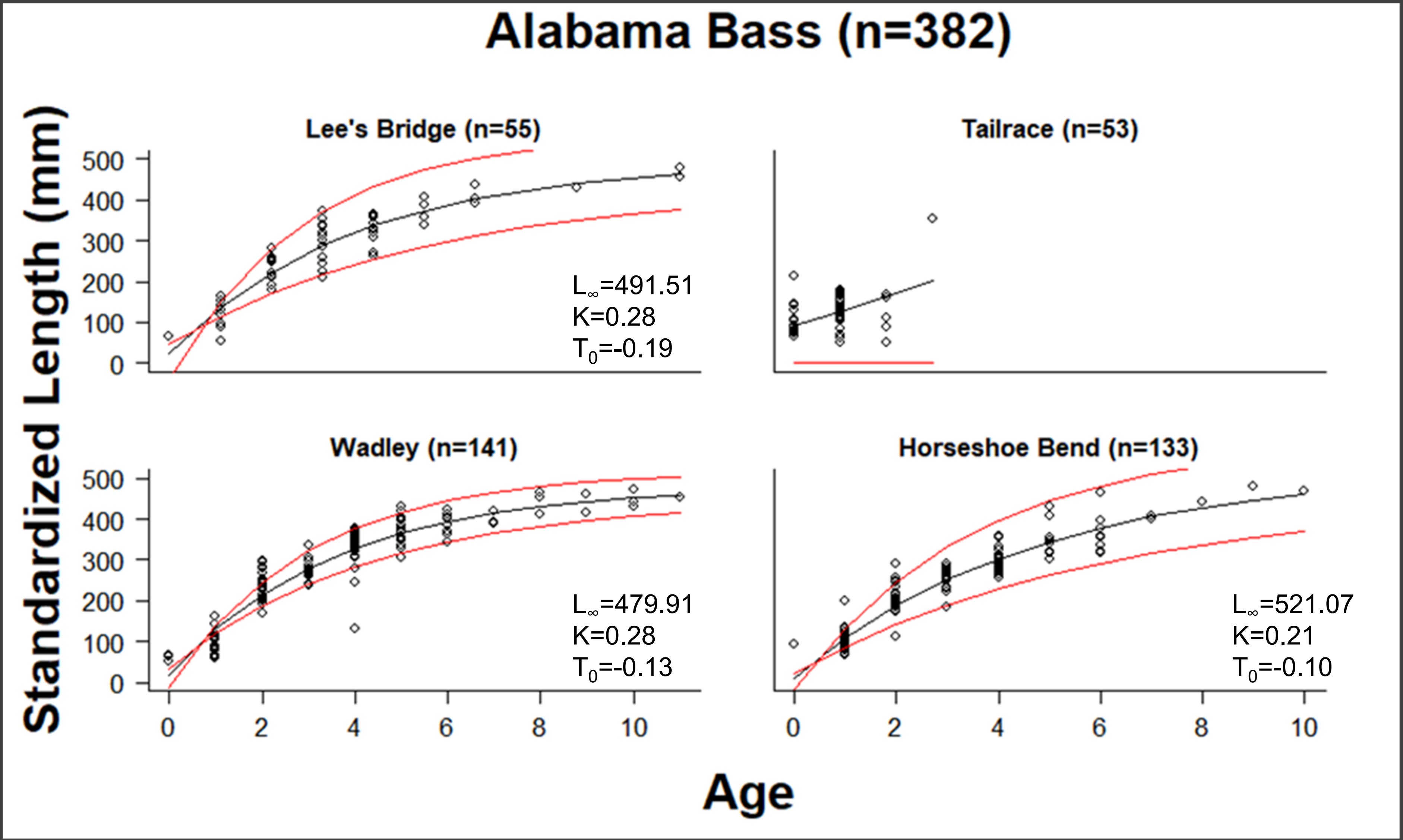

Redbreast Sunfish (n=277)
Lee's Bridge (n=19)
Tailrace (n=51)
L∞=229.81
K=0.32
T0=-0.80
Wadley (n=88)
L∞=291.26
K=0.17
T0=-1.03
Horseshoe Bend (n=119))
L∞=238.62
K=0.31
T0=-0.14
Standardized Length (mm)
Age
0
100
200
300
400
500
0
1
2
3
4
5
6
7



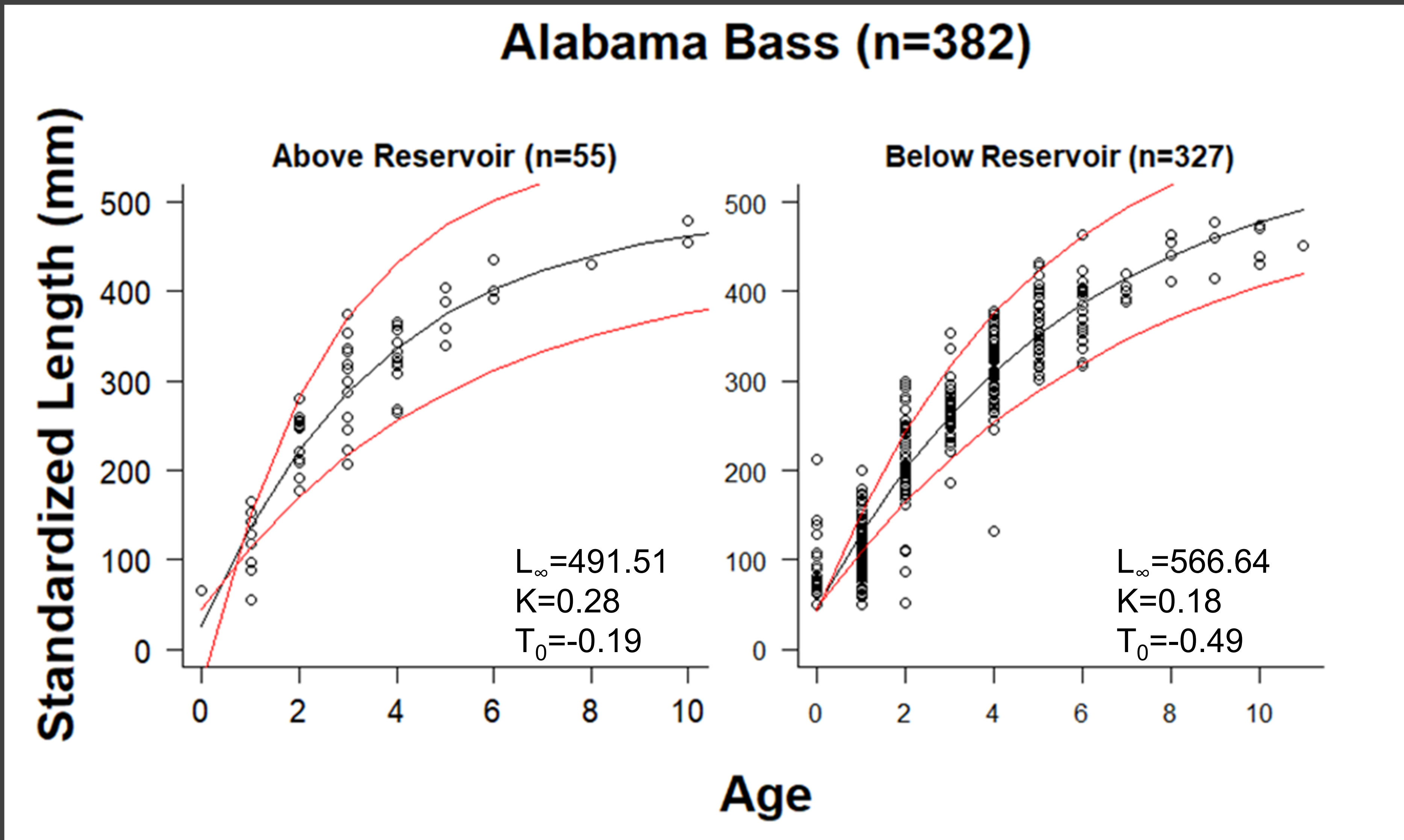
Redbreast Sunfish (n=277)
Below Reservoir (n=327)
Above Reservoir (n=19)
L_∞=253.48
K=0.24
T_0=-0.68
Standardized Length (mm)
Age
0
100
200
300
400
500
0
1
2
3
4
5
6
7



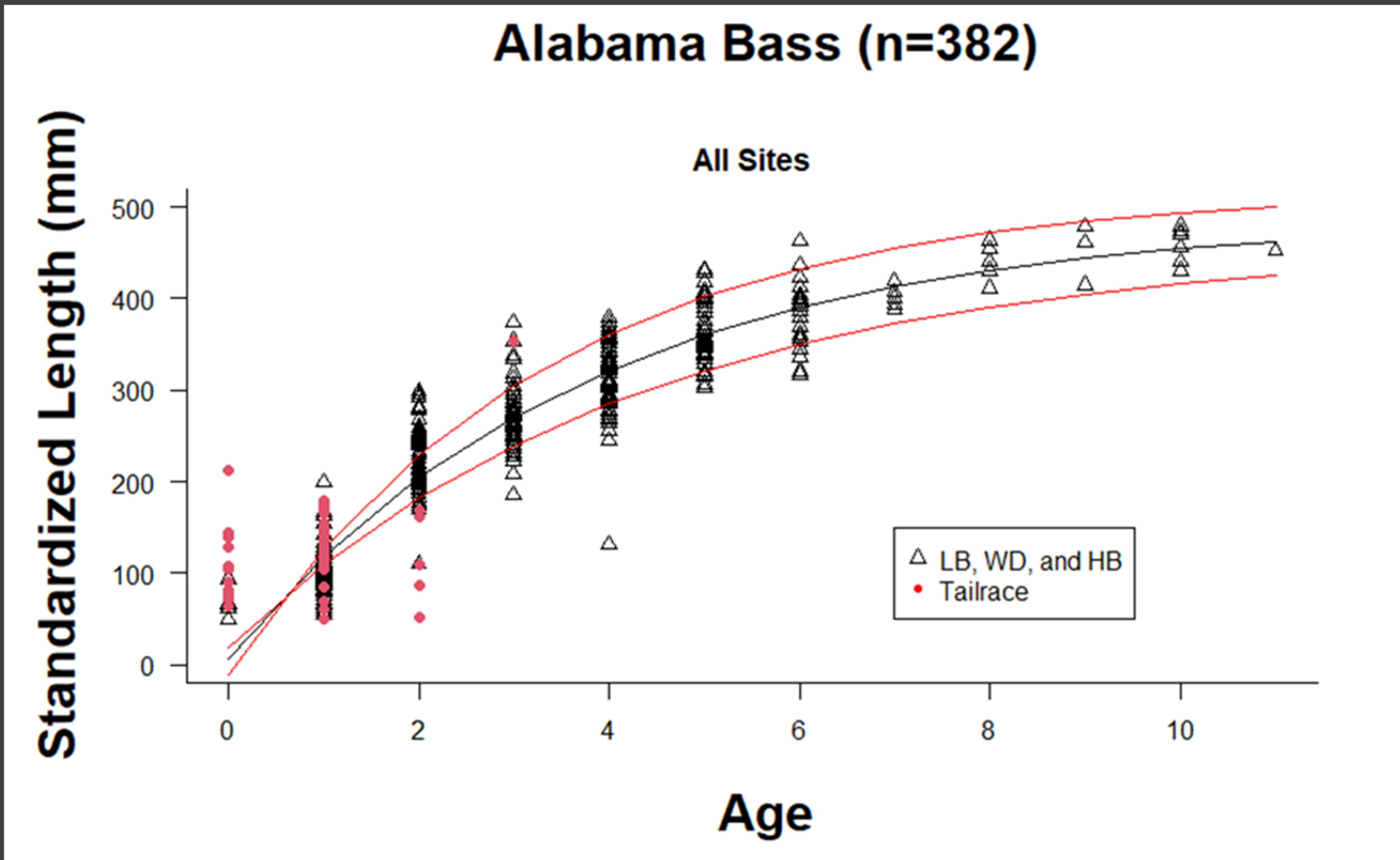
Alabama Bass (n=382)
All Sites
L∞=549.09
K=0.19
T0=-0.45
Standardized Length (mm)
0
100
200
300
400
500
0
2
4
6
8
10
Age



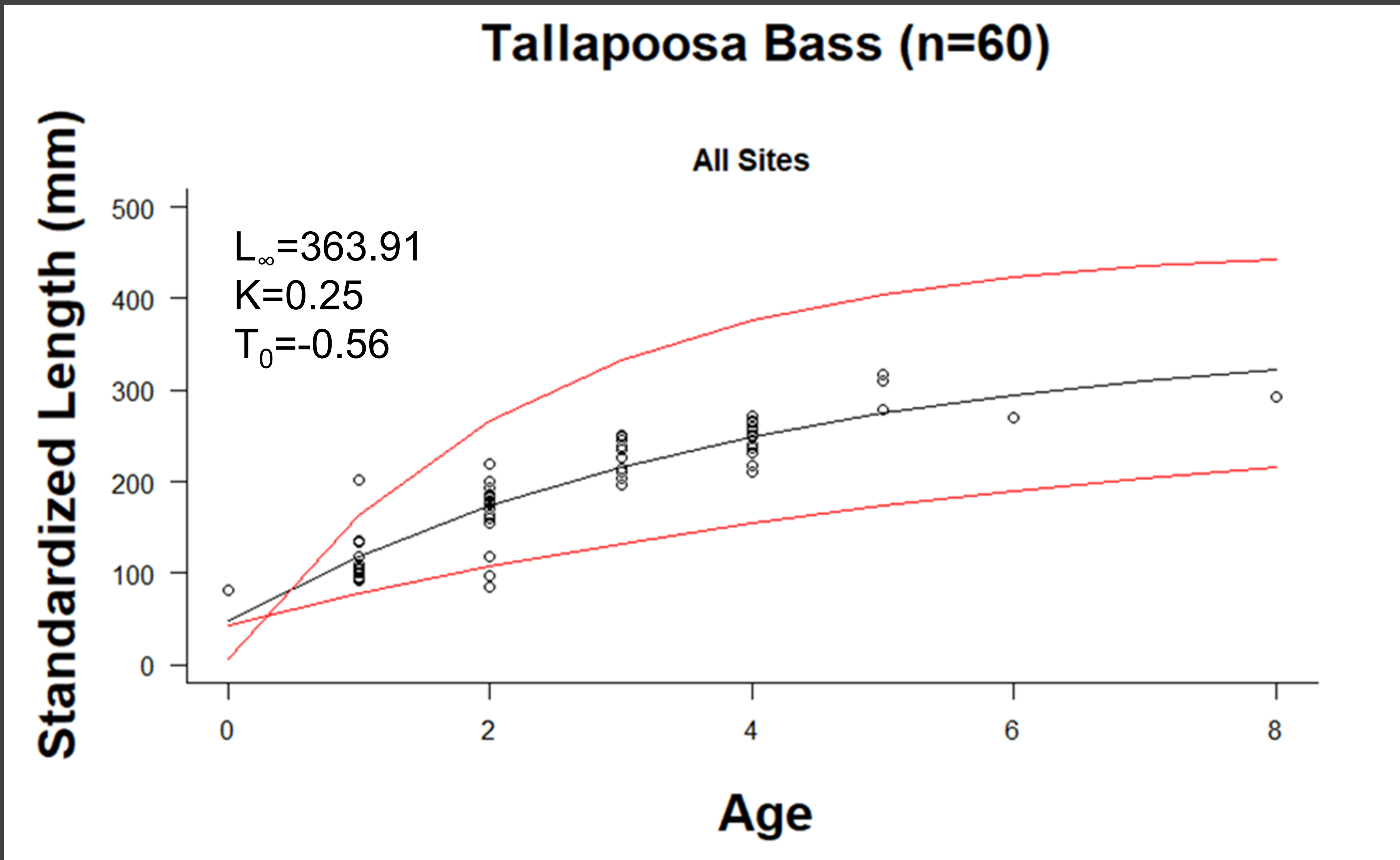
Alabama Bass (n=382)
Lee's Bridge (n=55)
Tailrace (n=53)
Wadley (n=141)
Horseshoe Bend (n=133)
Standardized Length (mm)
Age
0
100
200
300
400
500
0
2
4
6
8
10
L∞=491.51
K=0.28
T0=-0.19
L∞=479.91
K=0.28
T0=-0.13
L∞=521.07
K=0.21
T0=-0.10

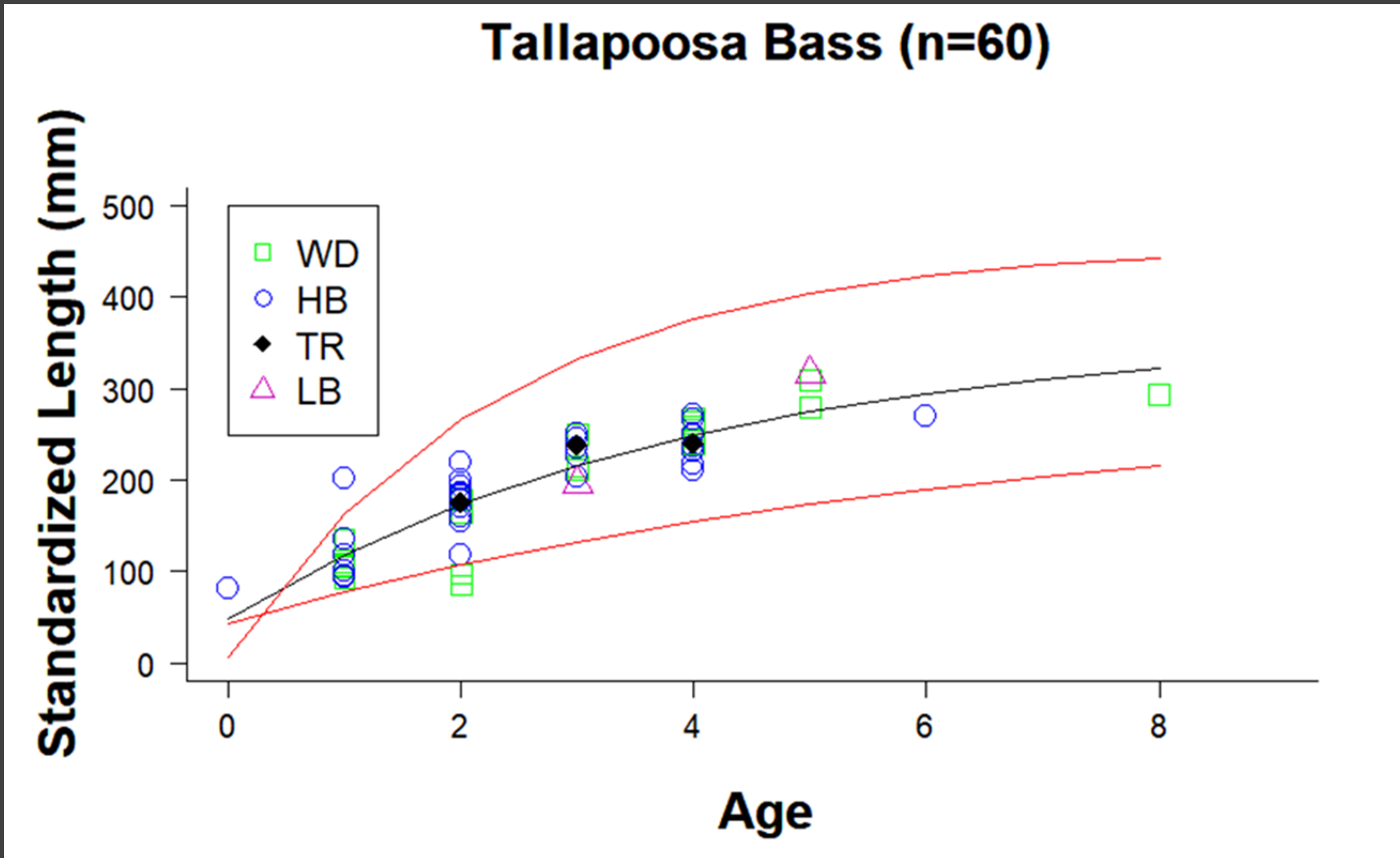


Alabama Bass (n=382)
Above Reservoir (n=55)
Below Reservoir (n=327)
Standardized Length (mm)
Age
L_∞=491.51
K=0.28
T_0=-0.19
L_∞=566.64
K=0.18
T_0=-0.49



