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Investigating the effectiveness of informal science education through quantitative and qualitative analysis: Ocean Commotion

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INVESTIGATING THE EFFECTIVENESS OF INFORMAL SCIENCE EDUCATION THROUGH QUANTITATIVE AND QUALITATIVE ANALYSIS: OCEAN COMMOTION, A CASE STUDY

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ABSTRACT

Informal science education serves as an important source for science education for both individuals and school groups. However, the effectiveness of school visits to informal science education events outside of either museums or science centers has received little investigation. This study explores the short-term effects of a hands-on learning experience on students' attitude and content knowledge. Specifically, it investigates the impact of Ocean Commotion, a one-day event where exhibitors present information and hands-on demonstrations about marine environments and products, especially those important to Louisiana. Pre-tests were utilized to document students' initial knowledge of and attitude toward wetlands and the ocean, as well as their attitude toward science in general. Following the event the same tests were administered again to capture any changes. The results showed that a one-day, hands-on event significantly increased student knowledge about and concern for marine environments, but did not have an impact on attitude toward science. This study demonstrates the value that transient learning events can provide and supports the development of similar events to promote not only ocean literacy, but also other topics as well.

CHAPTER 1

OCEAN COMMOTION, A CASE STUDY

INTRODUCTION

Informal science education (ISE) is learning that takes place outside of the classroom (Crane et al., 1994; National Science Teacher Association [NSTA], 1998; Gerber et al 2001b; National Science Foundation [NSF], 2001). ISE can happen anywhere, even in one's own backyard, but it is most commonly associated with science and history museums, nature centers, zoos and aquaria, and other institutions (NTSA 1998). In general ISE is more casual than classroom learning, especially since participation tends to be voluntary, self-directed, and self-motivated (NSF 2001).

Research on the effectiveness of informal science education is a relatively young field, as studies have been conducted only in the past two decades (Crane et al., 1994). Most of the early studies focused on learning that occurs in museums (Lucas, 1991). In an attempt to broaden the understanding of other categories of ISE, Gerber et al. (2001b) created an assay to investigate the influences of various types of informal learning to which children are exposed. While this was a positive addition to the vast amount of research on the effectiveness of ISE in museums (e.g., Ramey-Gassert and Walberg, 1994; Cox-Peterson et al., 2003; Martin, 2004; Mortensen and Smart, 2007; Phillips et al., 2007; Tal and Morag, 2007), it only examined the cumulative effects of various types of ISE.

Coastal environments are becoming more influential in people's lives, in as much as 1.2 billion people are living within 62 miles of a shoreline (Small and Nicholls, 2003). Therefore, it is important for students to learn about these places and to understand the scientific processes that occur there. The National Oceanic and Atmospheric Administration [NOAA] (2009)

recently produced a guide on "Ocean Literacy" in an effort to define fundamental concepts and principles of ocean science for K-12 curricula. NOAA (2009) defines ocean literacy as "an understanding of the ocean's influence on you – and your influence on the ocean."

Ocean Literacy is not only important for those that live near the coast, but also for those in inland areas. People in the middle of the country still have an impact on the ocean and coastal environments through their local watersheds. Students in these inland locations would rarely have an opportunity to visit coastal areas, especially in the context of learning and education, since they can be very far from these areas. Having an opportunity to interact with items from the ocean and wetlands would be invaluable in learning about ocean literacy.

A review of the literature showed there has been limited research on the impact of a single ISE activity or event. (For an extensive review of the literature, see Chapter 2.) Although there has been a movement to look at influences of individual events (Prokop et al., 2007; Baustian et al., 2008), so far there has been little work done in this area. This study investigates the impact of Ocean Commotion, a one-day event sponsored by the Louisiana Sea Grant College Program. This event strives to bring public and private organizations, as well as, researchers from the local college community and state and federal agencies together with students in a casual setting. These exhibitors present information and hands-on demonstrations about marine environments and products, especially those important to Louisiana. Ocean Commotion is unique because of the amount of support the event has received from Louisiana State University.

Every year, Ocean Commotion attracts around 3,000 visitors from regional schools, with grades ranging from K-8th, including students, chaperones, and teachers. Select students were given a test both before the event and after to determine the influence of Ocean Commotion. The evaluations not only examined the knowledge level of students, but also their attitude toward

marine environments. In addition, students participated in a follow-up survey that was independent of the pre- and post-tests. The aims of this survey were to evaluate students' attitude toward Ocean Commotion and to formally document the types of exhibits and activities students favor. This study is unique in that it evaluates the influence of an event that is independent of a permanent designed setting, like those at museums, zoos, and science centers. The aim of this study is to determine if Ocean Commotion, a hands-on learning experience focusing on the ocean and wetlands, increases students' knowledge of and the value they place on these environments, ultimately increasing the students' interest in science. Three specific hypotheses were tested: Attendance at Ocean Commotion

1) increases student knowledge about the ocean and wetlands.

2) positively affects students' attitude toward the ocean and wetlands.

3) positively affects students' attitude toward science.

METHODS

Selection of Schools

Participants in the study were students, ranging from fourth to eighth graders, from local urban schools. All teachers who registered their classes to attend Ocean Commotion were asked to take part in the research; of the 23 teachers who brought students to Ocean Commotion, 13 agreed to participate in the testing. All 13 teachers submitted the completed pre-tests; however, only seven of these teachers submitted the completed post-test, so their students composed the final study group (Table 1). The schools included three private schools, two public schools (one of which is a magnet school) and a laboratory school. One of the private schools had two separate classes participating. In total seven classes were used in the study. To retain anonymity

all of the classes were given a three-letter code and this code was used to create ID codes for all of the students.

Table 1. Information on schools included in the study

School	Type	Grade	Number of Students
EPR	private	4	56
EPJ	private	5	71
LLC	pubic*	7	96
RUV	private	4	50
SMF	pubic	7-8	18
SJP	private	7-8	121
WHL	public*	5	52

***magnet or laboratory school**

Ocean Commotion Logistics

Students were scheduled to visit exhibits during one of two session times. The morning session was reserved for fifth through eighth grade, while the afternoon session was for kindergarten through fourth grade. While this division was used for the logistics of the event, only third through eight grades were tested because the cognitive ability assessed by the study was targeted at third grade and above. Each session lasted for two hours, and student groups of ten, along with a chaperone, were allowed to freely move among the 68 exhibitors. Some students were observed to have assigned tasks, such as, recording a certain number of facts they learned during the session, whereas others had no observable tasks assigned.

Measuring Effects: the Instruments

Pre- and post-testing procedures as well as a follow-up survey were utilized to determine the influence of Ocean Commotion on students' knowledge and attitude toward wetlands and the ocean. The test was developed by the Louisiana Sea Grant educational staff, with assistance from experts in the informal science education field.

The first two parts of the pre- and post-tests examined attitude and content knowledge and were composed of questions answered using a five point Likert-scale. On this scale, A

equaled “strongly agree” and E equaled “strongly disagree” (Table 2). The letter answers were equated to numerical values, where “strongly agree” was a score of 5 and “strongly disagree” was a score of 1. While the tests and questions were already developed, these two parts were reformatted so that they could be used with scan sheets to expedite the data entry procedure. The third part was a free response questionnaire that focused on knowledge of wetlands and the ocean (Table 3). The in-class, follow-up survey focused on the students’ attitude toward the learning event and the types of exhibits that were favored (Table 4). For the complete tests, see Appendix A.

Table 2. Sample questions from content and attitude sections

Section	Subject	Question
contents	ocean	The Earth has one big ocean.
		What happens to the ocean has no effect on me. *
		All water eventually ends up in the ocean.
		It is OK is water does not have oxygen. *
		The ocean controls weather and climate.
		The ocean is so big we cannot pollute it. *
	wetlands	Invasive species are a problem in our wetlands and oceans.
		Shrimp and crabs do not need marshes in order to survive. *
		A swamp is not a wetland. *
attitude	ocean	I cannot do anything to protect the ocean. *
		We are all responsible to caring for the ocean.
		Everyone should learn about the ocean.
		Learning about the ocean is interesting.
		It is okay to put waste into the ocean. *
	wetlands	I think protecting wetlands is important.
		Wetlands are useless. *
		My actions can affect wetlands.

* scored in reverse order

Table 3. Questions from free-response questionnaire

Subject	Question
ocean	The ocean covers ______% of the Earth
	The ocean contains ______% of Earth’s water.
	List five things you know about the ocean.
	List all of the stages of the water cycle.
wetlands	Louisiana Loses _______ square miles of wetlands each year
	What is a wetland? Give an example of three types of wetlands in Louisiana.
	List five things you know about wetlands.
	List some of the natural and human-made lines of defense for coastal restorations and hurricane protection in Louisiana.

Table 4. Questions from follow-up survey

Was this the first time you went to Ocean Commotion?
Did you like going to Ocean Commotion?
Which kind of exhibits did you like the most?
What subject did you like learning about the most?
Which interactions did you like the best?
Which activities did you like the most?
Did you talk to anyone, other than your teacher, about what you did at Ocean Commotion?
Do you think you learned anything from attending Ocean Commotion?
Would you want to go to Ocean Commotion again?
Would you tell a friend they should go to Ocean Commotion?

Pre-tests were delivered to the teachers before Ocean Commotion, along with instructions for administering the test. The students were assured that the test results would not be seen by their teacher and would have no influence on their grades. Pre-tests were taken from a week to one day before attending Ocean Commotion. Teachers returned the pre-tests and received post-testing materials when they checked in for Ocean Commotion. The post-tests were administered to students four to eight days following the event. However, only seven of the 13 teachers that returned the pre-tests also returned the post-tests. A teacher evaluation was also given to determine the amount of preparation teachers did, any projects the students completed related to Ocean Commotion and which exhibits were favored and provided material for classroom use. However, only a few of these were returned, and the information that was provided was limited.

Six months after Ocean Commotion, the follow-up surveys were administered. Five of the seven teachers were able to participate. The author went into the classroom and administered the multiple-choice survey using an automatic response system. Students were given a paper copy of the survey and used the individual response device to answer the questions at their own pace. As the students input answers, the system automatically recorded them.

Data Preparation

Each student was assigned a unique code, developed from the school codes, to protect his or her identity and this code was used throughout data processing. For the content and attitude sections, the scan sheets were checked for identifying information so that all portions of the tests could be matched, and then they were brought to the LSU Office of Assessment and Evaluation for scanning. The results were imported to Excel spreadsheets and checked for misreading errors. Unreadable answers were marked with a blank while double answers were marked with an asterisk. They were then compared to the original scan sheets. If the correct answer was able to be determined, the change was made in the file. The tests used letter responses of "A" to "E" and were converted to a number scale so that statistical analysis could be performed. For most questions "A" corresponded to a score of 5 while "E" equaled a score of 1. Some of the questions were scored in reverse order; therefore, "A" was converted to a 1 and "E" to a 5. An average score was found for each student, where a score of 5 would be the highest possible average score.

The free response sections were entered into the computer by hand. The fill-in-the-blank answers were marked incorrect or correct to produce a score. The remaining answers, being of a qualitative nature, were converted to a quantitative value so that they could be analyzed statistically. The answers were listed at the top of an Excel spreadsheet, and a 1 was marked corresponding to each student who answered with that response. For example, a student who answered the question "What is a wetland" with "wet" and "land" would have a 1 marked in the column for wet and a 1 in the column for land, for a total of two answers. Once all of the responses were entered, the answers for each question were then broken down into general categories. For example, "List five things you know about the ocean" was broken down into

biological, chemical, geological, physical features, physical processes, relations to humans, other and incorrect. Total responses for each category were then summed to create a score.

Statistical Analysis

Before the data were analyzed for differences between the pre-tests and post-tests, preliminary analysis was performed using Levene's Test for Equality of Variances. Entire classes were missing from the post-tests, and the pre- or post-tests of individual students were missing as well. Both of these losses were tested to determine if the subset was representative.

Then the pre- and post-tests were compared to determine any changes. Data from the content and attitude section on the scan sheets were analyzed with paired sample *t*-tests, but before the data could be compared, a test was required to control for the study's design. Since the students participating in the study were grouped in the hierarchy of classes, rather than randomly chosen, the data from the students is nested within the classes (Kreft, 1995). As a result, the data might be skewed by the influence of the teacher or by other differences among the classes. A test of the interclass correlation was run on the content section, the attitude section, and the total incorrect answers of the free response section.

The change in mean score from the pre-tests to the post-tests was then analyzed to determine if any changes were significant. If the interclass correlation showed an influence due to differences among the classes, then a *t*-test was run for each of the classes individually to determine the significant changes. An effect size was also calculated, using the standard effect size equation, to determine the strength of the relationship. In addition, the influence of gender on attitude was analyzed with chi-square.

The free-response questions were analyzed differently from the other two sections of the test because of the qualitative nature of these answers. Each question was treated individually,

with the three fill-in-the-blank questions being analyzed together. The fill-in-the-blank questions were checked for correct answers and then totaled. The scores of the pre- and post-tests were then tested for significant changes. For five of the questions, descriptive statistics, such as frequency and percentage, were used to quantify the results. Unique categories were developed for each of these question based on the students' answers. The number of responses in each of the categories of answers were totaled and then converted to a percentage of the total number of answers for the question. These percentages were then used in a chi-square analysis to determine if the changes from the pre-tests to the post-tests were significant. In addition, all of the incorrect responses were tabulated for the free-response section. Since the incorrect responses had numerical values, again the *t*-test was used to determine any significant changes.

RESULTS

All thirteen teachers who agreed to participate in the testing submitted completed pre-tests (Table 5). The mean scores from the content and attitude sections are within standard deviations of one another, so the seven teachers who submitted post-tests were assumed to be a representative sample (Table 5 & Figure 1).

Table 5. Pre-test data for all schools

			Gender of Students (%)			Mean Score (out of 5)	
School	**Grade**	**N**	Male	female	unknown	content	attitude
EPR	4	56	27	39	34	3.5	4.3
EPJ	5	71	42	58	-	3.7	4.3
LLC	7	96	55	45	-	3.7	4.1
RUV	4	50	52	48	-	3.6	4.0
SMF	7-8	18	67	33	-	4.1	4.1
SJP	7-8	121	45	55	-	3.8	3.9
WHL	5	52	55	45	-	3.6	4.0
JMS	8	67	46	51	3	3.5	3.8
LPS	6	62	40	60	-	3.4	3.8
SEC	5	85	44	56	-	3.5	4.0
SAB	6	46	52	48	-	3.5	4.0
SFD	7-8	26	42	54	4	3.4	3.9
SFH	3	19	47	53	-	3.7	4.2

*note: percentages are rounded off to the whole number
schools in gray did not submit post tests

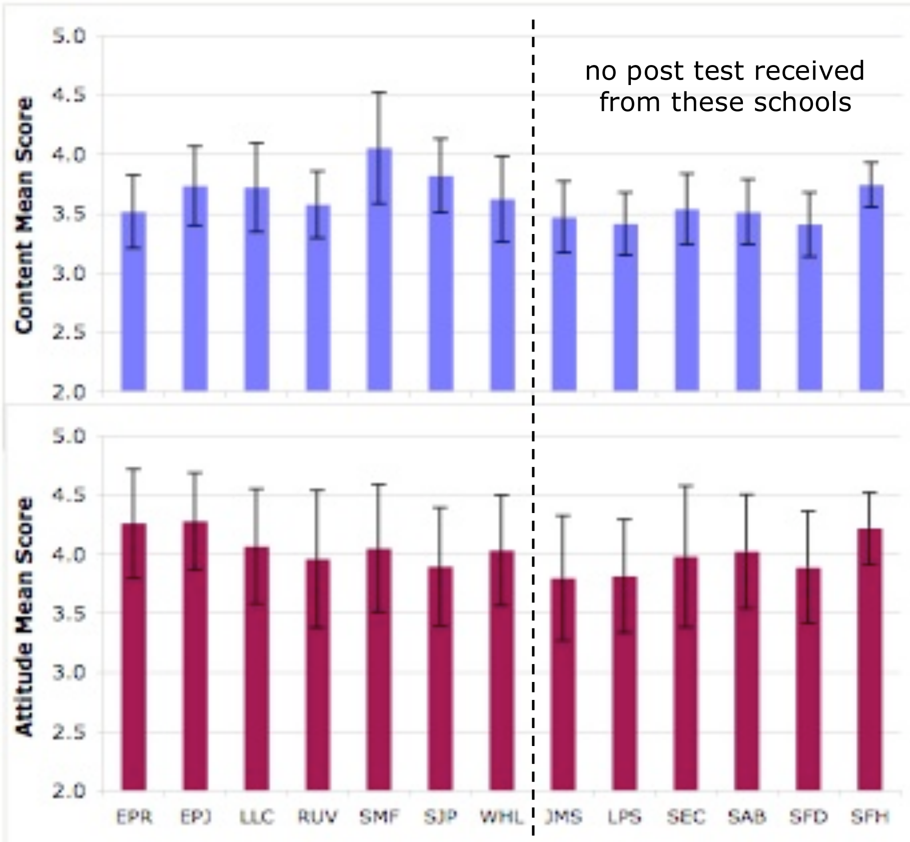

Figure 1. Mean score and std. deviation on pre-tests - all school. An average of five is the highest score possible

In addition, many individual students missed either the pre- or post-test (Table 6). The means of students with both pre- and post-tests were compared to students missing either pre- or post-tests at each school to determine the equality of the students. Both the content and attitude scores were analyzed using Levene's Test for Equality of Variances, which indicated that neither sets of scores varies significantly. The *t*-test for Equality of Means showed that the content and attitude scores were not significantly different. These two tests show that the missing 21% of the content responses and 26% of the attitude responses will not affect the results of the study. While the tests were not performed on the free response section, because of the limitation of the qualitative format, it was assumed that the 16% loss will not affect the results of that portion of the study.

Table 6. Number of students from each school with paired tests

School	Total # of students	Number of students with paired test: content	attitude	free response	Percent of total with paired test: content	attitude	free response
EPR	56	18	18	14	32%	32%	25%
EPJ	71	67	67	69	94%	94%	97%
LLC	96	89	89	95	93%	93%	99%
RUV	50	17	0	42	34%	0%	84%
SMF	18	18	18	18	100%	100%	100%
SJP	121	110	108	107	91%	89%	88%
WHL	42	38	37	35	90%	88%	83%
TOTAL	454	357	337	380	79%	74%	84%

Attitude toward the Ocean and Wetlands

Student attitudes about the ocean and wetlands were significantly more positive after students went to Ocean Commotion. On a scale of 1 to 5, before the event the mean attitude of all students was 4.06 and afterwards the mean score was 4.13. The intra-class correlation of 0.004 was not significant. The overall mean change of the six schools that had paired tests (RUV did not complete the attitude section on the post-test) was 0.07 with a standard error of 0.0216 (Figure 2). This change was a significant increase ($T = 3.21$, $p < 0.05$) with a small effect size of 0.21. The chi-square tests for gender found no effects at any of the schools.

