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Trophic state indicators are a better predictor of Florida bass condition compared to temperature in Florida's freshwater bodies

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Abstract Forecasted increases in global temperatures will likely have profound effects on freshwater fishes. Overlaid on increasing global temperatures, human populations are expected to grow, which will increase anthropogenic nutrient enrichment in freshwater ecosystems. Florida (US) represents the equatorial range limit for many freshwater fishes, thus these species are potentially at risk to climate warming. Likewise, Florida's population is expected to aggressively expand, increasing risk for nutrient enrichment. In this study, we examined whether maximum water temperatures or trophic state indicators (a proxy for nutrient enrichment) better explains variation in Florida Bass (*Micropterus salmoides floridanus*) condition across 23 different Florida freshwater bodies distributed throughout the state. Florida Bass lengths and weights, temperature, and chlorophyll-α, total phosphorous (TP), and total nitrogen (TN) measures were collected in the late summer and fall from 2010 to 2012. We described relationships between bass relative condition and environmental measurements (temperature, and trophic state indicators) across these lake-year combinations using linear and non-linear regressions. We found no significant relationship between temperature and bass condition ($r^2 = 0.01$). However, we found that trophic state indicators did predict bass condition ($r^2 = 0.39$–0.50). Though research is needed to more rigorously assess the effects of rising temperature on bass condition, our results may suggest that lake productivity is currently an influential driver on Florida Bass. As such, management efforts should continue to closely monitor and manage water quality and potential nutrient enrichment in Florida's freshwater waters, as bass condition appears to be closely tied to lake productivity.

Keywords Florida bass · Lake productivity · Florida · Condition

Introduction

Nearly all of the biochemical and physiological functions of fishes are influenced to some degree by

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temperature (Pörtner and Knust 2007). Thus, rising global temperatures represent a major potential driver of change for fishes, and aquatic systems (Ficke et al. 2007). At the level of an individual fish, rising temperatures will first increase fish energetic and aerobic demands (Pörtner and Knust 2007). To compensate for this novel energetic and aerobic load, fishes must increase consumption and respiration to maintain their optimal body mass and growth. Once temperatures cross a certain upper threshold, fish energetic and aerobic demands to maintain basic life functions (i.e., organ function), rise exponentially, reaching rates that exceed their intake capacity, consequently reducing energy allocation to other secondary functions (growth; reproductive investment etc.; Holt and Jørgensen 2015). If fish must endure these temperatures for prolonged periods, growth slows, energy reserves rapidly become depleted, and reproductive output decreases. These changes can then affect population dynamics, community structuring, and potentially ecosystem function (Pörtner 2001; Doney et al. 2012).

Overlaid on the stress of rising temperatures, human populations continue to grow, adding additional pressures on fishes and aquatic systems (McCauley et al. 2015). One anthropogenic stressor ubiquitous with population growth is anthropogenic nutrient enrichment and eutrophication (Bricker et al. 2008). Relatively minor nutrient loading can stimulate bottom up foodweb processes, which in some situations enhance fishing and wildlife viewing opportunities (Downing et al. 1990). However, at high levels of anthropogenic nutrient additions, water quality, turbidity and dissolved oxygen reach harmful levels for fish, submerged aquatic vegetation can reach densities that impair fish foraging, and vegetation communities could change in ways that negatively affect reproduction and foodweb dynamics (Kramer 1987; Miranda and Hodges 2000; Folke et al. 2004). These two stressors, rising temperatures and anthropogenic nutrient enrichment, provide an interesting contrasts for species conservation, and resource management decisions, as rising temperature represents a far-field driver that acts independently of local or regional management manipulations. Whereas, anthropogenic nutrient enrichment represents a near field driver that can be corrected or at least slowed by local management (Kelble et al. 2013). Thus, by identifying which of these drivers may be most influencing fish populations, resource managers can focus conservation efforts centered on either adaptation (i.e., rising temperatures) or mitigation (i.e., nutrient enrichment).

The state of Florida (USA) extends from latitude 24–30°N (approximately 800 Km north to south). The southernmost region of Florida almost extends to the tropics (23° North and South; Neilson 1995), while the northern most regions are found well within the subtropics. Despite Florida's geographical position close to the tropics, Florida's native freshwater fishes are largely temperate that colonized peninsular Florida from the northern regions of the United States. As such, south Florida approaches the equatorial range limit for many of Florida's native freshwater fishes (Gaiser et al. 2012). Similarly, Florida's human populations are exponentially rising and are expected to continue to grow, which has resulted in the eutrophication of many freshwater, coastal, and nearshore environments (Kelble et al. 2013). Given the somewhat certainty of these drivers increasing in strength in the future, and the gravity of effects they incur, we must develop a better understanding of how freshwater fishes respond to these stressors to implement the most effective conservation actions to protect them.

