


A comparison of juvenile bonefish diets in Eleuthera, The Bahamas, and Florida, U.S.

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Abstract Bonefish (*Albula* spp.) are a popular recreational gamefish; however, there is currently limited information on bonefish early life history stages. Here we examine the diet of juvenile bonefish (*Albula vulpes*) in Eleuthera, The Bahamas, and provide a comparison to previously collected data on bonefish (*Albula* spp., primarily *A. goreensis*) in Florida. In Eleuthera, amphipods and carideans were the most important prey items found in the digestive tracts of 111 juvenile bonefish collected in 2011 and 2012. There was no difference in the ranking of 14 prey taxa between years, however, there was a difference between sample locations on Eleuthera, The Bahamas, with fish being from either Rock Sound (west coast) or Savannah Sound and Half Sound (east coast). Prey species diversity, evenness, and richness were all lower on the west coast compared to the east coast of Eleuthera. There was also a higher probability of an

empty stomach with larger bonefish on the west coast, higher amphipod and caridean abundances in juvenile bonefish on the west coast, and higher amphipod abundance with larger bonefish of Eleuthera. Differences may be related to variation in habitat structure and/or prey availability between the sample locations of the island. There was no statistical difference in ranking between the 17 prey taxa categories in Eleuthera *A. vulpes* and Florida *A. spp* (86% *A. goreensis*) juvenile bonefish stomachs; however, only one taxon (*Amphipoda*) occurred in the top-five-ranked taxa between the two studies. Results reported here provide the first insight into juvenile *A. vulpes* diet and how bonefish diet may vary across embayments, regions, and species.

Keywords *Albula vulpes* · Juvenile bonefish · Dietary overlap · Gut content analysis · Index of relative importance · The Bahamas

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Introduction

Bonefish (*Albula* spp.) occur in tropical, shallow-water systems worldwide (Nelson 2006) and provide high recreational value in south Florida (Humston 2001), The Bahamas (Fedler 2010), and the greater Caribbean (Debrot and Posada 2004; Fedler and Hayes 2008). For example, the flats catch-and-release fishery, predominantly for bonefish, annually contributes \$141 million to the Bahamian economy alone (Fedler 2010), within Florida, the flats fishery is estimated to annually

contribute \$465 million to the Florida economy (Fedler 2013). *Albula vulpes* bonefish, the species that supports the majority of the recreational fishery (Wallace and Tringali 2016), populations have declined drastically in Florida in recent decades (Santos et al. 2017; Brownscombe et al. In Review; Kroloff et al. In Review), and this species is now considered Near Threatened on the International Union for Conservation of Nature (IUCN) Red List (Adams et al. 2012).

In order to conserve bonefish populations, it is essential to understand their ecology and to identify critical habitats at all life stages. Dietary analyses help to fill such life history knowledge gaps by providing information on basic ecological requirements, and can also shed light on habitat use (Adams et al. 2006). Specifically, gut content analysis elucidates the potential ecological value of distinct habitats as foraging grounds which may influence survival and fitness. Thus, gut content analysis completed on juvenile fish may provide information on the nursery function of distinct habitats (Adams et al. 2006).

Within Florida, efforts to capture juvenile *Albula vulpes* (Linnaeus, 1758), the most targeted species in the fishery, have been difficult in part due to the relatively disturbed nature of coastal habitats (Brownscombe et al. In Review). The collection efforts for juvenile *A. vulpes* have largely resulted in the capture of the cryptic species, *Albula goreensis* (Valenciennes 1847) (Wallace and Tringali 2016). While studies have examined the diet of adults (Colton and Alevizon 1983; Crabtree et al. 1998), there is limited information on the life history and diet of juvenile bonefish, especially for *A. vulpes* (Adams et al. 2007). Layman and Silliman (2002) performed diet content analysis for juvenile bonefish in Andros, The Bahamas; however, the species was unknown and the sample size was small ($n = 10$). Similarly, Snodgrass et al. (2008) reported on the diet of juvenile bonefish in Florida, but molecular genetic analysis revealed that the cryptic species *Albula* species *B*, now known as *A. goreensis*, was predominate (86%) in their specimens. In addition, Draghetti and Shenker (unpublished data) reported on the diet of 23 juvenile bonefish from Florida; however, genetic analysis indicated they were *Albula* species cf. *vulpes* (Wallace and Tringali 2010). In contrast, *A. vulpes* represents much of bonefish species in the fishery as determined in The Bahamas based on genetic analyses of larval (Adams et al. 2007) and juvenile bonefish from Eleuthera Island. Yet, there is no information on the diet of juvenile *A. vulpes* in The Bahamas.