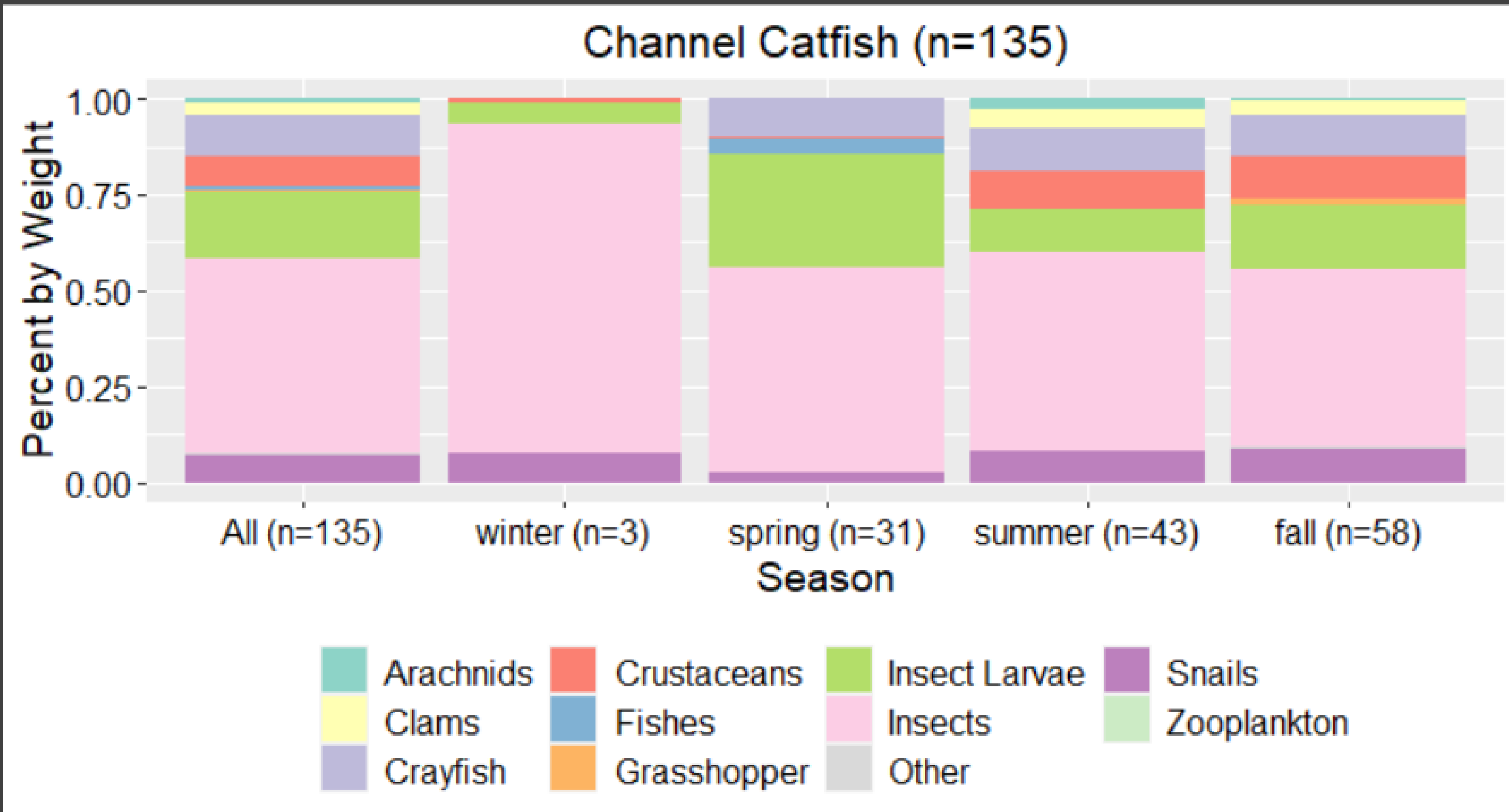
Alabama Bass (n=382)
All Sites
Standardized Length (mm)
500
400
300
200
100
0
0
2
4
6
8
10
Age
LB, WD, and HB
Tailrace


Tallapoosa Bass (n=60)
All Sites
L∞=363.91
K=0.25
T0=-0.56
Standardized Length (mm)
500
400
300
200
100
0
0
2
4
6
8
Age

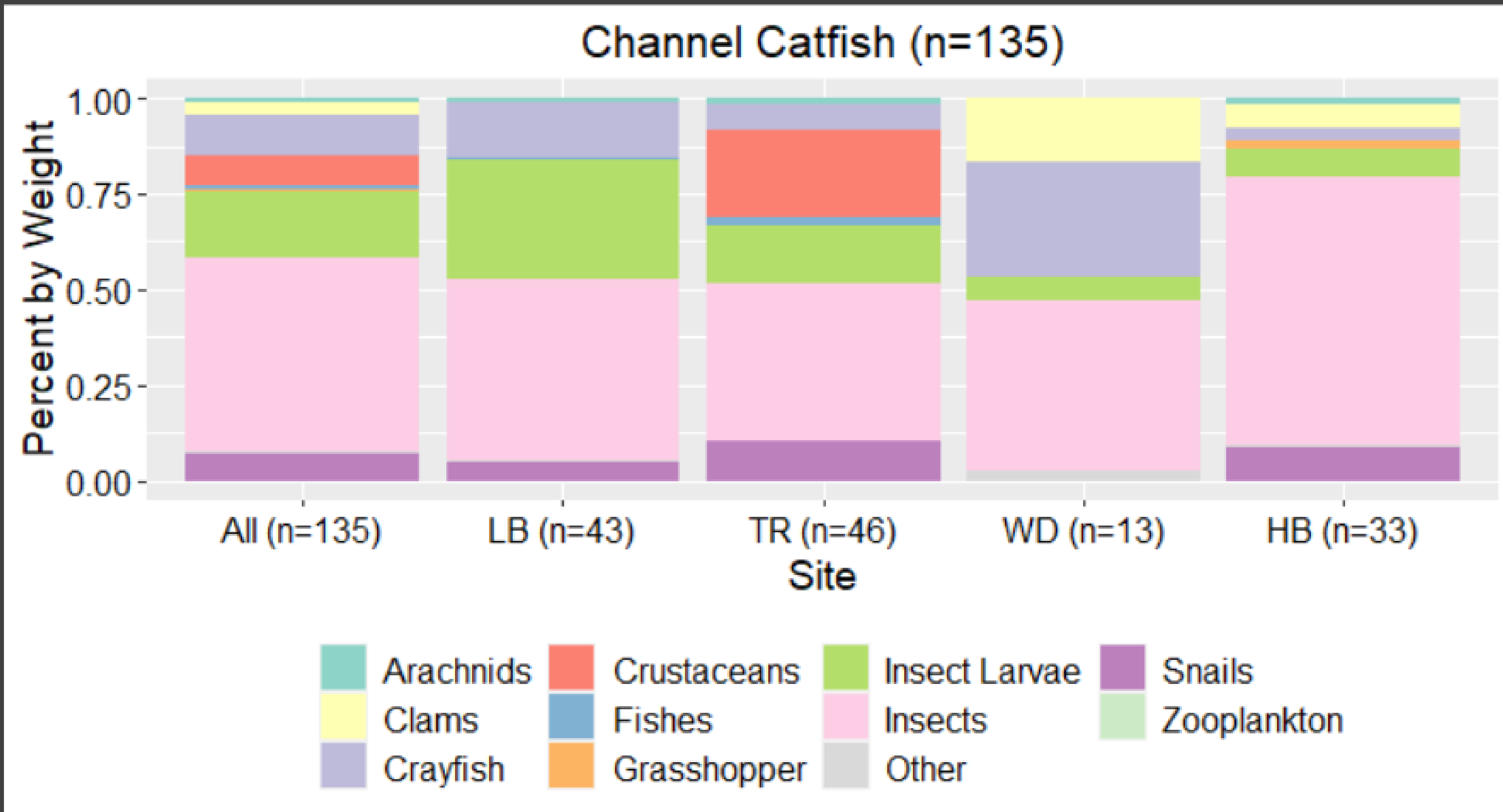


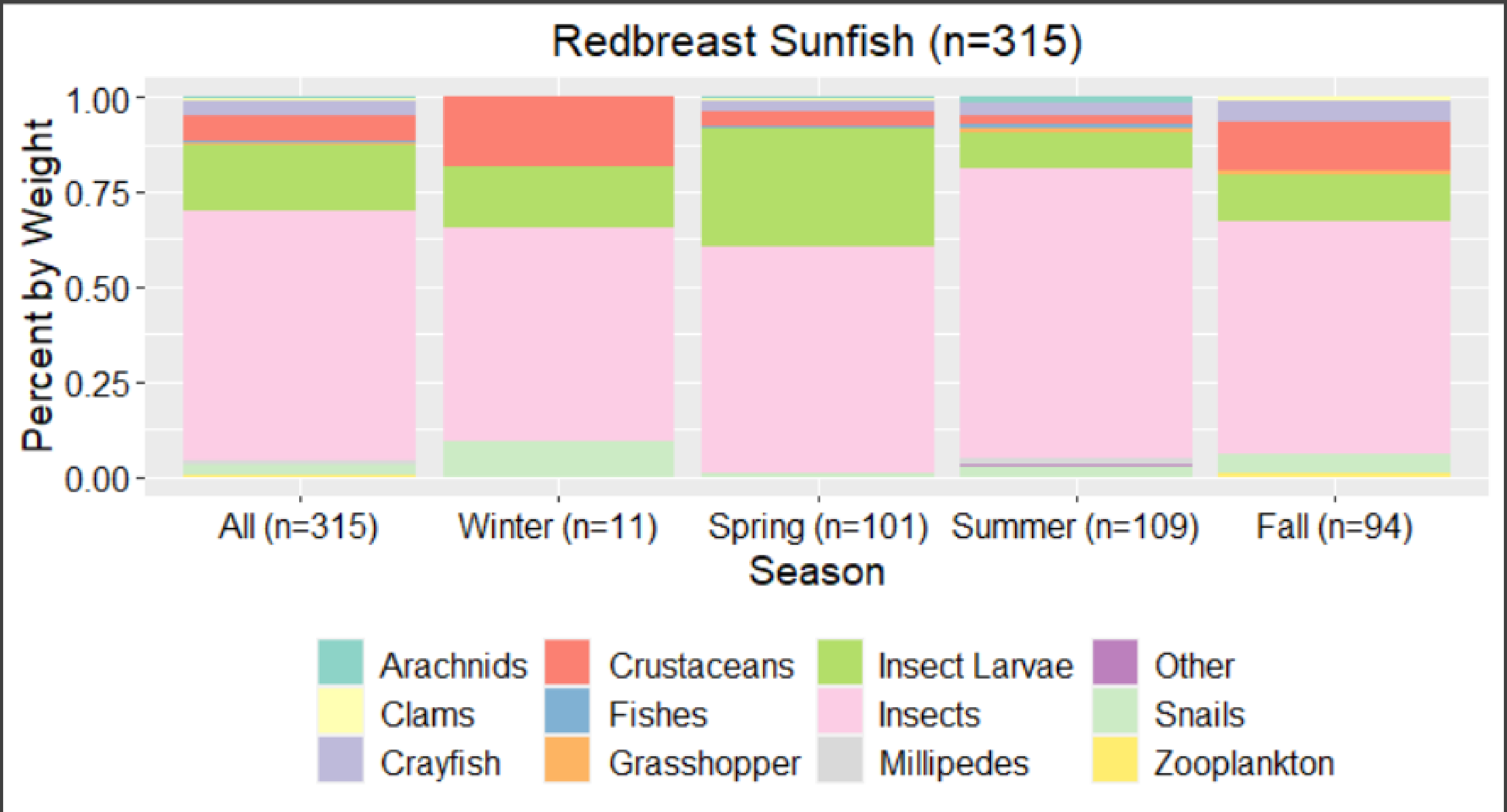
Tallapoosa Bass (n=60)
Standardized Length (mm)
500
400
300
200
100
0
WD
HB
TR
LB
0
2
4
6
8
Age

Results: diet

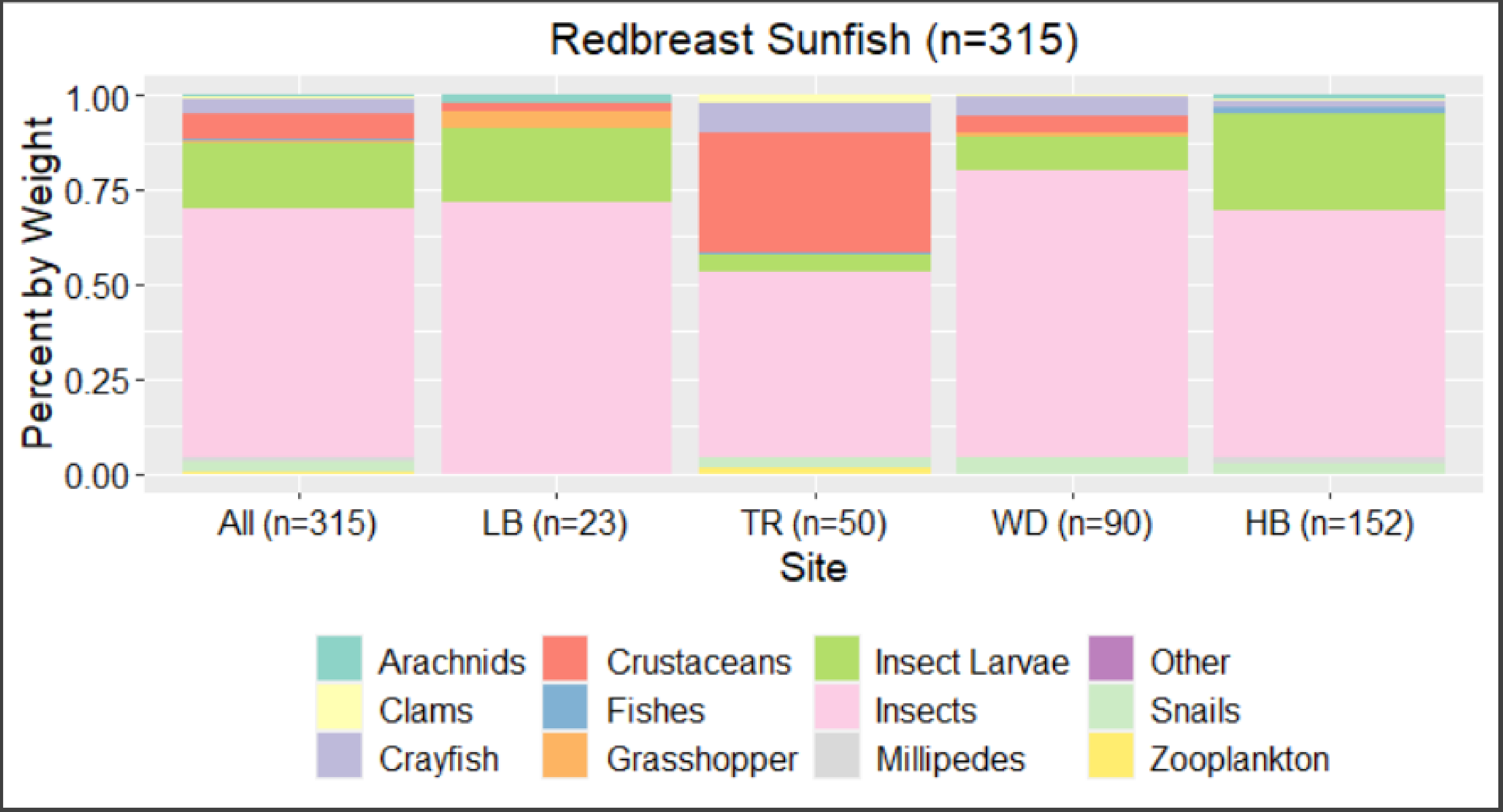


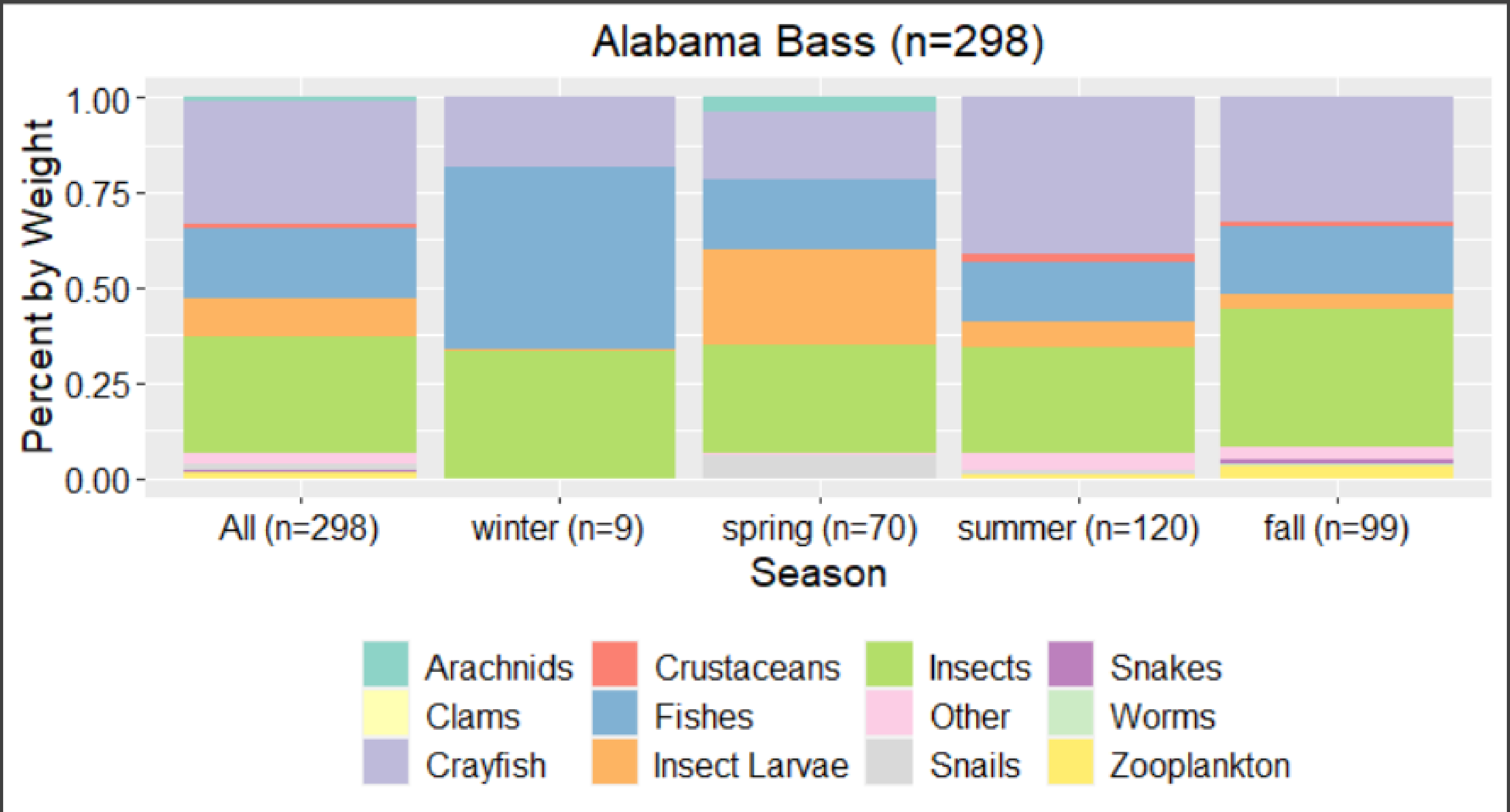
Channel Catfish (n=135)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=135)
winter (n=3)
spring (n=31)
summer (n=43)
fall (n=58)
Season
Arachnids
Clams
Crayfish
Crustaceans
Fishes
Grasshopper
Insect Larvae
Insects
Other
Snails
Zooplankton


Channel Catfish (n=135)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=135)
LB (n=43)
TR (n=46)
WD (n=13)
HB (n=33)
Site
Arachnids
Clams
Crayfish
Crustaceans
Fishes
Grasshopper
Insect Larvae
Insects
Other
Snails
Zooplankton