In this study, we conducted coarse evaluation of the effects of temperature and lake productivity on the condition of a common and abundant freshwater fish found throughout Florida, Florida bass (*Micropterus salmoides floridanus*). Condition is the ratio of body mass to length, and is a good proxy for energy reserves (Le Cren 1951; Murphy and Willis 1991; Peig and Green 2009). Further, body condition of fishes responds relatively quickly to changes in metabolic and aerobic scope, mediated by variation in temperature and trophic state, thus provides a fast-acting metric to identify effects of these environmental drivers on bass (Strobel et al. 2012). Bass demographics (e.g., length and weight), water temperature, and trophic state indicators were collected every fall from 2010 to 2012. We hypothesized that, because Florida bass occur at the equatorial extent of their native range, that temperature would have some influence on fish condition. Thus, we expect a weak negative relationship between temperature and condition, and a weak positive relationship between bass condition and trophic state indicators. We described relationships between condition, temperature, and trophic state indicators using linear and non-linear regressions.

Materials and methods

Study region and description of sampled waters

We assembled previously-collected temperature, trophic state indicators and bass length and weight measures from 23 Florida water bodies (both lakes and canals) from 2010 to 2012. The latitudinal gradient spanned 780 km across the state of Florida, from Lake Sampson (30.435602°N, −84.567316°W) in North Florida to the L-31 W canal (25.417936°N, −80.579789°W) in South Florida along the southeastern border of Everglades National Park (Fig. 1). The sampled water bodies vary in size and water quality, and exhibit a wide range of trophic states, including oligotrophic, eutrophic, and hypereutrophic systems (e.g., L-67A canal, Lake Griffin, and Lochloosa Lake, respectively). Most of the water bodies in this study are shallow (< 5.0 m) solution lakes, except for canals, which can be as deep as 6.5 m (Gandy and Rehage 2017).

Focal species and fish collections

Largemouth bass (*Micropterus salmoides sp.) are* widely distributed across the United States, and highly valued as a freshwater sport fish. In Florida, Largemouth and Florida Bass (*Micropterus floridanus)* co-occur in the wild in a natural intrograde zone and readily hybridize, but are recognized as separate species based morphology (Bailey and Hubbs 1949), and genetic differentiation (Philipp et al. 1983). Compared to Largemouth Bass, Florida Bass spawn later (Rogers et al. 2006), have similar tolerance of high temperatures (Florida