Documenting the diet of *A. vulpes*' juvenile life stage may help to elucidate essential juvenile habitat and prey requirements for this economically important species. Further, comparing diets across cryptic species and locations may be an opportunity to understand differences in the relative productivity and nursery value of different habitats across the greater region. Ultimately, this information can help with management decisions, for example, it may assist to identify areas of needed protection and preservation and thus support the goals of the Caribbean Challenge Initiative (i.e., 20% of Caribbean waters protected by 2020; Meyrick 2017). The objectives of this study were to determine the diet of juvenile *A. vulpes* bonefish captured off Eleuthera Island, The Bahamas during summers of 2011 and 2012, and to assess which factors affect the occurrence of food in the digestive tracts. In addition, compare the diet of juvenile bonefish captured off Eleuthera Island to Florida caught juvenile bonefish that were predominantly *A. goreensis* as reported by Snodgrass et al. (2008).

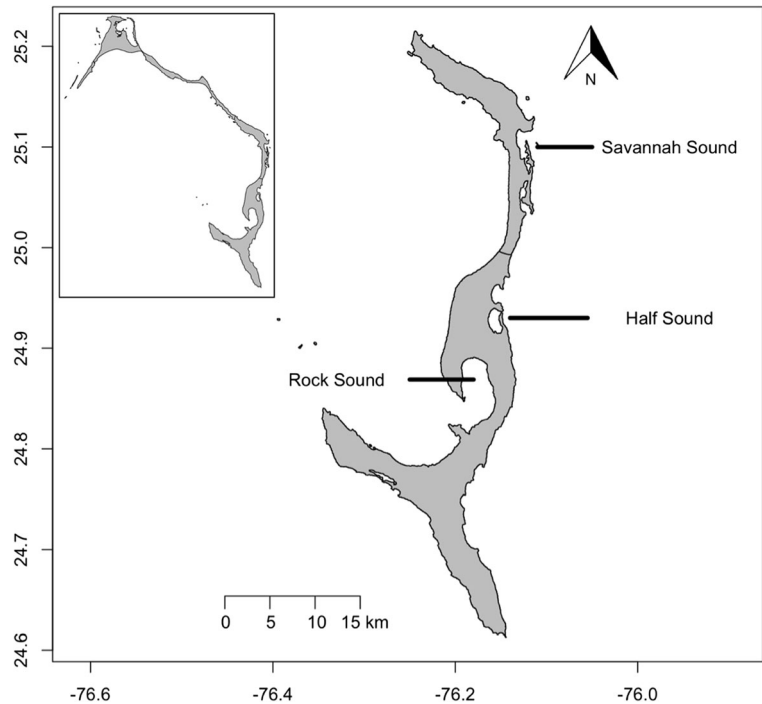
Methods

Fish collection

Juvenile bonefish were collected from May to October in 2011 and in 2012, as part of a larger study examining the distribution and habitats of bonefish in the near-shore areas of Eleuthera Island, The Bahamas (N 25 10 00 N and W 76 13 3 1). Sampling occurred during the day (08:00–20:00 h), using a 15.2 m long, 6-mm mesh seine. On six occasions in 2011, a 30.5 m long, 9-mm mesh seine was used. All captured juvenile bonefish were collected, put in a plastic bag, placed on an ice-pack in a cooler, and subsequently placed in a freezer. Juvenile bonefish were later genetically identified down to species level.

Diet analysis was performed on juvenile bonefish from three separate embayments on Eleuthera Island, we defined Rock Sound as one sample location (west coast) and Savannah Sound and Half Sound as the other sample location (east coast) (Fig. 1). While both coasts have similarly large embayments with red mangroves (*Rhizophora mangle*) and sandy beach perimeters, they have distinct habitat compositions and experience distinctive wave regimes. Rock Sound, the larger of the three, located on the western side of the island, is characterized by sparse and homogeneously distributed

Fig. 1 Map of the Eleuthera, Bahamas study area and of the three embayments. The west coast sampling location includes Rock Sound, and the east coast sampling location includes Savannah Sound and Half Sound



turtle grass beds (*Thalassia testudinum*), expansive shallow sandy flats, sharp calcium carbonate outcroppings, and tidal creeks. In contrast, Savannah Sound and Half Sound located on the east side of the island is composed of heterogeneous, dense, patchy, and richer turtle grass beds along with sandy bottom. Rock Sound on the west coast is separated from the east coast embayments by over 70 km, thus movement of juvenile bonefish between these sites was highly unlikely.

Fish measures and gut content analysis

Fork length (FL, to the nearest mm) and total length (TL, to nearest mm) were recorded for all collected bonefish. The digestive tracts of 111 bonefish were removed and either frozen or preserved in 10% buffered formalin or 75% ethanol. The contents of individual digestive tracts were later sorted and identified to major taxa to the highest resolution possible, typically of ‘order’ or ‘class’. When shell fragments from bivalves were encountered (sometimes in very large numbers), we could not determine the number of individual bivalves represented; thus, we recorded these collected fragments as a single bivalve. When food was macerated and unrecognizable or particulate matter encountered, it was classified as ‘Miscellaneous’. We recorded percent frequency of

occurrence (*O*) and percentage by number (*N*) of each taxon following Cortés (1997). Weights were not recorded because the variation in prey sizes in the diet of juvenile bonefish was relatively small, and we suspect that there was relatively little variation in weight between prey items. In addition, many prey items were macerated creating measurement and precision issues for determining weight. As suggested by Macdonald and Green (1983) the absence of prey weights in our analyses may make little difference in our comparison of diets for these juvenile demersal fish that feed on a narrower size-range of prey. Further, Baker et al. (2014) cautions against the measurement of prey biomass or volume since it is often comprised of unrecognizable digested particulates and thus may lead to unquantifiable and significant error. Without prey weight, we did not calculate the index of relative importance (*IRI*) ($O \times N \times W$) used by Snodgrass et al. (2008). Alternatively, we calculated an arbitrary importance index $I = O \times N$ for use in ranking prey taxon consumed, realizing that this index does not account for prey weight.