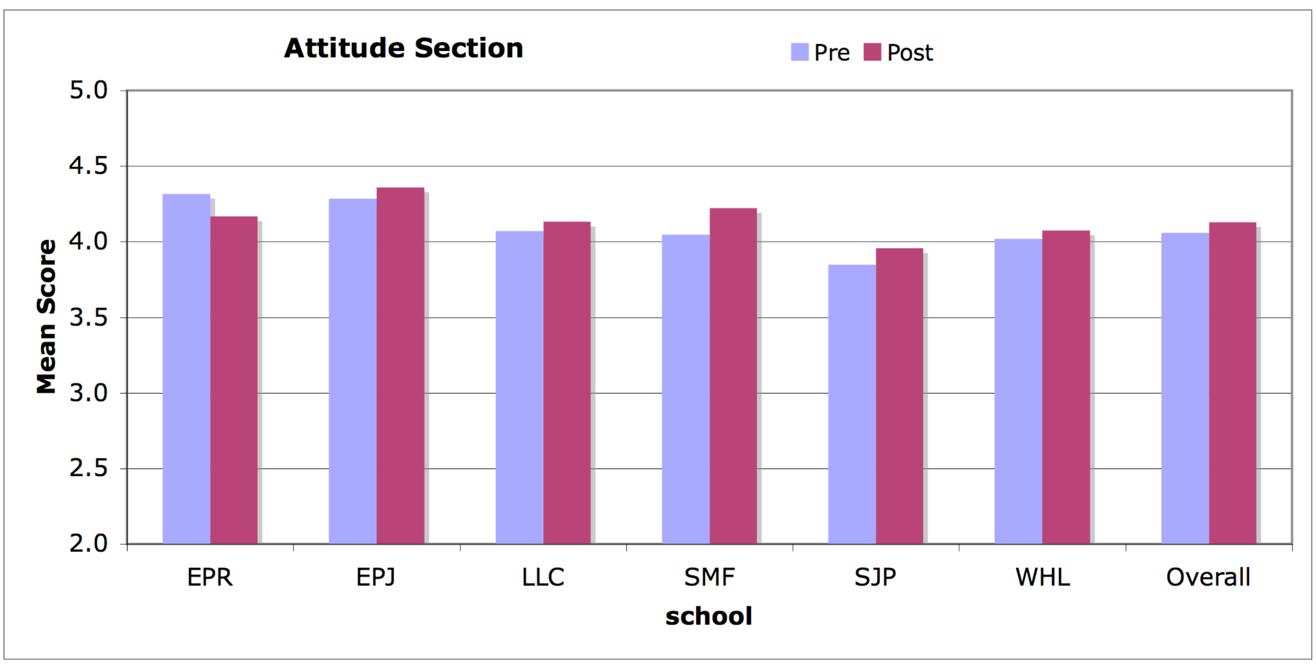

Figure 2. Pre and post mean scores for the attitude questions. Five is the highest score possible.

Content Section

The intra-class correlation, 0.0868, was significant indicating that there were differences among the classes. From the pre-tests to the post-tests there was an overall mean increase of 0.165 (0.0404 standard error), which is a significant increase ($T = 4.11$, $p < 0.05$) and a medium effect ($ES = 0.4837$). As a result of the significant intra-class correlation, the mean change in each class was evaluated (Figure 3). T-statistics were then calculated for each school individually (Table 7). Since the test statistic was split into seven different evaluations, the *p value* needed to be altered as well to maintain the correct error level. The 95% confidence level ($p = 0.05$) was divided by seven to create a new *p value* of 0.007. As shown in Table 7, only four of the schools showed a statistically significant increase at the 99.3% confidence level. Again, the chi-square tests for gender found no effects at any of the schools.

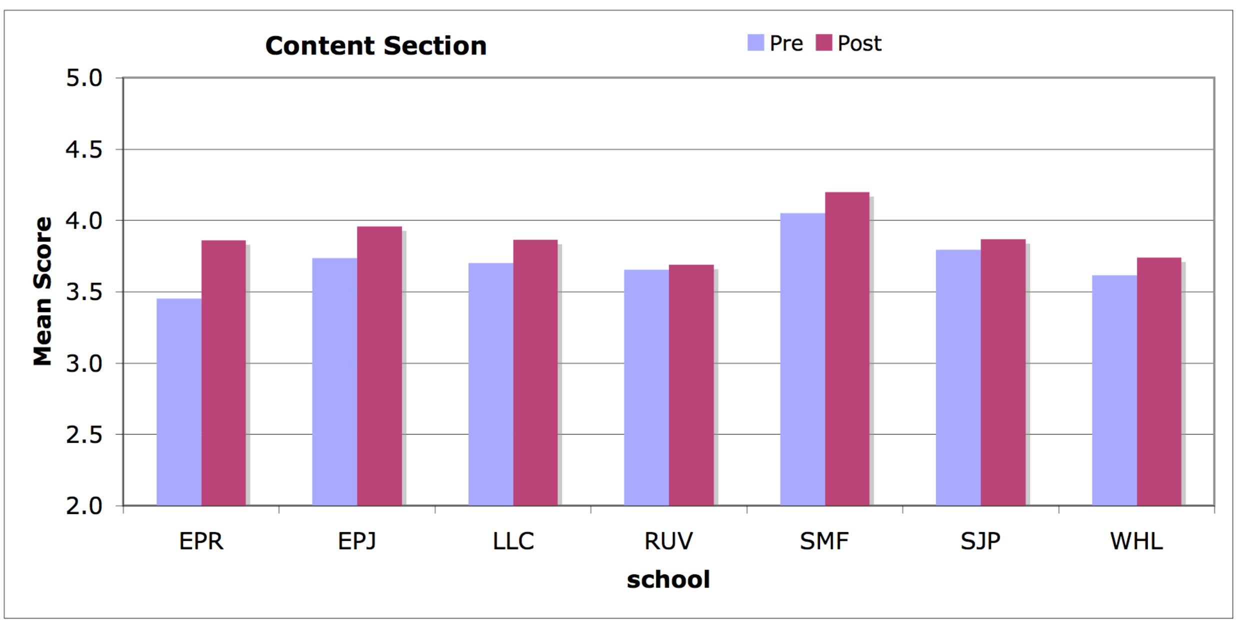

Figure 3. Pre and post mean scores for the content questions. Five is the highest score possible.

Table 7. Change in students' content knowledge

School	N	Pre-test M	Pre-test SD	Post-test M	Post-test SD	T statistic
EPR	18	3.46	0.326	3.86	0.357	6.248*
EPJ	67	3.74	0.336	3.96	0.381	6.589*
LLC	89	3.70	0.367	3.87	0.399	4.598*
RUV	17	3.65	0.291	3.69	0.390	0.422
SMF	18	4.05	0.471	4.20	0.427	2.818
SJP	110	3.80	0.328	3.87	0.416	2.649
WHL	38	3.62	0.362	3.74	0.387	3.333*

* $p < 0.007$

Free Response Section

With an interclass correlation of 0.0208, the difference among classes is not significant for total incorrect answers. Incorrect responses decreased significantly ($T = -4.175$, $p < 0.05$) on the post-test with an overall mean change of -0.345 and standard deviation of 1.610 (Figure 4).

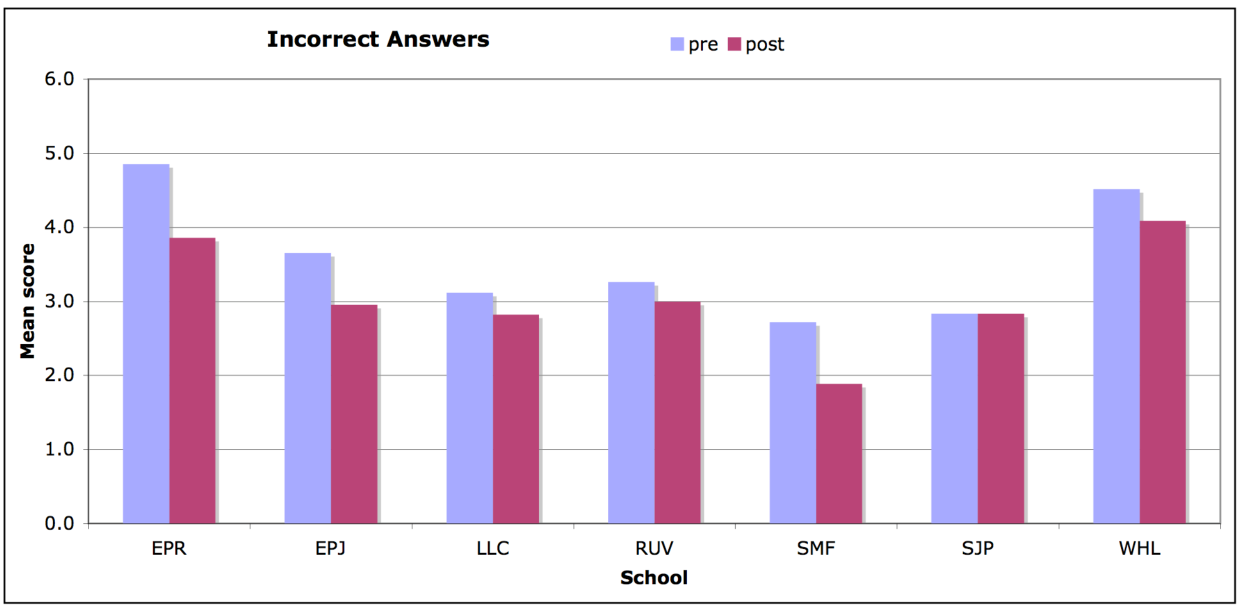

Figure 4. Mean number of incorrect answers on free response section for the pre- and post-tests.

The question that simply asked, "What is a wetland?" had a range of answers. Responses were as straightforward as wet and land and as complex as a list of the services that wetlands provide, like absorbing floodwater and providing a buffer to hurricanes. While the decrease at EPR was the only significant change when all of the correct answers are considered together

(Table 8 & Figure 5), a few more significant changes occur when the categories of the answers are considered (see "What is a wetland?" table in Appendix B). While the concept that "wetlands are wet" decreased at six of the seven schools, conversely the concept that "wetlands are land" increased at five of the schools. However only EPR and SMF had significant changes in these two categories.

Table 8. Results of *t*-test on responses to "What is a wetland?"

School	Categories	Pre-test freq.	Pre-test %	Post-test freq.	Post-test %	test	
EPR	correct	5	36%	2	13%	10.213	*
	blank/don't know	9	64%	12	80%	1.711	
	incorrect	0	0%	1	7%	6.667	*
EPJ	correct	75	65%	96	76%	0.851	
	blank/don't know	31	27%	30	24%	0.195	
	incorrect	9	8%	0	0%	7.826	*
LLC	correct	98	67%	98	67%	0.002	
	blank/don't know	46	32%	48	33%	0.020	
	incorrect	2	1%	1	1%	0.232	
RUV	correct	24	44%	22	42%	0.053	
	blank/don't know	31	56%	31	58%	0.039	
	incorrect	0	0%	0	0%	0.000	
SMF	correct	28	90%	43	98%	0.292	
	blank/don't know	3	10%	1	2%	4.588	*
	incorrect	0	0%	0	0%	0.000	
SJP	correct	146	78%	145	77%	0.006	
	blank/don't know	38	20%	43	23%	0.151	
	incorrect	3	2%	0	0%	1.604	
WHL	correct	38	69%	39	66%	0.066	
	blank/don't know	15	27%	15	25%	0.065	
	incorrect	2	4%	5	8%	1.933	

* $p < 0.05$ **$p < 0.1$

A qualitative examination of the students' answers to "What is a wetland?" showed more impacts. One of the students expressed an important concept on the post-tests that was not on his or her pre-test: that wetlands are "dry some of the year." This is a concept that can be hard to grasp, even for adults. Another qualitative change occurred with the understanding of the protection wetlands provide. On the pre-tests there were three students that listed protection,

whereas on the post-tests there was a range of not only of what the wetlands protect, but also the different events when they serve as protection. Fourteen different students supplied answers in which wetlands protect from erosion, storm surge, and floodwater. In addition, one student said it "acts like a sponge." Three of the schools had a decrease in students that either did not respond or indicated that they did not know, though only SMF had a significant decrease (Table 8). The changes in incorrect answers varied greatly, with two schools having an increase, three schools having a decrease, and two schools having no incorrect answers on either the pre- or post-tests. Additional graphs can be found in Appendix B.

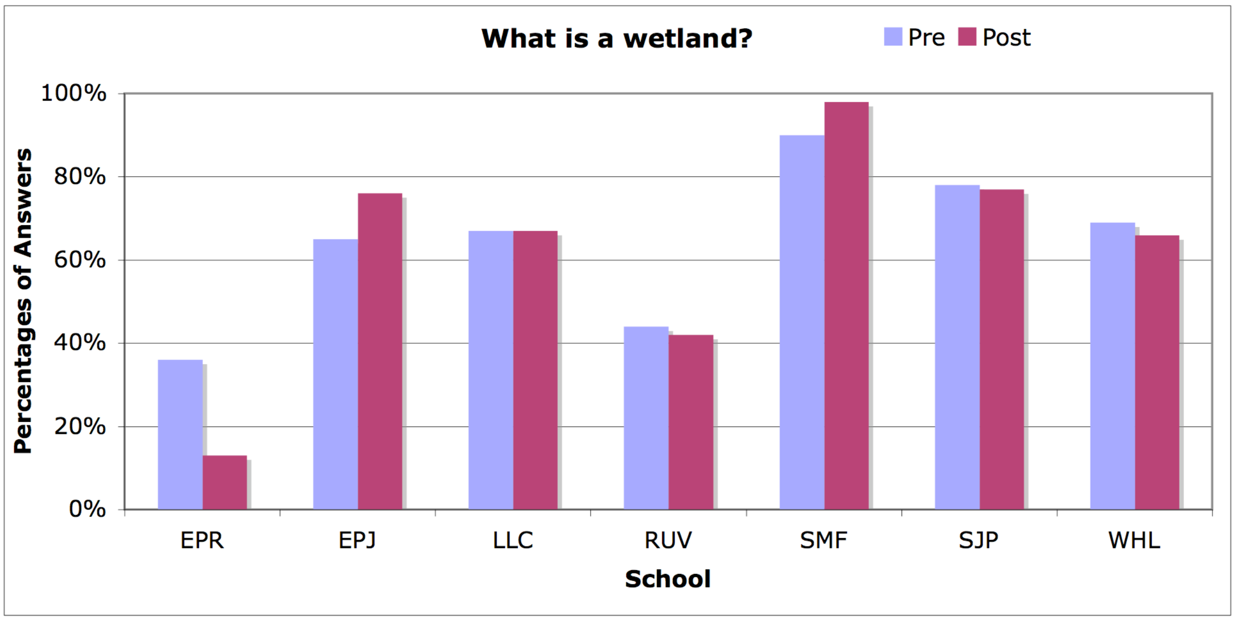

Figure 5. Percentage of correct answers to "What is a wetland?" at each school.

Paired with the question of "What is a wetland?" was the question that asked for examples of types of wetlands. These responses were much more clear-cut with answers being correct, incorrect, blank/don't know, or related to the location of wetlands (Table 9). Correct answers, consisting mostly of swamp, marsh or bayou, increased at six of the seven schools; however, none of these changes were statistically significant. Only the decrease in correct

answers and increase in incorrect answers at EPR were found to be significant. This is the opposite of what was expected. Graphs corresponding to Table 9 can be found in Appendix B.

Table 9. Results of *t*-test on responses to "Give an example of a type of wetland"

		Pre-test		Post-test			
School	**Categories**	freq.	%	freq.	%	test	
EPR	correct	27	69%	15	45%	4.929	*
	location	1	3%	2	6%	1.418	
	blank/don't know	1	3%	1	3%	0.039	
	incorrect	10	26%	15	45%	5.522	*
EPJ	correct	110	65%	121	67%	0.034	
	location	14	8%	14	8%	0.016	
	blank/don't know	14	8%	13	7%	0.073	
	incorrect	31	18%	32	18%	0.009	
LLC	correct	168	74%	177	76%	0.026	
	location	6	3%	8	3%	0.102	
	blank/don't know	21	9%	14	6%	0.686	
	incorrect	33	14%	35	15%	0.008	
RUV	correct	78	73%	88	77%	0.123	
	location	16	15%	13	11%	0.478	
	blank/don't know	5	5%	4	4%	0.166	
	incorrect	8	7%	9	8%	0.011	
SMF	correct	48	92%	50	96%	0.078	
	location	3	6%	2	4%	0.385	
	blank/don't know	1	2%	0	0%	0.000	
	incorrect	0	0%	0	0%	0.000	
SJP	correct	177	73%	207	75%	0.050	
	location	5	2%	11	4%	0.629	
	blank/don't know	25	10%	14	5%	1.733	
	incorrect	37	15%	43	16%	0.007	
WHL	correct	37	47%	48	58%	1.155	
	location	6	8%	8	10%	0.242	
	blank/don't know	10	13%	8	10%	0.409	
	incorrect	26	33%	19	23%	1.799	

* $p < 0.05$ **$p < 0.1$

Students were also asked what they knew about wetlands. Many of the answers were reiterated from the responses to the other two questions, such as they are "wet land", their locations and types of wetlands, but some new concepts did emerge such as their physical properties, their relation to human activity and wetlands are disappearing. However, analysis of

all of the correct answers showed only small increases that were far from being significant (Table 10 & Figure 6). Additional graphs can be found in Appendix B.

Table 10. Results of *t*-test on responses to "What do you know about wetlands?"

School	Categories	Pre-test freq.	Pre-test %	Post-test freq.	Post-test %	test
EPR	correct	54	92%	42	93%	0.018
	blank/don't know	0	0%	1	2%	2.222
	incorrect	5	8%	2	4%	1.257
EPJ	correct	267	94%	252	95%	0.006
	blank/don't know	5	2%	6	2%	0.063
	incorrect	13	5%	8	3%	0.319
LLC	correct	361	95%	384	96%	0.005
	blank/don't know	12	3%	4	1%	1.117
	incorrect	8	2%	13	3%	0.244
RUV	correct	121	86%	139	95%	0.365
	blank/don't know	8	6%	4	3%	1.062
	incorrect	11	8%	4	3%	2.494
SMF	correct	94	98%	82	100%	0.022
	blank/don't know	0	0%	0	0%	0.000
	incorrect	2	2%	0	0%	2.083
SJP	correct	358	93%	414	97%	0.056
	blank/don't know	14	4%	3	1%	2.004
	incorrect	11	3%	11	3%	0.017
WHL	correct	137	93%	140	93%	0.001
	blank/don't know	3	2%	2	1%	0.152
	incorrect	7	5%	9	6%	0.134

* $p < 0.05$ **$p < 0.1$

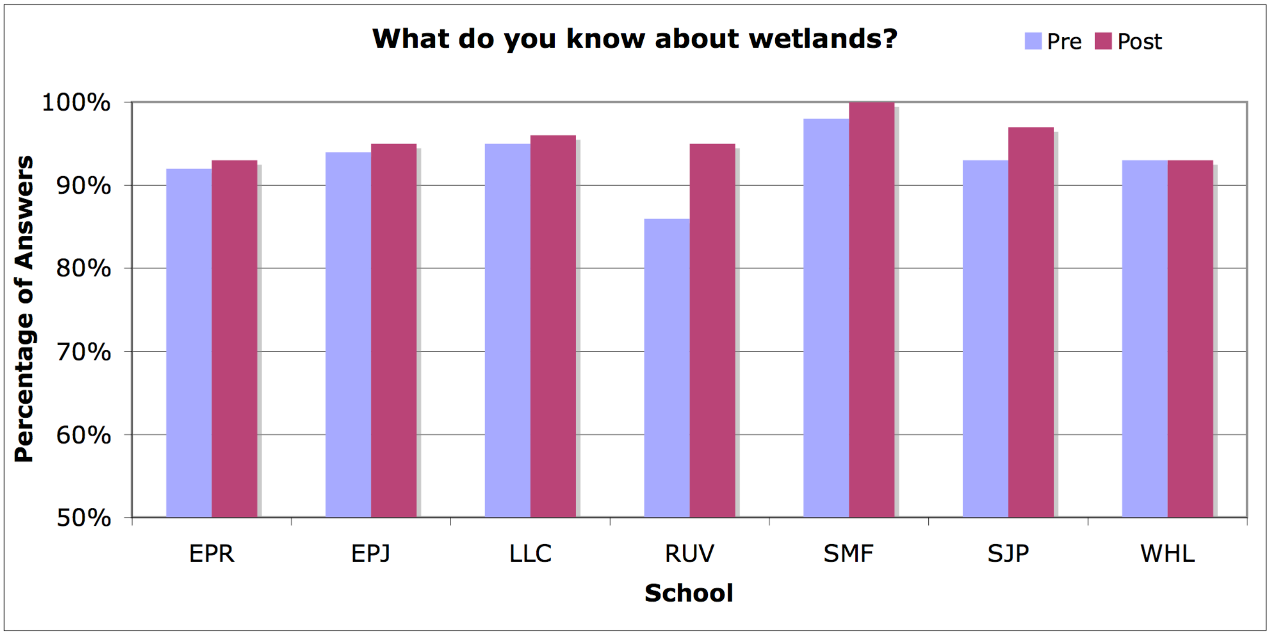

Figure 6. Percentage of correct answers to "What do you know about wetlands?" at each school.