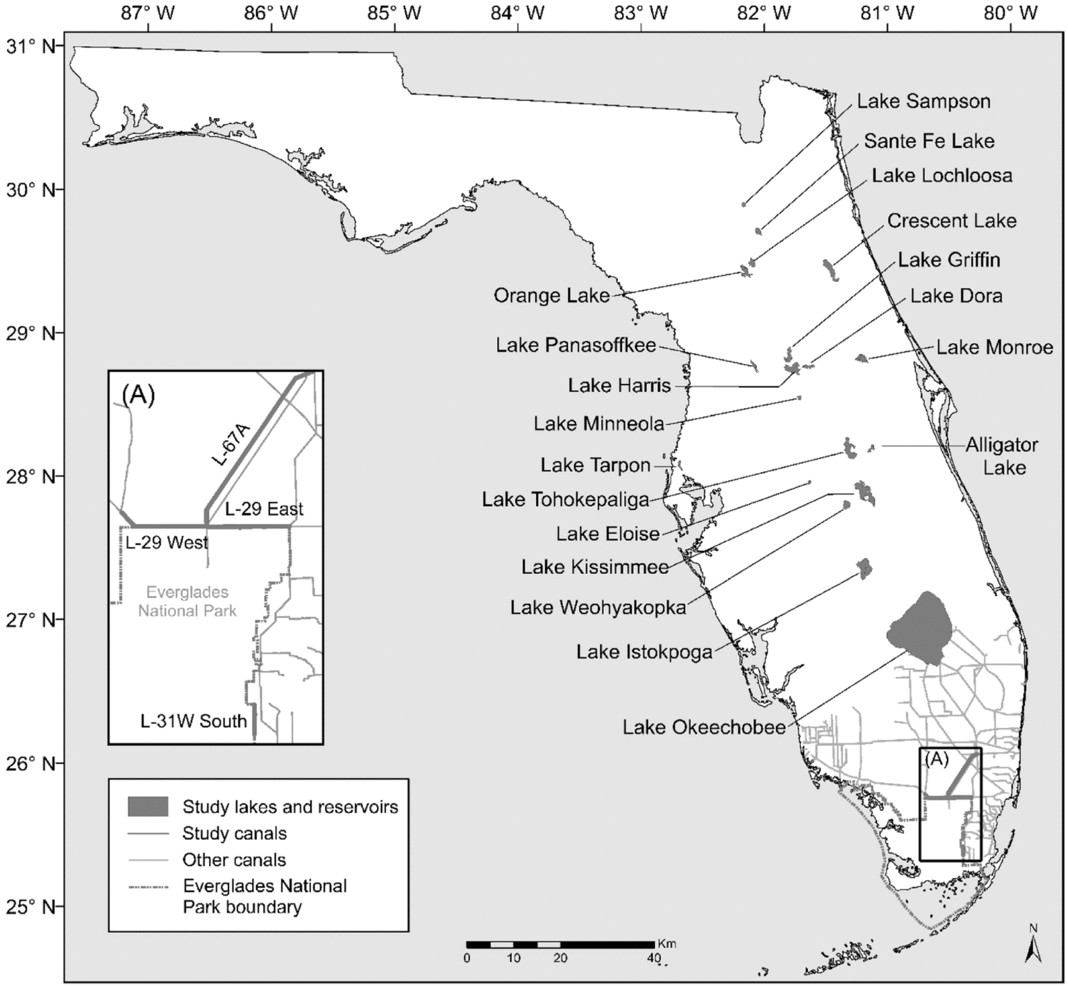

Fig. 1 Map showing the 23 freshwater bodies sampled during this study from 2010 to 2012

bass = 37.5 °C and largemouth bass = 36.5 °C; Fields et al. 1987), grow faster after the first year (Maceina et al. 1988), are less tolerant of cold-shock (Guest 1982), and reach a larger maximum size (Austin et al. 2012). Largemouth Bass were originally distributed east of the Rockies, ranging from southeastern Canada to northeastern Mexico, while Florida Bass are endemic to peninsular Florida (MacEina and Murphy 1992). However, introductions of both species have expanded their ranges to both warm and cool temperate waters in the majority of the U.S., South Africa, Mexico, Japan, Europe, and Central and South America (Gratwicke and Marshall 2001; Takamura 2007).

Historically, Florida populations of Largemouth Bass were limited to the north and west of the Choctawhatchee and Apalachicola River drainages, and Florida Bass to the south and east of the Suwanee, with an intergrade zone of hybrids (Bailey and Hubbs 1949; Philipp et al. 1983). While hybrids have occurred since the Pleistocene epoch (Near et al. 2003), stocking of Florida Bass beyond their natural species boundary either purposefully or unintentionally has greatly increased the distribution and abundance of pure and hybrid Florida Bass in the wild (Barthel et al. 2010). Bass sampled for this study were collected from peninsular Florida, where Florida Bass alleles occur more frequently than Largemouth Bass alleles with some populations most likely existing as pure Florida Bass (Barthel et al. 2010). For ease of reference, all sampled bass will herein be referred to as Florida Bass.

Florida Bass were collected using boat-mounted, generator-powered electrofishing (Smith-Root GPP 2.5–9.0 units) with a two anode, one-cathode configuration. Site locations for all sampled water bodies were selected using a stratified random sampling design (see Bonvechio et al. 2009; Gandy and Rehage 2017). Sites were sampled from September to November from 2010 to 2012. Each electrofishing sampling event ranged from 300 to 900 s of power application to fish at 3000 watts (adjusted for water conductivity and temperature) using pulsed-DC current at 60 pulses per second. Upon capture by one to two dip netters positioned at the bow of the boat, fish were placed in an aerated holding tank, body length measures were taken (total length; TL), weighed and released.

Water temperature and trophic state indicators

Water temperature measurements were collected using HOBO pro v2 water temperature loggers (Onset Computer Corp.). Temperature loggers were deployed approximately 1 m below the water surface, and within a 10 m proximity to the shore. Water temperature measurements were recorded in 30-min increments, ranging over a period of several weeks to months depending on water body. Because explicit water temperature measurements were available only during a sub-set time for most bodies of water examined, we constructed a series of regressions based on the relationship between maximum daily air and daily maximum water temperatures. Maximum daily air temperature data were gathered from the publicly-accessible National Oceanic and Atmospheric Administration National Climate Data Center weather stations (http://www.ncdc.noaa.gov/cdo-web/). Air temperature stations used for analyses were determined by those with the shortest Euclidian distance from the water body. Air-water temperature linear regressions were conducted for every water body-air temperature station pairing, allowing us to generate predictive linear equations between water and air temperatures (Boucek and Rehage 2014). In nearly all of the focal water bodies, maximum daily air temperature and maximum daily water temperature tracked each other well ($r^2 > 0.65$ for 22 of the 23 water bodies; Appendix Table 1).