Statistical analyses

We used a two-way ANOVA to compare the mean fork length of bonefish between years sampled, and between

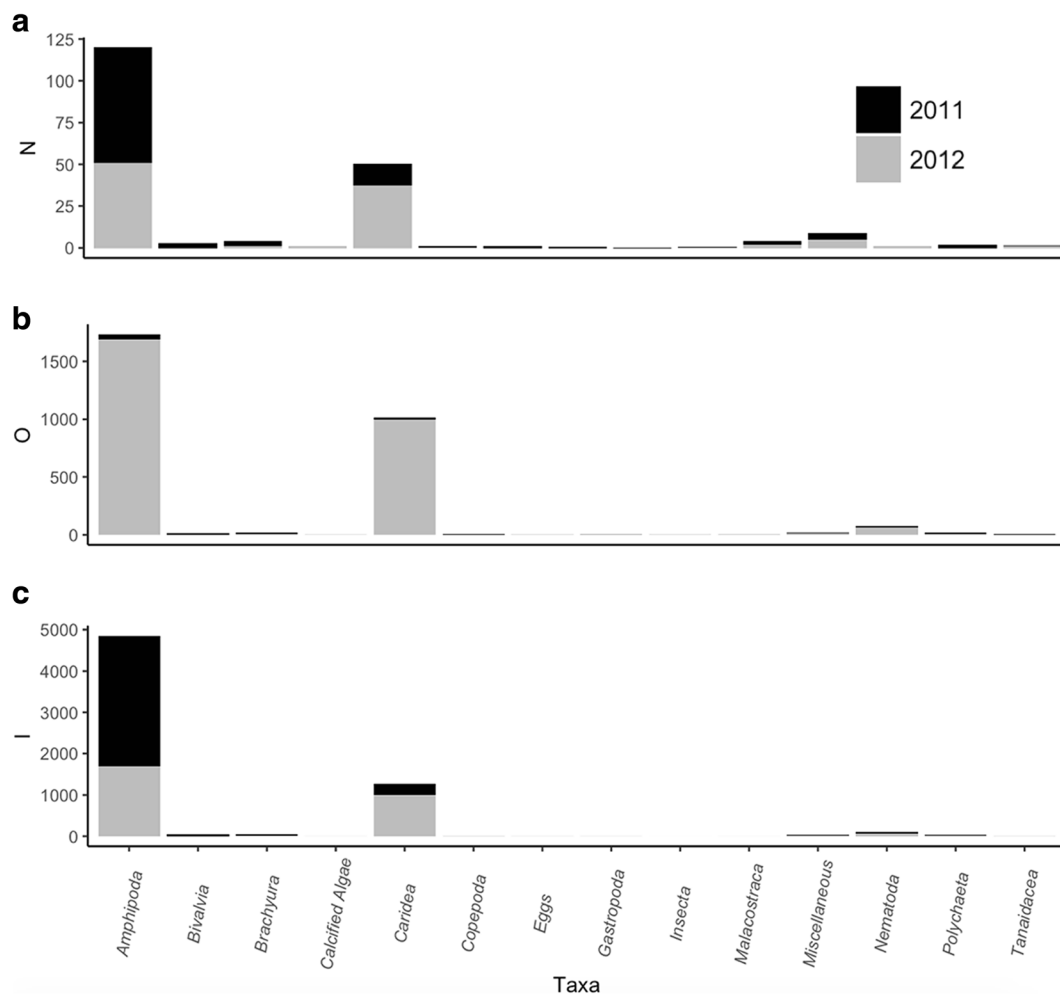


Fig. 2 Diet composition, **a** percentage by number (N), **b** frequency of occurrence (O), and **c** index of relative importance (I) of prey items in digestive tracts of juvenile bonefish in 2011 versus 2012, Eleuthera, The Bahamas

east and west coast sample locations. *I* values were used to rank the order of prey taxa found in bonefish digestive tracts for each year, and each sample location. The Mann-Whitney U test was used to determine if the ranking of prey taxon differed between the two years, and east and west coast sample locations. To further compare juvenile bonefish diets across Eleuthera's east and west coast, Shannon-Weaver Diversity index, Pielou's evenness index, and species richness were calculated for both sample locations.

