FEATURE

Reaching Underserved Populations through a Fisheries Education Program

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Environmentally literate citizens capable of making informed decisions are essential to successfully managed fisheries. Fisheries-focused environmental education programs may help build environmental literacy, but experimental evaluations are needed to determine the effectiveness of fisheries education programs. We begin addressing this need with a study of "Shad in the Classroom." The program engages students in American Shad *Alosa sapidissima* restoration through rearing and releasing fry. We used a pre/post, treatment (n = 777)/control (n = 57) evaluation during the 2016–2017 academic year. Participation in the program created large improvements in American Shad knowledge between tests ($P < 0.001$). All students gained knowledge, but African Americans ($P < 0.001$) and students identifying as "other" races and ethnicities ($P = 0.003$) fell behind their peers. Shad in the Classroom is an effective tool for teaching children about fisheries management but, may help ethnic minorities the least, suggesting a need to tailor content for diverse students.

INTRODUCTION

Environmental education (EE) is a strategy that may help address most pressing fisheries conservation challenges. Technical solutions exist for addressing key fisheries challenges and include: catch restrictions, gear modification, closed or protected areas, and quotas (Sinclair et al. 2002; Worm et al. 2009). These solutions, however, fail to address problems facing the world's fisheries (Cowx and Portocarrero Aya 2011), unless paired with education of key stakeholders including recreational and commercial fishers, and credible enforcement activities. The challenge, then, is developing citizens capable of making fisheries conservation decisions. The many fisheries conservation papers calling for public education efforts tacitly acknowledge this fundamental challenge (e.g., Zint and Dann 1995; Bjorkland and Pringle 2001; Cooke et al. 2013). Fisheries education efforts are working to address this need but have outpaced their own evaluation, as assessments of these programs are limited. Notable fisheries education efforts include Caring for Aquatics Through Conservation Habitats (CATCH; North Carolina Wildlife Resources Commission), Hooked on Fishing – Not on Drugs (Montana Fish, Wildlife, and Parks), Trout in the Classroom (Trout Unlimited) and New York State 4-H Sportfishing and Aquatic Resources Education Program (SAREP; Brown et al. 2003). Although environmental literacy encompasses more than knowledge (e.g., dispositions, skills, and motivations; Hollweg et al. 2011), a first step toward achieving environmental literacy is knowledge, including ecological knowledge. Accordingly, establishing clear links to gains in knowledge about fisheries represents a critical step in evaluating efficacy of these programs.

Program evaluations of fisheries-based EE curricula are rare, and tend to utilize pre- post-evaluations. These studies suggest programming promotes knowledge growth among children in programs focusing on native fish in Arizona (Pacey and Marsh 2013), fish and aquatic resources in Montana (Flowers 2007), and fishing and ecological knowledge in New York (Koupal and Krasny 2003). Similarly, participation in a fish-stocking lecture in Germany helped adults increase fish knowledge (Fujitani et al. 2016). In addition to utilizing an experimental design capable of assessing causality (vs. correlation), evaluations would benefit from exploring relationships between knowledge growth and other variables such as age, race, and gender. The only study we are aware of that evaluates how demographic variables relate to efficacy of fisheries-focused EE programs (Fernández Lo Faso et al. 2006) found no significant differences in knowledge growth among students of different sexes nor between students studying in schools from different locations. However, they identified a significant difference in knowledge growth between students of different ages, with 9- and 11-year-old students demonstrating the most growth, compared to students ages 6–8 years old and 12 years old. These findings suggest measuring how EE programing engages students of different ages, genders, and from different cultural groups is a critical step needed to ensure programming meets the needs of all students.