The separate categories did show some significant changes (see "What do you know about wetlands?" table in Appendix B). Most of the statistically significant changes were for responses related to wetland services; four of the schools showed a significant increase while one school had a significant decrease. One important idea on the post-tests that was not on the pre-tests is that wetlands serve as breeding grounds. Additionally, there were nine students who answered "animals you can't see with a magnifying glass." These two answers can be related, as fish eggs and fry can be difficult to see without magnification. Another service that wetlands provide is as a migratory destination. Both the pre- and the post-tests contained this answer; however, on the post-tests a student noted that it is "harder for birds to migrate because they're disappearing." This has an important relation to the fact that wetlands are disappearing. In the statistical analysis this concept increased at five of the seven schools, but only WHL's change was significant. The post-tests also included 18 students whose answers quantified the rate of loss, while one student understood that wetlands take a while to develop by answering "made over time." Some examples are "a football field every 30 minutes" and "100 square miles per year."

The question that asked, "What do you know about the ocean?" had no significant changes in the total correct and incorrect answers (Table 11 & Figure 7). The individual categories did not reveal much more in significant changes (see "What do you know about the ocean?" table in Appendix B). Only the categories physical characteristics and physical processes had significant changes. EPR and RUV both had a decrease in basic physical characteristics of the ocean and an increase in the more complex physical processes. Increase in physical characteristic was demonstrated when on the post-tests three students had answers on some of the features of sand. One student answered, "some sands settle quicker than others,"

while the other answers were "there are different types of sands" and "sand is made of different things." There were a number of other concepts that students learned about the ocean by attending Ocean Commotion, which was shown in the qualitative changes in their answers. One student mentioned the Coriolis Effect on the post-tests, while another student said the ocean "has earthquakes." Two students demonstrated the knowledge they learned about hurricanes by answering how ocean temperatures have to be in the 80s for hurricanes to form. Specific knowledge of ocean species also increased as one student answered, "dolphins are mammals that produce a high pitch for location." Despite the qualitative changes in the post-test answers, more than 60% of the categorized answers had a change of only a percent or two.

Table 11. Results of *t*-test on responses to "What do you know about the ocean?"

		Pre-test		Post-test		
School	**Categories**	freq.	%	freq.	%	test
EPR	correct	60	92%	53	95%	0.037
	blank/don't know	0	0%	1	2%	1.786
	incorrect	5	8%	2	4%	1.508
EPJ	correct	312	95%	318	97%	0.017
	blank/don't know	2	1%	1	0%	0.102
	incorrect	14	4%	9	3%	0.331
LLC	correct	439	98%	439	98%	0.000
	blank/don't know	2	0%	1	0%	0.000
	incorrect	7	2%	8	2%	0.015
RUV	correct	164	95%	158	92%	0.065
	blank/don't know	0	0%	3	2%	1.744
	incorrect	8	5%	11	6%	0.275
SMF	correct	91	94%	84	95%	0.014
	blank/don't know	0	0%	0	0%	0.000
	incorrect	6	6%	4	5%	0.251
SJP	correct	474	97%	485	97%	0.002
	blank/don't know	2	0%	0	0%	0.000
	incorrect	14	3%	13	3%	0.011
WHL	correct	153	96%	163	96%	0.004
	blank/don't know	2	1%	0	0%	1.250
	incorrect	5	3%	6	4%	0.027

* $p < 0.05$ **$p < 0.1$

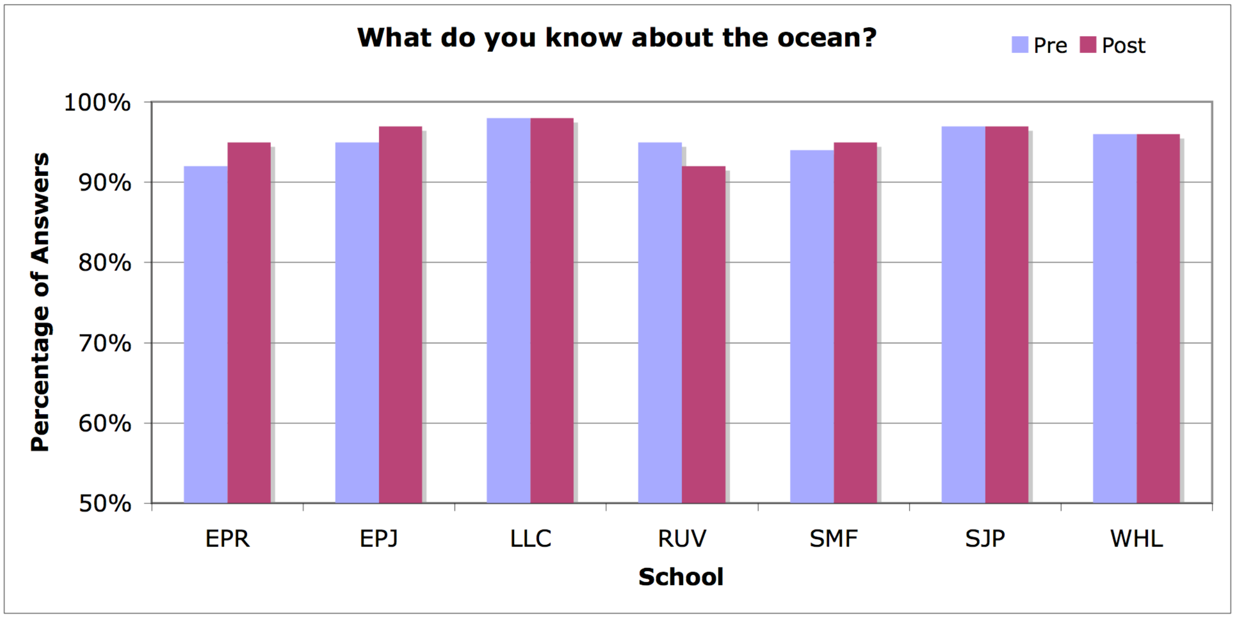

Figure 7. Percentage of correct answers to "What do you know about the ocean?" at each school.

In response to "List some lines of defense for hurricane protection" many of the students had unexpected answers. These answers, such as stocking up on supplies and FEMA, while not exactly incorrect, were not categorized as being correct. So the categories of preparation and emergency response were used to capture these answers (Table 12). While all of the schools showed an increase in correct responses to the hurricane protection question after Ocean Commotion, only WHL had a significant increase (Figure 8). The majority of schools showed a positive change for incorrect answers with six of the seven schools having a decrease in incorrect responses, though only three of the decreases were significant (Figure 8, 9, & 10). Changes in students that either had no response or responded with "don't know" was split, with four schools having an increase (3 significant) and three schools having a decrease (1 significant).

Table 12. Results of *t*-test on responses to "List some lines of defense for hurricane protection"

School	Categories	Pre-test freq.	Pre-test %	Post-test freq.	Post-test %	test	
EPR	defenses	1	4%	1	7%	0.989	
	restore/protect	0	0%	0	0%	0.000	
	preparation	1	4%	0	0%	3.846	*
	emergency response	0	0%	0	0%	0.000	
	blank/don't know	5	19%	13	93%	48.362	*
	incorrect	19	73%	0	0%	73.077	*
EPJ	defenses	71	54%	67	57%	0.060	
	restore/protect	0	0%	1	1%	0.847	
	preparation	15	11%	13	11%	0.000	
	emergency response	12	9%	6	5%	1.166	
	blank/don't know	6	5%	15	13%	3.824	**
	incorrect	27	21%	16	14%	1.455	
LLC	defenses	94	52%	134	69%	2.341	
	restore/protect	32	18%	19	10%	2.312	
	preparation	3	2%	6	3%	0.427	
	emergency response	1	1%	1	1%	0.002	
	blank/don't know	12	7%	11	6%	0.081	
	incorrect	38	21%	23	12%	2.598	
RUV	defenses	29	48%	32	51%	0.061	
	restore/protect	4	7%	6	10%	0.504	
	preparation	0	0%	0	0%	0.000	
	emergency response	0	0%	2	3%	3.175	**
	blank/don't know	18	30%	16	25%	0.382	
	incorrect	9	15%	7	11%	0.579	
SMF	defenses	24	63%	28	76%	1.129	
	restore/protect	5	13%	2	5%	3.238	**
	preparation	0	0%	0	0%	0.000	
	emergency response	1	3%	0	0%	2.632	
	blank/don't know	0	0%	4	11%	10.811	*
	incorrect	38	21%	37	8%	5.746	*
SJP	defenses	98	51%	121	57%	0.280	
	restore/protect	26	14%	40	19%	0.824	
	preparation	2	1%	1	0%	0.220	
	emergency response	4	2%	5	2%	0.014	
	blank/don't know	50	26%	25	12%	5.500	*
	incorrect	11	6%	21	10%	1.076	
WHL	defenses	22	27%	39	42%	3.663	**
	restore/protect	8	10%	6	7%	0.601	
	preparation	7	8%	10	11%	0.307	
	emergency response	6	7%	4	4%	0.717	
	blank/don't know	2	2%	6	7%	1.893	
	incorrect	38	46%	27	29%	3.595	**

* $p < 0.05$ ** $p < 0.1$

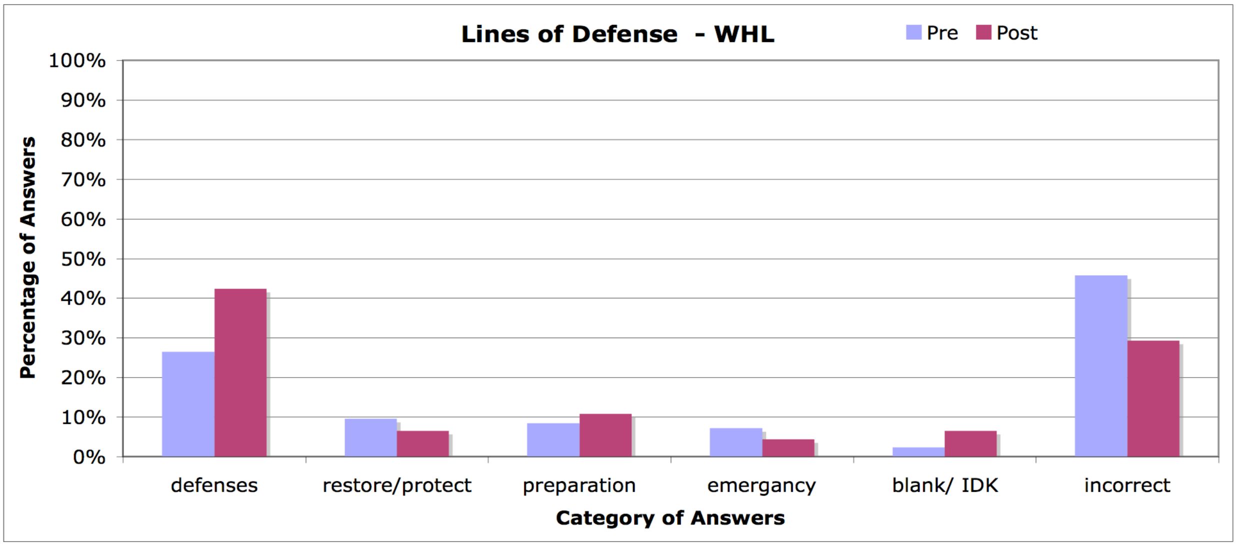

Figure 8. Students' answers for "Lines of defense" at WHL

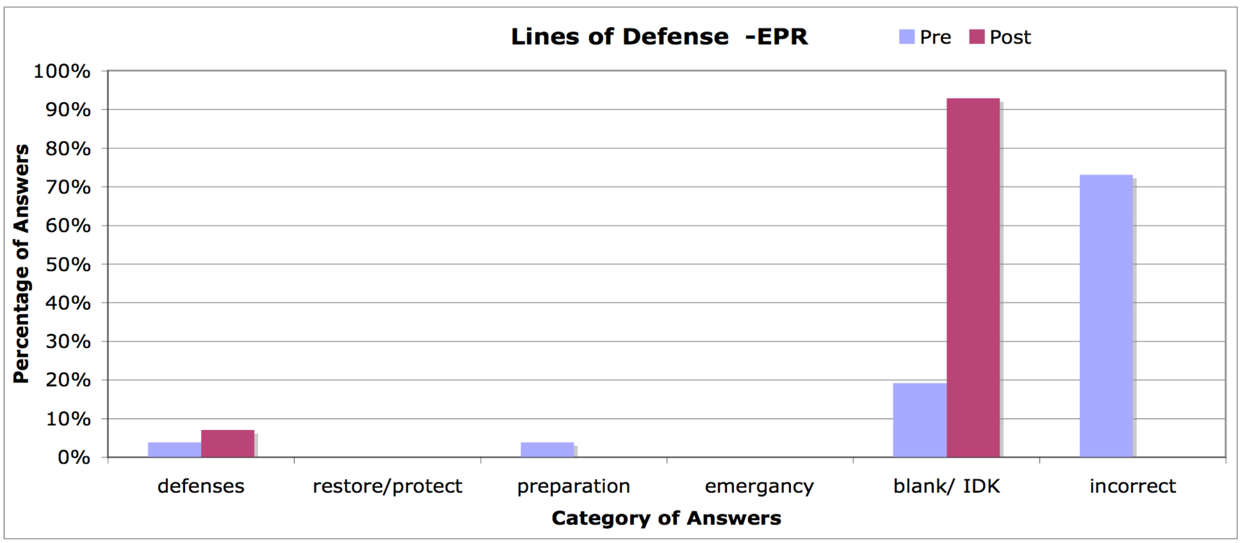

Figure 9. Students' answers for "Lines of defense" at EPR

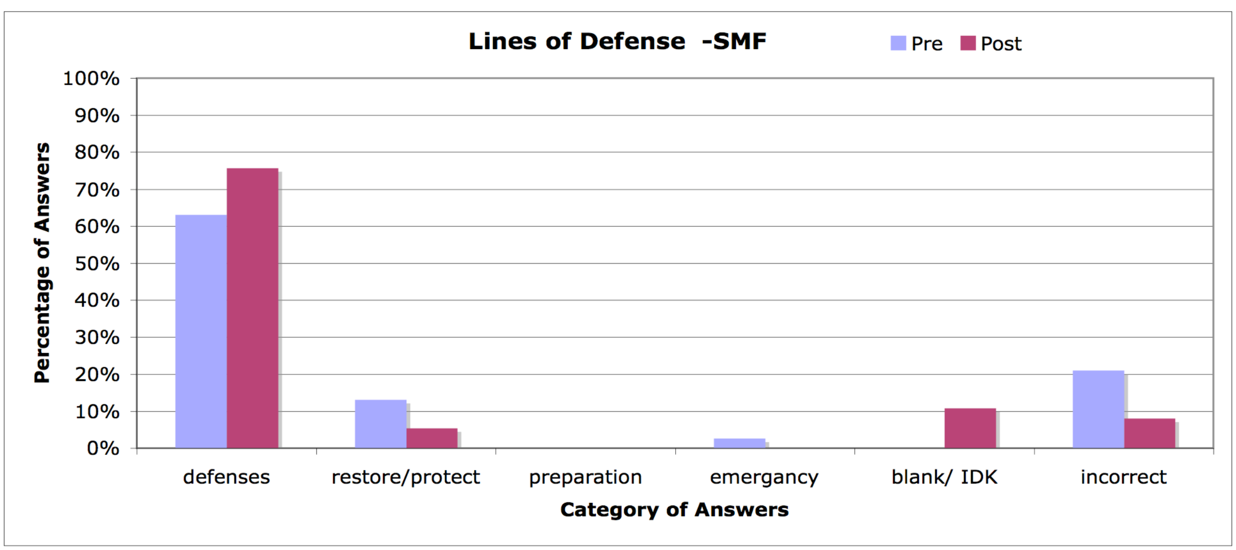

Figure 10. Students' answers for "Lines of defense" at SMF

The remaining two questions on the free-response section were able to be quantified, and were converted to a score. The question regarding the stages of the water cycle had a possible six stages, if a student listed anything related to one of these stages he or she received a point, but multiple items in a stage did not receive any additional points. Figure 11 shows the mean score at each of the schools. Only SMF did not have an increase in score after the event. The changes in scores were tested with a simple paired *t*-test: LLC, RUV, and SJP were significant with a 98% confidence interval (Table 13).

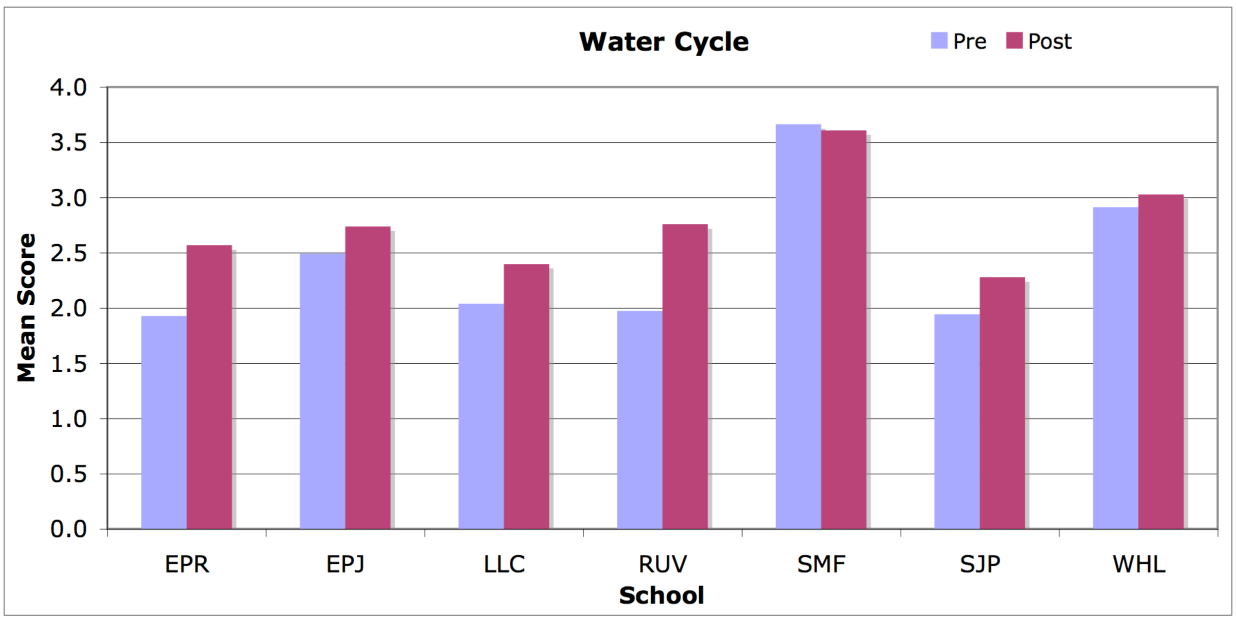

Figure 11. Mean number of answers, out of a possible six, on water cycle question for the pre- and post-tests.