Combining the 2011 and 2012 juvenile bonefish diet data; we used a series of Generalized Linear Models (GLM) to examine the factors contributing to variation in juvenile bonefish diet. The two years were merged because we did not detect a difference between years via the Mann-Whitney U test and therefore we combined

them for all subsequent analyses. The proportion of bonefish without prey items in their digestive tracts was modeled with a binomial GLM with capture location, fish length (FL), and the interaction between location and FL as predictors. For fish with prey items present, the most common two prey taxa, *Amphipoda* and *Caridea*, were also modeled as count models with GLMs and the same predictors as above. *Amphipoda* and *Caridea* were fit with both a negative binomial GLM and with a zero inflated model and assessed via the small sample size corrected Akaike Information Criterion (AICc). Further, for all models, mixed effects models (GLMMs) with seine haul, which occurred multiple times during a single sample day, nested within east coast and west coast sample locations as a random effect were compared to GLMs using AICc, and the best

Table 1 Diet composition, percentage by number (N), frequency of occurrence (O), index of relative importance (I), and rank (R) of prey items in digestive tracts of juvenile bonefish in 2011 versus 2012, Eleuthera, The Bahamas

Year	2011				2012			
	N	O	I	R	N	O	I	R
<i>Amphipoda</i>	69.3	45.7	3163.8	1	50.7	33.3	1688.9	1
<i>Caridea</i>	13.2	21.0	276.5	2	37.3	26.7	995.6	2
<i>Bivalvia</i>	2.8	16.0	44.8	3	0.0	0.0	0.0	
<i>Nematoda</i>	4.0	8.6	34.5	4	4.9	13.3	65.2	3
<i>Brachyura</i>	3.0	11.1	33.3	5	1.3	6.7	8.9	5
Miscellaneous	2.4	7.4	17.7	6	1.8	6.7	11.9	4
<i>Polychaete</i>	2.0	8.6	17.2	7	1.3	6.7	8.9	5
<i>Copepoda</i>	0.6	3.7	2.2	8	0.4	3.3	1.5	8
<i>Tanaidacea</i>	0.6	2.5	1.5	9	0.9	3.3	3.0	6
<i>Gastropoda</i>	0.6	2.5	1.5	10	0.0	0.0	0.0	
Eggs	1.2	1.2	1.5	11	0.0	0.0	0.0	
<i>Malacostraca</i>	0.2	1.2	0.2	12	0.4	3.3	1.5	8
<i>Insecta</i>	0.2	1.2	0.2	13	0.0	0.0	0.0	
Calcified Algae	0.0	0.0	0.0	14	0.9	3.3	3.0	7

models were used. For all models, backward model selection was used to determine fixed effects comparing single term deletions with log-ratio tests. Model selection and validation procedures were conducted following Zuur et al. (2009). All data analyses were conducted using RStudio (Version 0.98.1103), using MASS (Venables and Ripley 2002), pscl (Zeileis et al. 2008), lme4 (Bates et al. 2015), and glmmADMB (Fournier et al. 2012) packages.

We calculated *I* values (recalculated *IRI* ranks without prey weight) for the 139 juvenile bonefish (21 to 142 mm SL) diets reported by Snodgrass et al. (2008) in Florida to compare with the juvenile bonefish diet data from Eleuthera. Some prey taxa categories of Snodgrass et al. (2008) were combined to better match our prey taxa groups to facilitate comparison. We used the Mann-Whitney U test to compare ranking of prey taxa consumed by bonefish in our study to juvenile bonefish in Florida reported by Snodgrass et al. (2008).

Results

Digestive tracts were collected from 81 juvenile bonefish in 2011 (FL = 70.4 mm, range 47–98) and 30 juvenile bonefish in 2012 (FL = 59.2 mm, range 36–98), of which 52 contained prey in 2011, and 16 contained prey

in 2012. The mean fork length of bonefish was longer in 2011 versus 2012 samples [ANOVA test, $F = 18.709$, $p < 0.001$]. Digestive tracts were collected from 75 juvenile bonefish from the west coast of Eleuthera (Rock Sound, FL = 67.8 mm, range 36–98) and 36 juvenile bonefish from the east coast of Eleuthera (Savannah Sound, Half Sound, FL = 66.5 mm, range 38–87), of which 40 contained prey from the west coast and 28 contained prey from east coast. The 75 fish from the west coast of Eleuthera represent 27 distinct seine hauls, conducted on 17 different days between May 20, 2011 and July 3, 2012, the 36 fish from the east coast of Eleuthera represent 12 distinct seine hauls, conducted on 8 different days between June 18, 2011 and May 31, 2012. Further, on the eastern coast, 32 fish came from Savannah Sound and four fish from Half Sound.