Program evaluation can improve fisheries-focused EE by identifying best practices and the degree to which programming meets the needs of target audiences. There is also a need to focus evaluation efforts on impacts EE programs have on racial and ethnic minority populations (e.g., African American, Hispanic) for numerous reasons (Wheeler et al. 2007). First, these groups are projected to increase in numbers and even become majorities in many areas in the United States. Of the 145 million people projected to be added to the U.S. population between 1990 and 2050, 86.4% of the net change is projected to be among minority groups. Current minority groups will constitute a majority of the total United States population in 2050 (Colby and Ortman 2015), compared to only 24.4% in 1990 (Murdock et al. 1996). Second, although minority groups are increasing among the population, members of these groups continue to experience constraints to natural area access (Finney 2005; Shores et al. 2007). Constraints to using natural areas among underserved minorities reflect those for the population as a whole (e.g., lack of information, travel costs, alternative commitments to family and friends, lack of companions to participate with, fear of crime), but are more acute. Additionally, some may perceive or experience impacts of historic and institutionalized racism that has intentionally excluded minority groups from recreation activities and outdoor spaces in the past, and may continue to do so (Finney 2005). Third, education interventions in science and math domains are often less effective for students from underserved populations (Herring 1989; Bruschi and Anderson 1994; Kao and Thompson 2003), but EE programs may create a needed catch-up effect for members of these populations (Lieberman and Hoody 1998; Stevenson et al. 2017).

We begin addressing the need for experimental EE evaluation in fisheries programs, and their impact on racial and ethnic minority populations in particular, with a case study of an EE program called Shad in the Classroom. Shad in the Classroom is a program in which students learn about and take part in the restoration of American Shad *Alosa sapidissima* in North Carolina through raising American Shad from embryos. The Shad in the Classroom program provides a hands-on learning experience for students in grades 4–12 (ages 9–18 years old). The program typically begins 1–2 weeks before participating classes receive their American Shad embryos. Students then spend 5 days raising the embryos to the yolk-sac fry stage, and then release the fry into the appropriate river basin (see Methods for details). We tested three hypotheses: (1) participation in the Shad in the Classroom program would directly and positively impact American Shad knowledge, (2) females would gain more American Shad knowledge than males, and (3) minority students would gain more American Shad knowledge than non-minority students. The first hypothesis reflects evaluation of the program intended to promote increased knowledge about American Shad among children. The second hypothesis tests the assertion by previous studies that EE may mitigate the gap between male and female students in science. Specifically, although girls tend to exhibit less environmental knowledge than boys (Gifford et al. 1982; Blum 1987) and fall behind boys in science when taught using traditional science programming, females may exhibit higher growth in science knowledge in association with EE programming (Stevenson et al. 2013). The third hypothesis emerged from recent research suggesting EE, particularly outdoor versions, may create a learning catch-up effect for underserved students in terms of affect and behavior (Stevenson et al. 2013), despite the trend for these students to fall further behind on grades, standardized tests, and STEM performance in most other education interventions (Bachman 1970; Ogbu 1978; Reyes and Stanic 1988; Herring 1989; Whitworth and Barrientos 1990; Bruschi and Anderson 1994). This potential catch-up effect may be related to ceiling effects (i.e., students with high initial knowledge levels having less room to improve; Liefländer and Bogner 2014), as underserved students typically have less exposure to nature and outdoor education than other students (Floyd 1999) and, thus, have more room to benefit from nature-based programming (Stevenson et al. 2013).

METHODS

Shad in the Classroom Program

Shad in the Classroom is a curricular program that was developed by the North Carolina Museum of Natural Sciences, the North Carolina Wildlife Resources Commission, the U.S. Fish and Wildlife Service, and the Albemarle-Pamlico National Estuary Partnership. The program provides hands-on conservation science education to students in North Carolina in partnership with these agencies. All participating teachers attend a 1-day training workshop in February, and all classes participate in two core activities in late March or early April. First, students conduct daily embryo and larvae sorting, and water quality monitoring in American Shad rearing tanks for approximately 1 week. Second, students participate in a 1-day field trip to either the Neuse or Roanoke River basins to release their fry (depending on where the broodstock parents were collected). Participating teachers customize participation by choosing from among additional elective activities. The 3 most common elective activities completed by the 33 participating classrooms during the 2017 program year were the fish anatomy and dissection activity (conducted by 16 classes), a food web activity (14 classes), and a non-fiction reading activity chosen from a list compiled by Shad in the Classroom coordinators (14 classes; available: http://naturalsciences.org/learn/learning-resources/shad-in-the-classroom).