Using these air-water temperature predictive equations, we calculated predicted daily maximum water temperatures from maximum daily air temperature values for each water body from 2010 to 2012, and used those values for comparisons. Prior to analysis, we averaged the predicted maximum daily water temperatures over the 15-day period before fish were collected, as temperatures across a 15-day period should be sufficient to affect bass energy reserves and condition (Meka and McCormick 2005). We will refer to this 15-day average of predicted maximum water temperatures as T_{max} throughout.

We used measures of chlorophyll-α (Chl α), Total Nitrogen (TN), and Total Phosphorous (TP) as trophic state indicators. We obtained these observations for 2010–2012 from a variety of publicly available sources. Most observations came from the Florida LAKEWATCH dataset (http://lakewatch.ifas.ufl.edu/), which utilizes professionals and volunteers to obtain water quality samples from Florida's water bodies. In cases where LAKEWATCH measurements were unavailable, we obtained measures from the Florida Department of Environmental Protection's STORET program (http://www.dep.state.fl.us/water/storet/), which assembles and disseminates water quality measurements from Florida's water management districts. Lake Okeechobee measures came from Rogers and Allen (2009) and only represents the likely values of the lake from 2010 to 2012. The timing of the nutrient measures we used in our analysis were taken as close to the date of electrofishing surveys as possible. Nutrient samples were typically taken within 10–20 days of the electrofishing surveys.

Calculating of fish condition

We calculated bass condition using relative condition factor ($K_{n,}$ equation below).

$$K_n = \frac{W}{W'}$$

where *W* is the weight of an individual and *W′* is the mean weight of all fish of that size from a sampled population as predicted by a weight-length equation calculated for that population (Murphy and Willis 1991; Blewett et al. 2017). The relative condition factor is often preferred over the Fulton condition factor (K) because K_n compensates for allometric growth (Murphy and Willis 1991; Peig and Green 2009). Florida Bass measures used for *W* were from the 23 water bodies sampled from 2010 through 2012 (7095 Florida Bass), that both trophic state indicators and temperature measurements were available. For our W′ weight-length equation, we used bass TL and weights from a much larger dataset available through FWRI's Freshwater Long Term Monitoring program (Bonvechio et al. 2009). Thus, *W′* values were calculated from a sampled population of 137,185 Florida Bass caught across 140 freshwater bodies in Florida from 2006 to 2012. Thus, our W′ from this larger sample serves as a good representation of Florida Bass condition in Florida to compare with the subset of observations we used.

Prior to analysis, we excluded young of the year (YOY) fish (<15 cm TL) because YOY fish often preferentially allocate energy to growth rather than to building energy reserves (Murphy and Willis 1991). We also removed individual fish with K_n values less than 0.75, and greater than 1.25 (i.e., 25% heavier or lighter than the average fish of that size) as values at these upper and lower extremes are likely not reflective of the condition of the population in the water body. These unusually high or low values may be caused by measurement error, egg hydration, disease, parasite loads and other factors unrelated to energy reserves that would be affected by temperature mediated changes in metabolic and aerobic scope (Murphy and Willis 1996). We also removed electrofishing samples where less than five Florida Bass were caught, as five Florida Bass would not fully capture population demographics across the entire water body (Murphy and Willis 1996). For analysis, we used average K_n measured for each year (2010–2012) at each water body (23 total) as dependent variables. We dropped samples (waterbody-years) where Florida Bass demographics, trophic state indicators, or temperature were not available or too few Florida Bass were collected (<5 bass), leaving a total of 58 waterbody-year samples used for analysis. Quadratic equations and non-linear regressions were used to describe relationships between trophic state, temperature and condition. We compared r^2 values of regressions between trophic state indicators and condition, and temperature and condition to determine which environmental driver has a stronger influence on Florida Bass condition in Florida.

Results

Temperature

Overall, temperature varied across water body-years. At the upper end, T_{max} values approached the lethal limit for Florida Bass (33–34 °C; Lake Santa Fe 2010 & 2011; Fig. 2a). Conversely at the lower end of the observed temperature range in this study, T_{max} values were near the thermal optima for Florida Bass (22–25 °C; Fig. 2a).

Water quality and trophic state indicators

Trophic state measurements for the 23 water bodies also varied from systems that were oligotrophic to those that are hyper eutrophic. The Chl*α* values ranged from 2 to 139 $\mu g \cdot L^{-1}$ with a mean of 30 $\mu g \cdot L^{-1}$ suggesting generally productive, mesotrophic-eutrophic conditions (Fig. 2c; Appendix Table 2; Bachmann et al. 1996).