Table 13. Results of *t*-test on changes in mean score for water cycle question

School	mean change	t-test	sig value
EPR	0.6429	1.662	0.120
EPJ	0.2464	1.811	0.075
LLC	0.3579	2.595	0.011*
RUV	0.7857	2.602	0.013*
SMF	-0.0556	-0.212	0.834
SJP	0.3364	2.614	0.010*
WHL	0.1143	1.276	0.211

*$p < 0.02$

For the fill-in-the blank questions, there could only be correct or incorrect answers with a score of 0 to 3 (Figure 12). These mean changes were also tested and only LLC, with a mean change of 0.168, was found to be significant with a *t*-score of 2.606 ($p < 0.02$).

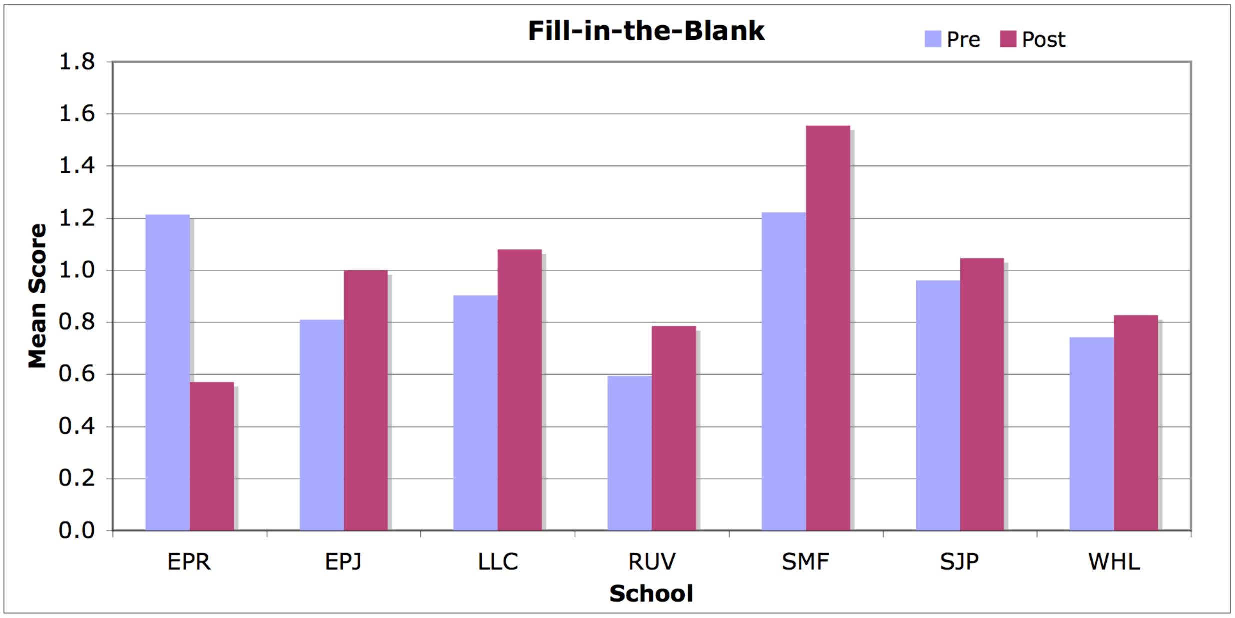

Figure 12. Mean number of correct answers, out of a possible three, on fill-in-the-blank questions for the pre- and post-tests.

Attitude toward Science

Participation in Ocean Commotion was hypothesized to influence not only students' attitude toward these environments, but also students' attitude toward science in general. In the attitude section, four statements investigated the students' attitude toward science. These statements were: "Science is interesting", "Science is a waste of time", "Science makes me think", and "I think that being a scientist would be exciting". The overall mean difference from the pre- to the post-tests on these statements was only 0.0096 (SD =0.58779) with a *t* statistic of 0.301, which is not significant. Each school was also tested individually, but none of the changes were significant within schools either. Thus Ocean Commotion was shown not to be an influence on attitude toward science.

Follow-up Survey

The follow-up survey focused on students' opinion of Ocean Commotion in general and the kinds of exhibits they liked. All of the attitudes were very positive: 89.4% of students liked going to Ocean Commotion, 77.7% would want to go again, and 75.8% would recommend it to a friend. Students were asked if they talked to anyone, other than a teacher, about what they did during the event and 73.7% said they did. Most students liked exhibits where they either were permitted to touch elements of the exhibit (36.4%) or participate in an activity (34.4%). Being allowed to take something home was also very popular, either an object the students were given (13.6%) or made (12.6%). The least popular exhibits were the ones where someone just talked to the students, with only 3% of the students picking this answer. In addition to investigating the preferred kind of exhibit, the survey also had a question on the interactions students liked the most. With this question, 10% liked listening to someone talk, as opposed to only 2.7% who preferred to talk themselves. The favorite interaction was participating in an activity (76.7%), whereas only 10.6% liked to watch others doing an activity. The subject students most liked learning about were sea animals and plants (46.4%), as opposed to the ocean itself (19.9%). Topics covering wetlands and marshes were preferred by 15.9%, issues with marine environments captured 13.9% of students, while dirt and soil topics were favored by only 4%. Those subjects that students most liked learning about were very reflective of the items with which students most enjoyed interacting. Live animals were most popular with students (55.6%), followed by fish and aquatic animals (9.5%), furs, skins and feathers (5.3%) and shells, rocks and sand (3.6%). Playing a game or doing an activity was also popular (26 %). While it is interesting to see what the students liked to do and learn about, the most compelling part of the survey was that 91.4% of the students believed they learned something at Ocean Commotion.

DISCUSSION

The findings of the study indicate that a short and intense one-day experience can have a positive impact on the knowledge of wetlands and the ocean and attitudes toward these environments.

Attitude toward the Ocean and Wetlands

Ocean Commotion had a positive influence on students' attitude toward the ocean and wetlands. In contrast, Prokop et al. (2007) presented in their review of the literature, that the length of time needed for informal science education to have a significant impact on students' attitude and knowledge was 14 days or more. However, this study found that the few hours students spent at Ocean Commotion did have a significant positive influence on attitude. However, it is not known if this impact lasts longer than the few days before the post-tests were administered. Additional work to confirm positive attitude after a greater interval of time would be useful in establishing effectiveness in promoting more life-long changes.

Although Ocean Commotion did have a significant positive influence on students' attitude, it was only a small effect, which could indicate a weak relationship. This finding could be related to two possible factors. The most likely reason is that students only had only a few hours available to spend visiting with exhibitors. As Prokop et al. (2007) discussed, longer exposure time will have a greater impact. Another possibility was the short window of testing. Taking a test only a few days after an event might not allow for the development of a change in attitude. In addition, a more in-depth test may find a stronger relationship between attending Ocean Commotion and an increase in attitude.

Knowledge of the Ocean and Wetlands

This study found that Ocean Commotion produced significant positive increase on students' knowledge. This was shown in two ways: the increase in correct knowledge and the decrease in incorrect information. The significant increase in knowledge with only a few hours of informal learning is again in contrast to the Prokop et al. (2007) suggestion that 14 days or more are needed to have an effect. By testing effect sizes the study found that Ocean Commotion had a larger effect on knowledge than on attitude. This is not surprising, since factual information is easier to both influence and to gauge. In addition, some of the content questions on the tests were created based on exhibits that participate every year, in efforts to determine the impact of those exhibits, so increases in knowledge would be expected.

Another reason the impact on knowledge was higher may have been because of the interactions that occur at Ocean Commotion. Tal and Morag (2007) talked about the importance of personal experience and interaction with others when learning science. They discussed intellectual development, specifically the socio-cultural view, in which learning science is believed to be based on "the idea that learners use personal experiences and interact with others to construct knowledge of the world." At Ocean Commotion students are not only allowed, but often encouraged, to interact with the exhibitors, fellow students and items in the exhibits.

RUV was the only school that did not have a significant change on the content section. Fourth graders from this school participated in the study, and while 49 of the 55 students had pre- and post-tests, the teacher made note of the difficulty of getting the students to finish the tests, saying that the test was too difficult for fourth graders. While this may have been true for the students at RUV, the other fourth grade classes in the study, EPR, had one of the highest increases in content knowledge. It is important to note that these two classes were the ones that

had the most compliancy issues, with less than 35% of students having paired tests for the content and attitude sections (Table 5).

The free response section of the tests showed that Ocean Commotion had various effects on students' knowledge. The overall frequency of incorrect response decreased significantly; from this it can be presumed that Ocean Commotion had a positive influence on students' knowledge of the ocean and wetlands by decreasing the incorrect concepts that students had. However, with an effect size of 0.214, the effect is interpreted as relatively small. This result is important, because educators need to ensure that students have the correct information. For two of the questions, types of wetlands and lines of defense, only two of the correct answers showed significant changes, while four of the incorrect answers showed significant changes. For the question on types of wetlands, there were only two significant changes, and they were both opposite of what was expected. EPR had a significant decrease for correct answers and a significant increase on incorrect answers. Since no other school had significant changes, it was assumed these negative changes were due to compliancy issues with the students; less than one-third of the students had both pre- and post-tests that were used in the analysis. Most likely students had already learned the predominant wetland types in Louisiana, especially marshes, swamps and bayous, either in class or at home, so that this question may reflect limited influence of Ocean Commotion.

The "lines of defense" question had more statistically significant changes. Three of the schools showed a significant decrease in incorrect answers and one school had a significant increase in correct answers. Four of the schools had a significant change in the blank/don't know responses. Three of these changes were increases and only one was a decrease. While these increases could indicate a negative impact, they could also mean that students are no longer

guessing at what the defenses are and realize there is a correct answer that they do not know. There were other significant changes, but they only show a fluctuation in how the students answered the question; this most likely indicates only what students were most recently thinking about. On one of the post-tests, a student wrote, almost verbatim, the lines of defense that were on the handout from the exhibit "Keeping Our Coast." This question was on the test in part to find out if students learned from this repeat exhibitor. Showing that students learned about coastal defense from a few minutes spent at one exhibit is important because of the impact that hurricanes can have and the need for a system of defense that is required for protection.

It is harder to determine a change in the students' knowledge from questions that did not have definitive answers. A frequency change from one category over another does not necessarily mean the students' knowledge increased; it more likely indicates what the student most recently heard or thought about. The question with the lowest number of significant changes was "What do you know about the ocean?" The lack of significant changes is most likely a result of the prevalence of documentaries on the ocean. Dingwall and Aldridge (2006) investigated the broad reach of documentary programs. A search on Amazon (2009) showed that Planet Earth, after 2 years on video, is the 3rd (DVD) and 4th (Blue-Ray) best-selling documentary and has been in the top 100 for more than a 1,000 days. This British Broadcasting Corporation [BBC] series includes two episodes that are strictly focused on marine areas, "Shallow Seas" and "Ocean Deep" (Fothergill, 2007). The creators of Planet Earth had previously produced Blue Planet: Seas of Life (Fothergill, 2007). In this documentary series focusing on the ocean, not only is the history of the ocean covered, but also the various ecosystems within the ocean, from north pole to south and from the shallow coast, to the open ocean, to the deep trenches (BBC, 2009).

The only categories for the “What do you know about the ocean?” question that showed any significant changes were “physical” and “physical processes.” The physical category included responses such as the percentage of Earth that is covered by water, the number of basins and other characteristics such as size, depth and temperature. Whereas, the physical processes had more complex concepts such as ocean currents, the effects of the moon’s gravitational pull, the ocean’s impact on climate impacts, and erosional capabilities.

Increasing conceptual knowledge is a part of NOAA’s commitment to an ocean literate society. While the analysis of responses related to humans did not have any significant changes, there was a qualitative change in some of the answers that students gave. Pollution was a frequent answer in this category; on the pre-tests 54 students had answers related to pollution and of those answers, most were related only to the fact that the ocean is being polluted. The post-tests had 81 students with answers related to pollution, and three of these students answered how people could help, for example by not littering. This change in perception and responsibility may reflect the impact of specific exhibits from Ocean Commotion, such as “Water Fit for a Bug,” “Groundwater Clean-up: Grab the Pollutants!” and “Green and Clean Team Workin’ in the Wetlands.”

Another qualitative change was the information provided on sand. On the pre- and post-tests, the question “What do you know about the ocean?” had numerous answers that the ocean contains sand. In contrast, the post-tests had three students who gave further details on this by explaining the physical properties of sand, such as the settling rates and their physical make up. These changes show the influence of exhibits where students interacted with sand such as “Sands Around the World” and “Sediments in Action.” At these exhibits students were able to observe sands under magnification and watch sand settle in glass jars.

The responses to “What is a wetland?” were more varied than expected. The question was intended to elicit the response that wetlands were “wet” and “land”, but instead the responses included types, location, biological factors and services that wetlands provide. Students that answered “wet” decreased significantly at one school and land related answers increased significantly. Over all, the pre-tests had more responses related to wetness and covered by water, whereas on the post-tests students had more responses of land and that wetlands are along the coast and where land meets the ocean. The concept of wetlands being physical land and not just a wet area is important, especially when it comes to protecting these areas. Responses of the types of wetlands decreased significantly at three of the schools. This could indicate that students understood that there is more to wetlands than just the types, after interacting with material from wetlands. As Tal and Morag (2007) discussed how interactions allow students to better construct knowledge, seeing and touching material from wetlands would help the students better understand wetlands. However, it could also indicate that students better understood what the question was expecting.

There were changes in the qualitative nature of some of the answers to “What is a wetland?” One student grasped the concept that wetlands can be dry for part of the year. In addition, many more students answered this question on the post-tests with information on how the wetlands protect surrounding land. Students’ answers showed that they learned that wetlands protect not only humans and our communities, but also the natural environment. Students answered that wetlands provide protection from not only hurricanes but also other coastal hazards, such as erosion, storm surge and flooding. Such an understanding should increase the importance of wetlands in the students’ minds.

The question that asked “What do you know about wetlands?’ had a wide range of responses, that generated the most categories for any of the questions. The services that wetlands provide had the most significant change, with three schools having a significant increase and two schools having a significant decrease for these responses. It is difficult to draw a conclusion from these mixed results. While a decrease in answers related to wetland services would not imply that students either forgot or no longer believed that wetlands provide a service, it may instead indicate that the students at these two schools probably did not have a focus on wetland services, and the students answered the question in other ways. However, it could be assumed that the classes showing an increase in responses about services discussed some of the important wetlands services, such as water filtration and flood protection, in their classes.

In the answers to “What do you know about wetlands?” two of the schools, EPR and EPJ had a significant decrease in answers related to physical properties of wetlands. Most of the answers in this category were basic concepts related to the size of wetlands, such as some are big and some are small, the color of wetlands and the temperature of wetlands. In addition, EPR had a significant increase in answers related to biology where many of the answers included animals and plants that live in wetlands. These changes may be a reflection of the numerous exhibits at which students can see and touch plants and animals found in Louisiana wetlands. However, since this question is very broad, the correct responses are almost innumerable. The change from physical answers to biological answers does not show an increase in knowledge, instead it shows only a change in how the students answered the question. Future studies may delve deeper by using questions targeted to find whether Ocean Commotion promotes higher levels of learning (Cox-Pertersen et al. 2003).

While the statistical changes were limited, there were some qualitative changes in the answers to “What do you know about wetlands?” On both the pre- and post-tests, students responded to the question by stating that wetlands are disappearing. However, on the post-tests many students went further by quantifying the loss. Understanding that wetlands are being lost at a high rate and stating the loss in terms that students can relate to, like an area the size of a football field every 30 minutes, makes the loss easier for the students to comprehend. On the post-tests one student answered it is “harder for birds to migrate because they’re [wetlands are] disappearing.” This shows the understanding of a complex idea that the loss of wetlands is impacting bird migration. Another complex idea that a student grasped was that it takes a long time for wetlands to develop. Understanding that wetlands are “made over time,” could lead to a better appreciation of wetlands and a greater desire to protect existing wetlands.

Attitude toward Science

The questions that targeted attitude toward science showed that Ocean Commotion had no effect on science attitudes. This was surprising, given the results of other studies. Prokop et al. (2007) discussed how informal learning that involves first-hand experience with science improves attitude toward science. One of the four main conclusions of the National Research Council (2009) was that “nonschool science programs can feed or stimulate the science-specific interest of adults and children, may positively influence academic achievement for students, and may expand participants’ sense of future science career options.”

There are a few possible reasons for the lack of change. One possible reason is that there were only four questions. Having only four questions drastically limits the scale, and detecting any change would be very difficult. One of the questions asked the students’ attitude toward the statement “Science makes me think”; however, agreeing with this statement does not necessarily

imply liking science, nor does disagreeing with the statement absolutely indicate a dislike of science. A student can like science and have an aptitude for it, but not find it difficult or feel that it requires much thinking. The time constraint could again be a factor since the post-tests were administered such a short time period after Ocean Commotion. Students would not have had time to turn the interest for things learned at Ocean Commotion to an interest in science.

Follow-up Survey

With 2008 marking the 11th annual Ocean Commotion there is a history of anecdotal comments on what types of exhibits students usually like the most. Dianne Lindstedt, the Marine Education Coordinator at Louisiana Sea Grant, noted that over the years exhibitors have changed their exhibits from a poster presentation style to interactive demonstrations and activities in response to seeing students gravitate to exhibits that were hands-on (D. Lindstedt, personal communication, October 29, 2009). Therefore, some of the results of this short, post-event survey were not surprising. More than 70% of the students indicated a preference for exhibits where they can either touch something or participate in an activity. Teacher comments over the years have also indicated the students' preference for live animals, so the finding that more than half of the students enjoy touching live animals is not unexpected.

The follow-up survey also delved into questions that are not as easily observed. One question asked students which subject they liked learning about. By far, the most popular subject was sea animals and plants. Topics on the ocean, wetlands and marsh, and problems with marine environments were close together, each having moderate student interest. There is much more to marine and coastal ecosystems than sea animals and plants or the wildlife that seems to be featured in most documentaries. There are numerous chemical and physical processes that are very important to the ocean, and only one of the seven Ocean Literacy

principles from NOAA (2009) focuses on marine life and ecosystems. Exhibits covering dirt and soils were only chosen by 4% of the students, but this could be because of the low number of exhibits that covered this subject. Only 4 of the 68 exhibits presented topics on dirt and soils.

Students attitude toward Ocean Commotion were overwhelmingly positive. Almost 90% of the students enjoyed attending, and less than a quarter of the students would not want to go again. The number of students who would tell a friend to go most convincingly shows the popularity of Ocean Commotion. Of the 297 students that responded, 225 would suggest that a friend attend this learning event. The most compelling part of the survey was that 9 out of 10 students believed they learned something. While this number might be skewed because the survey was administered in the classroom and students know that school is for learning, it is still a very high ratio.

Students were also asked if they talked to anyone, other than a teacher, about what they did at Ocean Commotion. This question was intended to show student enthusiasm about what they learned and is a reflection of their attitude toward the topics covered by the exhibits. Having 73.7% of students responding that they did discuss Ocean Commotion outside of school suggests a positive change in attitude that was not reflected in responses to specific attitude questions.