Sampling

Our sample was composed of public school students in North Carolina. Teachers who participated in the Shad in the Classroom program, administered by the North Carolina Museum of Natural Sciences during the 2016–2017 academic year, were asked to participate in the evaluation. Treatment teachers were self-selected as they asked to participate in Shad in the Classroom rather than being recruited to participate. We contacted each of the teachers enrolled in the 2017 Shad in the Classroom program (33 teachers from 27 schools: 13 elementary, 14 middle, and 6 high schools) to gain consent to participate in the student survey. Of the 33 teachers who participated in the program, 24 agreed to participate in our evaluation. Participating teachers then recruited additional teachers to participate in the control group through personal social networks at their respective schools. The participating classrooms represented Bertie, Carteret, Chatham, Durham, Hoke, Iredell, Johnston, Lenoir, Orange, and Wake counties in North Carolina. Teachers choosing to engage with Shad in the Classroom may have greater interest in science than control group teachers, but teachers did not participate in assigning students to classes.

We requested both treatment and control groups to administer 10 min pre- and post-surveys to their students between March and June of 2017. Although administration dates varied between classes, treatment students received the pre-test before starting Shad in the Classroom and received the post-test after completing the program. Similarly, students in the control groups received their tests at the same time as students in the same school in the treatment group were tested. Pre-tests were administered between March 2017 and April 2017. Post-tests were administered between May 2017 and June 2017. For the pre- and post-surveys, we sent participating teachers surveys, which they could choose to distribute electronically or on paper to their students. Students were not aware that there would be a post-test, and teachers did not help students review the survey to decrease the chance of bias. All surveys were completed during class time.

Instrument Development

We developed our instrument through an iterative process between the research team and American Shad experts at the North Carolina Museum of Natural Science. To measure American Shad Knowledge of students, we asked all students to answer four multiple-choice questions about American Shad life cycle, diet, habitat, and population threats (Table 1). In order to determine previous exposure to nature among students, we asked students to indicate if they participate in hunting or fishing. We also included demographic questions about age, gender, race/ethnicity, and grade level (Table 2).

Data Analysis

We did not test reliability of the American Shad knowledge scale as it is inappropriate to do so for knowledge scales (van Schuur 2003). Because the items on the scale varied in level of difficulty, we used item response theory to validate the scale instead of factor analyses. Item response theory analyzes scores using assumptions about the mathematical relationship between abilities (e.g., American Shad knowledge level) and item responses (Baker 2004). This analysis revealed that the average student is expected to score two out of a possible four points on the scale (Figure 1). We tested our hypotheses using linear regression models predicting the dependent variable (change in American Shad knowledge) with eight independent variables: control versus treatment, pre-test American Shad knowledge, hunting participation, fishing participation, gender, age, race,

Table 1. Descriptive statistics for survey items measuring American Shad knowledge. Correct answers are represented by bolded text. Coding used for each answer included in parentheses by each option. Means represent the percentage of students that correctly answered the question.

	Control Group				Treatment Group			
	Pre-test		Post-test		Pre-test		Post-test	
Question	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Which of these is NOT a life stage of a fish? a. **Polyp (1)** b. Fry (0) c. Juvenile (0) d. Adult (0) e. Larvae (0)	0.25	0.43	0.23	0.42	0.20	0.40	0.51	0.50
What do adult American Shad eat? a. Aquatic plants (0) b. Copepods (0) c. **Fish eggs and small fish (1)** d. Small fish (0) e. All of the above (0)	0.18	0.38	0.26	0.44	0.23	0.42	0.25	0.43
What factor has NOT lead to the decline of American Shad in the 20th century? a. Dams along the river (0) b. Overfishing (0) c. **Ocean temperatures (1)** d. Water pollution (0)	0.44	0.50	0.42	0.50	0.44	0.50	0.64	0.48
What pH range would be the healthiest for a fish (like American Shad) in the river? a. 1.4 – 3.8 (0) b. 4.2 – 6.2 (0) c. **6.8 – 7.4 (1)** b. 10.8 – 12.6 (0)	0.59	0.49	0.61	0.49	0.55	0.50	0.68	0.47

Table 2. Linear regression predicting increase in shad knowledge based on pretest science efficacy, pretest shad knowledge, gender, age, and race.