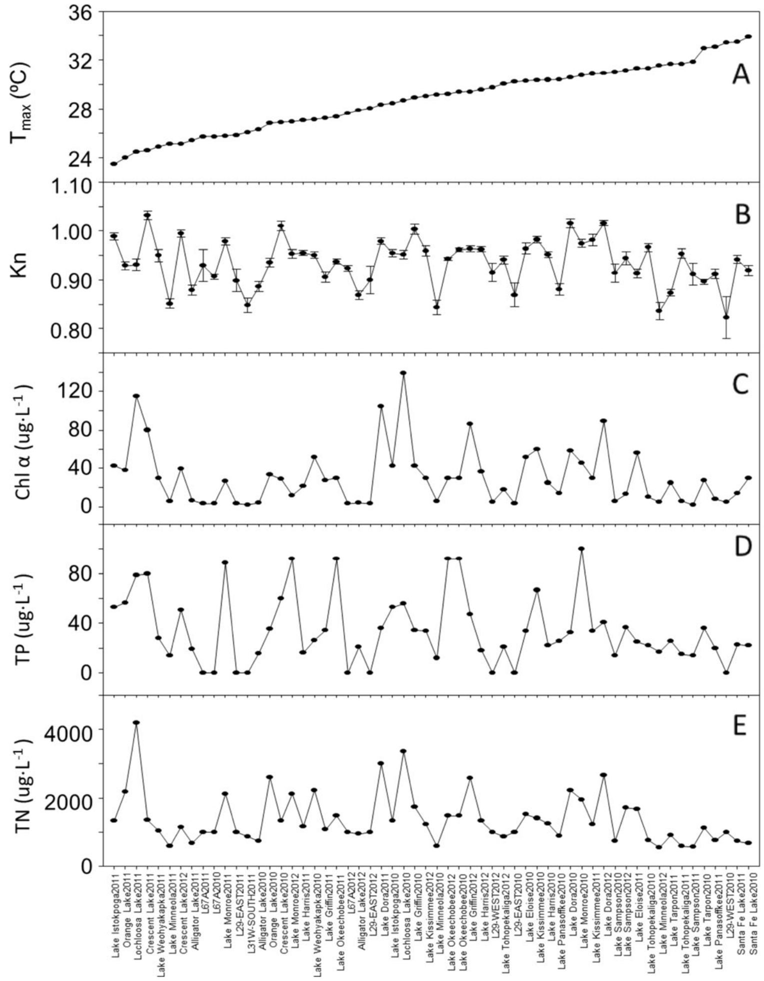

Fig. 2 Average **a** T_{max}, **b** $K_{n,}$ **c** Chl α, **d** TP, **e** TN values for each water body-year sampled in Florida from 2010 to 2012. Data points on each figure are arranged in ascending order from the coldest sample to the warmest

Similarly, TN and TP values varied across lakes, with TN ranging approximately 560 μg·L^{-1} to over 4188 μg·L^{-1} (Fig. 2e). Last, TP measurements spanned from 9 μg·L^{-1} to over 100 μg·L^{-1} (Fig. 2d). For the southern water bodies, Chlα concentrations (<28.5 °N) averaged 19 μg·L^{-1} and were lower than northern water bodies (>28.5 °N) averaging 41 μg·L^{-1}. The lowest Chlα (2.3 μg·L^{-1}) occurred in L-31 W, a south Florida canal, while the highest value (139 μg·L^{-1}) occurred in Lochloosa Lake in north-central Florida (Fig. 2c).

Fish samples

From 2010 to 2012, 7095 Florida Bass were sampled across 23 freshwater bodies that had both temperature and trophic state measures. Florida Bass demographics for each water body are summarized in Appendix Table 2. Average relative condition per water body per year ranged from 0.89 (S.E. ± 0 .04; L29 West yr. 2010, Fig. 2b) to 1.08 (S.E. ± 0.009 Crescent lake yr. 2011, Fig. 2b). The average K_n value for all water bodies was 1.00 (S.E. ± 0.001).

Temperature vs. trophic state indicators

Our results indicate first that temperature and trophic state indicators are not correlated in the focal lakes of study (r^2 = 0.01, Fig. 3a). Similarly, we did not find a relationship between K_n and T_{max} (r^2 = 0.03 Fig. 3b). In contrast, trophic state indicators better described variation in bass condition relative to T_{max}. Of the three trophic state indicators, Chlα, was the best predictor of bass condition (r^2 = 0.50, Fig. 3c) followed by TP (r^2 = .43, Fig. 3d) and then TN (r^2 = 0.39, Fig. 3e).