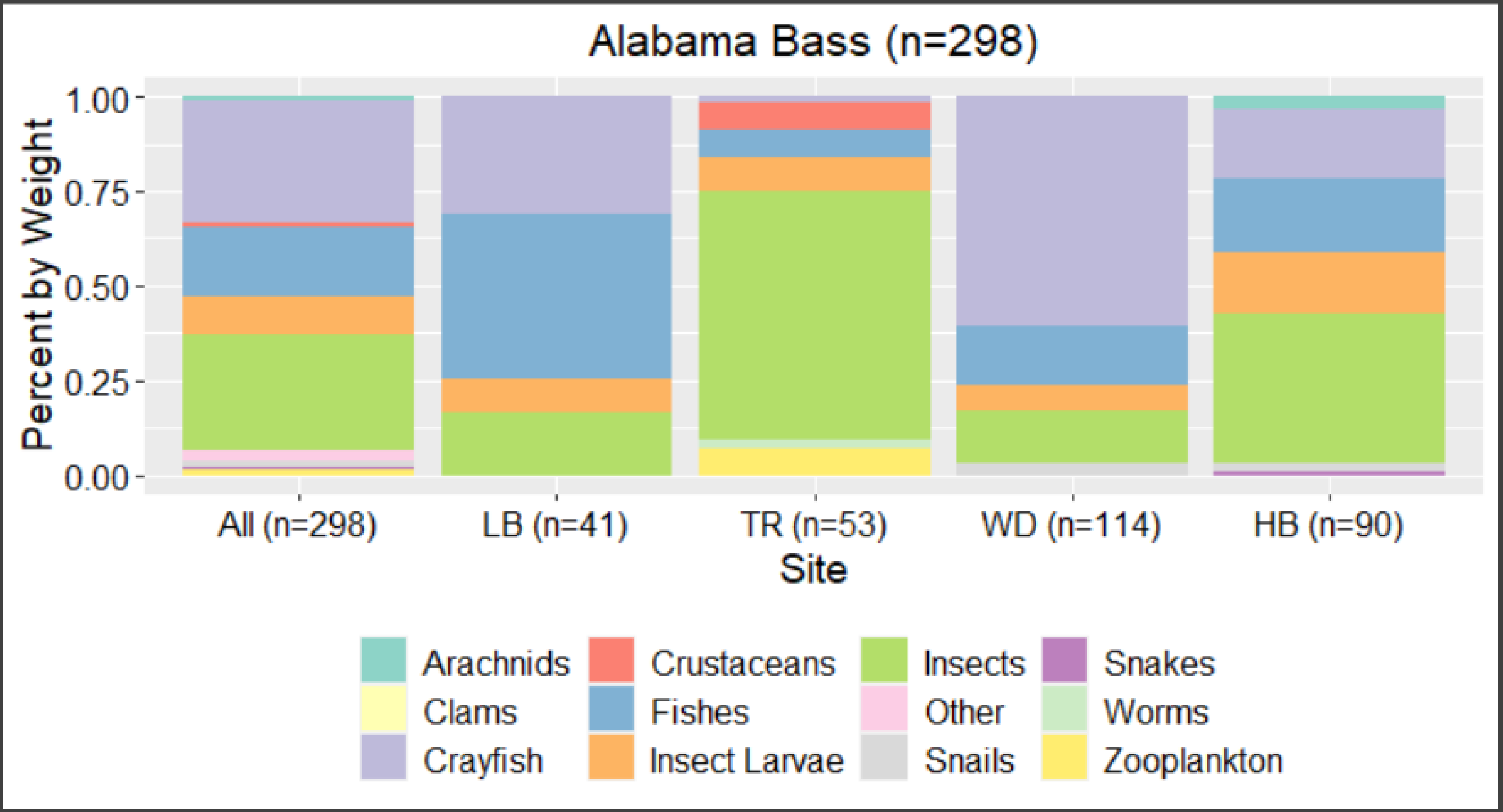


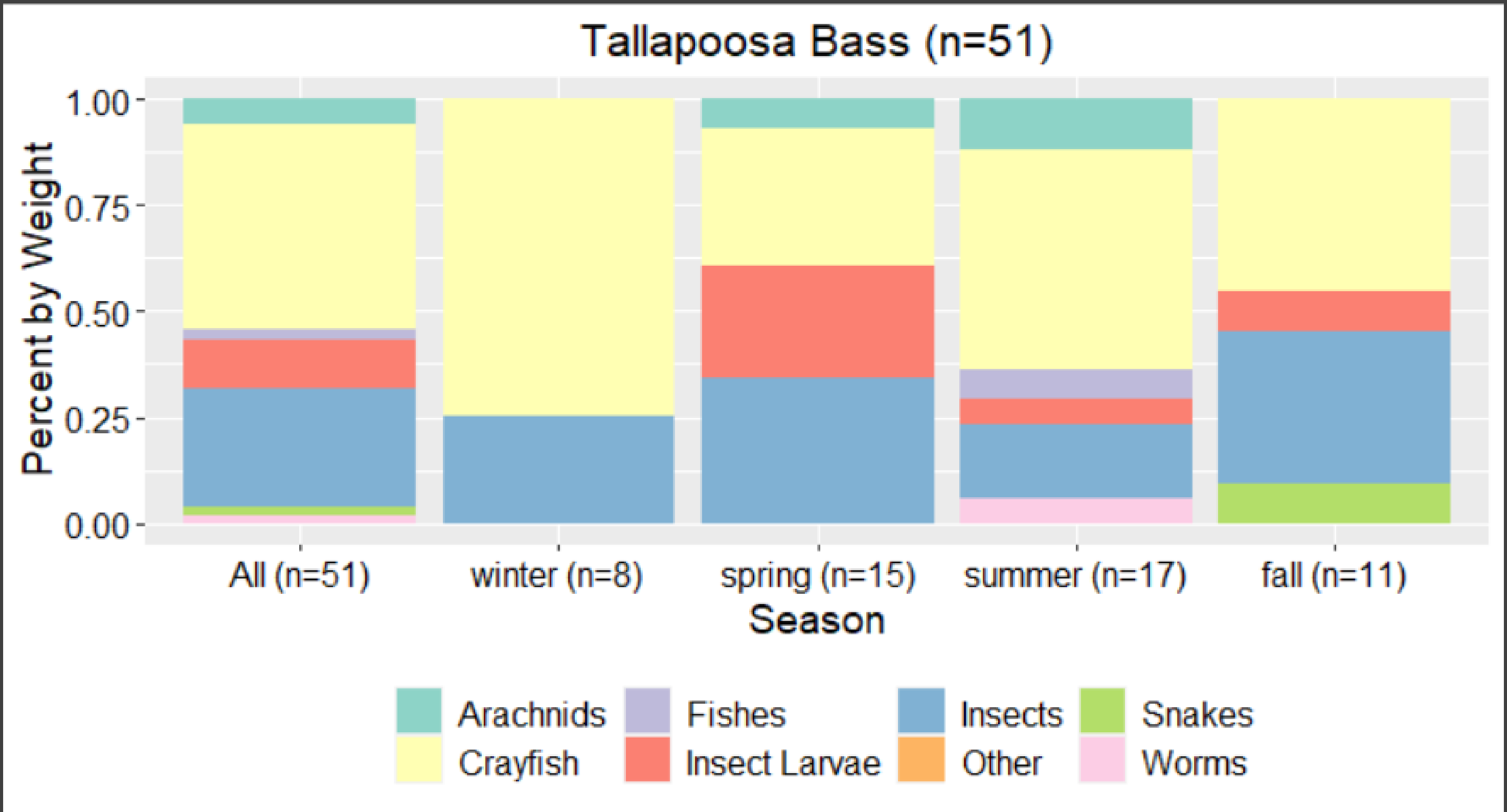
Redbreast Sunfish (n=315)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=315)
Winter (n=11)
Spring (n=101)
Summer (n=109)
Fall (n=94)
Season
Arachnids
Clams
Crayfish
Crustaceans
Fishes
Grasshopper
Insect Larvae
Insects
Millipedes
Other
Snails
Zooplankton

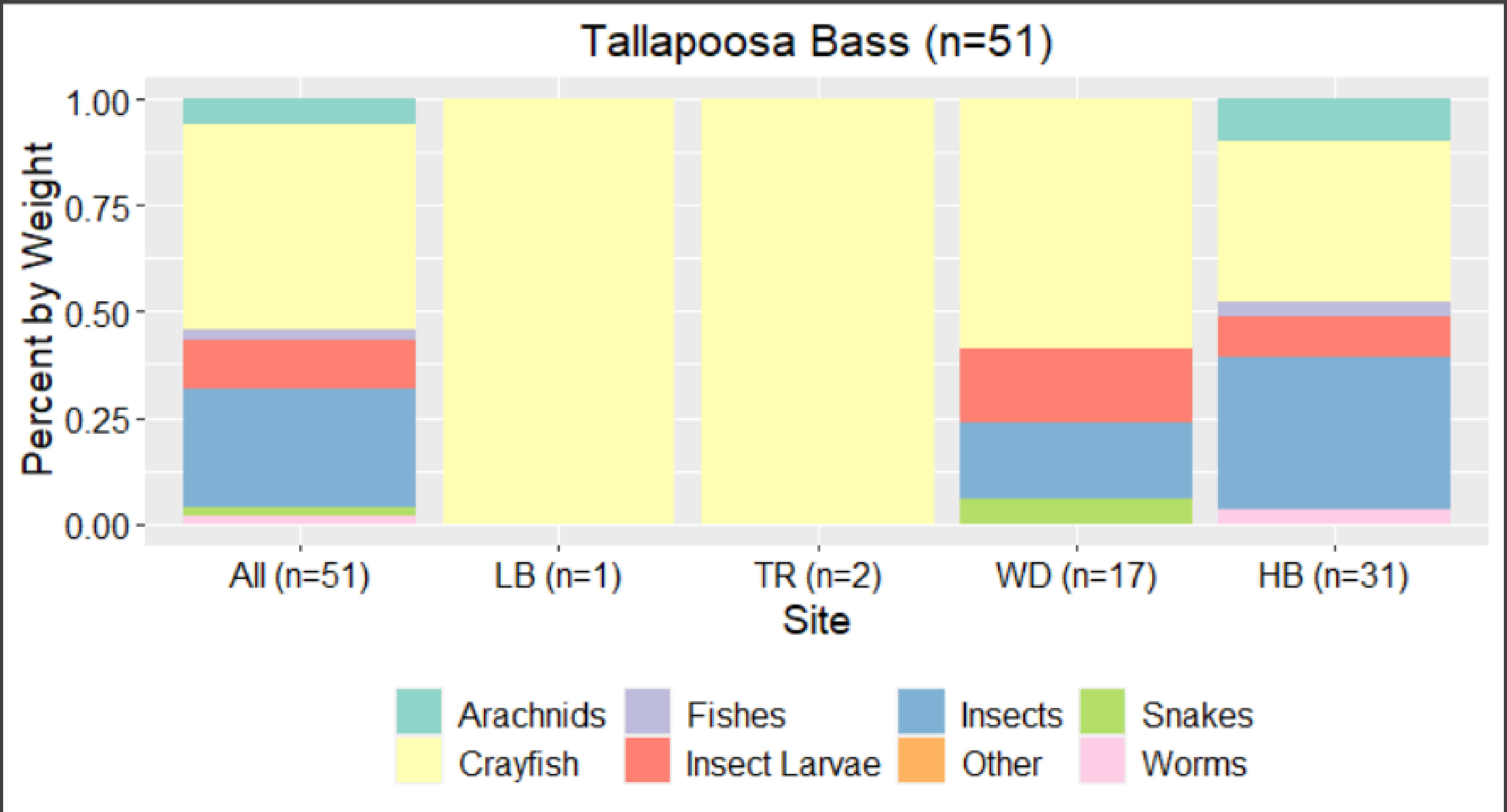

Redbreast Sunfish (n=315)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=315)
LB (n=23)
TR (n=50)
WD (n=90)
HB (n=152)
Site
Arachnids
Clams
Crayfish
Crustaceans
Fishes
Grasshopper
Insect Larvae
Insects
Millipedes
Other
Snails
Zooplankton



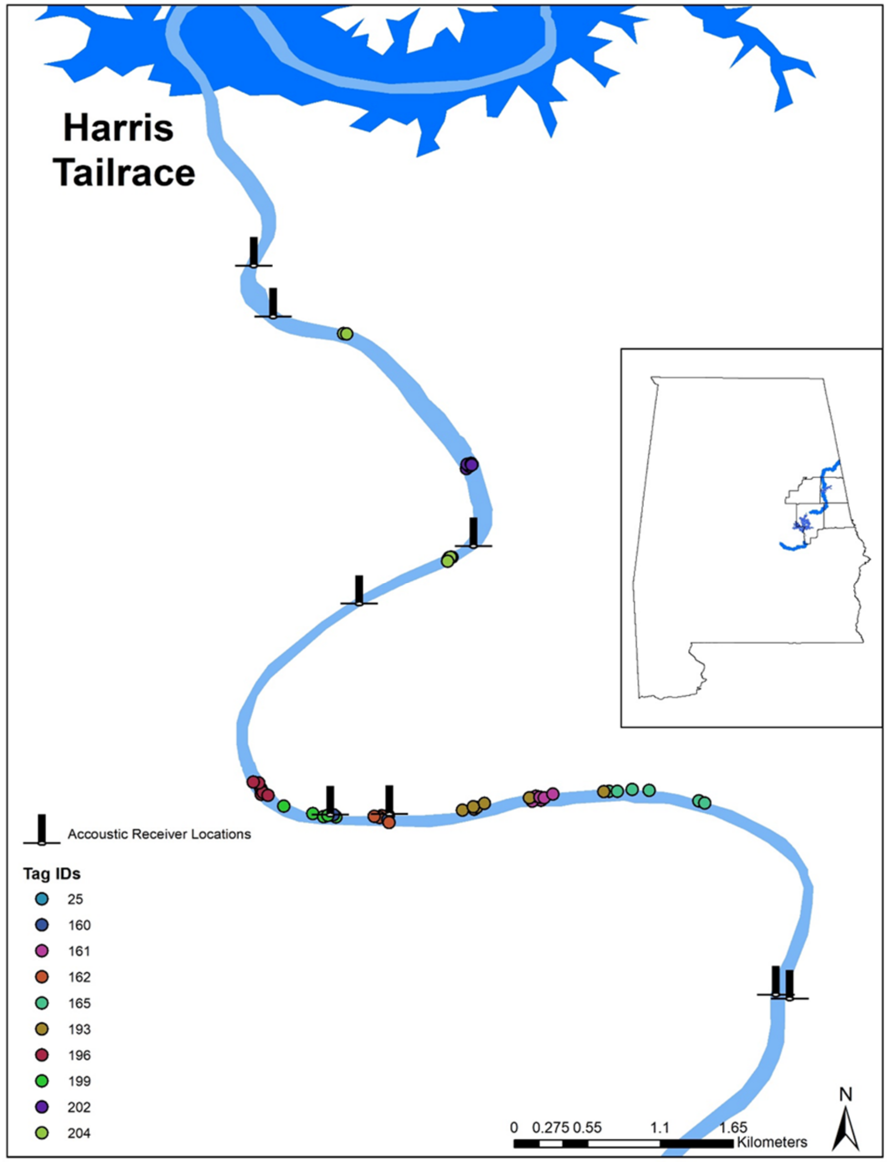
Alabama Bass (n=298)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=298)
winter (n=9)
spring (n=70)
summer (n=120)
fall (n=99)
Season
Arachnids
Clams
Crayfish
Crustaceans
Fishes
Insect Larvae
Insects
Other
Snails
Snakes
Worms
Zooplankton

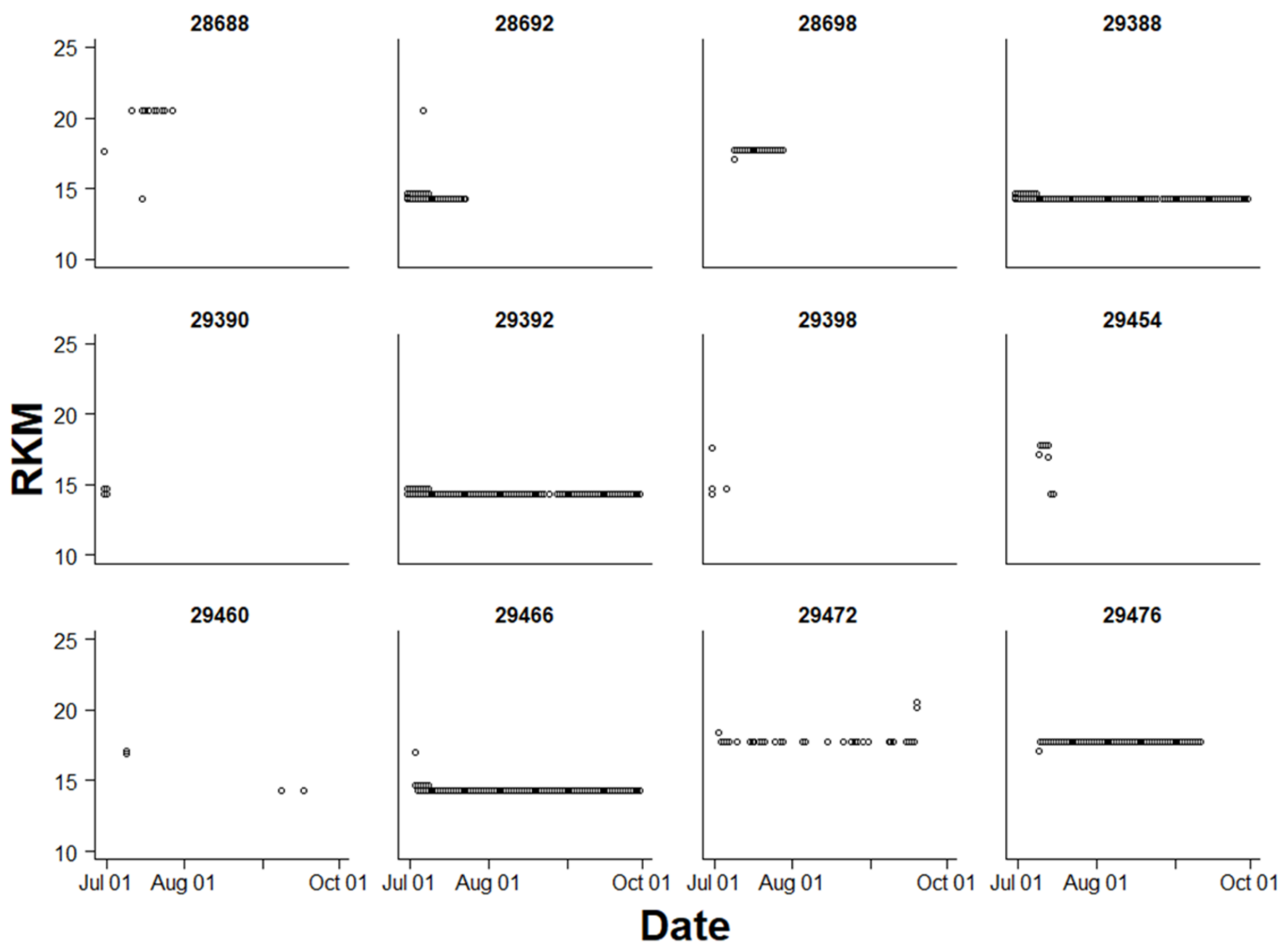

Alabama Bass (n=298)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=298)
LB (n=41)
TR (n=53)
WD (n=114)
HB (n=90)
Site
Arachnids
Clams
Crayfish
Crustaceans
Fishes
Insect Larvae
Insects
Other
Snails
Snakes
Worms
Zooplankton


Tallapoosa Bass (n=51)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=51)
winter (n=8)
spring (n=15)
summer (n=17)
fall (n=11)
Season
Arachnids
Crayfish
Fishes
Insect Larvae
Insects
Other
Snakes
Worms


Tallapoosa Bass (n=51)
Percent by Weight
1.00
0.75
0.50
0.25
0.00
All (n=51)
LB (n=1)
TR (n=2)
WD (n=17)
HB (n=31)
Site
Arachnids
Crayfish
Fishes
Insect Larvae
Insects
Other
Snakes
Worms

Results: telemetry

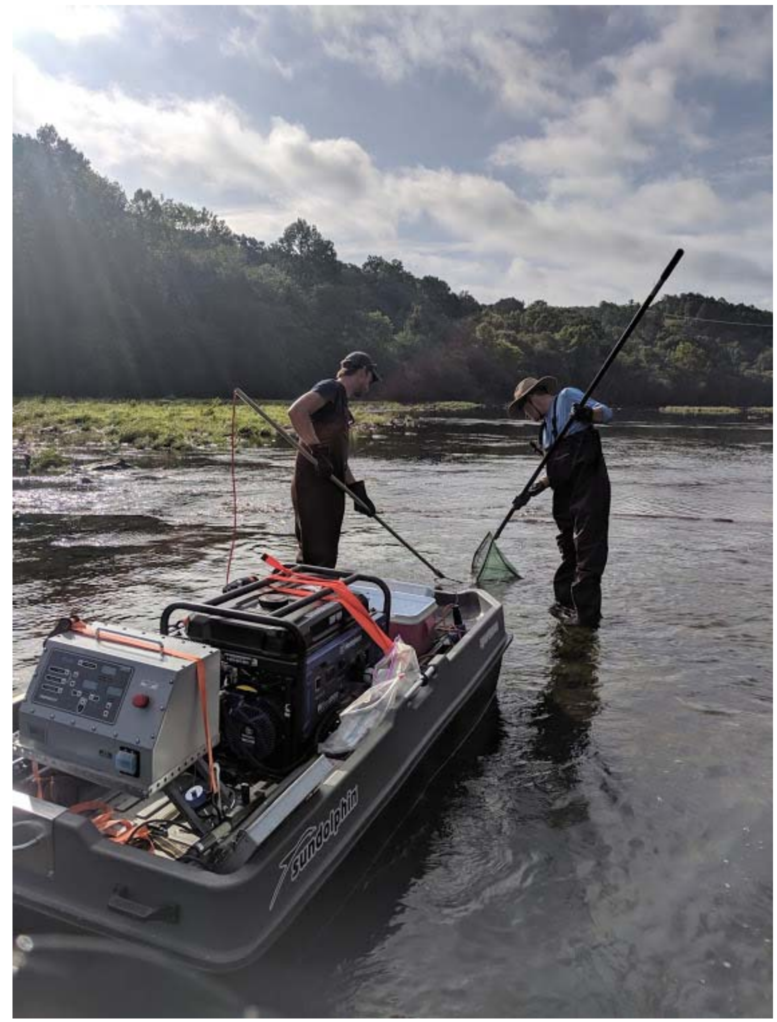

Harris Tailrace
Accoustic Receiver Locations
Tag IDs
25
160
161
162
165
193
196
199
202
204
0 0.275 0.55 1.1 1.65
Kilometers
N



28688
28692
28698
29388
29390
29392
29398
29454
29460
29466
29472
29476
RKM
25
20
15
10
Jul 01
Aug 01
Oct 01
Date

Discussion: community

- Findings agree with previous literature
  - Seasonal variation in catch rates
  - Sunfishes and minnows most common
  - No dramatic upstream-downstream diversity shifts
  - Native darter and minnow species persist in regulated stretch
  - Centrarchid catch rates remain high below Harris Dam
  - Catastomids and centrarchids still dominant above Harris

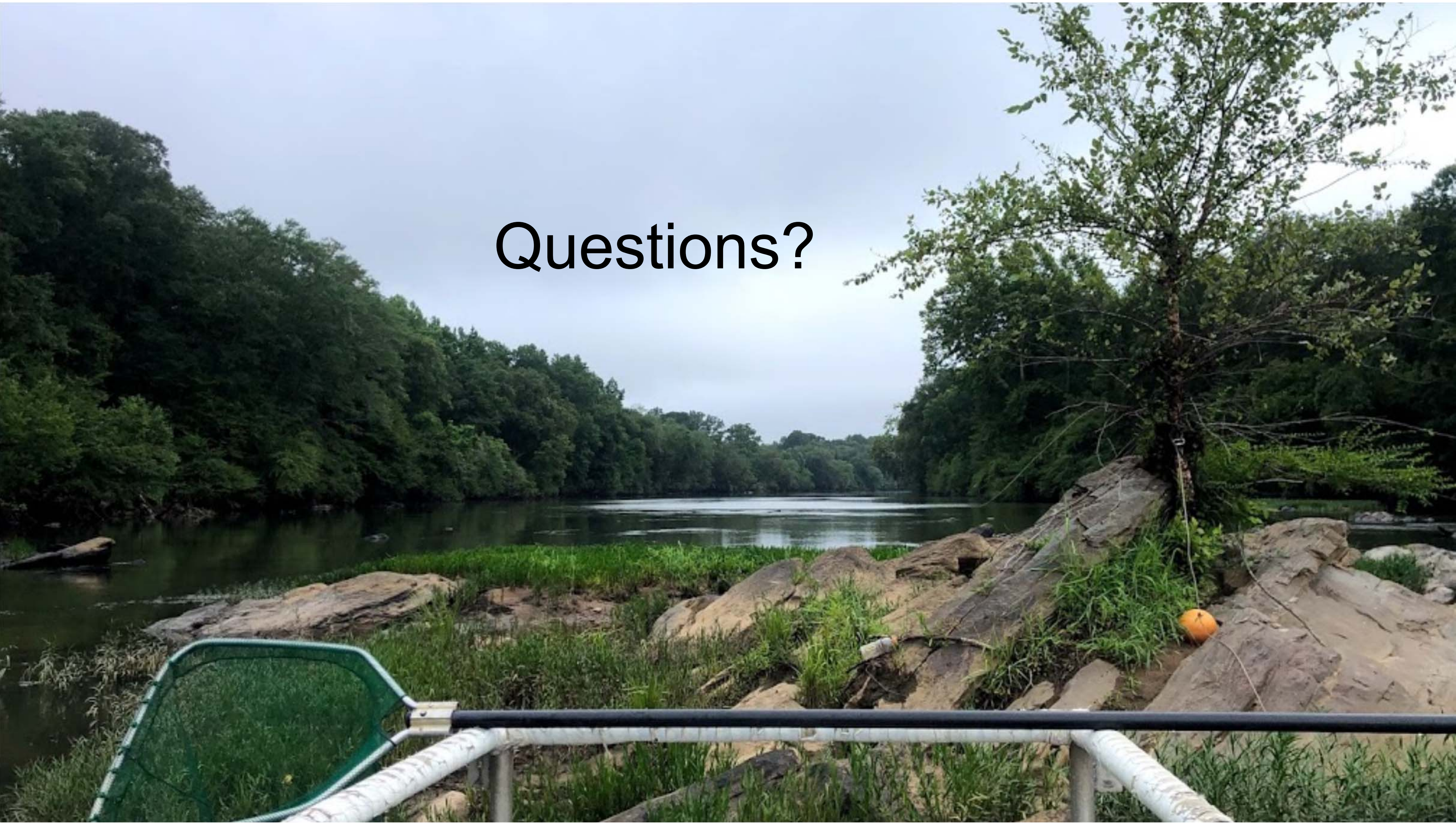


Discussion: age-and-growth

- Body condition
  - Higher in the tailrace
    - Not related to TL
- Length-at-age
  - von Bertalanffy parameters similar to published estimates
  - Calculation of site-specific parameters limited
- Diet
  - Variation by site and season
  - Similar to previous studies