Variable	*B*	β	*P*
Pretest shad knowledge	−0.794	−0.630***	<0.001
Treatment[a]	0.775	0.158**	0.008
Gender[b]	0.007	0.003	0.908
Age	−0.013	−0.020	0.671
White	(reference)		
Black or African American	−0.402	−0.110***	<0.001
Asian or Pacific Islander	−0.257	−0.042	0.133
Hispanic	−0.205	−0.054	0.064
American Indian	−0.274	−0.020	0.453
Multiracial	−0.146	−0.036	0.20
Other	−0.414	−0.083**	0.004
Constant			
R^{2,c}	0.368		
Rho[d]	0.115		

Note: Included are the unstandardized (B) and standardized (β) coefficients.

[a] Coded 1 = control, 2 = treatment.

[b] Coded 0 = male, 1 = female.

[c] Random effect is significant (non-zero).

[d] Rho is the proportion of residual variance explained by the household unit effect.

***P* < 0.010, ****P* < 0.001.

and grade level. We included a random effect for teacher in order to account for the possibility that students in the same class may have similar levels of American Shad knowledge associated with a shared instructor or classroom environment.

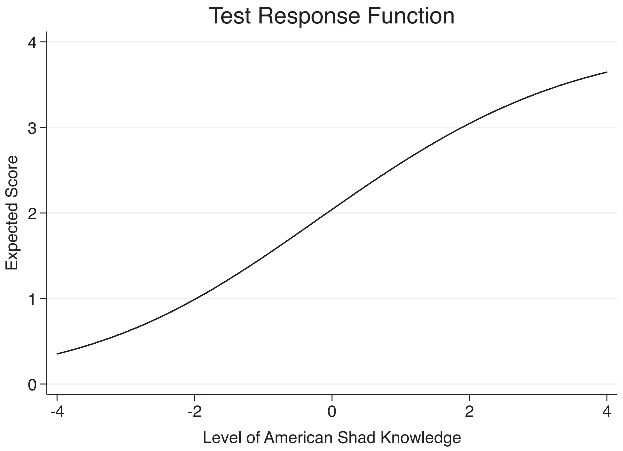

Figure 1. Test response function for American Shad knowledge scale. Expected score of American Shad knowledge scale represented on y-axis. Level of American Shad knowledge on x-axis, with 0 representing average student ability.

RESULTS

There were 777 participants in the treatment group and 57 participants in the control group. Most students (89%) were 10–15 years old (44 students were 9 years old and 47 students were 16 or older). For the entire sample, students were 53% female and 51% white, with fewer African American (14%), Hispanic (12%), American Indian (1%), and Asian/Pacific Islander students (4%). Some students identified as multiracial (11%) or other (7%). For the control group, specifically, the average student age was 13.5 years (SD = 2.05), and there were slightly more males (49%) than females (47%), with 4% of students choosing not to answer. Control students were primarily white (70%). For the treatment group, the average student age was 12.8 years old (SD = 2.00), and there were slightly more females (53%) than males (42%), with 5% of students choosing not to answer. Half (50%) of the treatment students were white. Scores for pre-test and post-test American Shad knowledge ranged from 0 to 4 for students in the treatment and 0 to 3.00 for students in the control group. Control students scored an average score of 1.50 of a possible 4 points on the pre-test (SD = 0.96) and 1.40 of a possible 4 points on the post-test (SD = 0.99) for American Shad Knowledge. Treatment students scored an average score of 1.30 of a possible 4 points on the pre-test (SD = 0.99) and 2.07 out of a possible 4 points on the post-test (SD = 1.07). Control students had significantly lower scores on average for questions one ($\bar{x} = 0.23$, SD = 0.06, $P < 0.001$) and three ($\bar{x} = 0.42$, SD = 0.06, $P < 0.001$) on the post-test, compared to treatment students ($\bar{x} = 0.51$, SD = 0.02; $\bar{x} = 0.64$, SD = 0.02).

Results supported Hypothesis 1, as treatment was the most important variable, other than pre-test score, for predicting change in American Shad knowledge (Table 2). As expected, increased American Shad knowledge was negatively related to pre-test scores measuring American Shad knowledge, indicating a strong ($\beta = -0.627$, $P < 0.00$) ceiling effect (Table 2). We found mixed support for our hypotheses concerning target audiences. We did not detect gender effects on improved American Shad knowledge and, thus, did not find support for Hypothesis 2 (Table 2). Additionally, our findings contradicted Hypothesis 3. Specifically, students of all ethnic backgrounds gained knowledge about American Shad following the program (Figure 2), but African American and students identifying as "other" learned less than their white peers (Table 2).