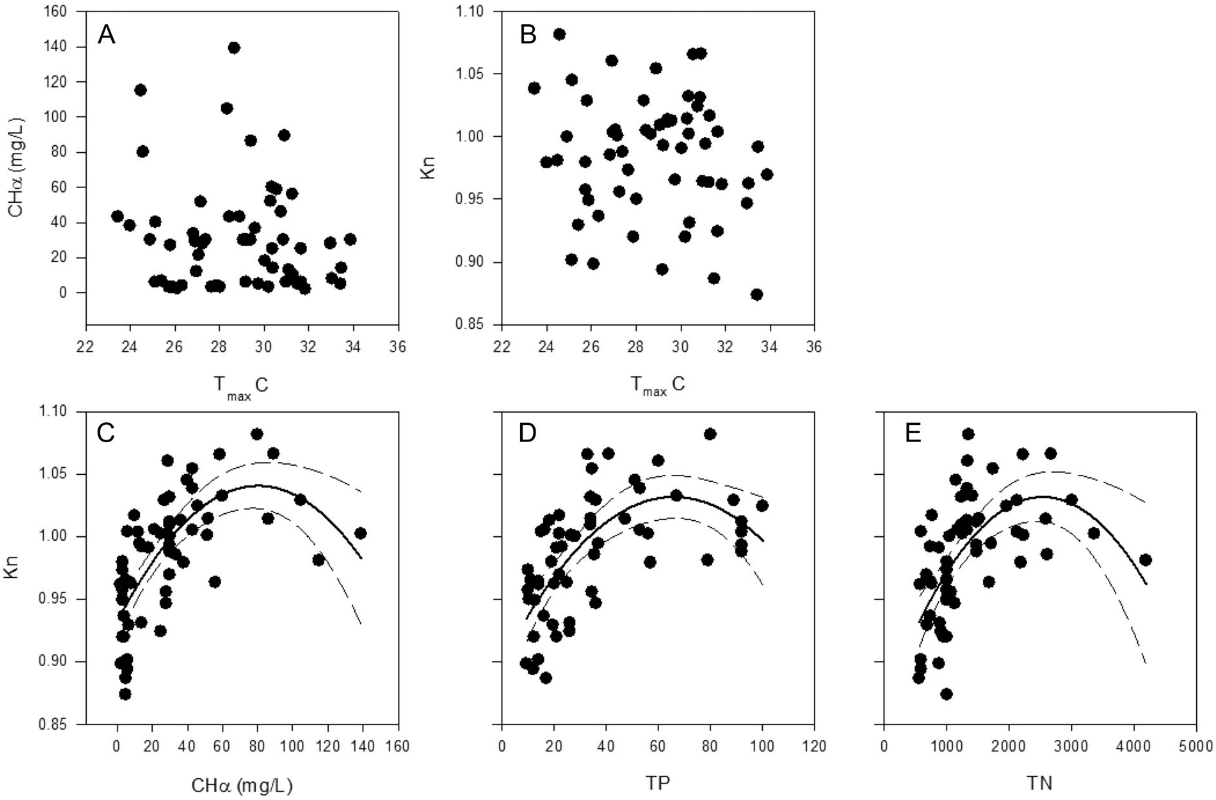

Fig. 3 Scatter plot describing relationships between **a** T_{max} and Chlα, **b** mean Kn and Tmax, **c** Chl α and Kn, **d** TP and mean Kn, and **e** TN and mean Kn in Florida from 2010 to 2012. Solid lines represent regression line and dashed lines represent the 95% confidence intervals around those lines

Discussion

Global change presents novel challenges for freshwater communities (Ficke et al. 2007). Of these challenges, increases in temperature and human population growth are some of the most threatening (Ficke et al. 2007). Our results show that present temperature regimes in Florida may be is less important in influencing the condition of Florida Bass relative to lake trophic state. As such, resource managers should continue closely monitoring and managing nutrient inputs into Florida freshwaters, as this driver seems to be a more immediate agent of change. We argue for two reasons for why temperature was a less strong predictor of Florida Bass body condition compared to trophic state indicators. First, temperatures experienced by bass during this study may not have been of sufficient amplitude, duration, or had a rate of change fast enough to increase metabolic demand beyond what could be compensated by increased intake; and second, Florida's freshwater bodies have enough thermal micro refugia, allowing Florida Bass to avoid daily periods of stressful temperature conditions. We further discuss the rationale for each of these two reasons below.

During this study, maximum daily water temperatures likely reached levels above optimal temperatures for Florida Bass. For instance, the T_{max} of 24 out of the 58 samples were at or over 30 °C., and, six T_{max} datapoints fell within Florida Bass upper lethal limits (33.5–37.5; Fields et al. 1987 and Eaton and Scheller 1996). At these temperatures, Florida Bass metabolism and oxygen demand should rise exponentially (Pörtner and Knust 2007). If intake remains constant, the resultant outcome is that individual fish must allocate more energy and oxygen to vital life functions (i.e., liver function), reducing energetic allocation to growth, reproduction, and energetic reserves (Pörtner and Knust 2007). Though temperature likely reached stressful levels, they may not have had the necessary duration or amplitude to overwhelm Florida Bass energetic intake capacity. This is especially the case in Florida's meso and eutrophic lakes, where forage species are in high abundance. Other studies have shown that increases in food availability can offset negative effects of temperature. For instance, Weitere et al. (2009) found that an invasive clam *Corbicula fluminea* occurring at temperatures above their thermal optima maintained high growth rates in more productive streams with high planktonic biomass. However, these clams experienced negative growth and high mortality in more oligotrophic systems, where food was more limited.