Discussion: telemetry

- Stationary acoustic receivers
  - Black basses not displaced by peaking flows
  - Agrees with previous findings with the same/similar species
- Manual tracking
  - Fish regularly detected within a few hundred meters of previous location

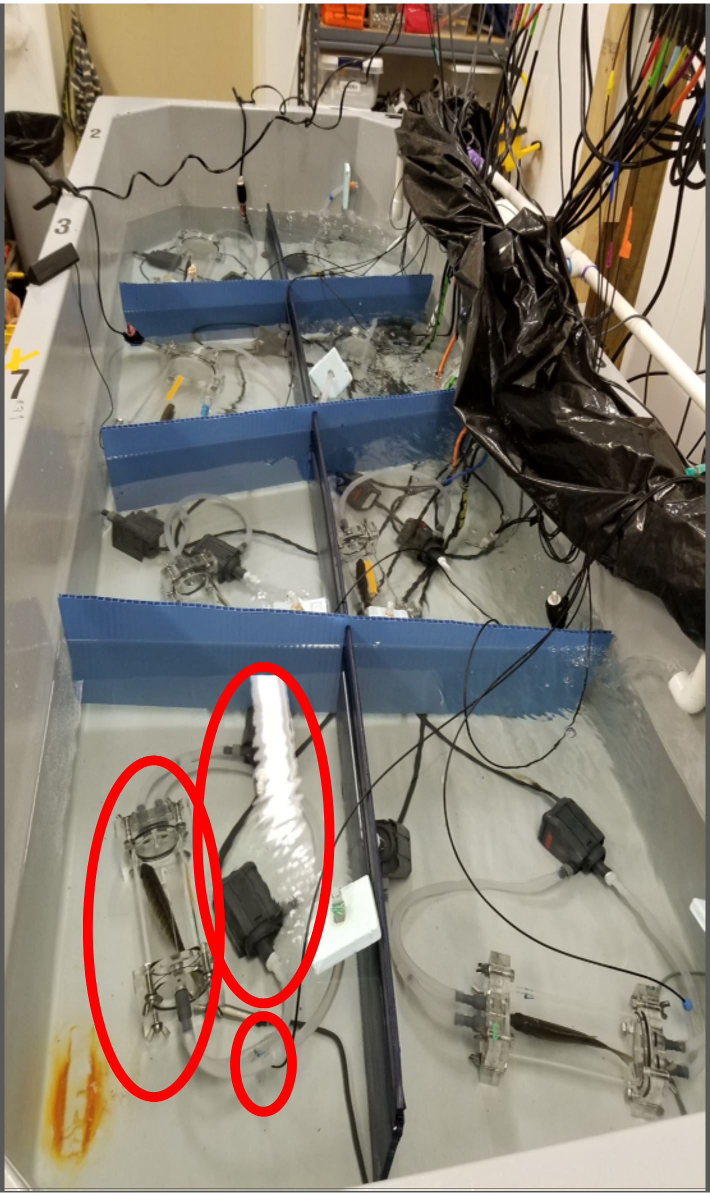

Questions?

Objective 4

- Quantify effects of temperature and flow variation on target fish species energy budgets using bioenergetics modeling
  - Part 1: Respirometry
    - Static Respirometry
    - Swimming Respirometry

Static Respirometry

- 8 chamber system (Loligo)
  - Medium chambers: ~600 ml
  - Large chambers: ~2600 ml
- Intermittent flow respirometry
  - Automated
- Temperature controlled
- Oxygen measured electronically



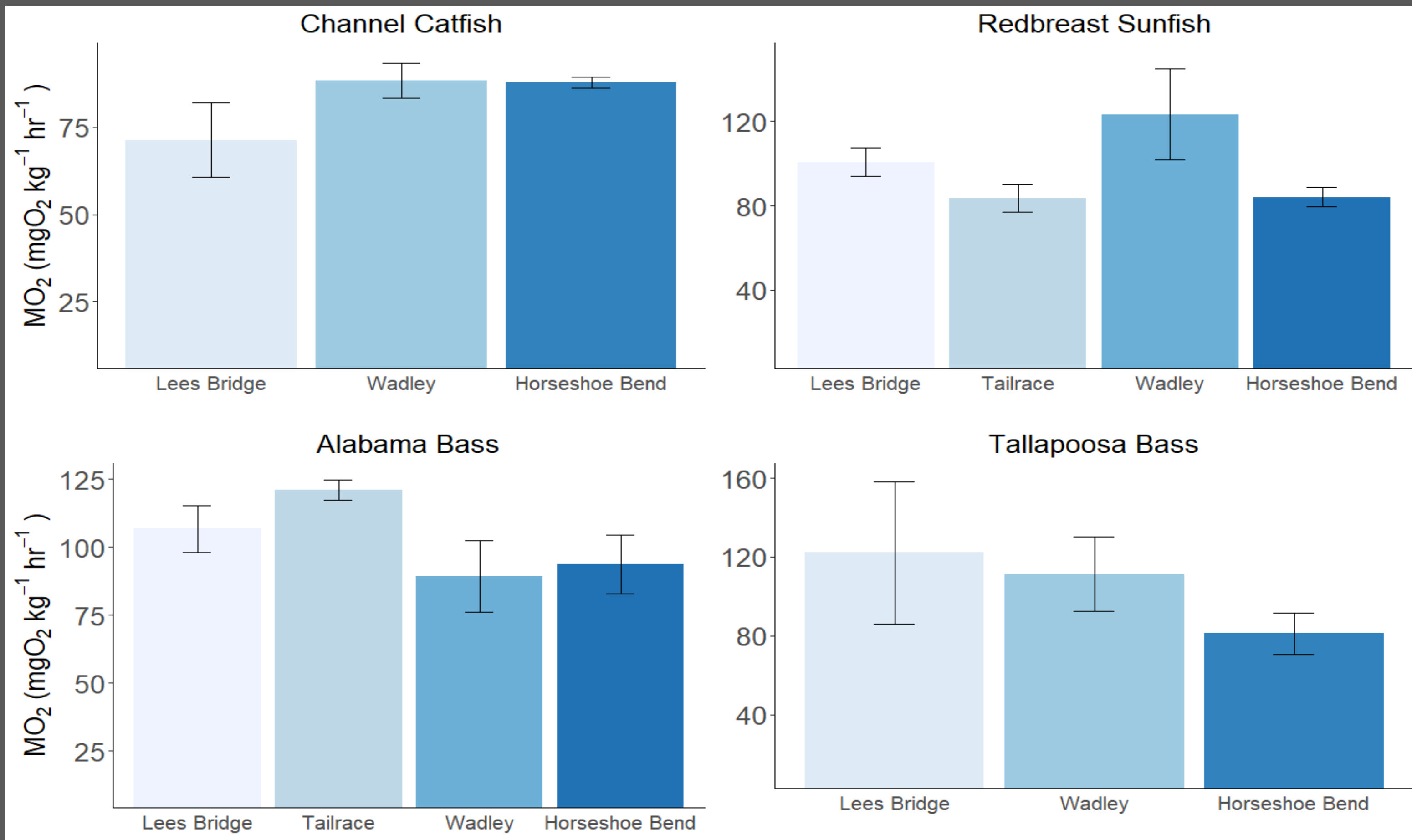
Static Respirometry

- Fish weighed
- Acclimated in chamber
  - 12 hr + 1
  - Intermittent flow respirometry
    - 1200/180 s
- Closed respirometry

Static Respirometry

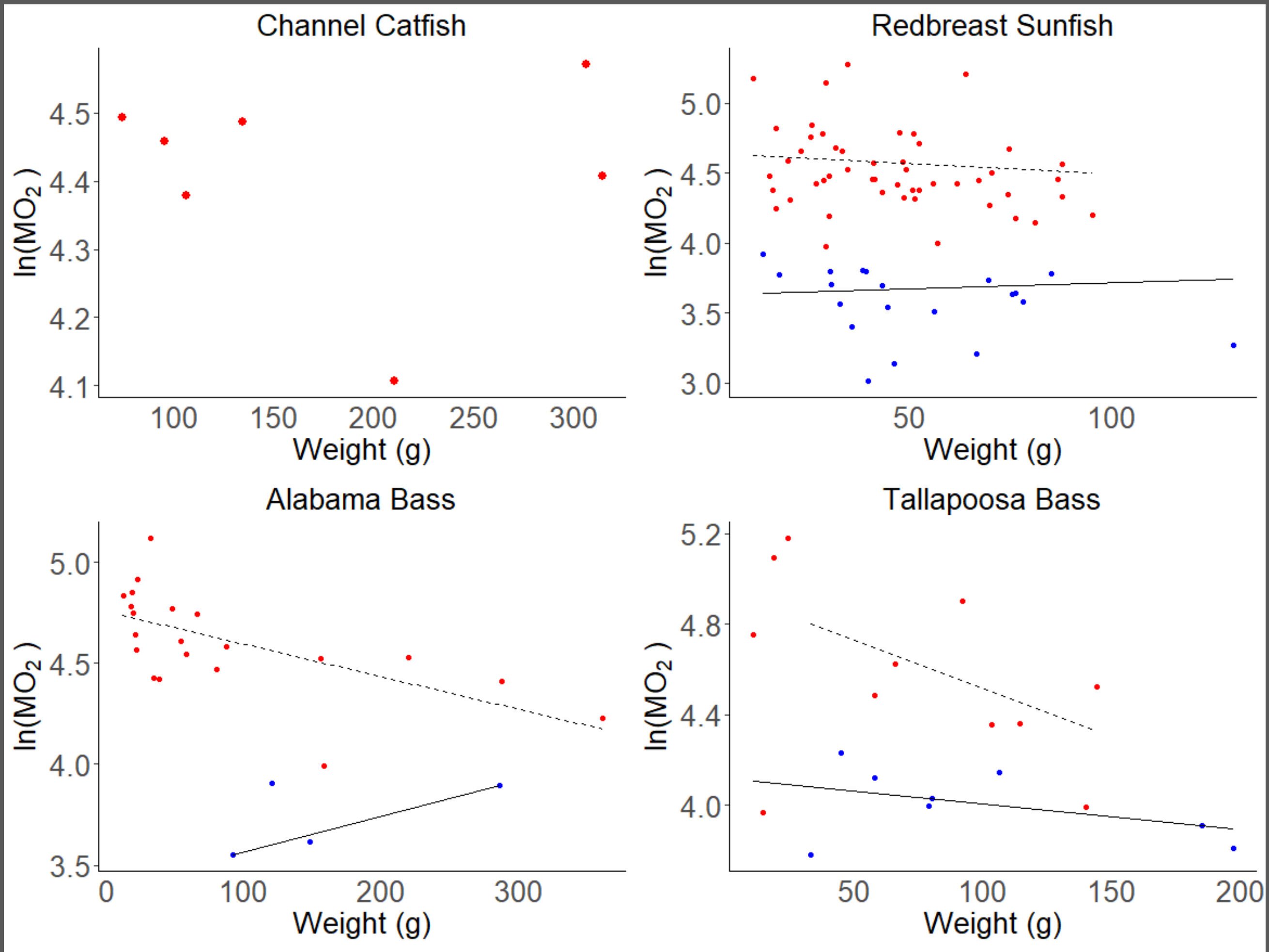
- 10 C
  - Channel Catfish (n=2)
  - Alabama Bass (n=11)
  - Redbreast Sunfish (n=21)
  - Tallapoosa Bass (n=14)
- 21 C
  - Channel Catfish (n=9)
  - Alabama Bass (n=28)
  - Redbreast Sunfish (n=51)
  - Tallapoosa Bass (n=12)
- 28 C
  - Alabama Bass (n=1)
  - Redbreast Sunfish (n=8)

Static Respirometry 21°C



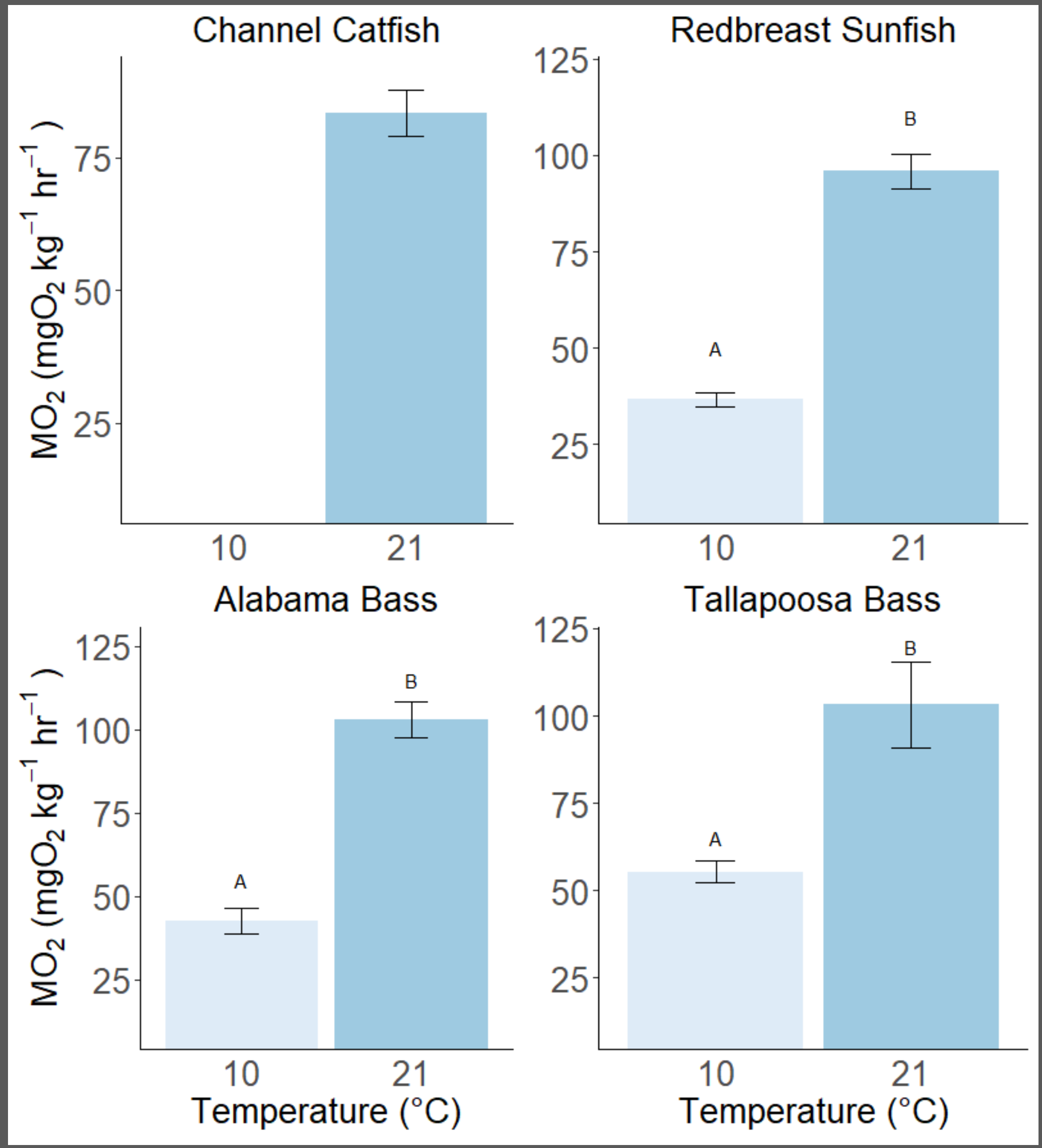
Static Respirometry

weight and metabolic rate



- No relationship for Channel Catfish
- Blue = 10 C
- Red = 21 C
- Biased toward smaller individuals

Static Respirometry at 10 and 21 C

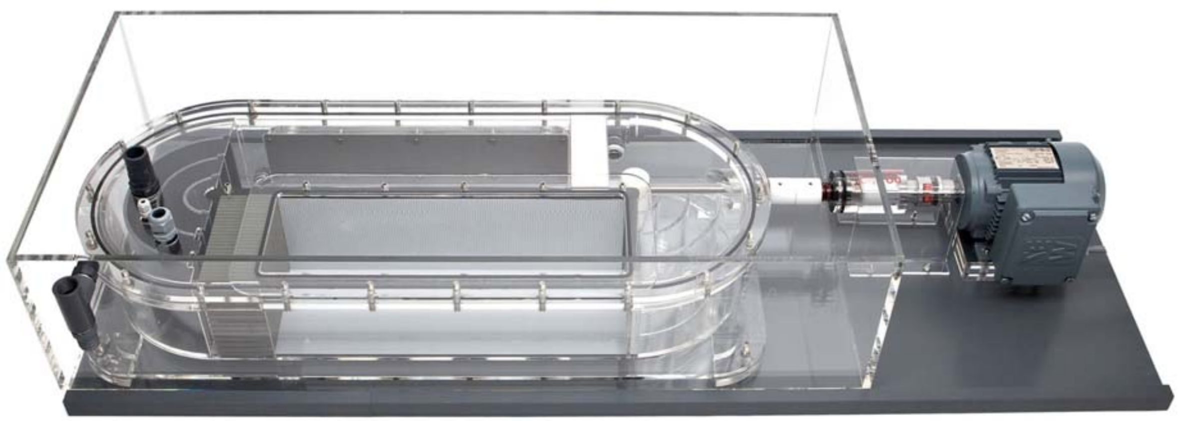


Swimming Respirometry & Performance

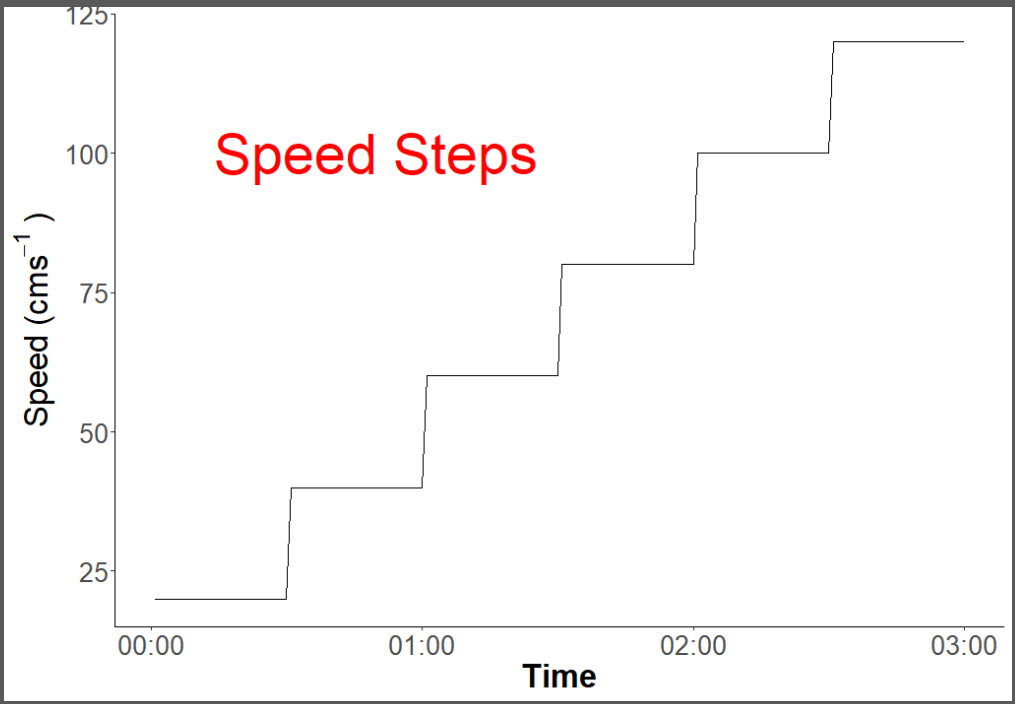
- Active metabolic rates
  - Metabolic rate of fish at given swimming speed
- Swimming performance
  - Critical swimming speed

Swimming Respirometry & Performance

- 90 L Loligo swimming respirometer
- Temperature controlled
  - Water reservoirs
- Oxygen measured electronically
- Speed control automated