Implications and Recommendations

This study indicates that a short and intense one-day experience can have a positive impact on knowledge and attitudes of students in grades fourth through eighth. This finding can serve as a justification for the time and funding required for an event of the magnitude of Ocean Commotion. While anecdotal evidence is helpful in gaining support for events, having statistically sound evidence of learning is often required by school administrations and funding

agencies. The findings of the study can also serve as a guide to help increase the effectiveness of events like Ocean Commotion. The follow-up survey showed that students preferred interactive exhibits. This information can be used in the future to design exhibits where students can see or touch the concepts that are being conveyed, instead of only hearing about them. Another recommendation would be to attempt to have exhibits on subjects that might not be as popular, such as plants and soils, as there are some students who enjoy and might benefit from these subjects.

Based on the evaluation process itself, there are other recommendations that can be made. Few of the teacher surveys were returned, and those that were had very general answers. A brief phone interview could quickly gather pertinent information, and teachers might be more likely to participate. In addition, to confirm information on student activities during the event, observations could be conducted. One of the few comments that were received was that the tests are too long. Perhaps future studies could be more focused and examine one topic. With a smaller focus there could be more specific questions for a more refined survey. Doing multiple, more focused, surveys over time would result in a more complete picture of the impact.

It is important to note that there is a difference in demographics of the classes that participated in the study compared to all of the classes that attended the event. For 2008, 58.7% of the students who attended Ocean Commotion went to public schools, 39.9% attended to private schools, and 1.4% of the students were home schooled. This was very different from the students who were involved in the study; there were no home-schooled students, and the study had a much higher percentage of students who attended private school (64.2%). In addition, while 35.8% of the students went to public schools, 20.7% attended a university-affiliated school, where tuition is charged. In effect, only 15% of the students attended a tuition-free

school. Obtaining results from a more representative demographic would provide additional support for the effectiveness of informal science education with all types of education.

SUMMARY AND CONCLUSION

This study investigated the effectiveness of a one-day, hands-on learning experience to determine if such a short time period could have an influence on students' knowledge and attitude toward the ocean and wetlands. Specifically, the aim of the study was three-fold to test the impact on: students' knowledge of the ocean and wetlands, students' attitude toward the ocean and wetlands, and students' attitude towards science in general. The results of the study show that the first hypothesis was supported: students' knowledge of ocean and wetlands will increase. The second hypothesis that students' attitudes toward the ocean and wetlands will be positively influenced, was also proven to be true. Conversely, the third hypothesis, that students' attitude toward science will increase, was not supported by the results. However, there was additional support for the effectiveness of Ocean Commotion in the qualitative changes in students' responses to the open-ended questions and attitude toward the event in general.

Future research could include a more thorough evaluation of science interest and perhaps a longer time span between the event and the evaluation. These alternative methods might allow additional insight into the correlation between the changes in knowledge and attitude toward environments, as well as attitude toward science in general. Furthermore, this study provides concrete evidence of the educational value that Ocean Commotion can provide. It also helps to support the development of similar events to promote ocean literacy in other regions of the country.

CHAPTER 2

LITERATURE REVIEW

LITERATURE REVIEW ON INFORMAL SCIENCE EDUCATION

"Today is the class field trip to the museum." For most students this statement would elicit excitement and anticipation, if for no other reason than the prospect of getting out of the drudgery of the typical classroom. Museums have been hosting class trips since the early 1900s (Magoon, 1916), helping to produce a rich history of educational activities that occur outside of the classroom. Excitement for class trips is just as prevalent today as it was at the turn of the 20th century. However, it has been only in the past few decades that these events have been given serious consideration as sources of scientific learning by both teachers and researchers.

Overview of Informal Science Education

Events like a class visit to a science or natural history museum are considered informal science education (ISE), which is learning that takes place outside of the classroom (Crane et al., 1994; NSTA, 1998; NSF, 2001). These events are not limited to museums; they also occur at other institutions such as nature and science centers, zoos and aquaria, arboretums, and planetariums (NSTA 1998). With much of informal learning being voluntary and self-directed (NSF, 2001), learning can occur through unexpected forms. Multimedia, such as television programs and documentaries, as well as community-based organizations, also serves as ISE (Crane et al. 1994).

One way to achieve self-motivated learning at a more traditionally structured location, like a museum, is by turning learning events into a game. Games engage participants, make learning fun and often lead to subconscious learning where participants do not realize that they are absorbing new information. Recently there has been an explosion of educational games,

especially educational video games and media; however, this concept is much older than our modern twist. In 1916, Eva Magoon presented a paper on "A Museum Game" that documented the development of games to be used in association with a docent-lead lecture. The game is of the "seek and find" style where students were given cards that contained sentences with missing facts (Magoon, 1916). Answers were located in the museum exhibits, and students were allowed to find the answers at their own pace, all the while learning additional facts along the way. While this may not be the inception of the museum learning game, it serves as a record of the historical use of games, both to place inconspicuous control on the students' behavior and to promote voluntary learning.

Early Years

Early documentation of other activities like Magoon's are difficult to find, and it is not until the 1960s that articles on informal education began to appear regularly. Despite limited documentation, many institutions were making strides to fill the new role of "places of learning," instead of being focused strictly on research and preservation. A pamphlet by Educational Facilities Laboratories (1975) reported on fifteen such museums that were emerging as "experience-orientated rather than object-orientated" institutions. However, they represented only a small percentage of the museums that were open. By the 1960s there were over 5,000 museums open in the United States (Hornung 1987). A review by Sorrentino and Bell (1970) found that limited research had been conducted on the value of fieldtrips prior to their assessment; of the 70 articles reviewed, only eleven involved empirical studies, with only nine of those cases supporting the value of fieldtrips. Sorrentino and Bell concluded that, while field trips are claimed to be valuable, the research supplied little support.

The 1970s saw ISE research become its own specialty field, moving away from being a subfield of museum research. However, the field was not as focused as it is today. Formal and informal education were used to label more than the dynamic between activities that happen inside and outside the classroom. Scribner and Cole (1973) used these labels to differentiate between learning in primitive vs. traditional societies. They considered informal education to occur in primitive societies where there is no formal education system and children learned by observing adults. However, Scriber and Cole did note the cognitive differences between formal and informal learning. They made the point that informal learning is everyday learning and it is disconnected from the learning that occurs in schools, especially in terms of content.

Views on Informal Education

There are various views on how informal education should be approached. In 1969, Frank Oppenheimer, a physicist turned educator at the forefront of the informal education movement, founded the Exploratorium, an informal science center that promotes hands-on learning through exploration, that is a leader in educational research today. In 1975, Oppenheimer had a vision of what informal education could be and the important role it can play in the public education system. In a letter published in *Physics Today*, Oppenheimer (1975) promoted a change not only in the public education system, but also the way in which the system itself is perceived. Society expects a myriad of tasks from schools that are nearly impossible to achieve for all children, so Oppenheimer suggested instead a system that utilizes the variety of education that is available outside of schools. He promoted such places such as libraries, museums, recreational complexes and parks, educational television and liberal arts production – in general places that offer experiences in addition to information.

Like Oppenheimer, Zubrowski (1982) promoted the use of aesthetic curiosity to teach science. Through his work at the Boston Children's Museum, Zubrowski noted that the use of soap film and bubbles engages children far better than a lecture on either surface tension or light spectrum. He advocated the incorporation of play in science education, since play is closely intertwined with exploration and tends to build curiosity. In addition, during play children do not need any motivation to explore the properties of the material they are playing with, and some activities, like marbles that seem to defy gravity, can be intellectually stimulating.

The majority of the literature has positive, if not statistically supported, views of informal education; however, not everyone share this view. Shortland (1987) wrote a very negative commentary in *Nature* against interactive science centers with the tag line "But what – if anything – do children learn at them?" Shortland viewed play as purely that, believing that children did not take the time to do more than play and passed over activities such as either reading labels or interacting with staff members. He did present a valid point that labels can be either too complicated or over simplified, and children might not read them; however, that does not imply a lack of learning occurring. Shortland's view is in direct contrast to Zubrowski's (1982) advocation for more play; according to Zubrowski, "If educators are to design an educational experience that addresses the child as a whole human being rather than a learning machine or computer, then they need to recognize not only the importance of play at all levels of learning, but also let it flourish in all kinds of educational situations."

Informal Education in Theory and Practice

In 1975, Oppenheimer suggested a conversion to a system of informal educational opportunities. While his ideas were not implemented, schools and teachers still frequently visited informal educational institutions. In 1979, Gottfried noted that school groups made up

25% of visitors to science centers and provided a large portion of museums' budgets, in spite of the lack of research on the effectiveness of school visits. The 1980s were marked by a dramatic increase in research, though most of the studies focused on museums and science centers (Lucas 1983). One example is Wright's (1980) study of the effectiveness of a museum visit to show the value of museum visits to school administration. In the study some students visited the Kansas Health Museum for a review of human biology. Students that had the review at the health museum had a significant increase in knowledge, while students that received an in-class review did not show any increase in knowledge after the review session. Wright concluded that a review lesson that involved multisensory, hands-on experiences at the museum "contributed to a superior comprehension and application of knowledge and concepts."

Even when the formal schooling years have concluded, informal education is still important to the adult student. Lucas (1983), in a discussion of scientific literacy and informal learning, remarked that people are constantly exposed to potential educational encounters in their everyday lives, and it is through these out-of-school encounters that most people learn science. He goes on to discuss how the world is changing with the majority of people using highly scientific devices in their everyday lives and the rapid rate at which devices and processes are evolving. Another important comment Lucas (1983) made is that people cannot rely on school as the only location for science learning; without informal science education venues many adults would not be able to function in the modern world because of the dramatic changes that have occurred since they were in school. Continued learning is especially important for people "to participate in decisions about scientifically and technologically influenced political issues," such as cloning, climate change and alternative power. Collins and Bodmer (1986) discussed three reasons why the public needs to understand science. The first reason was that a significant

portion of the national budget is spent on science and technology. In the second reason, Collins and Bodmer reflected on the influence science has on daily life, specifically in the areas of work, food supplies, shelter and medicine. The third reason explained the pervasiveness of science and technology, especially due to their expense and importance to society.

In the 1980s researchers started to focus on the difference between formal and informal education. Resnick discussed some of the main contrasts in 1987. The first difference was the way in which students act independently in the school context, whereas their activities in the rest of the world are performed in social groups. For example: jobs involve numerous people, where the knowledge needed is spread across many individuals, including those who make the tools and machinery that are used (Resnick, 1987). Another difference was the expectation that students use pure mental powers to do work in school, while many everyday activities outside of school rely on tools. Resnick concluded that schools taught theoretical principles instead of applied knowledge.

Other individuals in the field echoed these important differences. Hornung (1987) reflected how the increase in the number of museums during the mid 20^{th} century led to awareness that the educational system, because of its strict use of oral lectures, had a lack of visual literacy. Hornung noted that despite the problem being known for over 20 years, many schools used only reading and lectures to teach. The opposite is the case in many informal centers, which use observation, investigation, and creation to stimulate learning (Chamberlain, 1987). A survey of 160 science and natural history museums found that many of them had programs where hands-on activities were the focus (Bierbaum, 1988). Harte (1989) discussed how the typical classroom is "teacher-initiated, labor-intensive, abstraction-rich and experience-lean," which he argued leads to students who want to escape the drudgery, often by actual or

mental truancy. He believed the major difference is that schools are rich in content while science centers are based on experience.

ISE as a Valid Discipline

The 1980s saw the start of informal education being recognized for its value to public education. Katz and McGinnis (1999) conducted a historical review of the institution of informal learning. The National Park System began in 1872 with the opening of Yellowstone, and many of the major cities had zoos opening around that time as well, including Central Park Zoo in 1861 and the Philadelphia Zoo in 1874 (Katz and McGinnis, 1999). Despite the long history of informal education in the United States, Katz and McGinnis noted how "their impact as informal science education offerings was largely ignored by formal educators and policymakers." It was not until the 1970s that this began to change, with 1983 marking a major recognition of the value of informal educational institutions with the National Science Board publication *Educating Americans for the 21st Century* (Katz and McGinnis, 1999). Hein and Alexander (1998) also noted that it was not until the 1980s that school visits to museums were acknowledged as being beneficial, especially in terms of their lasting impact.

With this increased acceptance, some of the literature began to focus on how to best utilize informal learning centers. After a review of twenty-seven studies, Koran et al. (1989) detailed the importance of preparation before visiting a site, active visitor involvement instead of passive observation and visitor initiative as key factors for optimizing school visits. In Prather's review (1989), he concluded that field trips, when not integrated into a curriculum, offer little educational value. However, with planning and incorporation these same trips become invaluable, providing factual and conceptual learning. He also pointed out they can "dramatically effect means for changing students' attitudes towards science." Harte (1989), the

director of the Learning Exchange in Portland, Oregon, promoted the integration of school and science centers. He remarked how a system of education that tends to stifle inquiry-based learning and dialogue leads to many more students entering the world undereducated and lacking basic decision-making skills. Hornung (1987) also discussed the importance of exhibit integration, since typical visitors to museums and science centers come to exhibits “cold” and often without the ability to place the exhibits into some context, be it historical, cultural, or contextual framework. Without a framework for learning, the visitor absorbs much less from the visit. Hornung (1987) noted that intergration is a benefit of traditional education as new material is built on existing knowledge. He concluded that collaborations work best, where students receive preparation for the visit and then have all the benefits of the informal learning environment.

The field of informal science had a very slow start in the U.S., especially considering that museums were open before the country was founded; the first public museum, the Natural History Museum of South Carolina, was established in 1773 (Hornung, 1987). For 200 years, there were only a handful of studies (Koran et al., 1989 and Prather, 1989), but as previously mentioned, the 1970s and 1980s marked an increase in studies. Because of this increased research and the movement away from museum studies, the field of informal science education started to emerge as a new discipline in the 1990s. However, as with most burgeoning fields, there were many obstacles to overcome. Wellington (1990) discussed how informal learning in science is still “relatively under-funded, under-valued and under-researched.” While most individuals in museums and other learning communities acknowledged the value and importance of informal education by 1990, there are still opponents. Lucas (1991) calls informal learning ‘Info-tainment’ and likens it to history, where “inaccurate portrayals of events” often occur.

Lucas (1991) used the example of an Industrial Revolution exhibit that showed the industrial machines and technological improvement, though they were shown in the absence of the political and social problems that were associated with these advancements.

ISE Institutions and Their Impact

The kind of science that is learned in science centers has also been debated. Lucas (1991) is critical of the level of science stating, "the range of science … is low, concentrating on deterministic, rather than stochastic interrelationships." Wellington (1990) admits that "science centers in practice contribute almost exclusively to *knowledge that* and rarely contributes to knowledge of how and why phenomena occur" but counters it should not be dismissed because it can indirectly contribute to high-order thinking. He goes on to discuss how hands-on science has more than just cognitive gains; there are also psychomotor and affective contributions. Anyone who has watched children 'at play' in a hands-on science center has seen the enthusiasm and animation children bring to the exhibits. Wellington (1990) believes that this excitement and the development of an eagerness to learn far outweigh any lack of immediate deeper cognitive understanding. The idea that play and interaction is important is not new and probably is best exemplified by Rachel Carson and her vision for a lifelong sense of wonder (Carson, 1998). After almost forty years Carson's ideas were being built on, supporting the belief that creating a sense of wonder of the world prepares young minds to learn (Edeiken, 1992).

As the field of informal education developed, the research moved away from simple investigations of the effectiveness to how students actually use the learning centers. One way of studying this is through behavioral observations. Tuckey (1992) did research along this line at Satrosphere, an interactive science center in Scotland. One of the observations noted was the number of exhibits visited in a 10-minute time period. Tuckey found that students went to the

same numbers of exhibits throughout the visit, which he noted was in contrast to other studies where students stopped at more exhibits at the beginning of a visit and fewer at the end. Another observation involved how students grouped themselves. Three group types became apparent: single-person, pairs, and groups. In this study, students in pairs seemed to be most productive during the visit, keeping on track with moving through the exhibits and learning through discussion. Alone, students tended to form "transient partnerships" and did not optimize their time at the center; instead they either wandered aimlessly or spent most of the time at one or two exhibits. In groups, only some of the students actually interacted with the exhibit while others only observed (Tuckey 1992). Tuckey noted this and how teachers can use the knowledge that pairs tend to work more effectively to lead their students more effectively through science centers and museums. In addition to observations, Tuckey (1992) also interviewed the students a week after their visit to the center to see what the pupils recalled of the visit. Exhibits that were recalled the most were not necessarily the biggest exhibits, but instead were those that had a lot of interaction. Tuckey's finding that "exhibits requiring active participation are more likely to be remembered" holds true, because the participants are using more than just their eyes; the more senses used the more likely the activity is remembered. When asked what they had learned, 50% could not recall anything; however, 25% had positive attitudes toward science in general. Some of the students did learn new scientific principles, and a few applied those concepts to situations in their everyday lives (Tuckey, 1992).

In addition to research on the value of informal education institutions, there were also inquiries about how to improve the usage and integration of informal centers with school learning. Bitgood (1991) presented a good summary of some suggestions to improve field trips:

1. Integrate the museum program into the school curriculum.
2. Conduct a front-end evaluation of student knowledge, interest, and experience.

3. Prepare students for the setting and agenda.
4. Prepare students with pre-visit activities for the classroom.
5. Make the field trip experience-driven rather than information-driven.
6. Design the on-site activities with care.
7. Test the impact of the program as it develops.
9. Minimize behavior problems by planning.

However, these suggestions are directed at various individuals throughout the educational spectrum, including exhibit designers, staff members, and teachers.

Griffin (1994) argued that despite numerous papers discussing and presenting ways to optimize the potential educational experience by incorporating informal science centers with schools, little progress had actually occurred. In addition, Griffin doubted the use of 'successful strategies' by school groups visiting museums. To investigate this, Griffin (1994) conducted a study of classes at thirteen different schools that went on museum visits. Based on interviews with teachers and students, Griffin found that most of the classes had very little preparation, usually an organizational overview at most. Integration and relation to schoolwork is a very important factor for positive learning experiences. However, Griffin found that "very few students could see a purpose for their visit other than a day out, or at best 'to learn things,' but with no clear idea of what these 'things' were." One of the biggest problems Griffin observed was that teachers did not perform to the standard of 'basic good teaching practice.' Specifically, they either worked only with a small part of the class or just acted in a supervisory role watching for proper behavior. Another issue Griffin found was how the students viewed the activity. Students that had a worksheet to complete viewed the worksheet as a hindrance to interacting with exhibits. While they wanted to be free to explore, Griffin found a contradiction in the students' view of individual exploration, since they considered learning to occur only while doing written, school-like work. Despite the support for play, both teachers and students viewed "play areas" as purely that and not as places of learning. Griffin watched as many teachers did

not allow children to enter more hands-on areas under the assumption that playing meant students were not learning and therefore would be a waste of time. While teachers planned on having follow-up activities after the visit, it usually fell to just picking up worksheets and grading them, and sadly that is all the students had anticipated. Griffin concluded that teachers are not using the suggestions that research has made and in fact they are "imposing all of the features (and restrictions) of formal learning onto an informal setting," causing the field trips to fall short of their full potential for learning.