There was no difference between mean fork length of bonefish between sample locations [ANOVA test, $F = 0.278$, $p = 0.599$]. Fourteen prey categories were identified with *Amphipoda* and *Caridea* ranking highest (based on *I* values) in both years (Fig. 2, Table 1), at east and west coast sample locations (Fig. 3, Table 2), and for both years combined (Fig. 4, Table 3). There were no differences in the ranking of 14 prey taxa between years (Mann-Whitney U test, $U = 84$, $Z = 0.62$, $p = 0.2676$). There was a statistical difference in the ranking of 14 prey taxa between sample locations

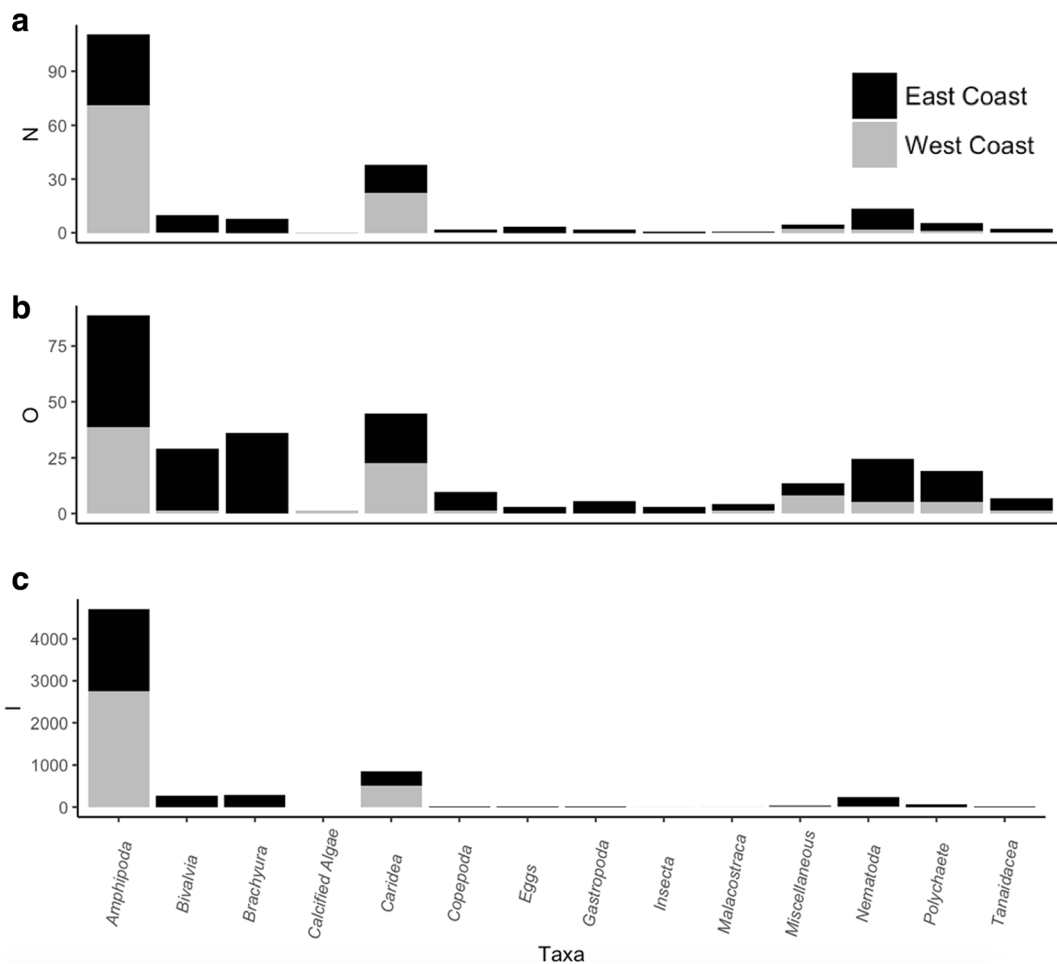


Fig. 3 Diet composition, **a** percentage by number (N), **b** frequency of occurrence (O), and **c** index of relative importance (I) of prey items in the digestive tracts of juvenile bonefish from east coast (EC) and west coast (WC) sampling locations, Eleuthera, The Bahamas

(Mann-Whitney U test, $U = 51$, $Z = 2.14$, $p = 0.0162$); further, the west coast had a lower mean Shannon-Weaver Diversity index (0.157), mean Pielou's evenness index (0.273), and mean species richness (0.867) than in east coast (respectively 0.522, 0.67, 2.028).

AICc indicated that GLMs explained relationships better than GLMMs (with seine haul nested within sample locations as a random effect) and thus the results of the GLMs are presented only. Using the top models, as indicated by AICc, to compare juvenile bonefish diets across sample locations and bonefish sizes, there was a near significant effect of the interaction between sample location and fish size on the proportion of bonefish with empty stomachs ($p = 0.057$, binomial GLM), a significant effect of sample location ($p < 0.001$) and fish size ($p = 0.026$) on the abundance of *Amphipoda* (negative binomial GLM), and a significant effect of sample

location ($p = 0.03$) on the abundance of *Caridea* (zero-inflated negative binomial GLM, Table 3). Although only near significant ($p = 0.057$), larger bonefish on the west coast were more likely to have empty stomachs. However, fish on the west coast were also more likely to have higher numbers of amphipods, as did larger fish. West coast bonefish were also more likely to have a greater number of *Caridea* in their stomachs.