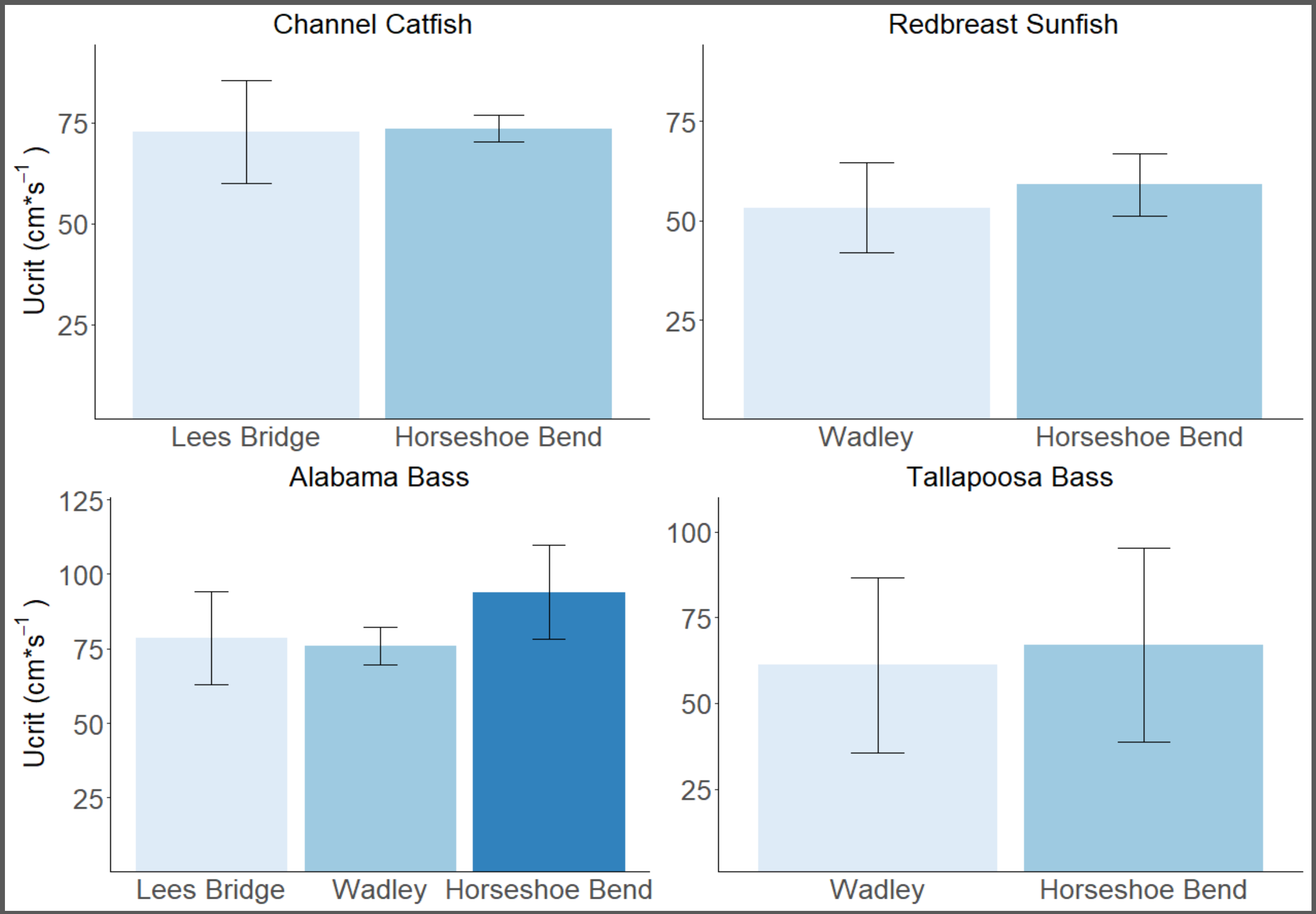


Swimming Performance

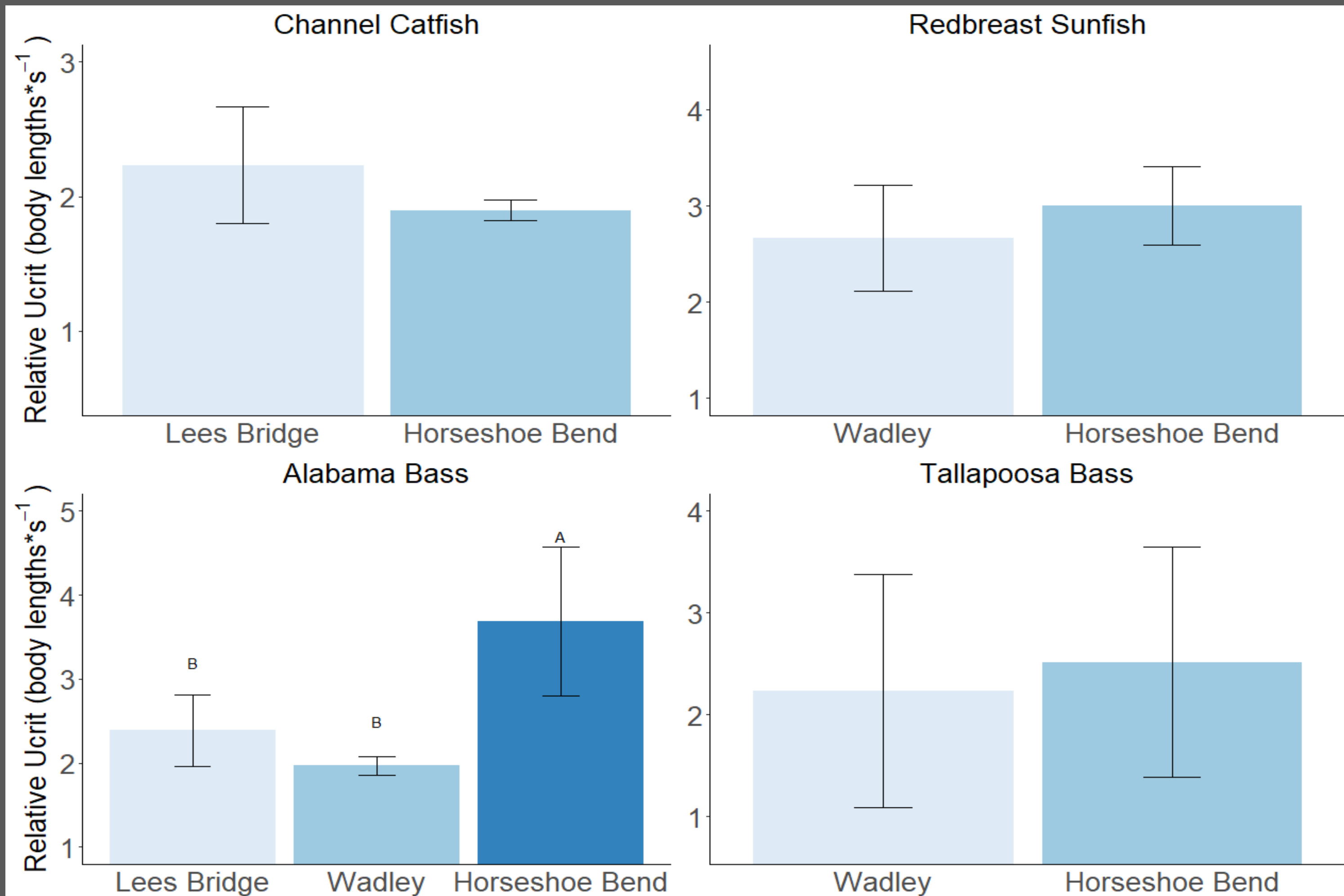


- Critical Swimming Speed
- $U_{crit} = U_1 + U_2(\frac{t_1}{t_2})$
  - U_1 - last completed bout
  - U_2 - velocity increment
  - $\frac{t_1}{t_2}$ - proportion of time at last step
- Bass – 30 min
- Redbreast Sunfish – 45 min
- Channel Catfish – 30 min