Recent Changes

The Twentieth Century ended with informal science education truly coming into its own. This was marked by the National Science Teacher Association Board of Directors officially adopting a position statement on informal science in 1998 (NSTA 1999). Informal Science Education was broadly defined as programs and experiences developed outside of the classroom by institutions and organizations. Furthermore, the statement asserted how important it is to "recognize and encourage the development of sustained links between the informal institutions and schools" and the "power of informal learning experiences to spark curiosity and engage interest in the sciences during the school years and throughout a lifetime" (NSTA, 1999). The major benefits noted in the statement include the ability of ISE to help meet education standards, enhance classroom science, incorporate parents and care-givers, provide occasions to experience science in action, promote continued science education for the general public and reach a broader spectrum of people and learning styles – all through noncompulsory means (NSTA, 1999).

In 2001 the National Science Foundation (NSF) wrote an overview of ISE that set some of the goals and objectives for this field of education. They stated that the main goal was to "increase public understanding of science, mathematics and technology." This goal broadens the

scope for informal education considerably, from school-age youths to the public in general. Informal science education should be voluntary, self-paced, visual- or object-orientated and lifelong (NSF, 2001). Furthermore, informal science institutions contribute to life-long learning by informing the general public of new scientific advances in an easy-to-understand and non-intimidating manor. The overview (NSF, 2001) also noted that ISE helps meet some of the goals stated by NSTA such as the increased participation of minorities and providing access to people who might not otherwise have access, such as rural and inner-city inhabitants. However, the NSF focuses more on the long-term influences, noting how ISE can "improve scientific and technological literacy of children and adults so they are informed about the implications of science, math, and technology (SMT) in their everyday lives … and are aided in making informed, responsible decisions about SMT polices that have social implications."

Considering this expanded view on informal learning, a group of researchers investigated the influence of students' activities outside of school on their scientific reasoning ability. Gerber et al. (2001a) assumed activities that are not scientifically orientated such as hobbies, sports and chores can have an impact on students in the same way that more scientifically based pursuits do. The authors developed an index, the Informal Learning Opportunities Assay, which assesses the types and frequencies of learning students undergo outside of school (Gerber et al., 2001b). Items that were considered influential were quite varied, including the number of books in a household; involvement in sports, clubs or band; and trips to other countries (Gerber et al., 2001b). Based on the number of these items and activities, the student's environment was considered either enriched if the number was high or poor if the number was low. The score generated by the assay was then compared to students' scientific reasoning. Students' who had enriched environments outside of school had higher scientific reasoning, while students who had

few activities had lower reasoning (Gerber et al., 2001a). Based on the research, Gerber et al. (2001a) suggested the promotion of student activities outside of school such as clubs and sports. The authors also supported the continued funding of social organizations for children such as 4-H Clubs and other school and community activities (Gerber et al. 2001a).

Beyond the Classroom

Researchers also investigated the influence of informal learning on older audiences. A study by Brossard et al. (2005) investigated the impact of a scientific project in which individuals participated in the data collection. The project was a birdhouse network for which participants would set out nest boxes for cavity-nesting birds and then make observations on the birds and their activity. Since the participants were instructed how to properly collect scientific data, the project was intended to increase the participant's knowledge of the nature of scientific inquiry. In addition, the impact of the observations on participants' attitudes toward biology was also tested. Broussard et al. (2005) found the project had an impact on participants' knowledge of bird biology, but changes in attitude and understanding of the scientific process were not statistically significant.

Dingwall and Aldridge (2006) looked at one source of informal scientific learning by investigating the influence of television wildlife programming. They noted how "wildlife and natural documentary programming has a very broad reach" to a wide variety of viewers. Producers of these programs build credibility with the viewers by developing partnerships with sources of cultural and intellectual prestige, such as Jane Goodall, Sir David Attenborough and the United Nations Educational, Scientific, and Cultural Organization [UNESCO]. Dingwall and Aldridge (2006) surmised these documentaries have the potential to serve as authoritative sources on biological and environmental science for the general public.

Although a large number of informal sources of education are available to ordinary citizens, the impact of these sources had not been investigated until recently. Falk et al. (2007) examined the overall influence of free-choice learning on the public's interest and understanding of science. Using telephone interviews with individuals in the Los Angeles area, Falk challenged the common view that the general population is scientifically illiterate. Falk et al. (2007) argued that the surveys assessing public knowledge of science only test for broad general knowledge instead of specific knowledge that most people tend to have on only a few topics. Two sets of interviews were conducted in 1997 and 2000. The 1997 survey found self-reported interest in science and technology had a mean of 7.0 on a 10-point scale with almost half of the individuals responding 8 or higher. When asked about their knowledge of science and technology, most participants rated their knowledge as "higher than average" with only 25.5% "feeling they knew less than the average person" (Falk et al. 2007). The 2000 survey again investigated scientific knowledge, but also included sources of that knowledge. They found that 91% of the people interviewed "felt that there was at least one area of science and/or technology that they had some reasonable knowledge of, a knowledge that exceeded the norm when compared to an 'average' person." Interest and curiosity were the most frequently cited reasons for this knowledge. As for the source of their knowledge, Falk et al. used three broad categories: school, work place and informal/non-formal sources. Forty-three percent of the individuals stated that informal/non-formal sources increased their knowledge in the subject they identified, whereas 34% said formal schooling and 23% work or work-related training. Based on these responses, the authors concluded that school and free-choice learning are equally important to science literacy. Falk et al. (2007) speculated that school learning provides basic foundational knowledge, whereas free-

choice learning builds on this knowledge; more importantly it provides motivation and develops curiosity and a desire to learn more.

Integration of Formal and Informal Learning

Investigation of the interaction between formal and informal learning did not stop with the commencement of broader research. Cox-Petersen et al. (2003) examined the impact of docent-guided tours on student learning and whether recent science reform recommendations had any influence on these tours. Based on observations, the researchers found that tours were typically highly structured and that the docent delivered a structured narrative while the students and teacher followed in one big group. Less than a quarter of the tours used techniques of self-directed learning. Independent learning, or even the option to choose what they looked at, was not allowed, making the informal setting much more like a formal school lecture (Cox-Petersen et al., 2003). The authors also conducted interviews to determine how the students viewed the tours. Students' responses in the interviews primarily indicated what they liked or factual knowledge presented; they did not link the visit to their class activity. Further investigation included what the students learned, and only 9% of the students' responses involved higher levels of learning. Also, numerous students either had misconceptions or made improper generalizations after the tours. However, the students' attitudes toward the tours were very positive, with 92% of students responding "yes" when asked if they liked the tour. In addition, most of them responded enthusiastically when asked what they liked about the tour, with over half of the responses related to the exhibits themselves. These findings showed that the national reform efforts, which recommended learning concepts and incorporating thinking skills, had been unheeded. Instead, the tours had little connection to science education standards and were predominantly fact-based (Cox- Petersen et al., 2003).

Worksheets are one way to help increase the integration of curriculum during museum trips. A recent study by Mortensen and Smart (2007) reevaluated the effectiveness of worksheets. The authors discussed how much of the previous literature viewed worksheets in a negative light, saying that students do not learn from them and worksheets are criticized for being constraining and school-like. Mortensen and Smart (2007) believed the negativity toward worksheets was due to most relying too much on the use of exhibit labels and monopolizing all of the students time, at the expense of using the museums as they were intended: free-choice, interactive, social learning environments. To investigate an alternative to the typical worksheet Mortensen and Smart worked with the North Carolina Museum of Natural Science, which had developed a free-choice worksheet where chaperones of school groups used it to guide small groups of students. Mortensen and Smart observed some of the visiting school groups, both those using the guide and those that were not, and recorded conversations that were related to curriculum. The results showed groups using the guide had a much higher percentage of curriculum-related conversation. In addition, the diversity of the conversation increased with use of the guide in that more topics were discussed. Marianne and Smart (2007) concluded that the worksheets increased the students' curriculum-related conversation, which can be assumed to increase the students' knowledge in the future. They also assumed the free-choice nature of the worksheet is better aligned with the museums' characteristics and does not implement classroom restrictions on free-choice learning environments.

During the 21st Century many more schools have started to work with informal learning institutions. A study by Phillips et al. (2007) looked at the support that informal science intuitions (ISI) provide to schools. After creating a database of 2,507 institutions, the researchers sent a survey to these ISI to learn the number and types of programs they offer to schools. The

results showed that 73% “provided support in the way of programmes, workshops, material curricula, etc. to districts, schools, teachers, or students in the broad area of science education besides a one-day field trip.” These institutions predominantly serve elementary schools, with middle and high schools accounting for only 27% of the schools served. Phillips et al. (2007) also examined the utilization of the these programs, finding 53% of the ISIs’ programs could handle more participants, while only 24% had to turn people away, suggesting that most programs are under-utilized. Prokop et al. (2007) tested the effect of a one-day field program on students’ attitudes and knowledge toward biology. The study involved 6th graders from urban and rural schools; the experimental group went on a one-day ecology field trip to visit three different ecological systems. Results showed that students who participated in the field trip had significantly higher scores on the post-test over the pre-test, while the control groups showed change in neither attitude nor knowledge. Neither gender nor school location were found to have a significant impact on the results. Based on these results, Prokop et al. (2007) promoted first-hand experience since it “contributes to deeper understanding and perception of relationships between animals, plants and their environments.”

Field programs, like the one Prokop et al. (2007) studied, could serve another worthy goal of simply getting people outside. In America there has been a steady decline of outdoor activities as measured by visitors to national and state parks, the number of hunting or fishing licenses issued and surveys on camping (Biello, 2008). Outdoor events could be more important to appreciation of science that one would think, as discussed by Gerber et al. (2001b). In addition, an article by Mervis (2009) reported the importance of learning that occurs in all kinds of locations, including those that have not been historically included in studies on informal

learning. These articles are only two examples of the recent increased attention that ISE has received.

The Future of Informal Science Education

Despite the progress that the field of informal learning has made, there is still much work to be done. Learning that occurs outside of school is still often either undervalued or overlooked as sources of learning in spite of the fact that individuals spend much more time out of, than in school (National Research Council, 2009).   As recently as 2009, the National Research Council developed a committee on "Learning Science in Informal Environments" to perform a thorough review of literature, determine the current state of knowledge,and develop recommendations for the future. The development of this committee shows not only the importance of informal learning, but also the need for continued research and validation of the field. The work previously discussed, in addition to the conclusions of the committee, stands as a copious amount of evidence that all forms of informal learning, including informal learning institutions, learning programs, science related media and everyday experiences, do increase science learning. This is important not only for teachers and administrators, but also for policy makers and researchers (National Research Council, 2009).

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APPENDIX A

Example of Test Given to Students both Before and After Ocean Commotion

Directions: This is a part of an LSU research project about students and the ocean. This is not a graded test. Please read each statement and answer the best you can.

SECTION 1 Questions 1 - 26

Pick one of the following choices to answer each statement. Mark your answer on the scan sheet.

A	B	C	D	E
O	O	O	O	O
Strongly agree	Agree	Neutral	Disagree	Strongly disagree

1. I know a lot about the ocean.
2. The Mississippi River drains into the Gulf of Mexico.
3. The ocean is salty.
4. Louisiana is connected to the ocean
5. Bottlenose dolphins are fish
6. The Earth has one big ocean.
7. What happens to the ocean has no effect on me.
8. Migratory birds do not travel through Louisiana.
9. The ocean bottom has mountains, valleys, and plains.
10. Invasive species are a problem in our wetlands and oceans
11. All water eventually ends up in the ocean.
12. It is OK if water does not have oxygen in it.
13. The Gulf of Mexico is a part of the ocean.
14. Plankton is made up of both plants and animals.
15. The mouth of the Mississippi River is in Mississippi.
16. Sand consists of tiny bits of animals, plants, rocks, and minerals.
17. The ocean controls weather and climate.
18. Shrimp and crabs do not need marshes in order to survive.
19. The ocean is an important part of the water cycle.
20. Marshes are nursery areas for baby fish.
21. The ocean is so big we can't pollute it.
22. We do not have whales in the Gulf of Mexico.
23. The ocean is so big we will never run out of fish to eat.
24. The ocean does not absorb CO_2 (carbon dioxide).
25. A swamp is not a wetland.
26. Fish use fins to swim and to stay still.

Content Section

SECTION 2 Questions 121 - 159

Pick one of the following choices to answer each statement. Fill in your answer on the scan sheet.

A	B	C	D	E
O	O	O	O	O
Strongly agree	Agree	Neutral	Disagree	Strongly disagree

121. I think protecting wetlands is important.
122. I cannot do anything to protect the ocean.
123. Science is interesting.
124. I think preserving our coast is our future.
125. Clean water is important to have.
126. I enjoy watching TV shows about the ocean.
127. Wetlands are useless.
128. We are all responsible for caring for the ocean.
129. It is OK to litter.
130. I am concerned about the health of our wetlands.
131. Science is a waste of time.
132. I enjoy watching nature shows on TV.
133. Everyone should learn about the ocean.
134. Climate change is a serious environmental issue.
135. I think protecting the ocean is important.
136. Learning about the ocean is interesting.
137. Science makes me think.
138. I think that being a scientist would be exciting.
139. I enjoy learning about the ocean.
140. I would like to do something that would help protect wetlands.
141. My actions can affect the wetlands.
142. It is okay to put wastes into the ocean.
143. My actions can affect water quality.
144. I like to go to the beach.

Name________________________________ Teacher Code________________

School code/Grade ______________________ Date_______________________

1. Louisiana loses _____ square miles of wetlands each year.
2. The ocean covers _____% of the Earth.
3. The ocean contains _____% of Earth's water.
4. What is a wetland? Give an example of three (3) types of wetlands in Louisiana.
5. List at least five (5) things that you know about the ocean.
6. List at least five (5) things that you know about wetlands.
7. Write three (3) questions that you would like to know the answer to about the ocean or wetlands.
8. List several animals that you know are found in the ocean or wetlands.
9. List all of the stages of the water cycle.
10. List some of the natural and human-made lines of defense for coastal restoration and hurricane protection in Louisiana.

Free Response Section

1. Was this the first time you went to Ocean Commotion?
    a. Yes
    b. No
    c. I did not go

2. Did you like going to Ocean Commotion?
    a. Yes
    b. No

3. Which kind of exhibit did (would) you like the most?
    Exhibits where
    a. someone talked to you
    b. you got to touch something
    c. you participated in an activity
    d. you were given something to take home
    e. you made something to take home

4. What subject did (would) you like learning about the most?
    a. the ocean
    b. wetlands and marsh
    c. sea animals and plants
    d. dirt and soils
    e. problems with marine environments

5. Which interactions did (would) you like the best?
    a. listening to someone talking
    b. talking about your own stories or knowledge
    c. watching others do something
    d. doing something yourself

6. Which activities did (would) you like the most?
    a. touching live animals
    b. touching fish and other aquatic animals
    c. touching furs, skins and feather
    d. handling shells, rocks and sand
    e. playing a game or other activity

7. Did you talk to anyone, other than your teacher, about going to Ocean Commotion?
    a. Yes
    b. No

8. Do you think you learned anything from attending Ocean Commotion?
    a. Yes
    b. No

9. Would you want to go to Ocean Commotion again?
    a. Yes
    b. No

10. Would you tell a friend they should go to Ocean Commotion?
    a. Yes
    b. No

Follow-up Survey

APPENDIX B

Additional Tables and Graphs from
Free Response Questions

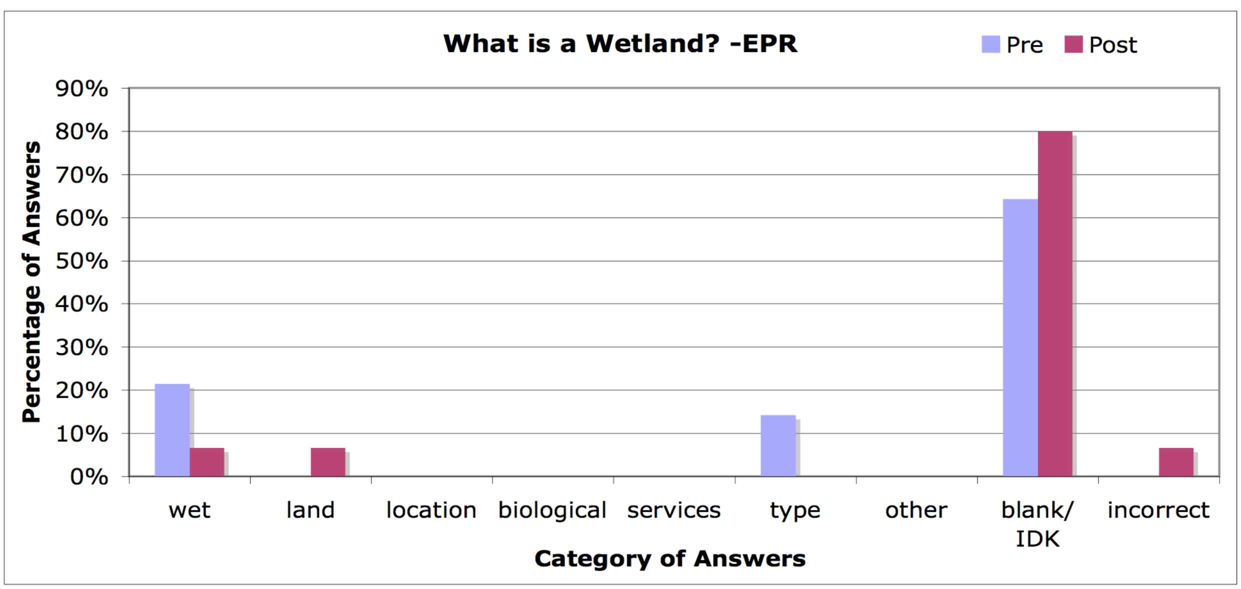
Question: What is Wetland?

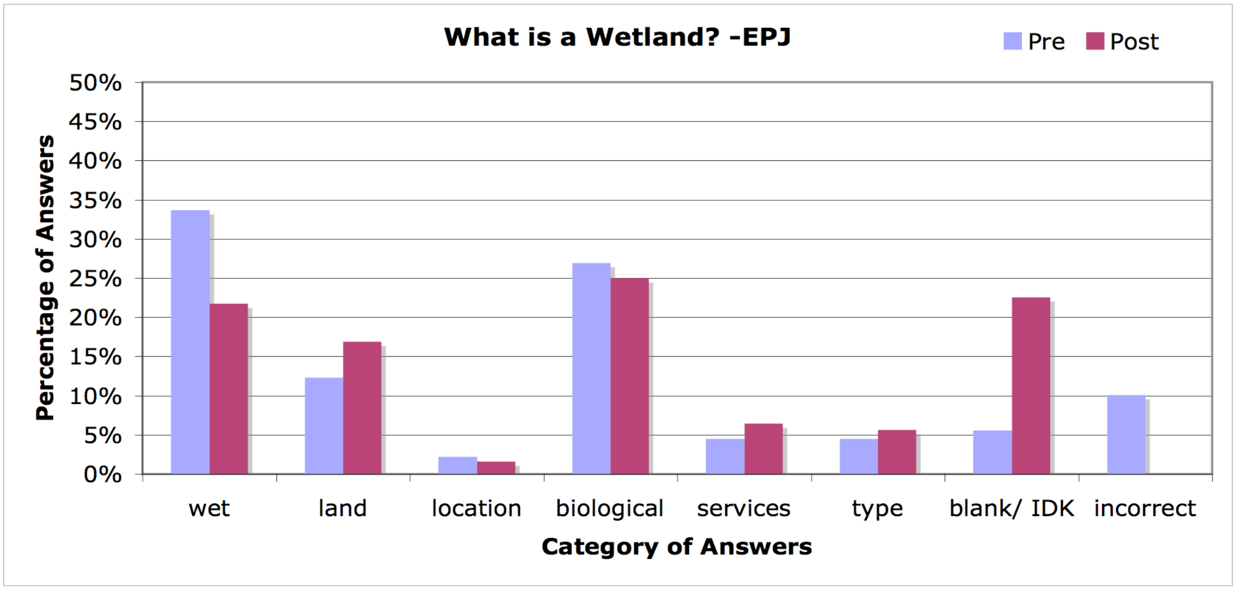
T-Test on Answers to "What is a wetland?"