Comparing our combined 2011 and 2012 juvenile bonefish diet data from Eleuthera to the recalculated I values from Snodgrass et al. (2008), only one taxon (*Amphipoda*) was in common across the top-five-ranked taxa between the two studies. Yet, there was no statistical difference between the 17 prey taxa categories in the comparison of Eleuthera and Florida juvenile bonefish stomachs (Mann-Whitney U test, $U = 149$, $Z = -0.14$, $p = 0.4443$) (Table 4).

Table 2 Diet composition, percentage by number (N), frequency of occurrence (O), index of relative importance (I), and rank (R) of prey items in the digestive tracts of juvenile bonefish from east coast (EC) and west coast (WC) sampling locations, Eleuthera, The Bahamas

Location Index	EC				WC			
	N	O	I	R	N	O	I	R
<i>Amphipoda</i>	39.0	50.0	1949.2	1	71.4	38.7	2760.9	1
<i>Caridea</i>	15.8	22.2	351.5	2	22.2	22.7	503.7	2
<i>Bivalvia</i>	7.9	36.1	285.6	3	0.0	0.0	0.0	
<i>Brachyura</i>	9.6	27.8	266.8	4	0.2	1.3	0.2	8
<i>Nematoda</i>	11.3	19.4	219.7	5	2.0	5.3	10.7	4
<i>Polychaete</i>	4.5	13.9	62.8	6	0.9	5.3	4.9	5
<i>Copepoda</i>	1.7	8.3	14.1	7	0.2	1.3	0.2	9
Miscellaneous	2.3	5.6	12.6	8	2.2	8.0	17.5	3
<i>Tanaidacea</i>	1.7	5.6	9.4	9	0.4	1.3	0.5	6
<i>Gastropoda</i>	1.7	5.6	9.4	10	0.0	0.0	0.0	
Eggs	3.4	2.8	9.4	11	0.0	0.0	0.0	
<i>Malacostraca</i>	0.6	2.8	1.6	12	0.2	1.3	0.2	10
<i>Insecta</i>	0.6	2.8	1.6	13	0.0	0.0	0.0	
Calcified Algae	0.0	0.0	0.0	14	0.4	1.3	0.5	7

Discussion

This study provided the first in-depth diet description for *A. vulpes* juvenile bonefish. Amphipods and carideans were the most important in the diet of juvenile bonefish at Eleuthera Island; bonefish captured on the west coast (Rock Sound) had higher abundances of amphipods and larger fish had higher numbers of amphipods, which were nearly all identified as gammarid amphipods. Further, *Caridea*, the second most important prey taxa, were more abundant on the west coast. Although, near significant, larger bonefish on the west coast appeared to be more likely to have empty stomachs. Variation in prey availability across the different sample locations likely exists as highlighted with west coast bonefish exhibiting lower Shannon-Weaver Diversity index, Pielou’s evenness index, and species richness of prey items versus on the east coast. Further, diet rankings statistically differed across sample locations. For fish collected from the west coast, bivalves and gastropods were never found in bonefish digestive tracts; however, they did occur in digestive tracts of bonefish collected from the east coast. In addition, *Brachyura* was nearly absent in digestive tracks in bonefish from the west coast compared to the east coast. Whether *A. vulpes* captured in west coast actively selected amphipods and carideans or were limited by general prey availability

remains unclear. Potentially, bonefish from the west coast may be ingesting higher levels of amphipods and carideans to compensate for the reduced availability of other taxa.

The more diverse composition and heterogeneous structure of habitats (i.e., sand and dense seagrass patches) in the embayments on the east coast likely lead to greater diet diversity compared to the relatively homogeneous, sparsely-vegetated sand flats of Rock Sound. Although juvenile bonefish collected by sampling efforts in Eleuthera occurred almost exclusively over unvegetated or sparsely-vegetated habitats, the dense seagrass beds that were characteristic of east-coast locations may nonetheless serve as nurseries for invertebrate prey taxa (Thayer et al. 1984; Heck and Crowder 1991), potentially increasing the diversity of prey communities in adjacent unvegetated areas where bonefish appeared to forage. The edges along conjoining habitats or “ecotones” associated with heterogeneous patchy seagrass habitats may also serve as important areas for both juvenile fish, such as bonefish, and invertebrates by providing foraging opportunities in the unvegetated areas while also providing protective vegetated shelter nearby (Orth et al. 1984). In addition, the greater proximity and connectivity of the east coast sites to pelagic deep-water habitats and large fringing coral reefs compared to the west coast may also have