DISCUSSION

This study provides a model for experimental studies capable of evaluating causal effects of fisheries education programs. We found preliminary evidence of a causal relationship between participation in Shad in the Classroom and growth in American Shad knowledge. The program worked for all students despite some differential effects related to ethnicity. The quasi-experimental design employed in this study is difficult to avoid in formal education settings where intact groups (classrooms) are typically a focal unit, and complete randomization (i.e., random selection of classrooms in addition to students) is difficult, but the method has long been accepted as one way to develop causal inference (Campbell and Stanley 1966). Future research, particularly in informal (i.e., nature-based programming such as EE camps, conservation education programs, agricultural education programs) settings, may more easily

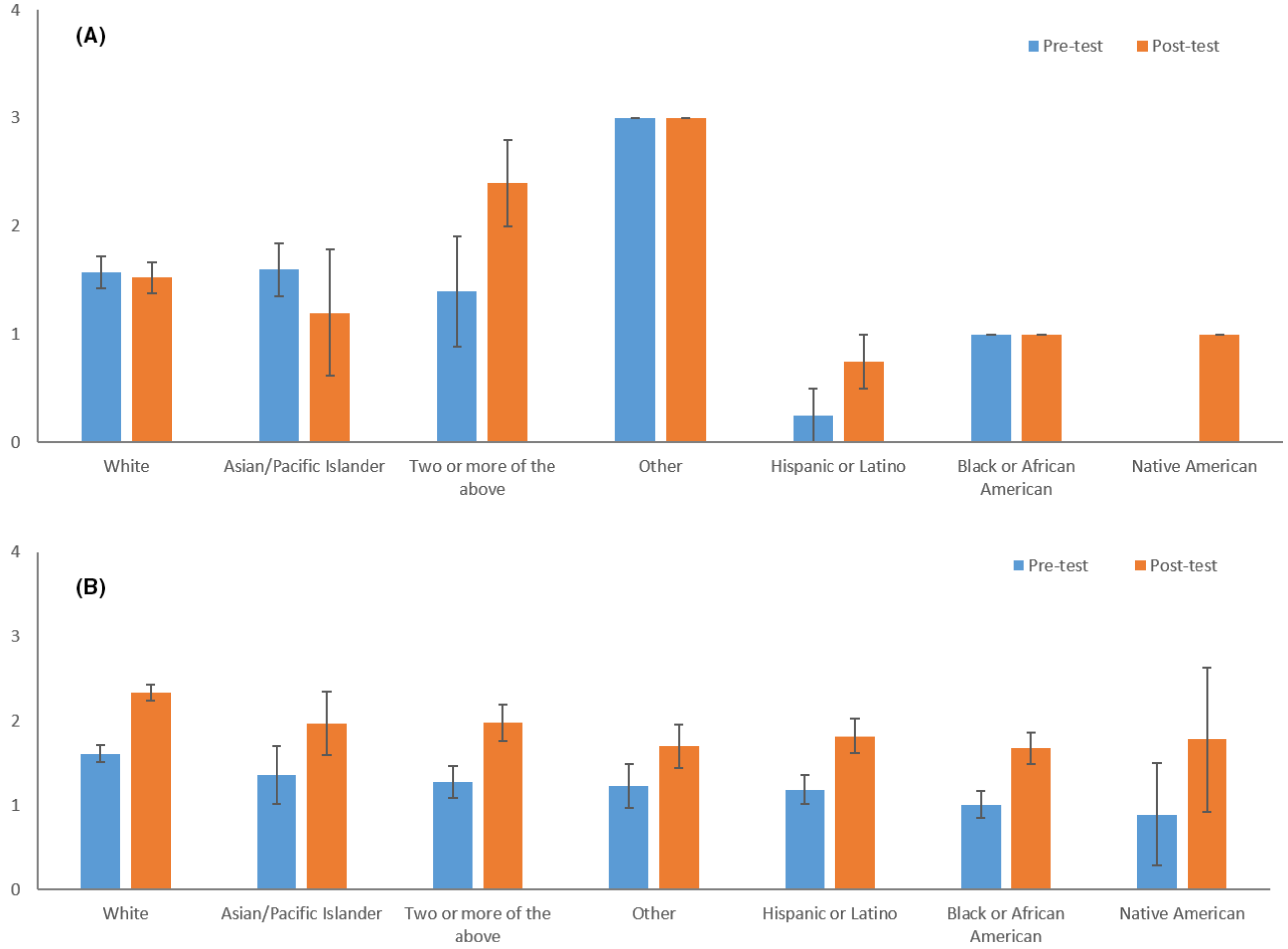

Figure 2. Differences in American Shad knowledge growth by ethnicity, based on mean scale score. **(A)** Pre– and post–test comparison scores for the control group; standard errors bars included. **(B)** Pre– and post–test comparison scores for the treatment group; standard error bars included.

employ traditional experimental designs in order to determine causality between informal education programs and knowledge outcomes. In addition, these studies may consider evaluating how programmatic elements impact variables such as attitudes and behaviors, beyond the causal relationship of knowledge and the program, explored here.

Although all students gained American Shad knowledge, stark differences in pre-test scores associated with ethnicity persisted through the treatment, which was troubling. The lower pre-test scores among ethnic minorities may be rooted in the same explanations for general academic gaps related to ethnicity. Typically, academic achievement gaps related to ethnicity can be almost completely attributed to covariance between minority status and low socioeconomic status. Low academic achievement is more of a link to poverty than culture (Hair et al. 2015). Lower income students are often at a disadvantage academically from an early age, with challenges related to less access to early childhood education (Westat 2010), family structure (e.g., single parents), crime rates (Westat 2010), and food security (Faught et al. 2017). These factors mean students living in poverty typically enter school at a disadvantage, and low-income schools have less access to innovative curricular materials, higher teacher turnover, and less funding (United States Department of Education 2017). Unfortunately, we did not detect the expected catch-up effect for underserved students (Larson et al. 2010) from Shad in the Classroom, and African American students actually gained less knowledge than other groups. Previous studies documenting a catch-up effect, however, focused on effect (Stevenson et al. 2013) and behavior (Larson et al. 2010), but not content knowledge. Collectively, this research suggests catch-up effects from EE for underserved students may include multiple dimensions of environmental literacy but not content knowledge.