		Pre-test		Post-test			
School	**Categories**	freq.	%	freq.	%	test	
EPR	wet	3	21%	1	7%	7.756	*
	land	0	0%	1	7%	6.667	*
	location	0	0%	0	0%	0.000	
	type	2	14%	0	0%	14.286	*
	biological	0	0%	0	0%	0.000	
	services	0	0%	0	0%	0.000	
	other	0	0%	0	0%	0.000	
	blank/don't know	9	64%	12	80%	1.711	
	incorrect	0	0%	1	7%	6.667	*
EPJ	wet	30	26%	27	21%	0.457	
	land	11	10%	21	17%	1.922	
	location	2	2%	2	2%	0.007	
	type	4	3%	7	6%	0.478	
	biological	24	21%	31	25%	0.307	
	services	4	3%	8	6%	0.839	
	other	0	0%	0	0%	0.000	
	blank/don't know	31	27%	30	24%	0.195	
	incorrect	9	8%	0	0%	7.826	*
LLC	wet	39	27%	32	22%	0.504	
	land	21	14%	22	15%	0.012	
	location	10	7%	14	10%	0.437	
	type	7	5%	6	4%	0.057	
	biological	20	14%	21	14%	0.012	
	services	0	0%	1	1%	0.680	
	other	1	1%	2	1%	0.223	
	blank/don't know	46	32%	48	33%	0.020	
	incorrect	2	1%	1	1%	0.232	
RUV	wet	12	22%	11	21%	0.027	
	land	11	20%	10	19%	0.033	
	location	0	0%	0	0%	0.000	
	type	0	0%	0	0%	0.000	
	biological	1	2%	1	2%	0.001	
	services	0	0%	0	0%	0.000	
	other	0	0%	0	0%	0.000	
	blank/don't know	31	56%	31	58%	0.039	
	incorrect	0	0%	0	0%	0.000	

SMF	wet	16	52%	19	43%	0.750	
	land	8	26%	22	50%	7.721	*
	location	1	3%	1	2%	0.165	
	type	1	3%	0	0%	3.226	**
	biological	1	3%	1	2%	0.165	
	services	0	0%	0	0%	0.000	
	other	1	3%	0	0%	3.226	**
	blank/don't know	3	10%	1	2%	4.588	*
	incorrect	0	0%	0	0%	0.000	
SJP	wet	57	30%	41	22%	1.438	
	land	50	27%	50	27%	0.000	
	location	7	4%	11	6%	0.463	
	type	11	6%	10	5%	0.028	
	biological	17	9%	19	10%	0.054	
	services	4	2%	11	6%	1.725	
	other	0	0%	3	2%	1.596	
	blank/don't know	38	20%	43	23%	0.151	
	incorrect	3	2%	0	0%	1.604	
WHL	wet	13	24%	16	27%	0.239	
	land	6	11%	11	19%	2.024	
	location	3	5%	2	3%	0.482	
	type	7	13%	0	0%	12.727	*
	biological	9	16%	9	15%	0.039	
	services	0	0%	0	0%	0.000	
	other	0	0%	1	2%	1.695	
	blank/don't know	15	27%	15	25%	0.065	
	incorrect	2	4%	5	8%	1.933	

$* p < 0.05$ $** p < 0.1$




What is a Wetland? -EPJ
Pre
Post
Percentage of Answers
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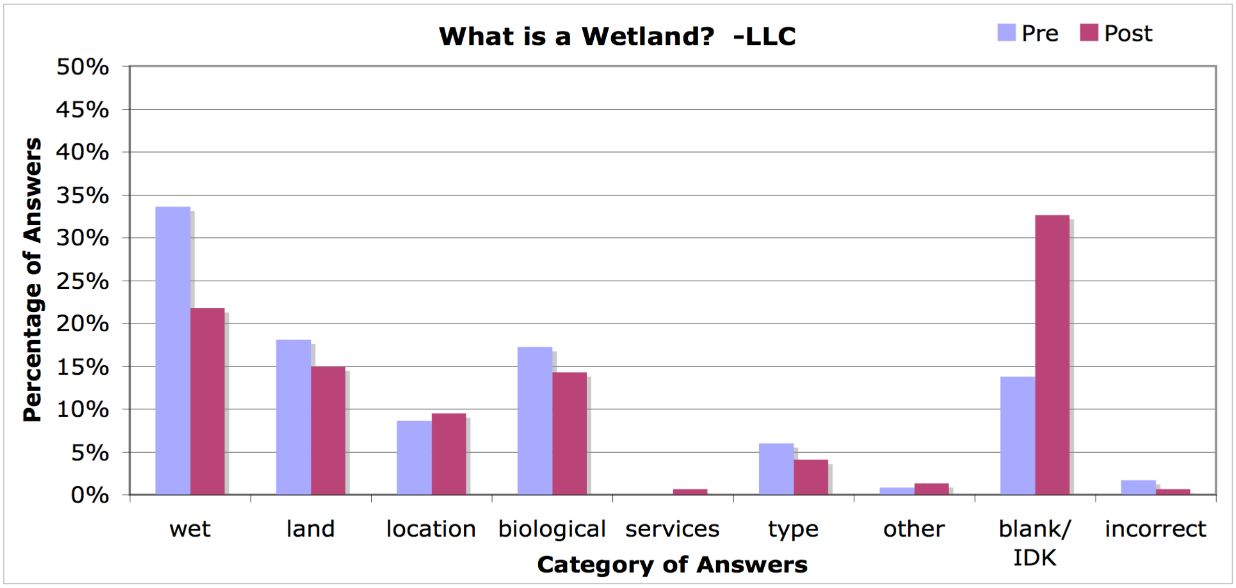
Category of Answers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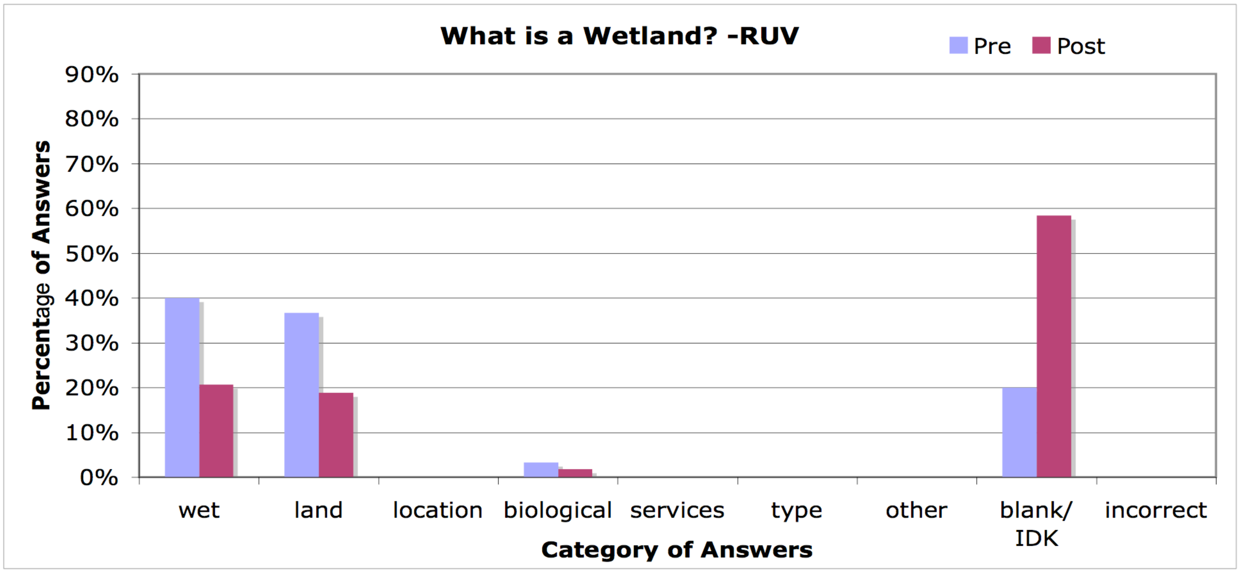
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Pre
Post
Percentage of Answers
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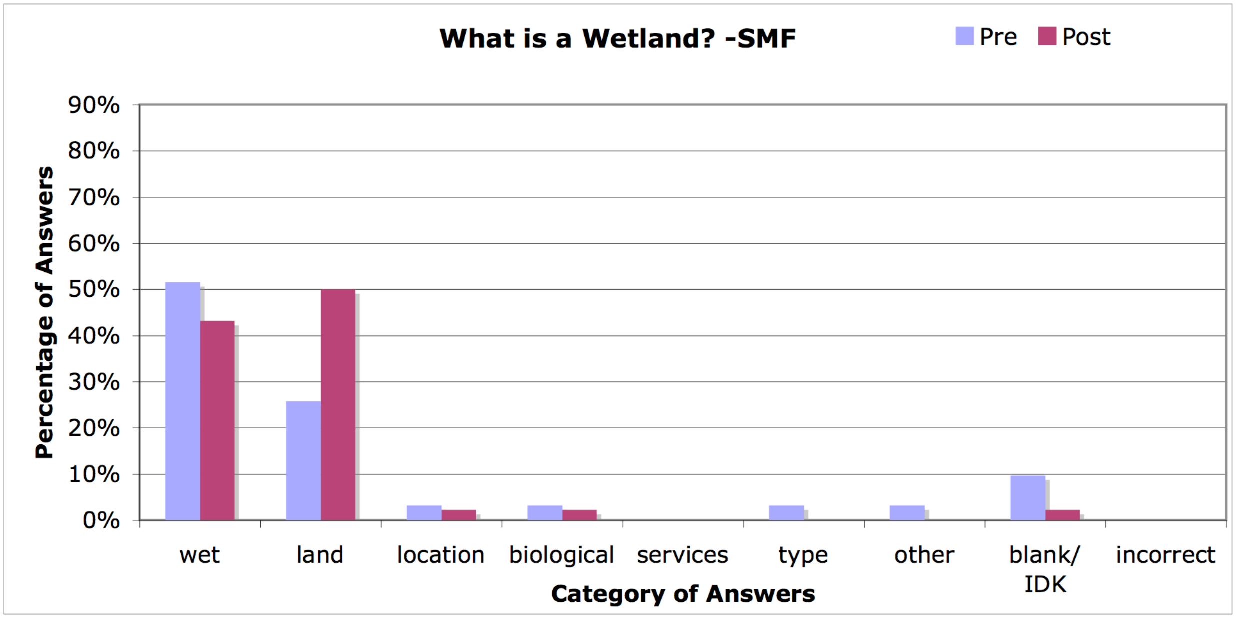
Category of Answers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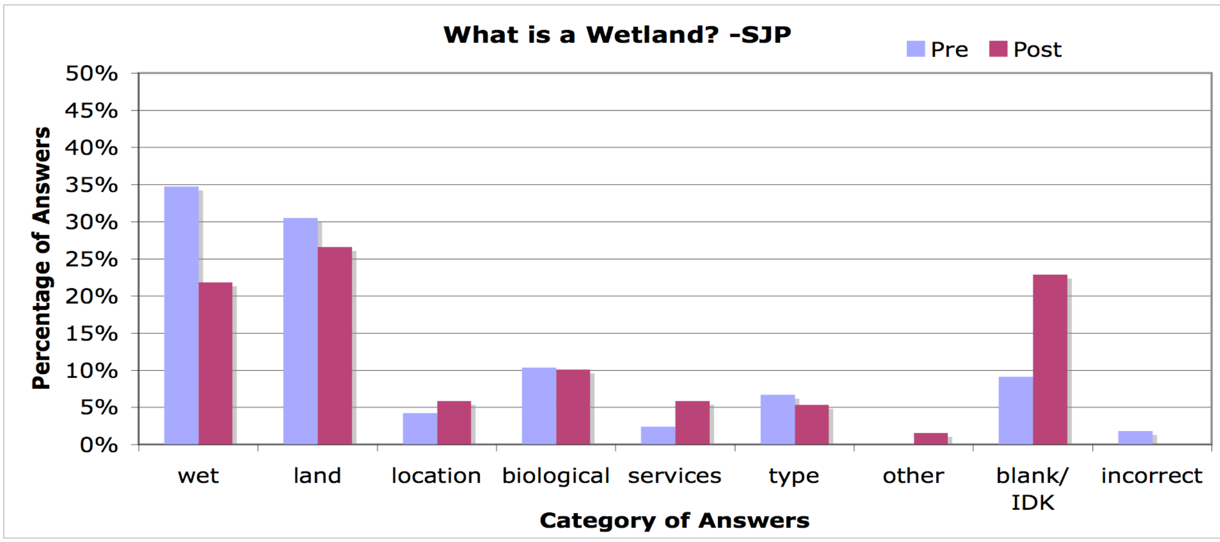
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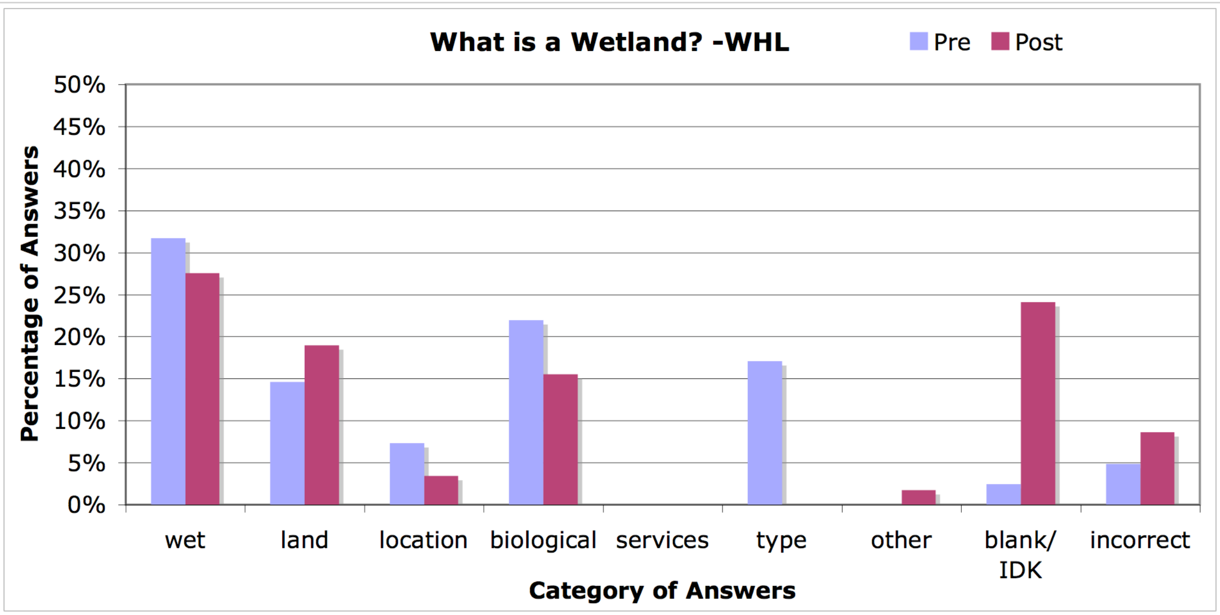
Category of Answers


What is a Wetland? -WHL
Pre
Post
Percentage of Answers
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45%
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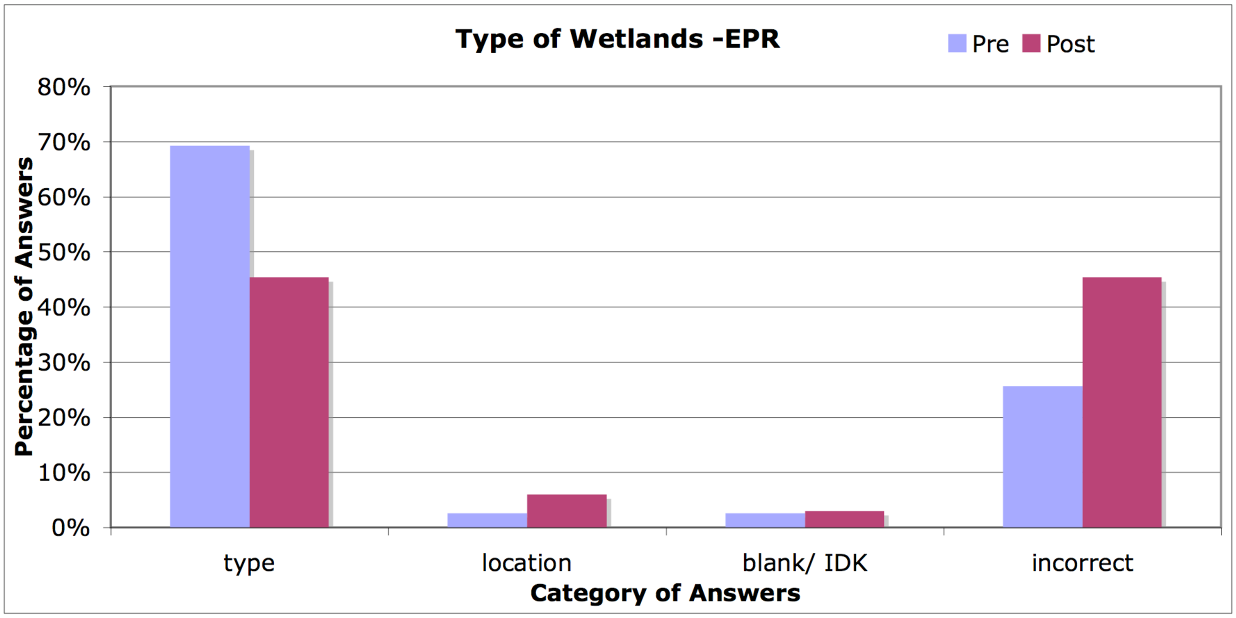
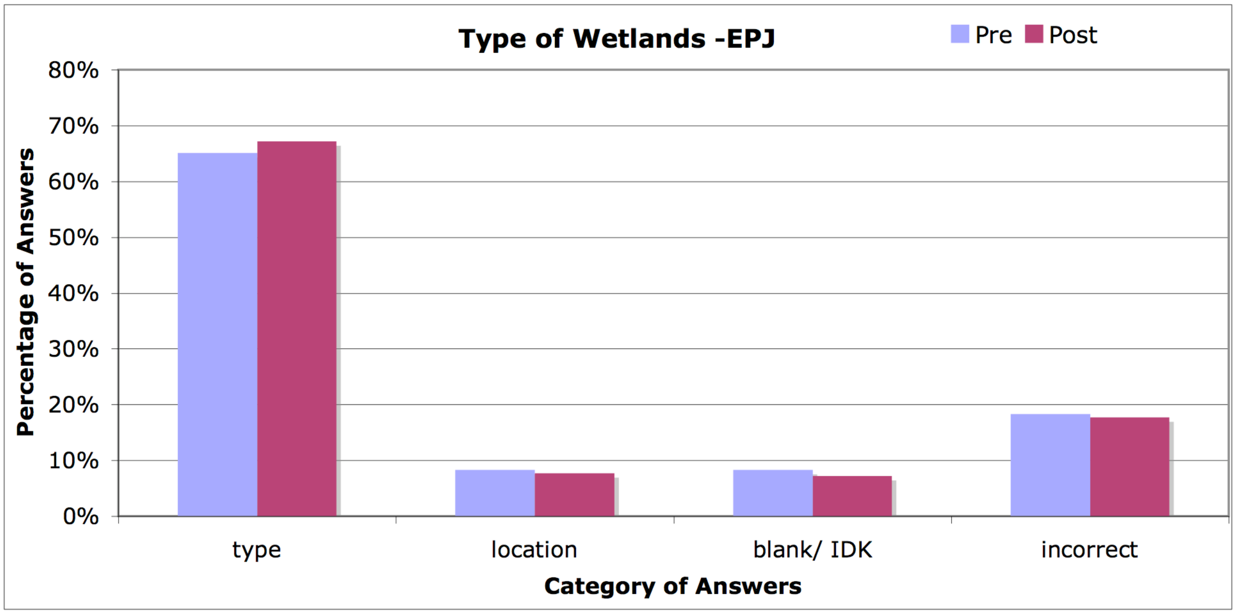
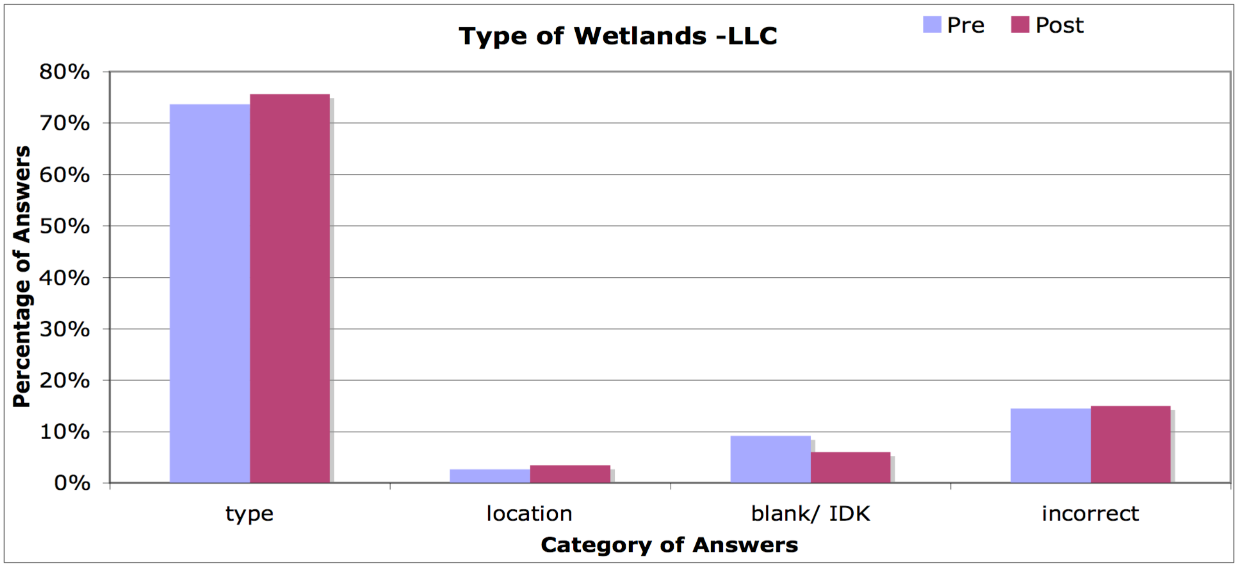
Category of Answers