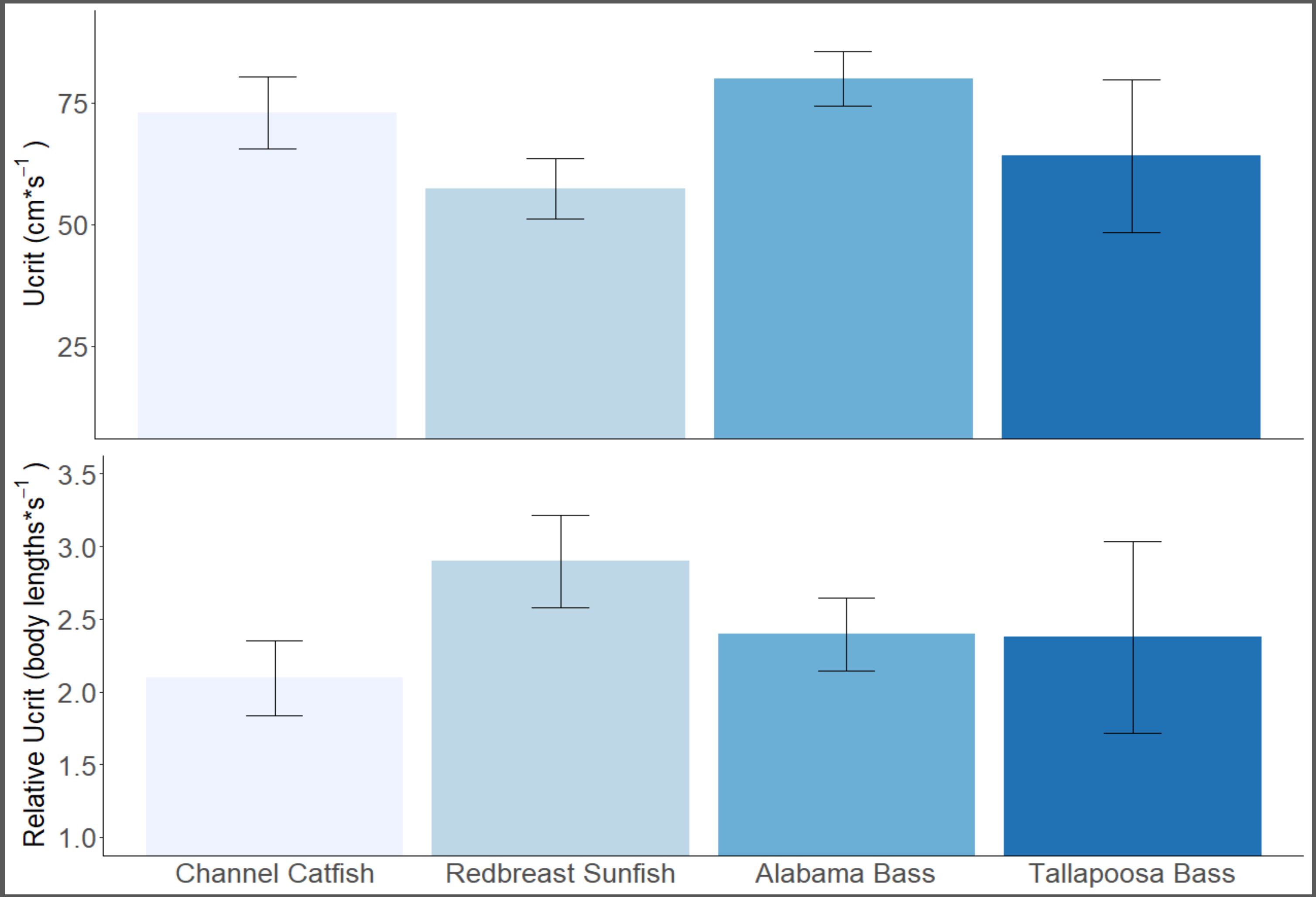
Critical Swimming Speed



Relative Critical Swimming Speed

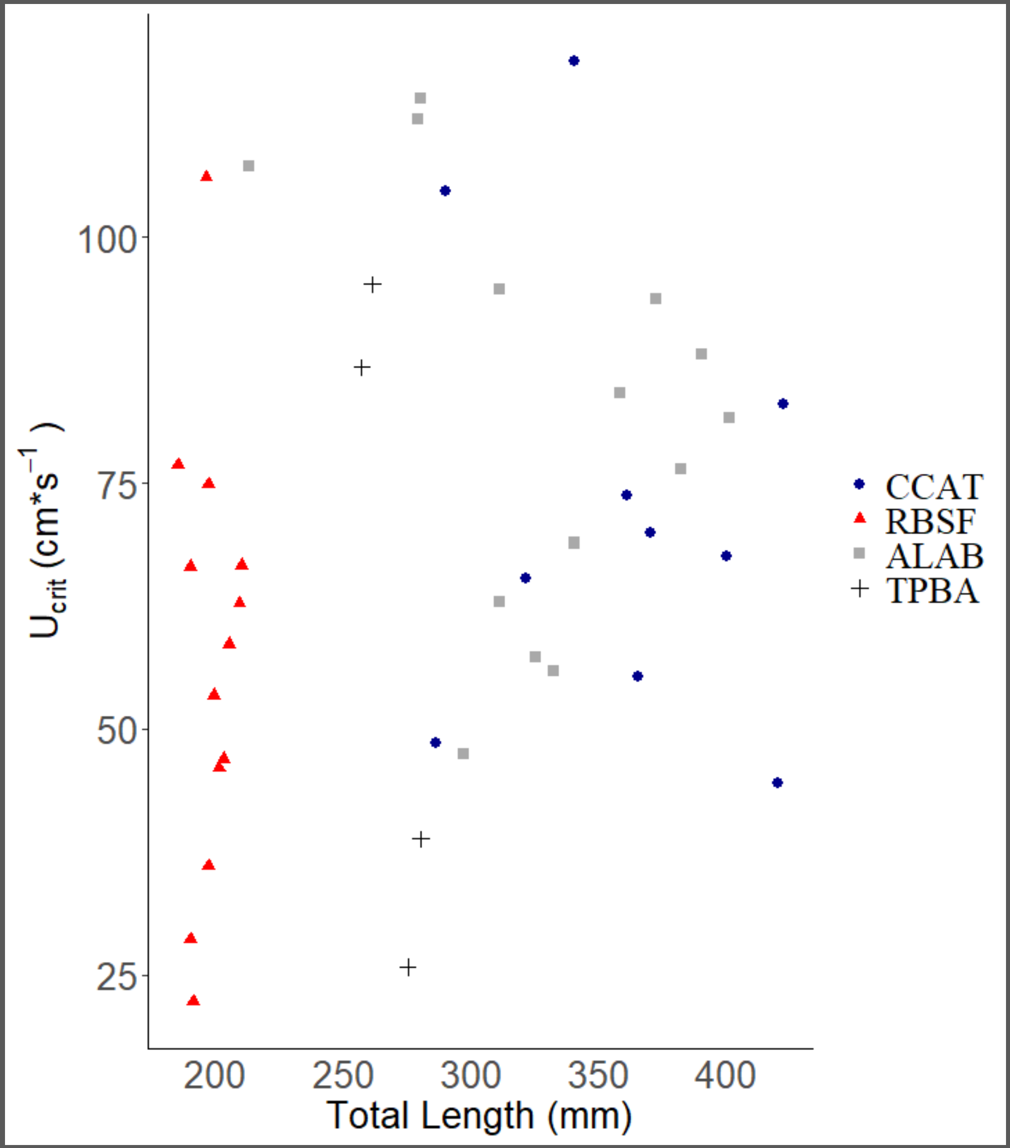


Critical Swimming Speed of grouped species

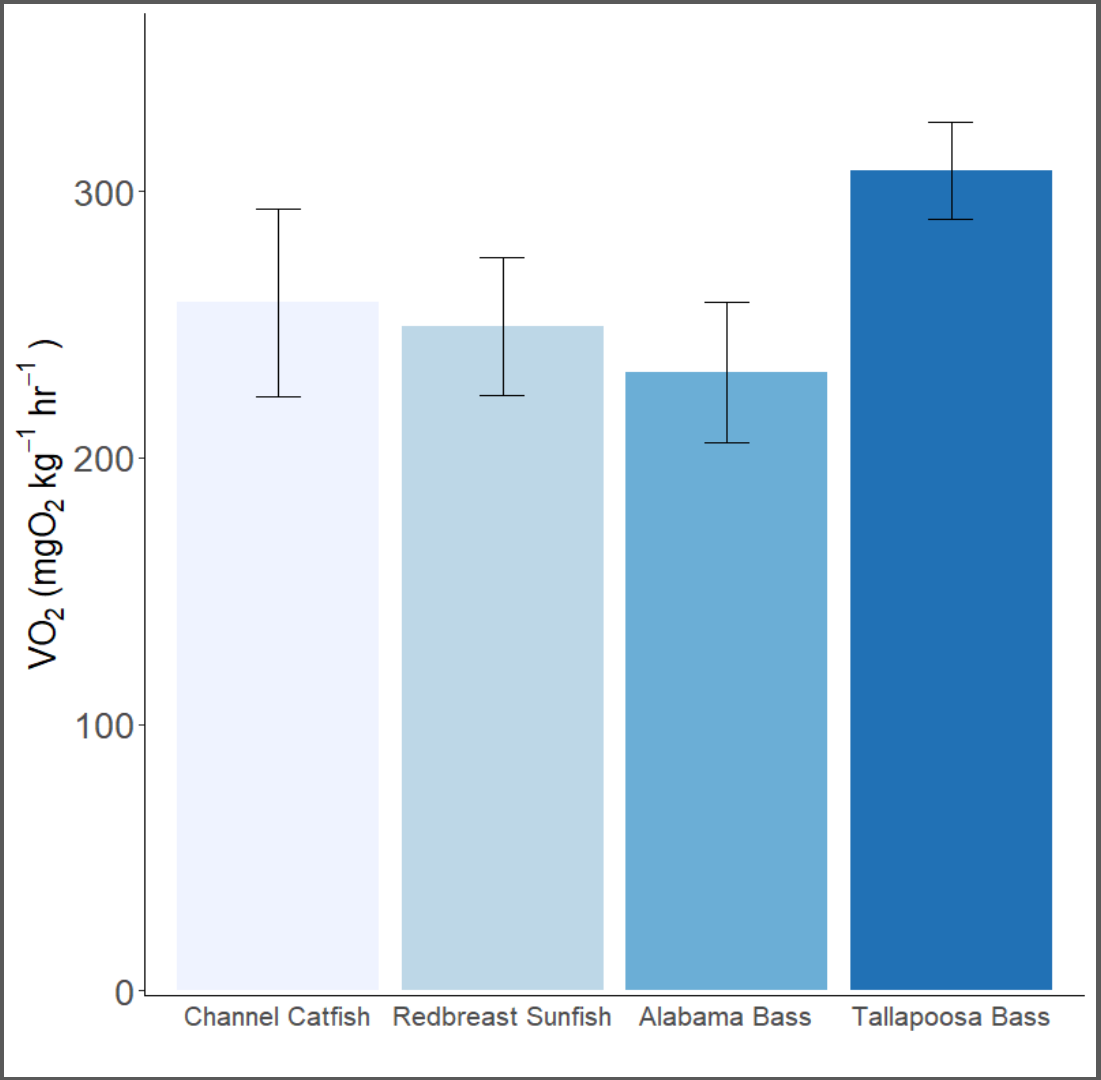


Relationship between length and U_{crit}

- Size range limited for RBSF and TPBA

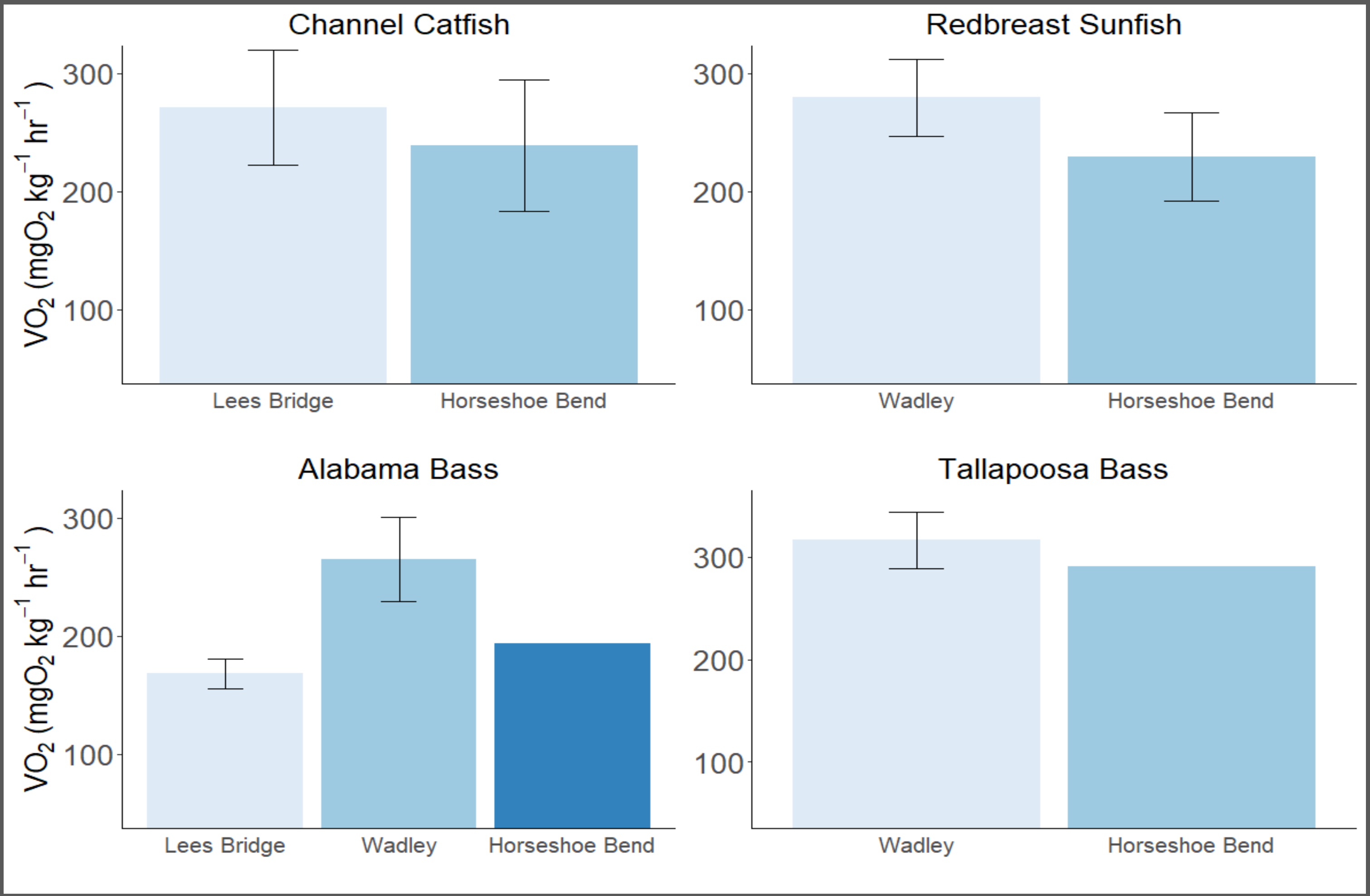


Average MMR

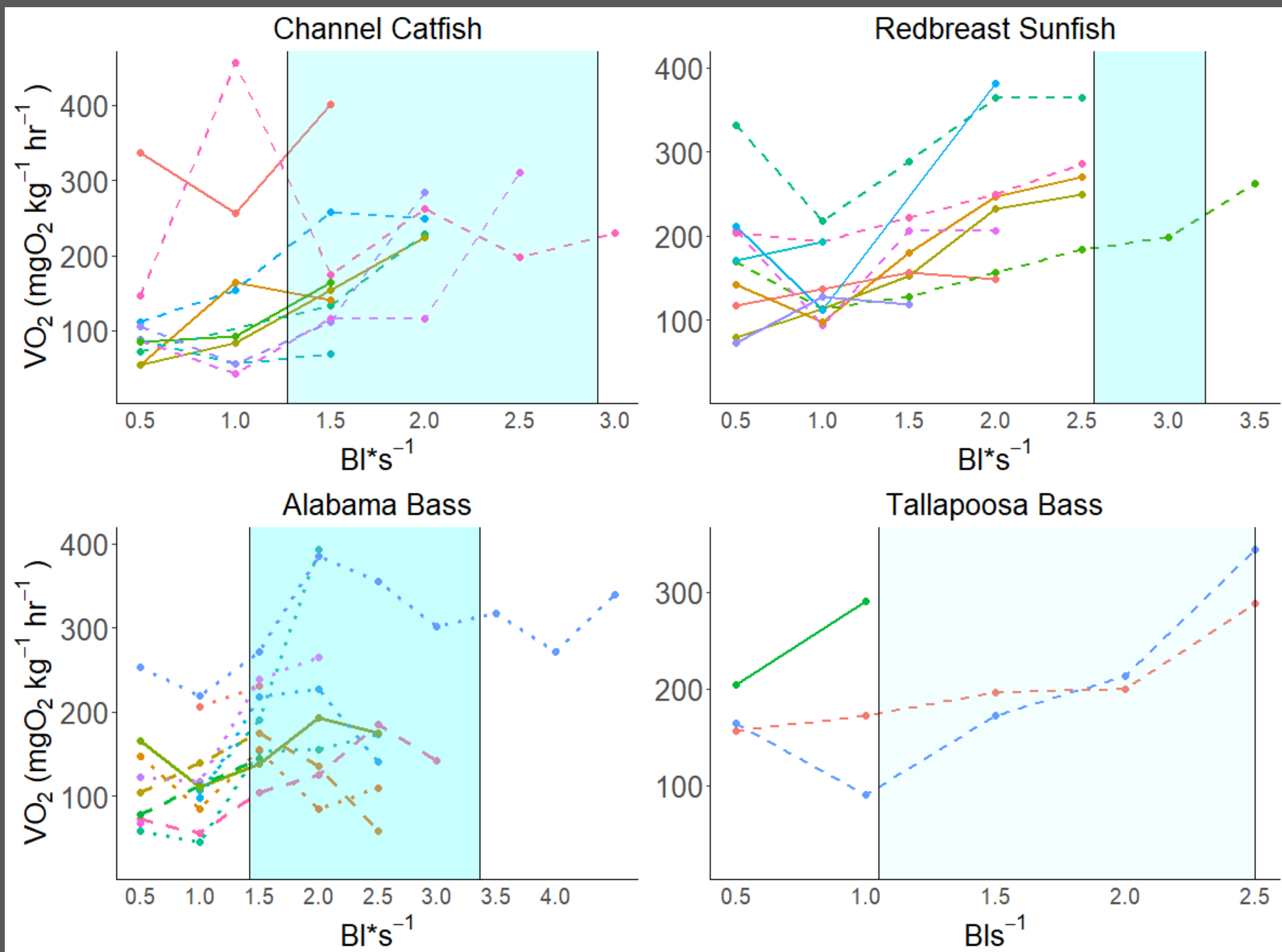


VO_2 (mgO_2 kg^{-1} hr^{-1})
300
200
100
0
Channel Catfish
Redbreast Sunfish
Alabama Bass
Tallapoosa Bass

Average MMR for each species and site

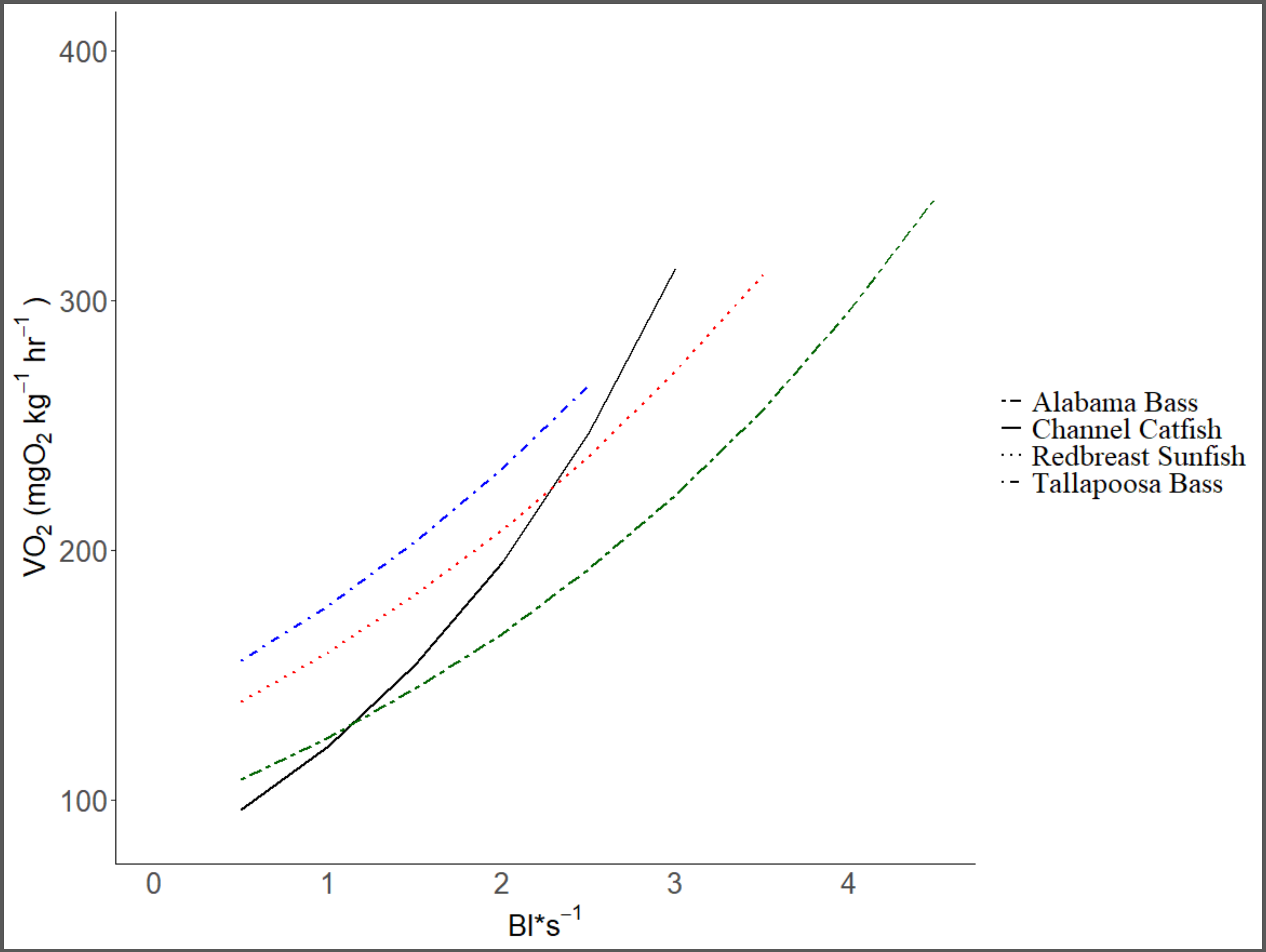


AMR for each relative speed

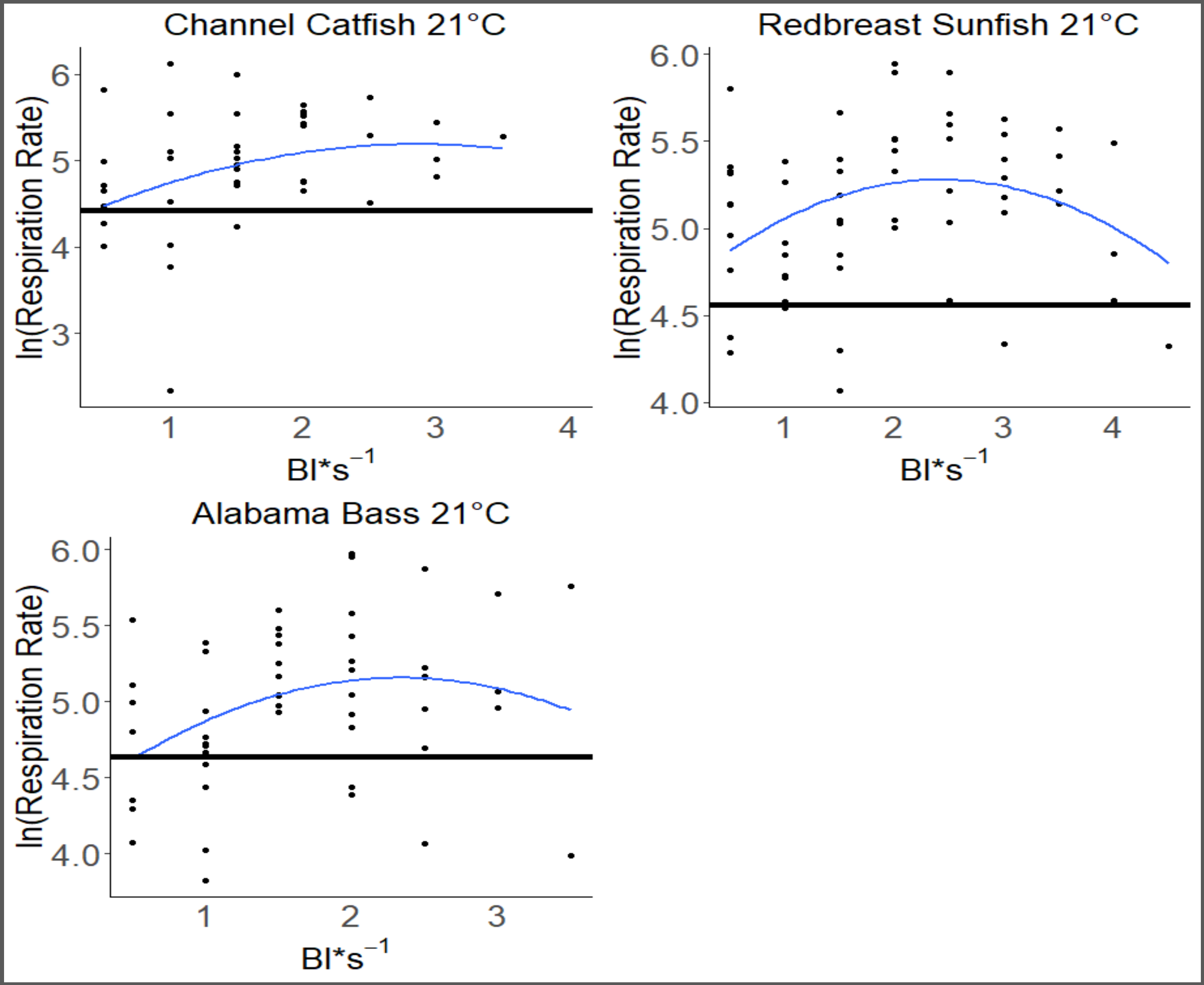


- Blue boxes are average U_{crit} ± 1 SD

Prediction curves for each species at a given relative speed



Aerobic Scope

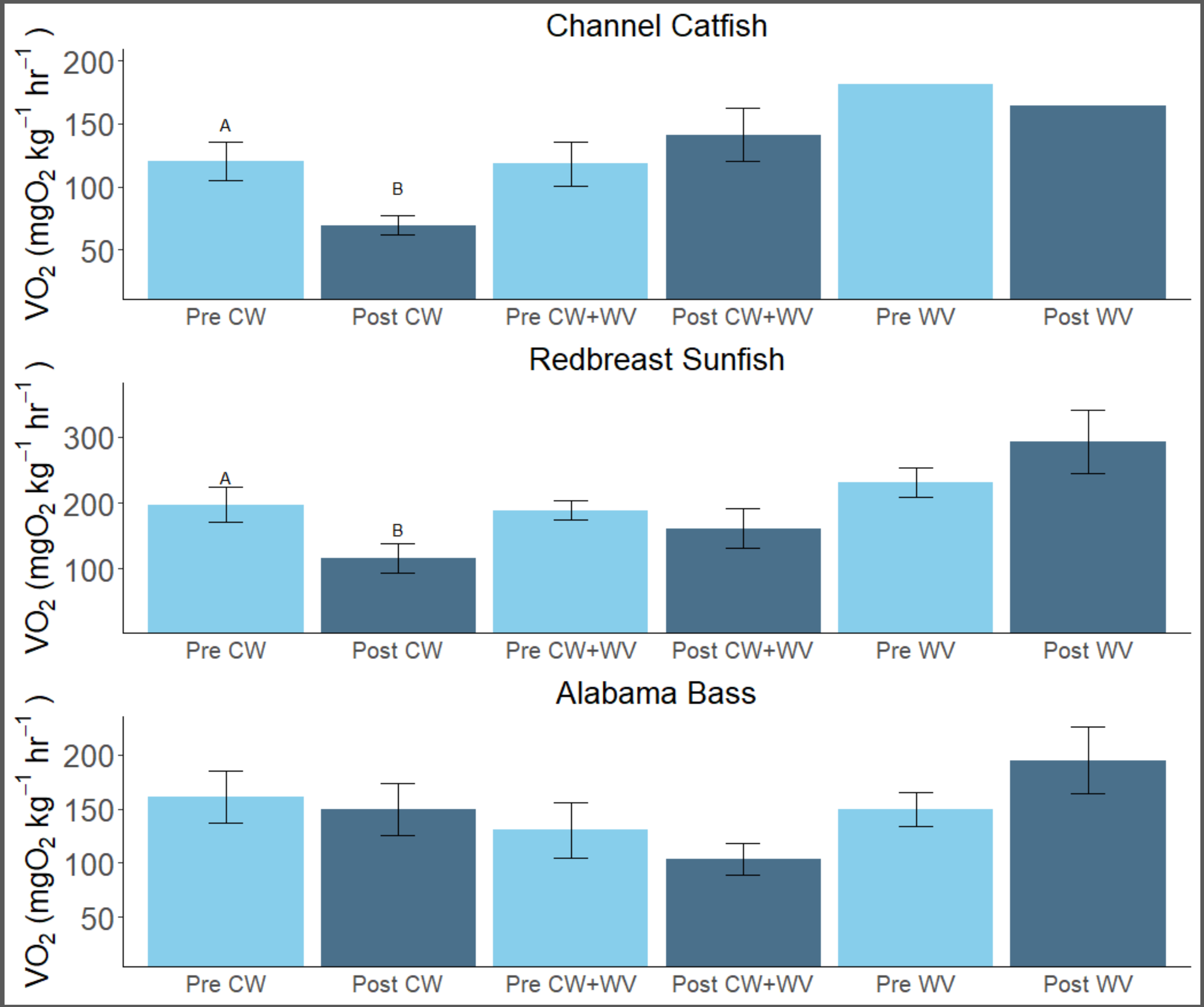


Water changes

- 3 conditions:
  - Speed maintained at 0.5 U_{crit}, temperature decreased from 24 to 19 C
  - Speed increased from 0.5 U_{crit} to U_{crit}, temperature decreased from 24 to 19 C
  - Speed increased from 0.5 U_{crit} to U_{crit}, temperature maintained at 24 C
- Water exchanged after 2 hours
  - Respiration rate recorded pre and post water exchange
  - Water exchanged and velocity increased over 5-8 minutes