The tendency for African Americans to fall behind other students in American Shad knowledge may indicate a need for revising Shad in the Classroom, and perhaps other fisheries-related EE curricula, to resonate more with underserved students. Although fisheries EE practitioners may be ill equipped to address the structural and systemic roots of achievement gaps, culturally responsive curricula can help mitigate their effects (Gruenewald and Smith 2014). Ethnic minorities often have low self-perceptions of science efficacy (Parker and McDonough 1999), a perception teachers must carefully work to counter, particularly when such self-assessments are compounded by expectation biases among teachers themselves (Peterson et al. 2016). Tools for addressing this challenge include promoting diverse representation of educators interacting with students (Stets et al. 2017) and place-based education practices that use local examples as solutions to global issues (Gruenewald and Smith 2014). Similarly, some research suggests ethnic minorities are less comfortable in nature due to barriers including lack of cultural acceptability, limited access to green spaces, or perceived safety concerns (Finney 2005), which means the students who are often least confident in their science abilities may also be the most distracted and least comfortable in natural learning environments. There are no easy solutions to this challenge, since prolonged exposure to nature may be the only consistent pathway to making students comfortable with learning in natural environments (Soga and Gaston 2016). That said, programs such as Shad in the Classroom may contribute to the cumulative time in nature required for promoting comfort in nature and environmental attitudes among adolescents (Stevenson et al. 2013). These design elements can more easily be integrated if curricula development teams include experts who have personal experience with the cultural groups concerned (Lewis and James 1995). As we move into an increasingly more diverse society, fisheries education must provide culturally sensitive curricula with diverse educators to remain relevant. Examples may include targeted outreach to bring in underrepresented minorities, use of local examples in curricula, and intentional recruitment of staff that reflects the target audiences, and training for staff to increase comfort in nature and attend to cultural differences among students and how they may relate to fisheries and other natural resources.

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