A second plausible reason why we did not observe an effect of temperature on Florida Bass condition is due to the availability and the ability of Florida Bass to moderate exposure to stressful conditions via microclimate selection (Bernardo 2014; Boucek et al. 2017). Recent work has shown that the effect of stressful temperatures on mobile species appears less dictated by solely their abiotic lethal limits, but rather by behaviors that allow individuals to utilize suitable microhabitats/ μ-climates (Sunday et al. 2014; Boucek et al. 2017). We speculate that Florida Bass in the focal water bodies likely take advantage of these refuge habitats when they are available.

One potentially important feature in Florida lakes that can create thermal refugia is submerged aquatic vegetation (SAV), including invasive hydrilla (Hoyer et al. 2008). The hydrology of Florida lakes ensures that the much of the surface area of the lake is essentially littoral, creating high percent area of SAV coverage (Hoyer et al. 2008). Unlike northern lakes where aquatic plants might not provide adequate shading, Florida has abundant aquatic plant coverage that likely offers these microclimates/microhabitats that Florida Bass utilize during daily periods of stressful temperatures. However, the role that microhabitat availability provided by SAV cover plays in influencing Bass condition in Florida is not well known, and should be explored further.

When forecasting potential effects of climate warming on fishes, we must account for not only direct physiological stress caused by increasing temperatures, but also other processes affected by increased temperatures that may then in turn affect fish (Doney et al. 2012). One potentially important effect of warming water bodies that could alter fish performance in Florida are reductions in oxygen availability, and increased frequency of hypoxic and anoxic events. Warming often increases heterotrophic respiration, reducing dissolved oxygen (North et al. 2014). Similarly, oxygen solubility decreases as waters warm (Ficke et al. 2007). These changes in dissolved oxygen mediated by temperature may have a more pronounced affect in eutrophic systems, where warming in those systems is expected to further increase productivity, and consequently increasing diel variation in dissolved oxygen (Tadonleke 2010). On top of these external changes to oxygen availability, oxygen demand of freshwater fishes will increase with temperature (Pörtner 2001). As such, changes in oxygen availability mediated by increasing temperatures may become a stronger driver of Florida freshwater fish performance in the future, and is an area of future research.

Results from our study agree with findings from Shoup et al. (2007) and Mclnerny and Cross (1999) that found that Northern Largemouth Bass growth in Illinois lakes and Black Crappie (*Pomoxis nigromaculatus)* growth in Minnesota lakes were more influenced by prey availability and trophic state than temperature. However, our findings disagree with Beamesderfer and North (1995), McCauley and Kilgour (1990), and Britton et al. (2010) that found positive relationships (r^2 = 0.46–84) between bass growth, annual temperature, and latitude (a proxy for regional temperature) using populations across a large geographic range (i.e., continental U.S.). These contradictory results may indicate relationships between Largemouth Bass individual performance and temperature only emerge at very broad temperature ranges, beyond what was measured here. Further, temperate freshwater fishes like Largemouth Bass and Black Crappie experience more natural variation in temperature than any other species group and are considered thermal generalists (Ficke et al. 2007; Tewksbury et al. 2008). Temperate fishes inherent adaptions to a wide thermal range may explain why only very large differences in temperature result in measurable effects on temperate species performance.

Very high trophic states as indicated by TP, TN, and Chl- α leads to diminishing returns in body condition, particularly for large predator fishes in Florida (McInerny and Cross 1999). In this study, we found that condition peaked at Chl-α concentrations 80–90 μg·L^{-1}, and decreased beyond that. Our results agree with findings from Mclnerny and Cross (1999), that showed that growth for Black Crappie reached an asymptote with Chl-α concentrations at approximately 100 μg·L^{-1}, and decreased with higher Chl-α concentrations. Hypereutrophic water bodies create several stressors including periods of hypoxia and anoxia, and dense vegetation that can hinder foraging efficiencies of sight feeding piscivores, both of which can reduce condition (Bachmann et al. 1996). In Florida lakes and elsewhere, trophic states of approximately 90–100 μg·L^{-1} could be used as critical management targets, that lakes should not exceed. Though, as temperatures warm, the adverse effects of eutrophication will occur at lower nutrient inputs, and could be considered in management (Tadonleke 2010).