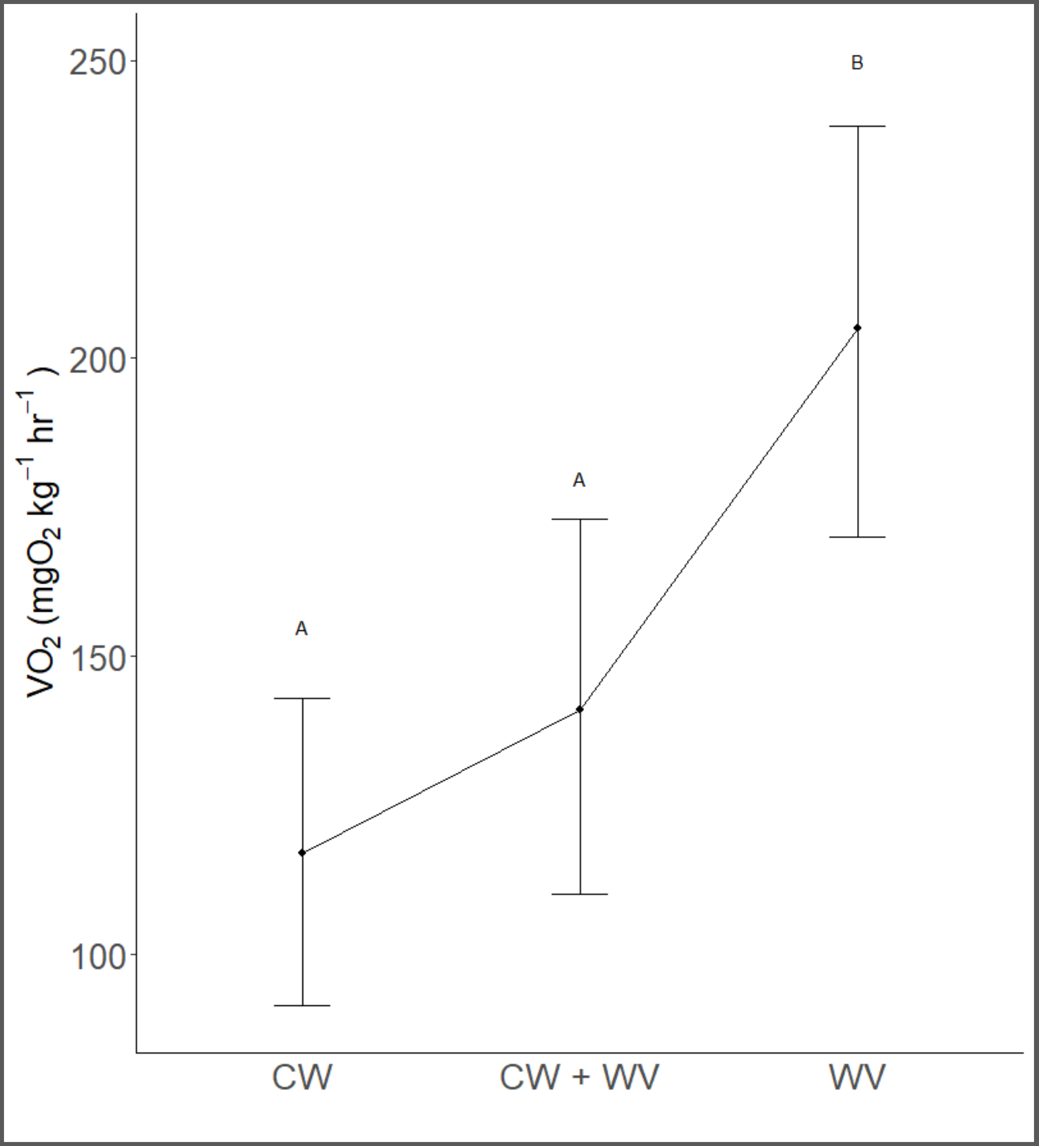
Water changes

CW: cold water exchange
WV: water velocity increase



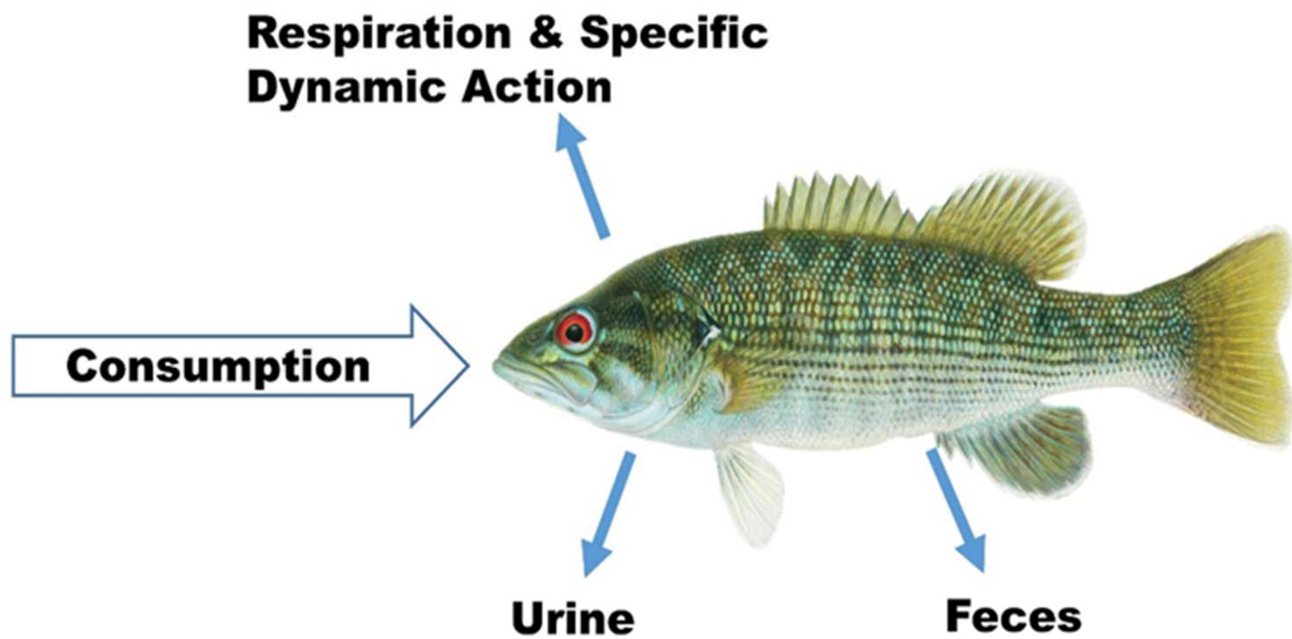
Water changes

- Pre exchange respiration rate is covariate
  - all species grouped together



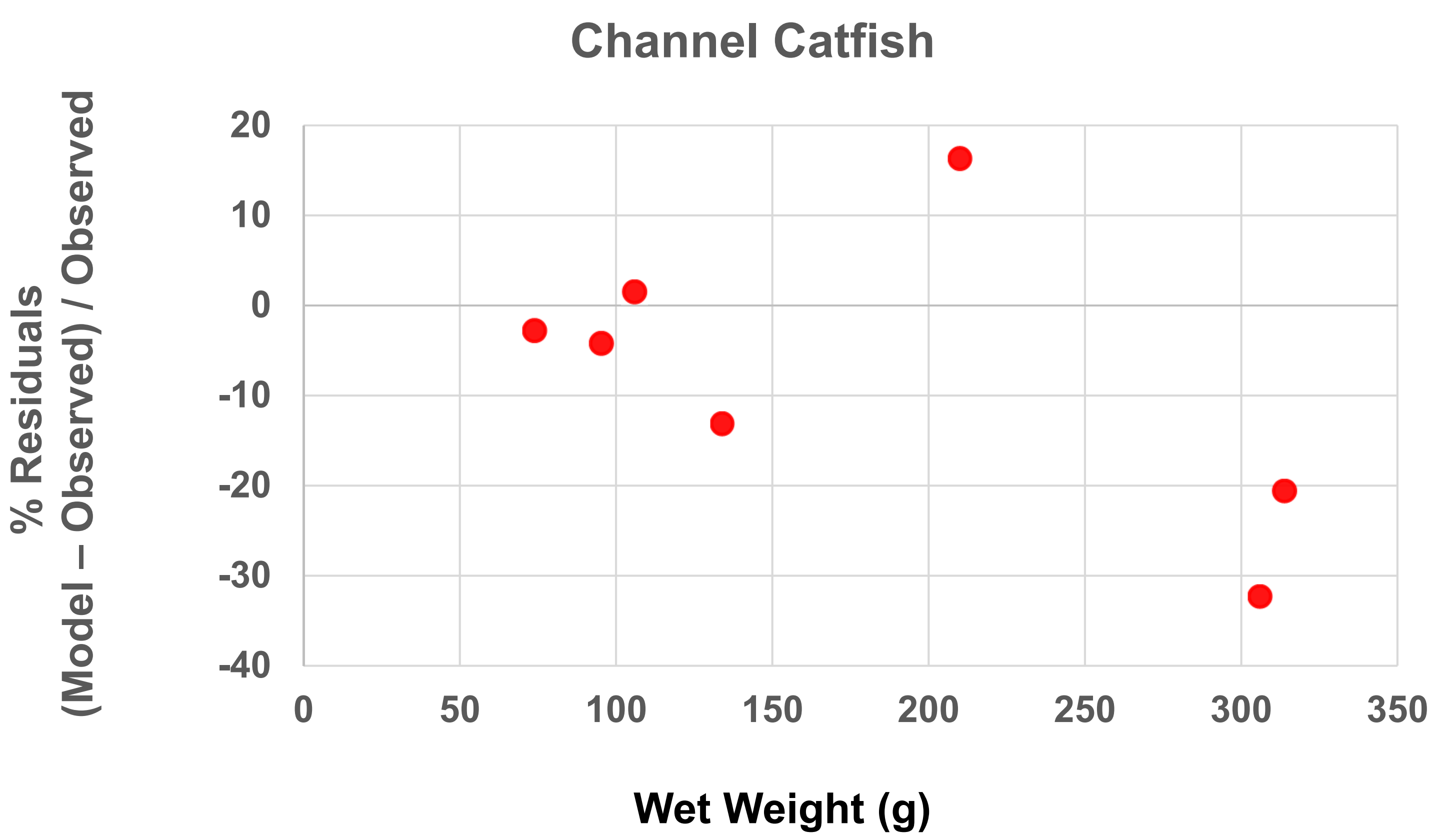
Objective 4a Conclusions

- Fish may be incapable of swimming at water velocities generated in the tailrace
  - Implications: must seek refuge habitats
- No differences in MO_2 across sites within species
- Max VO_2 corresponds with U_{crit}
- AMR is influenced by both temperature and water velocity. Decreased temperature limits fish response to increasing water velocity by lowering AMR
  - Implications: fish may not be able to compensate effectively for increased muscular demand at colder temperatures

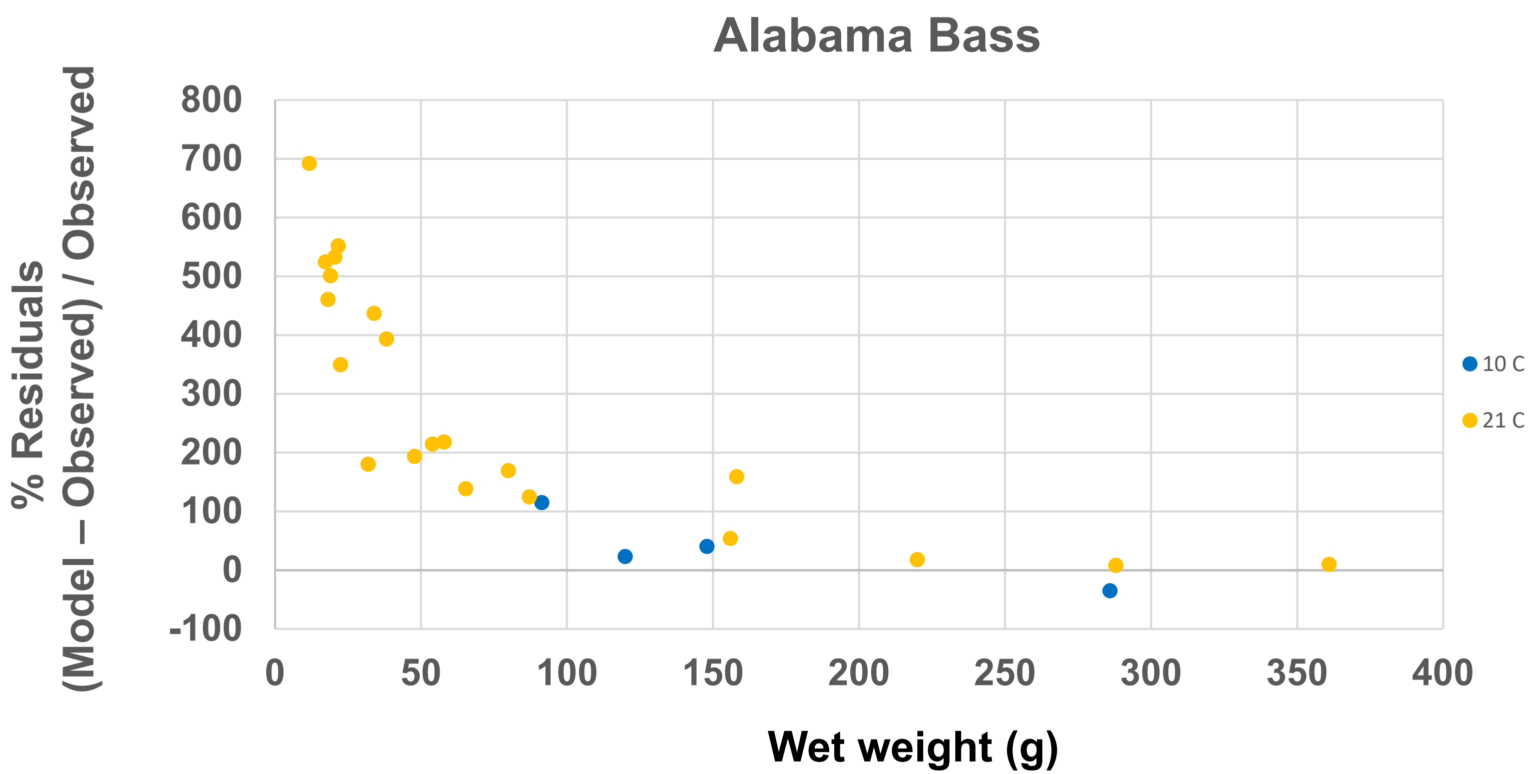


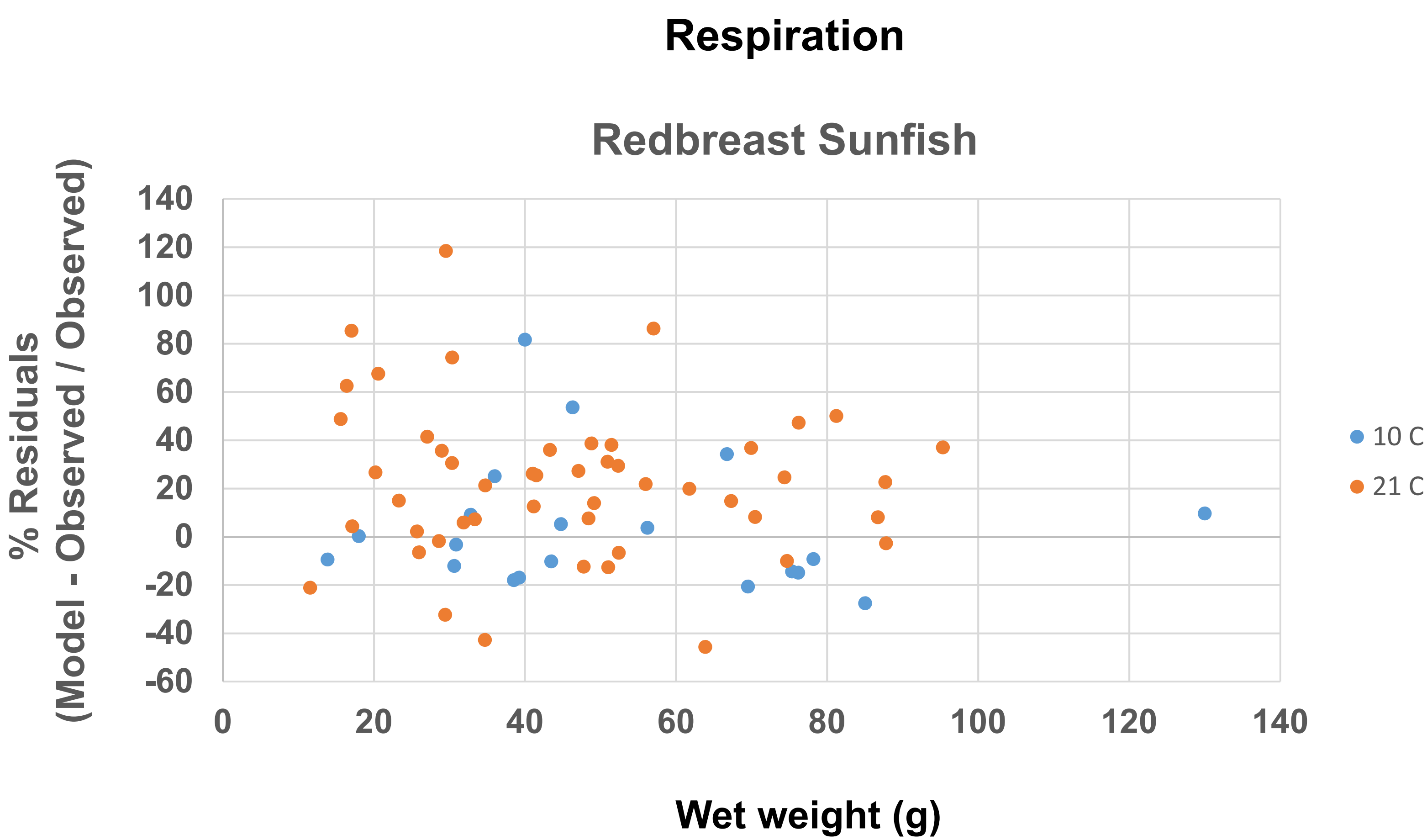
Growth = Consumption - (R + F + U + SDA)

Respiration



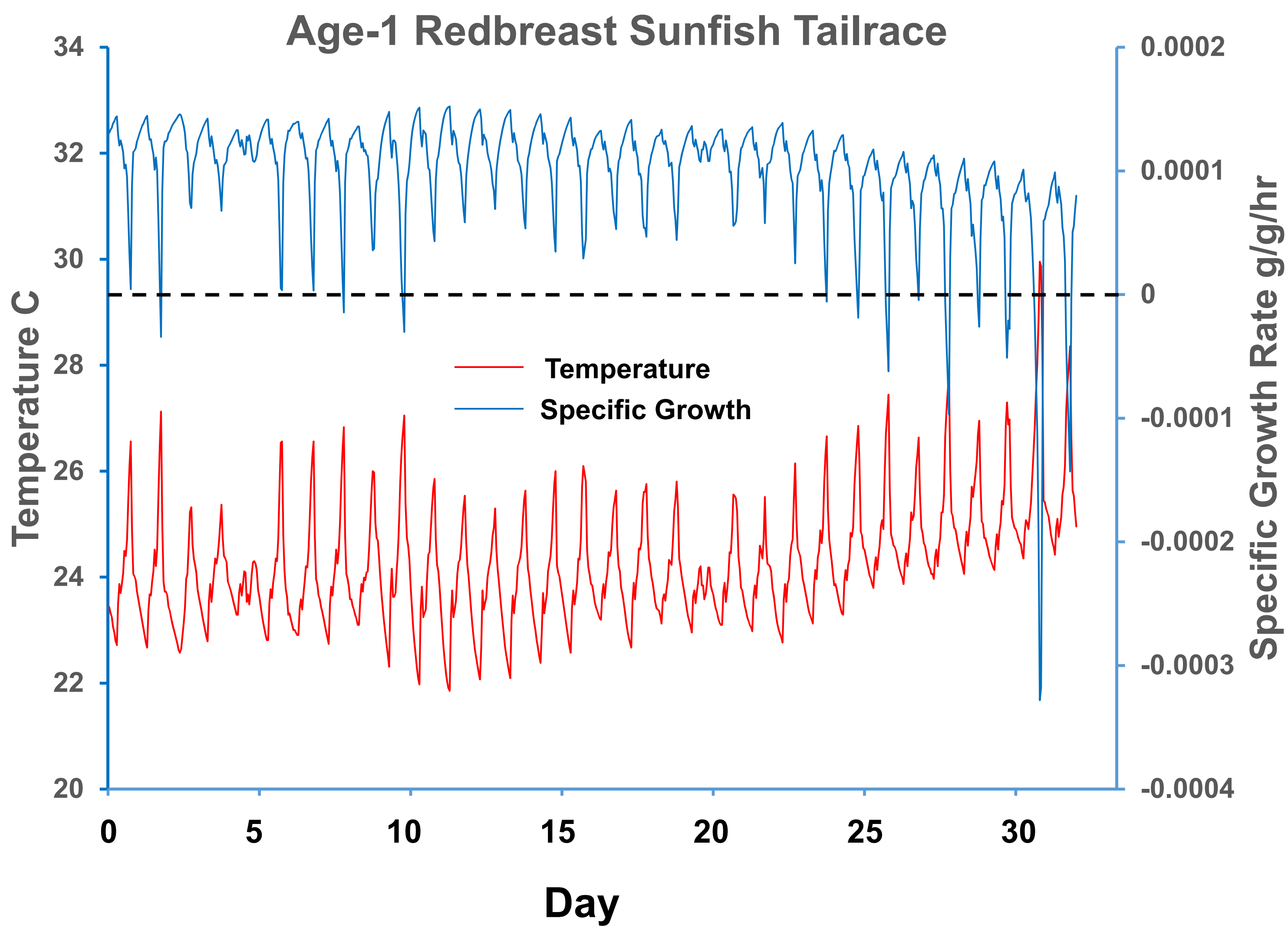
Respiration



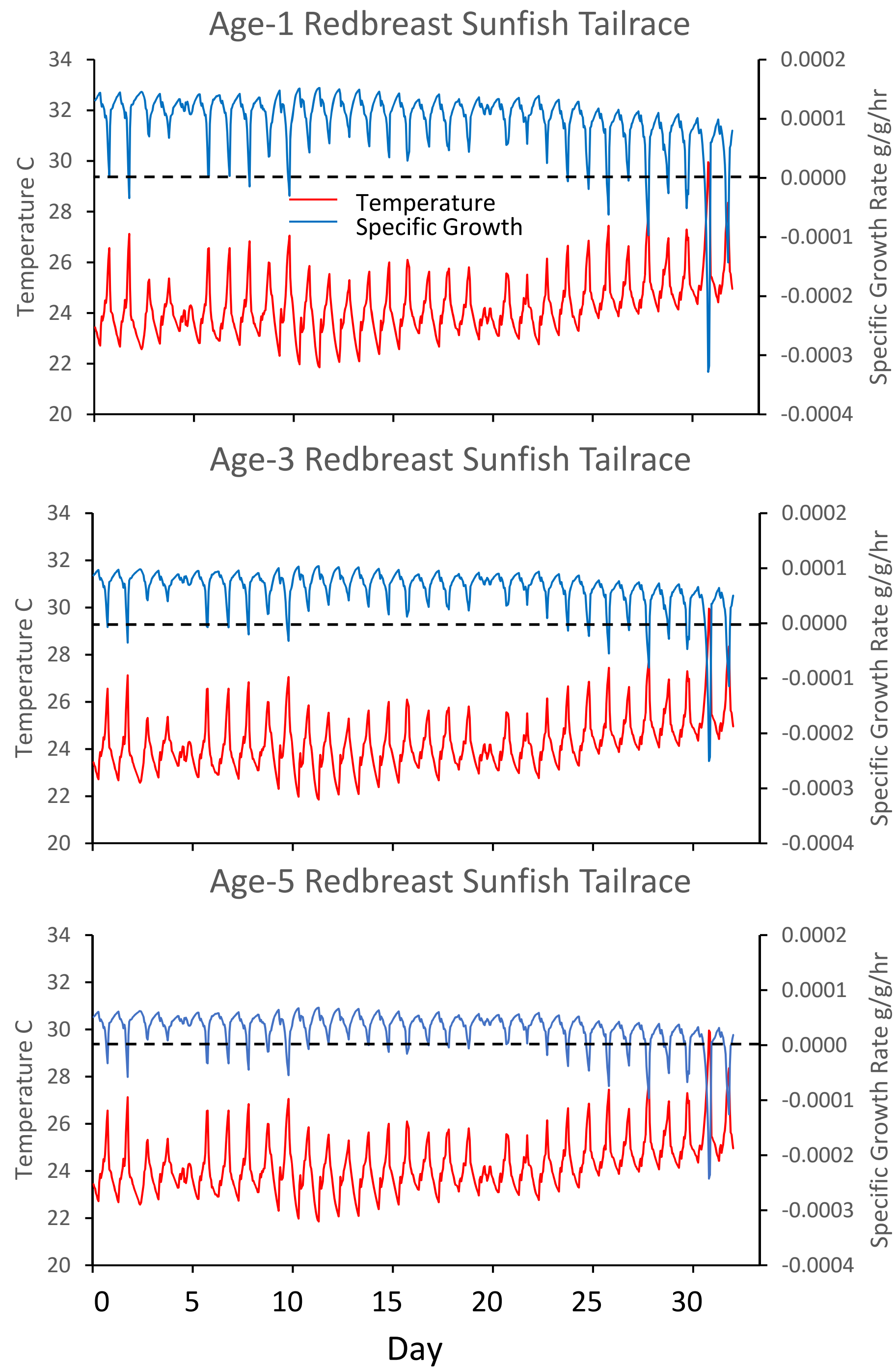

Respiration
Redbreast Sunfish
% Residuals
(Model - Observed / Observed)
140
120
100
80
60
40
20
0
-20
-40
-60
0
20
40
60
80
100
120
140
Wet weight (g)
10 C
21 C

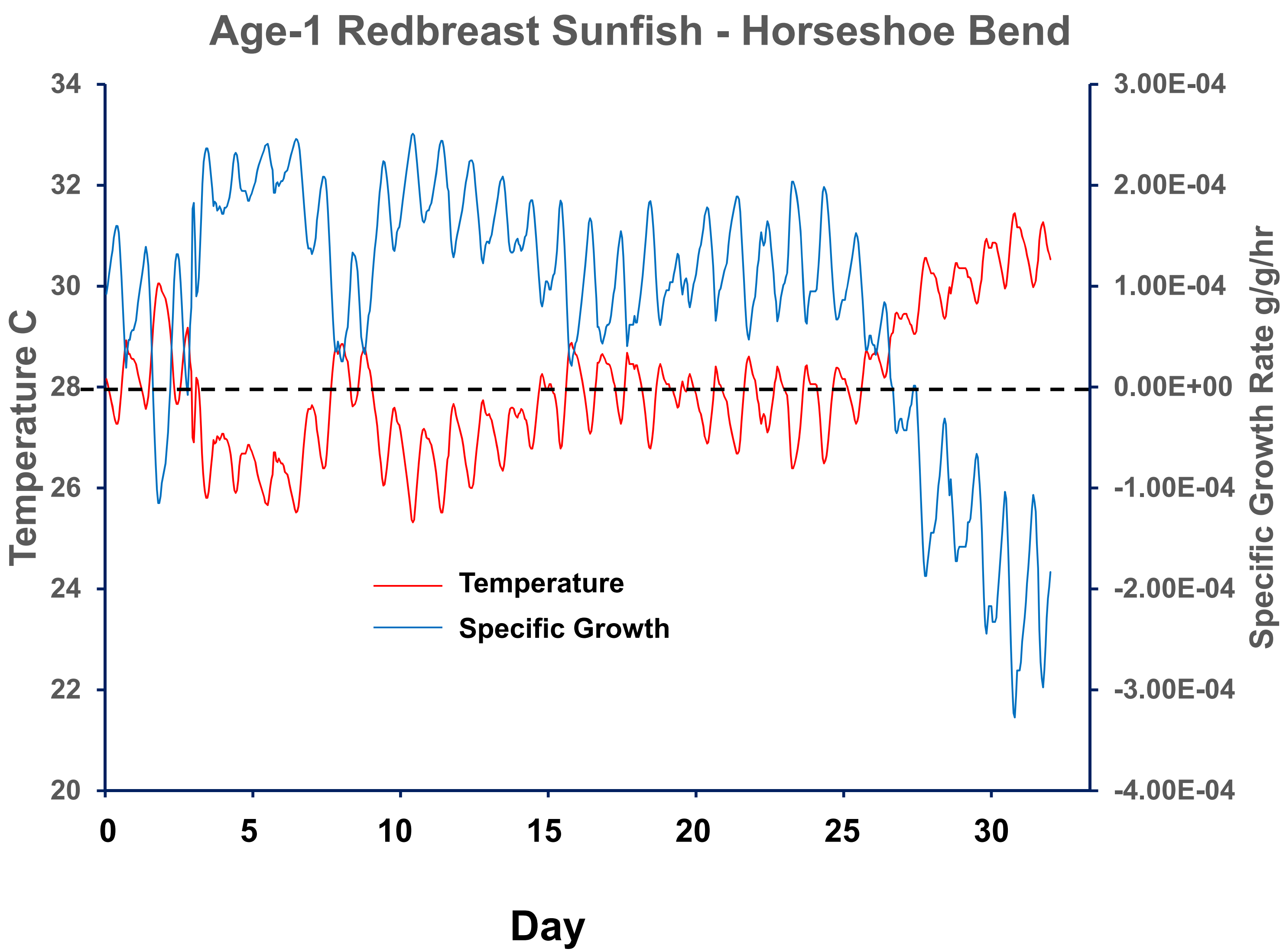
Redbreast Sunfish Bioenergetics Simulations