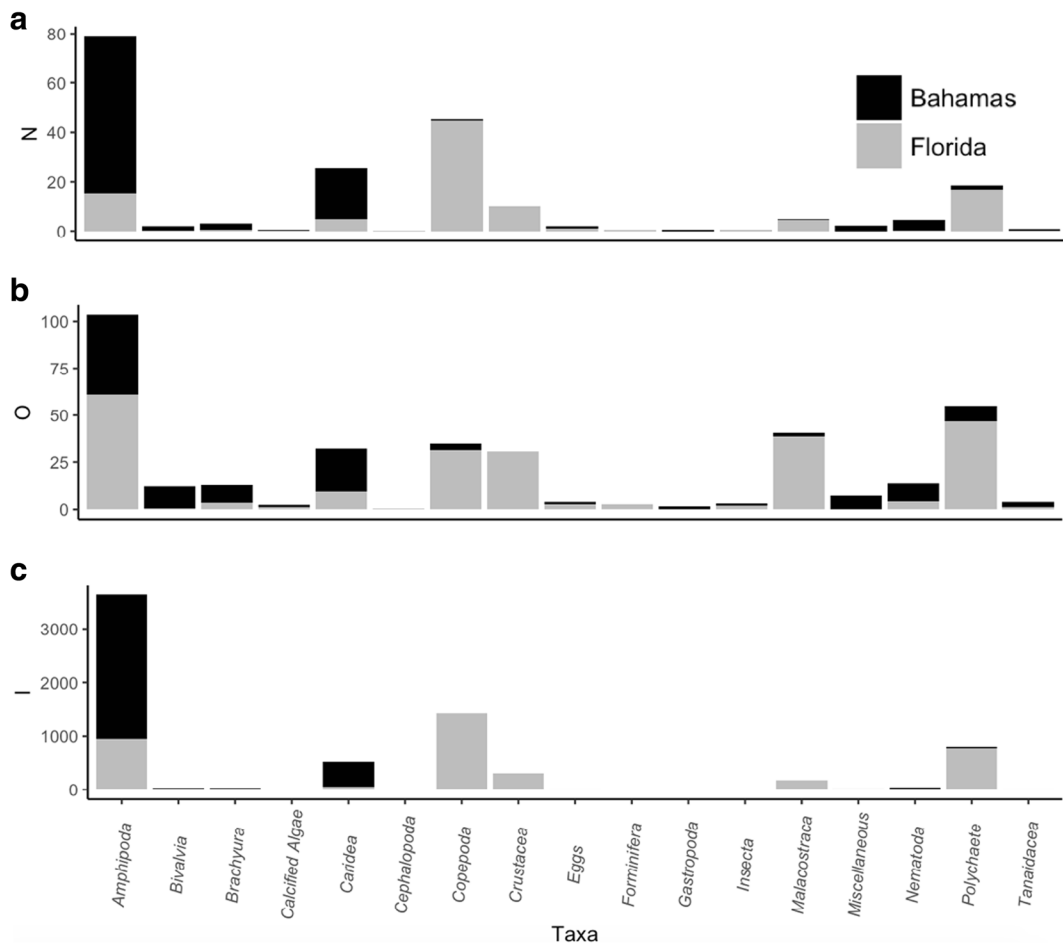


Fig. 4 Diet composition, **a** percentage by number (N), **b** frequency of occurrence (O), and **c** index of relative importance (I) of prey items in the digestive tracts of juvenile bonefish (primarily

A. vulpes) from Eleuthera, The Bahamas and juvenile bonefish (primarily *A. goreensis*) from Florida, reported by Snodgrass et al. (2008)

contributed to the higher diet diversity. Together, the greater diversity of diet and fewer empty stomachs on east coast might imply that east coast sites may have greater nursery function due to enhanced growth or survival, even if these sites had an equivalent or lower abundance of juvenile bonefish compared to the west coast.

Comparisons between Eleuthera Island bonefish to Florida bonefish diets were difficult to assess due to unquantified differences in environmental characteristics and by differences in dominant species, nonetheless some insights may be gained. Only one taxon, *Amphipoda*, was shared across the top-five-prey taxa of Eleuthera and Florida juvenile bonefish. It is unclear why Eleuthera prey rankings did not differ statistically from those of juvenile bonefish in Florida, it may be due to the inclusion of 17 taxa in the analysis, overwhelming

the effect of large differences in the top-five-ranked taxa between the two studies. While prey indices (i.e., Shannon-Weaver Diversity index, Pielou's evenness index, and species richness) were not possible to calculate from Snodgrass et al. (2008), *O* values from Florida indicate a greater diversity of occurrence in prey items. It may not be surprising that a greater diversity in prey items (based on *O* values) exist in Florida than in our study across Eleuthera. In terms of wave exposure (windward vs. leeward) and to some degree benthic habitat, the sites where bonefish in Florida were collected were more similar to the east coast Eleuthera sampling locations than to the west coast Eleuthera sampling location (Rock Sound). Within Florida, nearly all juvenile bonefish have been found on windward habitats (Adams et al. 2007) like that of east coast Eleuthera juvenile bonefish habitats, thus, you may expect greater

Table 3 Generalized linear model outputs for the proportion of juvenile bonefish with empty stomachs (binomial model), the abundance of *Amphipoda* present (negative binomial model), and the abundance of *Caridea* present (zero-inflated negative binomial GLM). Significant results are italicized

Response variable	Parameter	Estimate	SE	z-value	p value
Prey absent	Intercept	4.12	1.94	2.13	<i>0.033</i>
	Location	-3.17	2.31	-1.37	0.170
	Fork length	-0.09	0.03	-2.69	<i>0.007</i>
<i>Amphipoda</i>	Location: Fork length	0.07	0.04	1.91	0.057
	Intercept	-2.16	1.24	-1.74	<i>0.082</i>
	Location	1.70	0.43	3.95	< <i>0.001</i>
<i>Caridea</i> - count	Fork length	0.04	0.02	2.23	<i>0.026</i>
	Intercept	0.04	0.46	0.08	0.934
	Location	1.29	0.59	2.19	<i>0.03</i>
<i>Caridea</i> - binomial	Log(theta)	-1.4	0.28	-4.9	< <i>0.001</i>
	Intercept	-262.02	854.02	-0.31	0.759
	Total length	3.27	10.68	0.31	0.76

diversity in Florida for the same reasons you see inter-coasts differences in Eleuthera.