The projected response of Florida Bass to increased freshwater temperatures poses an unknown but potentially risk-prone scenario for Florida Bass in Florida (Ficke et al. 2007). Our results suggest that at current temperature regimes in Florida, other factors such as trophic state may play a larger role in influencing the individual performance of Florida Bass. As such, management efforts should continue to closely monitor and manage water quality in Florida's freshwater waters, as bass performance appears to be closely tied to variation in trophic state. However, as global temperatures continue to rise, temperature's influence on Florida Bass dynamics will inevitably increase. Therefore, we must continue to develop long term plans that may account for future climate disturbances to conserve Florida's freshwater fishes.

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Appendix

Table 1 The relationship between maximum daily air temperature and maximum daily water temperature in Florida from 2010 to 2012. Water temperature data were determined using HOBO pro v2 water temperature loggers (Onset Computer Corp.). Air temperature data were determined from National Oceanic and Atmospheric Administration weather stations nearest to the water body

Water Body	Regression Equation	r^2 Value
Alligator Lake	Y = 0.9376× – 0.8871	0.68
Crescent Lake	Y = 0.9267× – 0.13373	0.73
L-29 East	Y = .8969× + 0.0203	0.73
L-29 West	Y = 0.9718× – 2.4182	0.74
L-31 W South	Y = 0.2648× + 17.832	0.41
L-67A	Y = 0.9257× – 1.5286	0.68
Lake Dora	Y = 0.8273× + 6.2086	0.76
Lake Eloise	Y = 0.7152× + 11.888	0.75
Lake Griffin	Y = 0.9936× – 1.5924	0.79
Lake Harris	Y = 0.879× + 1.2648	0.79
Lake Istokpoga	Y = 1.1116× – 5.4233	0.74
Lake Kissimmee	Y = 1.0928× – 6.9602	0.72
Lake Minneola	Y = 0.973× – 1.4535	0.71
Lake Monroe	Y = .8419× = 7.5769	0.76
Lake Okeechobee	Y = 0.9391× + .1409	0.77
Lake Panasoffkee	Y = 0.625× + 5.327	0.58
Lake Sampson	Y = .9066× + .1353	0.78
Lake Tarpon	Y = 6.9522× + 96.138	0.67
Lake Tohopekaliga	Y = 0.6501× + 7.9784	0.66
Lake Weohyakapka	Y = 1.0232× – 5.0467	0.73
Lochloosa Lake	Y = 0.9426× – 3.9658	0.78
Orange Lake	Y = 0.9087× – 2.0822	0.80
Santa Fe Lake	Y = 0.856× + 0.0827	0.72

Table 2 The number of Florida Bass sampled and the mean length, weight, body condition (K_n), predicted 15 day average maximum daily water temperature prior to each bass sample, and CHlα for each of the 24 Florida water bodies sampled from 2010 to 2012

Water Body	# Caught	Total Length (mm)	Weight (g)	Average K_n	Temp (°C)	CHl α $\mu g \cdot L^{-1}$
Alligator Lake	187	256.63	230.66	0.93	26.55	4.90
Crescent Lake	304	309.78	594.84	1.06	25.55	49.67
L-29 East	41	246.71	259.33	0.94	28.05	3.63
L-29 West	24	240.76	215.93	0.95	30.58	4.87
L-31 W South	12	332.22	666.42	0.89	26.63	2.26
L-67A	301	256.18	292.52	0.97	26.38	3.63
Lake Dora	548	328.84	627.76	1.06	29.95	84.16
Lake Eloise	184	341.67	704.31	0.99	30.79	54
Lake Griffin	495	313.02	543.80	1.02	28.50	60.25
Lake Harris	690	306.60	481.51	1.01	29.02	27.61
Lake Istokpoga	259	315.41	551.37	1.02	25.96	43
Lake Kissimmee	314	303.17	501.20	1.03	30.10	40
Lake Minneola	98	274.66	309.55	0.90	28.61	5.67
Lake Monroe	361	297.65	509.21	1.02	27.85	28.33
Lake Okeechobee	1524	292.47	431.15	1.00	28.68	30
Lake Panasoffkee	86	265.52	293.91	0.95	31.73	11
Lake Sampson	75	288.71	402.71	0.98	31.32	7
Lake Tarpon	426	309.05	471.31	0.94	32.32	26.5
Lake Tohopekaliga	281	292.96	435.50	1.00	31.01	11.33
Lake Weohyakapka	132	309.44	483.98	0.97	26.09	29
Lochloosa Lake	168	340.92	554.10	0.97	26.58	127
Orange Lake	210	288.36	398.49	0.98	26.39	35.75
Santa Fe Lake	212	321.08	604.08	0.98	33.21	29.33

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