Initial and final weights from von Bertalanffy equations and P-value (proportion of maximum consumption) produced for model runs for July 15 – August 15 at the tailrace and Horseshoe Bend.				
	Initial Weight (g)	**Final Weight (g)**	**P-value for tailrace**	**P-value for Horseshoe Bend**
Age 1	**14.27**	**15.16**	**0.357**	**0.395**
Age 3	**65.98**	**68.61**	**0.397**	**0.436**
Age 5	**130.16**	**132.64**	**0.395**	**0.44**
hours simulated	**768**			

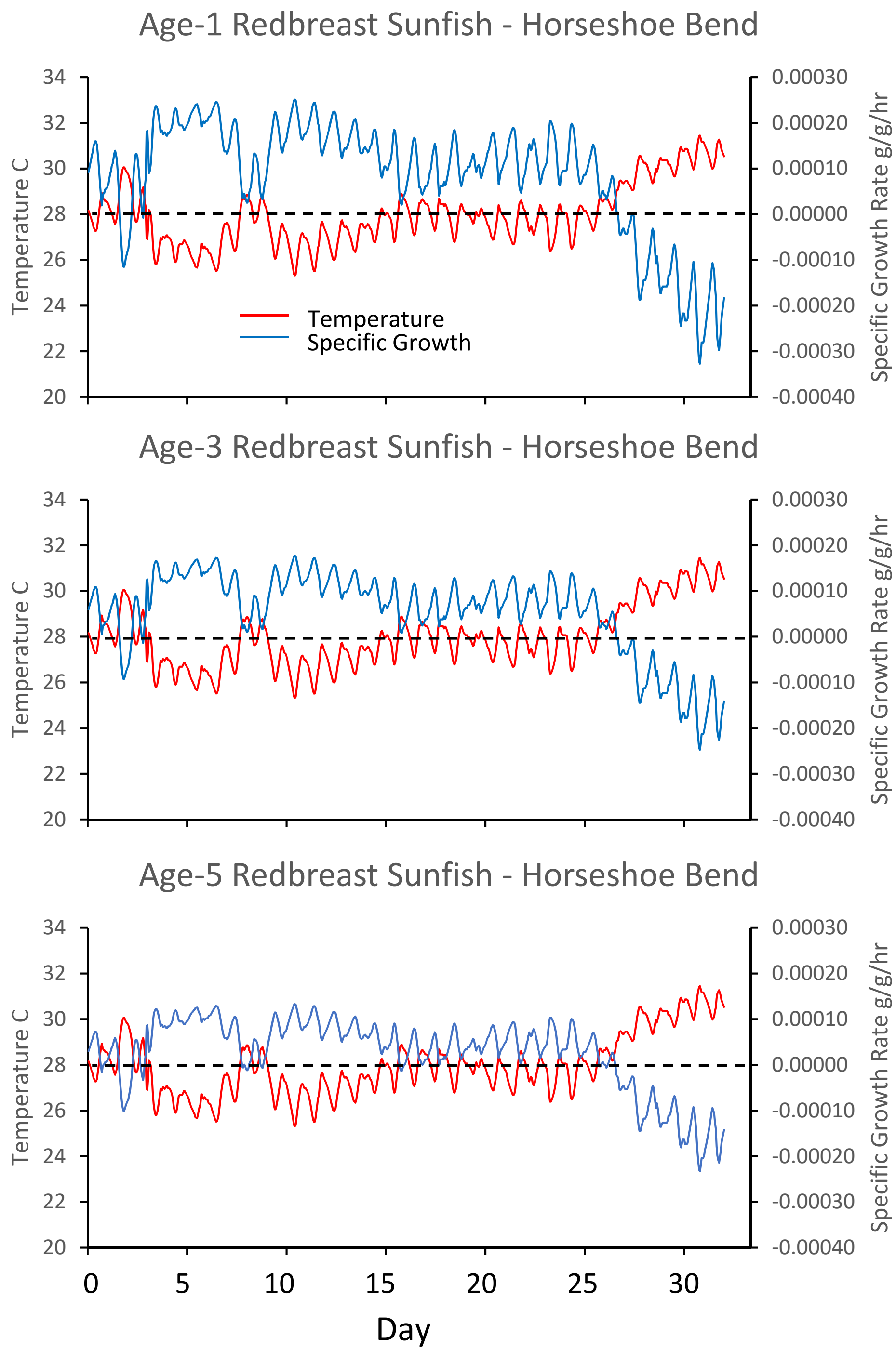


Age-1 Redbreast Sunfish Tailrace
Temperature C
Specific Growth Rate g/g/hr
Day
Temperature
Specific Growth
34
32
30
28
26
24
22
20
0.0002
0.0001
0
-0.0001
-0.0002
-0.0003
-0.0004
0
5
10
15
20
25
30

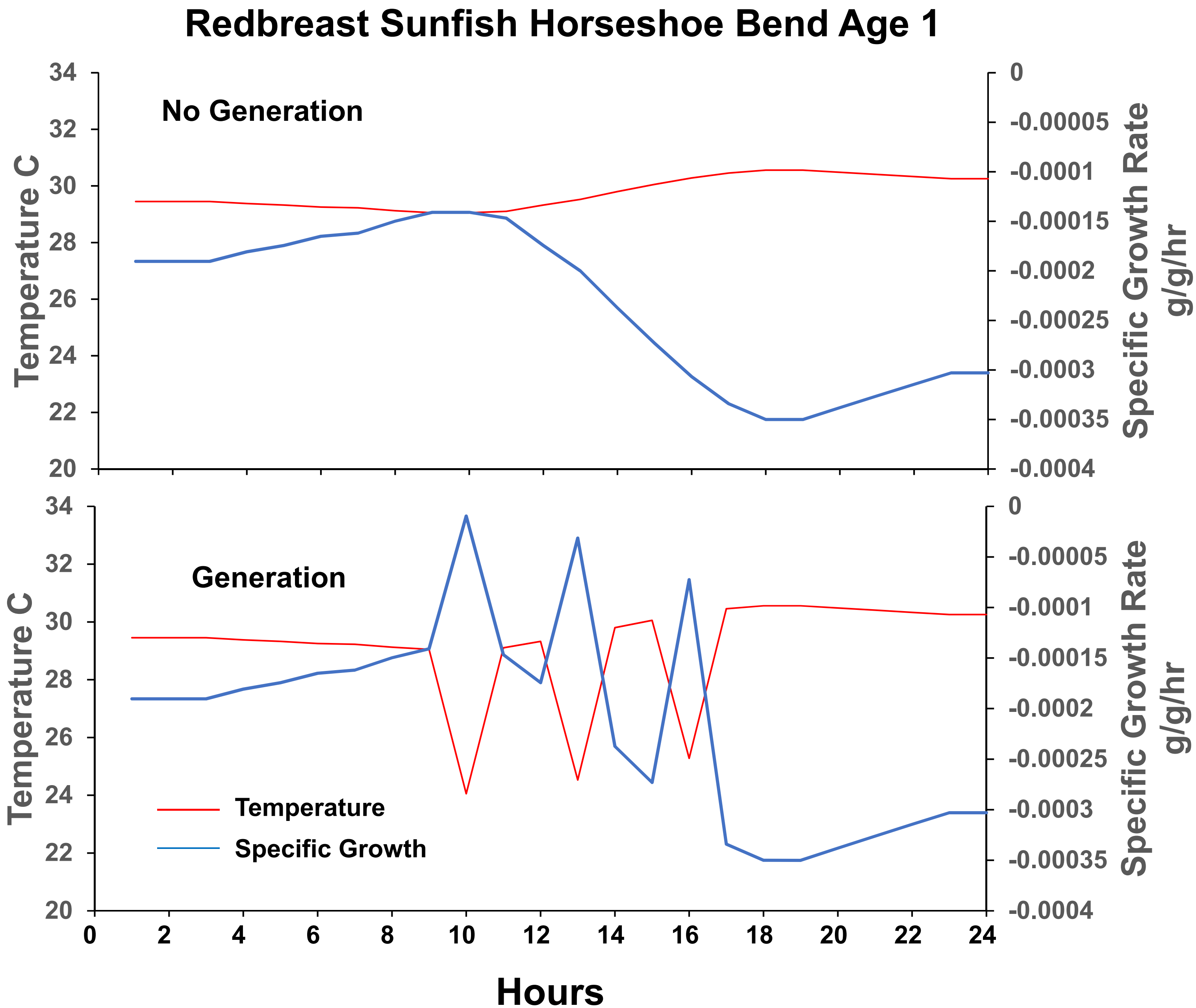

Age-1 Redbreast Sunfish Tailrace
Age-3 Redbreast Sunfish Tailrace
Age-5 Redbreast Sunfish Tailrace
Temperature C
Specific Growth Rate g/g/hr
Temperature
Specific Growth
Day
34
32
30
28
26
24
22
20
0.0002
0.0001
0.0000
-0.0001
-0.0002
-0.0003
-0.0004
0
5
10
15
20
25
30



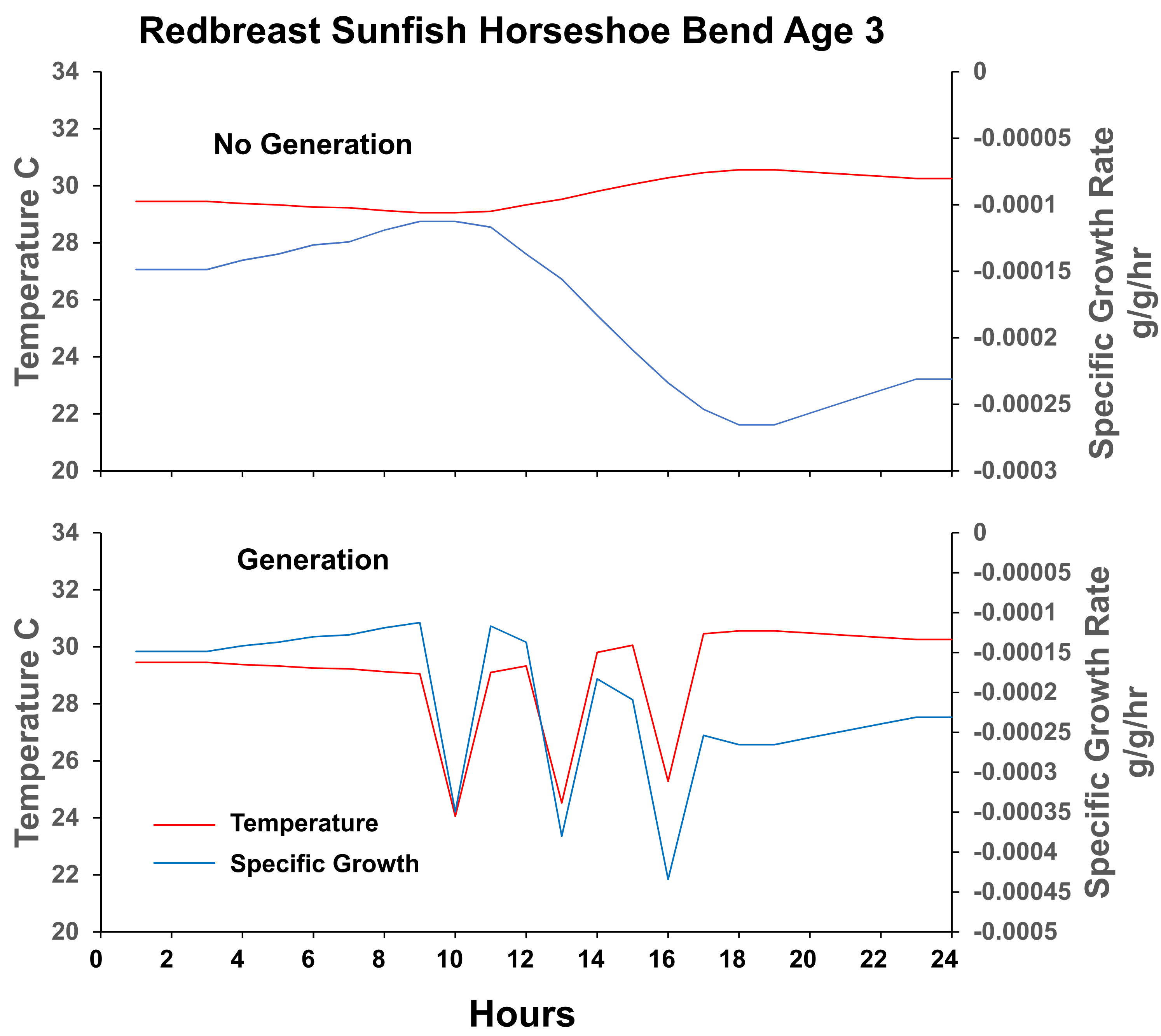
Age-1 Redbreast Sunfish - Horseshoe Bend
Temperature C
Specific Growth Rate g/g/hr
Day
Temperature
Specific Growth
34
32
30
28
26
24
22
20
3.00E-04
2.00E-04
1.00E-04
0.00E+00
-1.00E-04
-2.00E-04
-3.00E-04
-4.00E-04
0
5
10
15
20
25
30

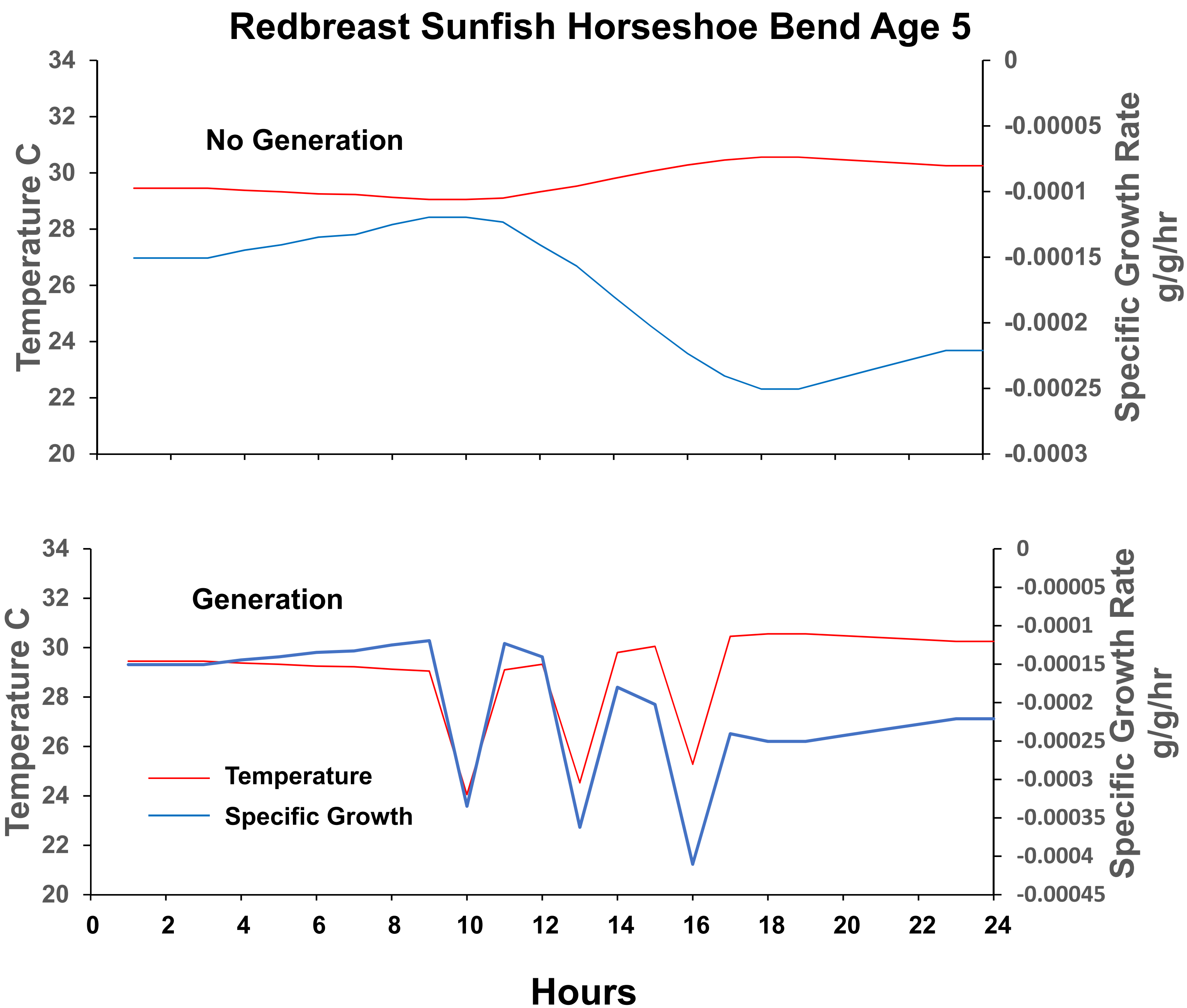


Age-1 Redbreast Sunfish - Horseshoe Bend
Temperature
Specific Growth
Age-3 Redbreast Sunfish - Horseshoe Bend
Age-5 Redbreast Sunfish - Horseshoe Bend
Temperature C
Specific Growth Rate g/g/hr
34
32
30
28
26
24
22
20
0.00030
0.00020
0.00010
0.00000
-0.00010
-0.00020
-0.00030
-0.00040
0
5
10
15
20
25
30
Day



Redbreast Sunfish Horseshoe Bend Age 1
No Generation
Generation
Temperature C
Specific Growth Rate g/g/hr
Temperature
Specific Growth
Hours
34
32
30
28
26
24
22
20
0
-0.00005
-0.0001
-0.00015
-0.0002
-0.00025
-0.0003
-0.00035
-0.0004
0
2
4
6
8
10
12
14
16
18
20
22
24


Redbreast Sunfish Horseshoe Bend Age 3
No Generation
Generation
Temperature C
Specific Growth Rate g/g/hr
Temperature
Specific Growth
Hours
34
32
30
28
26
24
22
20
0
-0.00005
-0.0001
-0.00015
-0.0002
-0.00025
-0.0003
-0.00035
-0.0004
-0.00045
-0.0005
0
2
4
6
8
10
12
14
16
18
20
22
24



Redbreast Sunfish Horseshoe Bend Age 5
No Generation
Generation
Temperature C
Specific Growth Rate g/g/hr
Temperature
Specific Growth
Hours
34
32
30
28
26
24
22
20
0
-0.00005
-0.0001
-0.00015
-0.0002
-0.00025
-0.0003
-0.00035
-0.0004
-0.00045
0
2
4
6
8
10
12
14
16
18
20
22
24

Bioenergetics simulations for Redbreast Sunfish

Weight loss in simulations over 24 hr		
Age	**No Generation**	**Generation**
Age-1	-0.43%	-0.41%
Age-3	-0.33%	-0.39%
Age-5	-0.33%	-0.38%

Summary of Bioenergetics Model Simulations

- Only the Redbreast Sunfish model had reasonable fits to measured respiration. Catfish and black bass models were not adequate.
- Water temperatures downstream were high enough in late summer to predict reduced growth in Redbreast Sunfish
- Simulated pulses of generation in late summer produced slight declines in growth in age-3 and 5 Redbreast Sunfish due to increased activity cost in downstream warmer water.
- From an energetics perspective, pulses of increased flow would have the greatest impact on fish growth during the warmer periods (higher respiration rates)

Project Summary

- Given few reliable temperature thresholds (i.e. minimum, maximum, spawning temperatures, etc.) for our target species were available, testing of fish from this system in controlled laboratory setting would be required.
- Analysis of the historical temperature data supports that variation has been similar during pre- versus post-Green Plan periods.
- Relative weight and body condition were not compromised in the tailrace relative to downstream sites for the target species.
- To our knowledge, these data represent the first comprehensive sampling effort of the Harris Dam tailrace fish community. With these data, species diversity and richness varied little among sites, although the most common species varied by site and season.

Project Summary (con't)

- Our results suggest that high flow rates, including that from hydroelectric peaking generation, can exceed the prolonged swimming capability of our target species.
  - Riverine fishes may seek refuge during high flow.
  - Fine scale tracking in the field or experimental lab trials to determine the behavioral responses to increased flow for species of differing body size and vagility would be necessary to identify, maintain, or even enhance refuge habitats.
- Bioenergetic simulations and respirometry patterns suggest that temperature and the interaction of temperature and flow can significantly influence growth conditions for fishes in the Tallapoosa River. Cooler water in the tailrace appears to improve growth conditions for Redbreast Sunfish with uncertain influence on swimming performance.
- Similar work with species not targeted in this project may be warranted to determine impacts of flow and temperature fluctuations on the broader fish community.