Differences in Eleuthera-Florida diets may also arise due to other habitat characteristics or due to

the mixed-species sample (86% *A. goreensis*) collected in Snodgrass et al. (2008). Feeding strategies may differ across bonefish species; juvenile *A. vulpes* in The Bahamas in this study appear to

Table 4 Diet composition, percentage by number (N), frequency of occurrence (O), index of relative importance (I), and rank (R) of prey items in the digestive tracts of juvenile bonefish (primarily

A. vulpes) from Eleuthera, The Bahamas and juvenile bonefish (primarily *A. goreensis*) from Florida, reported by Snodgrass et al. (2008)

Location	Bahamas				Florida			
	N	O	I	R	N	O	I	R
<i>Amphipoda</i>	63.5	42.3	2688.7	1	15.5	61.2	948.6	2
<i>Caridea</i>	20.7	22.5	465.3	2	4.8	10.1	48.5	6
<i>Nematoda</i>	4.3	9.9	42.3	3	0.3	4.3	1.3	11
<i>Brachyura</i>	2.5	9.9	24.6	4	0.5	3.6	1.8	9
<i>Bivalvia</i>	1.9	11.7	22.6	5	0.1	0.7	0.1	15
Miscellaneous	2.2	7.2	15.9	6	0	0	0	
<i>Polychaete</i>	1.8	8.1	14.5	7	16.8	46.8	786.2	3
<i>Copepoda</i>	0.6	3.6	2.0	8	44.7	31.7	1417	1
<i>Tanaidacea</i>	0.7	2.7	1.9	9	0.1	1.4	0.1	14
<i>Gastropoda</i>	0.4	1.8	0.7	10	0	0	0	
Eggs	0.8	0.9	0.7	11	1.1	2.9	3.2	7
<i>Malacostraca</i>	0.3	1.8	0.5	12	4.6	38.9	178.9	5
Calcified Algae	0.3	0.9	0.2	13	0.1	1.4	0.1	13
<i>Insecta</i>	0.1	0.9	0.1	14	0.2	2.2	0.4	12
<i>Forminifera</i>	0	0	0	15	0.6	2.9	1.7	10
<i>Cephalopoda</i>	0	0	0	16	0.1	0.7	0.1	16
<i>Crustacea</i>	0	0	0	17	10	31	310	4

ingest a greater number of benthic prey items, including amphipods and general benthic infauna and epifauna (e.g., *Bivalvia*, *Nematoda*, *Tanaidacea*) compared to the *A. spp.* (majority *A. goreensis*) Florida diet study where the highest ranked prey item was *Copepoda* (often characterized as planktonic organisms). Further, in contrast with Snodgrass et al. (2008), Eleuthera bonefish increased amphipod ingestion with an increase in body size.

We describe the diet of juvenile *A. vulpes* for the first time in The Bahamas, and attribute the variation in diets across Eleuthera as a result of differing habitat characteristics and thus prey availability. Future investigation is warranted between prey availability and benthic habitat characteristics in relation to juvenile *A. vulpes* abundance and ecology across both Eleuthera Island and Florida. Understanding and protecting essential juvenile nursery habitat is critical for the conservation and management of any marine species (Beck et al. 2001). Over the past 30 years, the Florida bonefish populations have experienced significant declines (Frezza and Clem 2015; Santos et al. 2017), some estimate by 20% due to habitat loss (Adams et al. 2012). While bonefish prey abundance has not experienced significant decadal changes across Florida, Liston et al. (2013) did find prey availability to be highest in the Lower Florida Keys, where the most robust bonefish populations occur. However, prey abundance changes were only assessed using adult bonefish diet studies without mention of juvenile bonefish prey base. Declines in juvenile habitat or prey availability could be a contributing factor in the decline of bonefish in Florida. Thus, our study, that provides the first in-depth description of juvenile *A. vulpes* diet, may serve as a basis to evaluate juvenile bonefish prey abundances within Florida and across their greater range.

Here we have provided an analysis of juvenile *A. vulpes* bonefish diet in two different embayments in Eleuthera, The Bahamas, identifying important prey types, and potential causes of variation in diet related to environmental conditions. Eleuthera represents a relatively undisturbed habitat; this information may serve as a basis for understanding bonefish juvenile ecology in other regions including Florida, where juvenile *A. vulpes* bonefish remain elusive and the population has experienced severe decline.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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