Question: Give an example of three (3) types of wetlands in Louisiana.






Type of Wetlands -LLC
Pre
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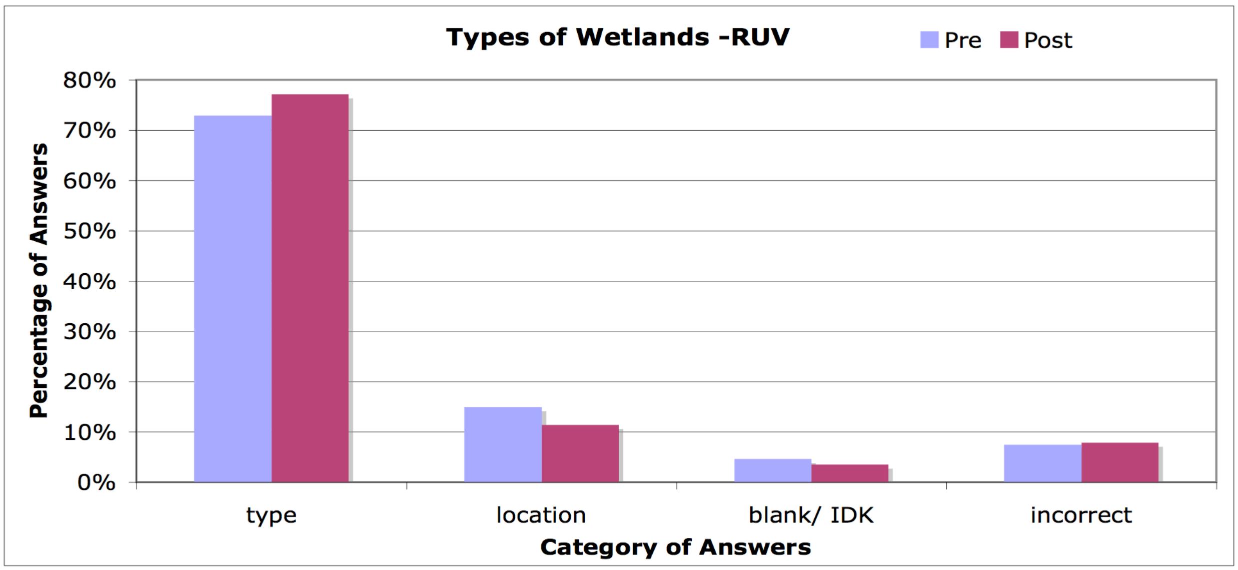
Category of Answers


Types of Wetlands -RUV
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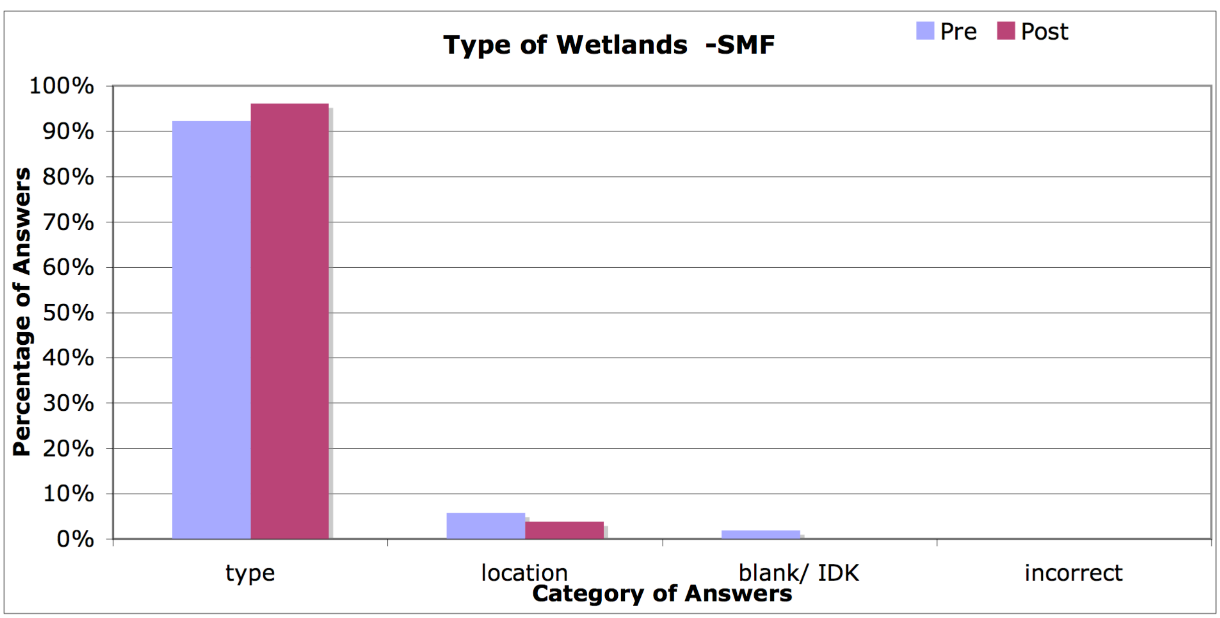
Percentage of Answers
type
location
blank/ IDK
incorrect
Category of Answers


Type of Wetlands -SMF
Pre
Post
100%
90%
80%
70%
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40%
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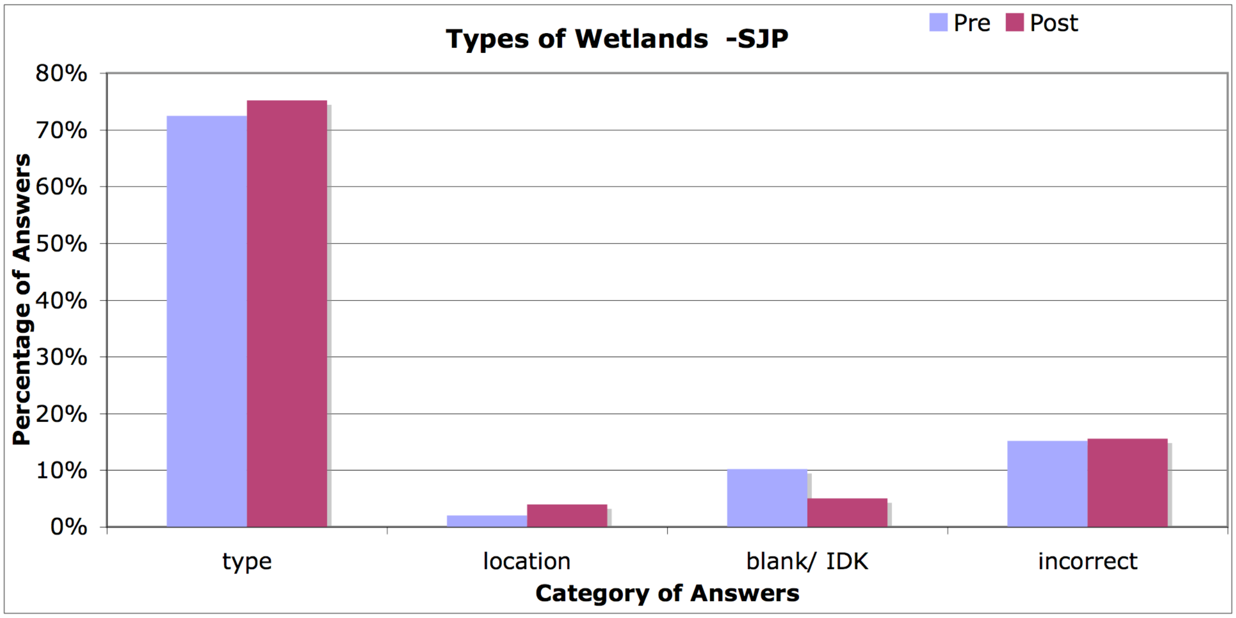
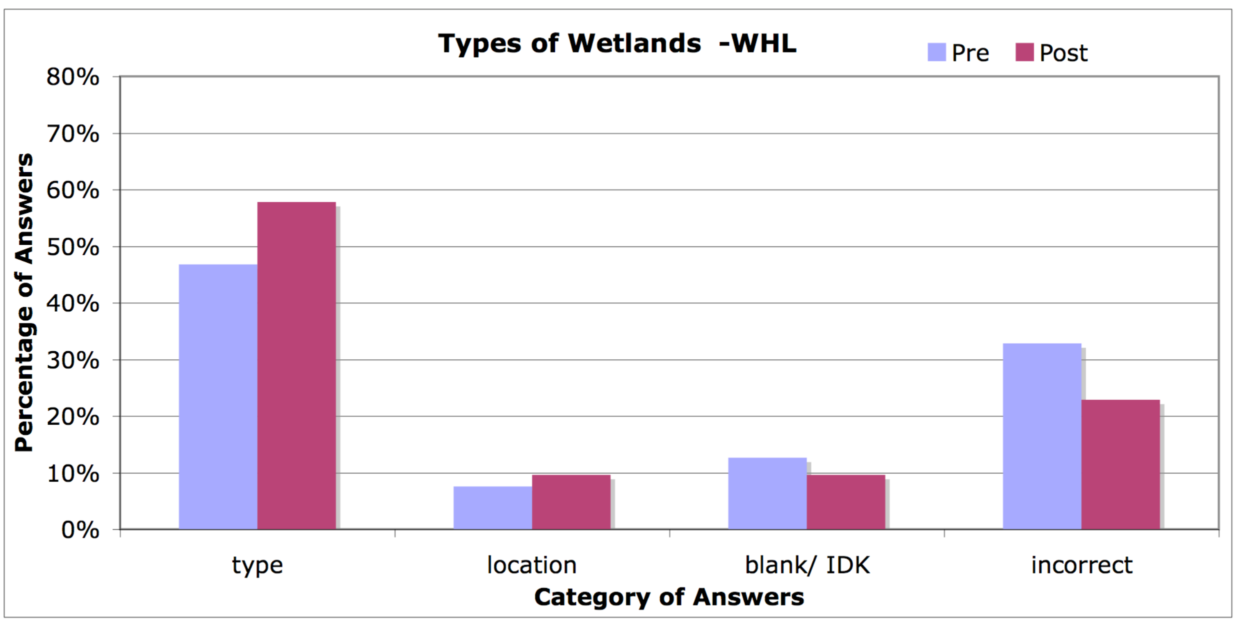
Percentage of Answers
type
location
blank/ IDK
incorrect
Category of Answers


Types of Wetlands -SJP
Pre
Post
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Answers
type
location
blank/ IDK
incorrect
Category of Answers


Types of Wetlands -WHL
Pre
Post
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Answers
type
location
blank/ IDK
incorrect
Category of Answers

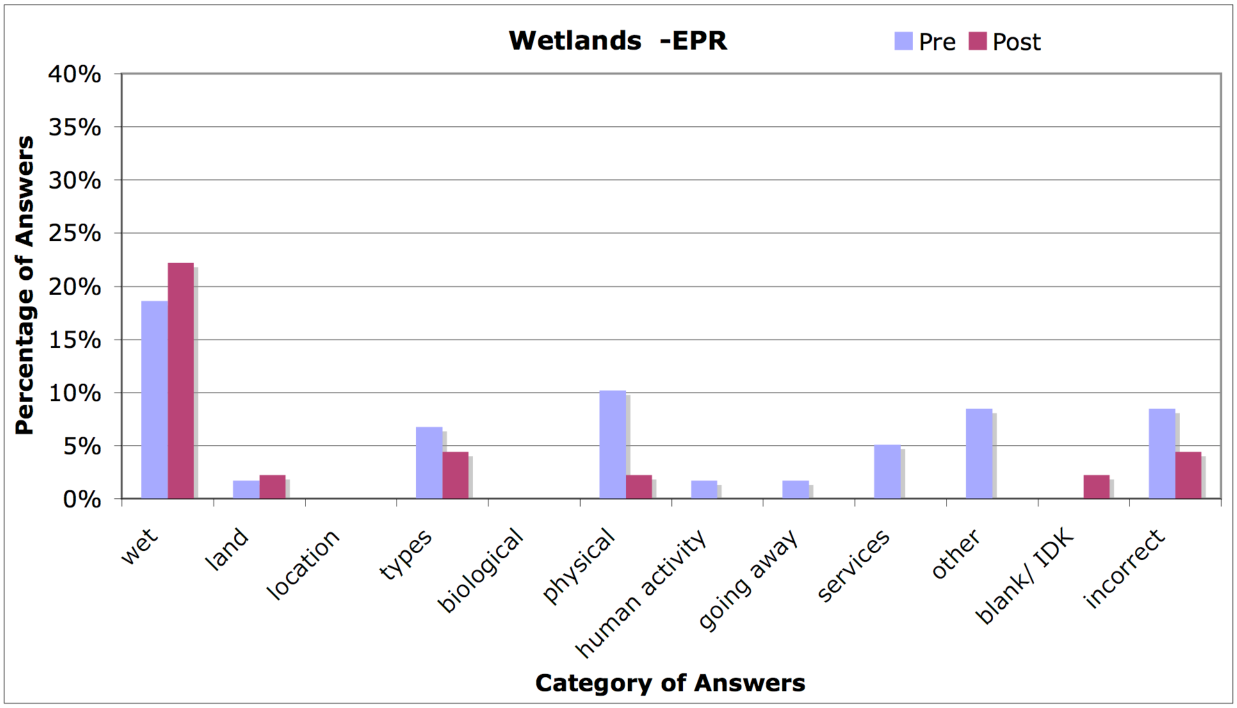
Question: List at least five (5) things that you know about wetlands.

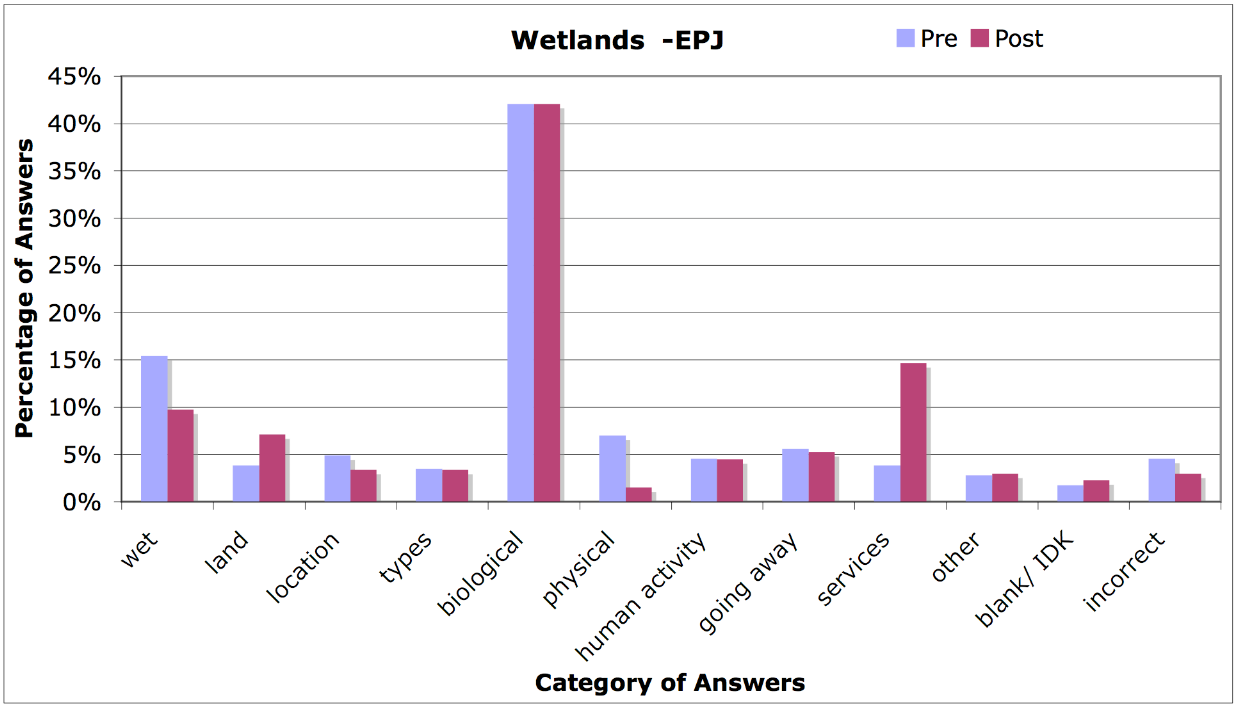
T-Test on Answers to "What do you know about wetlands?"

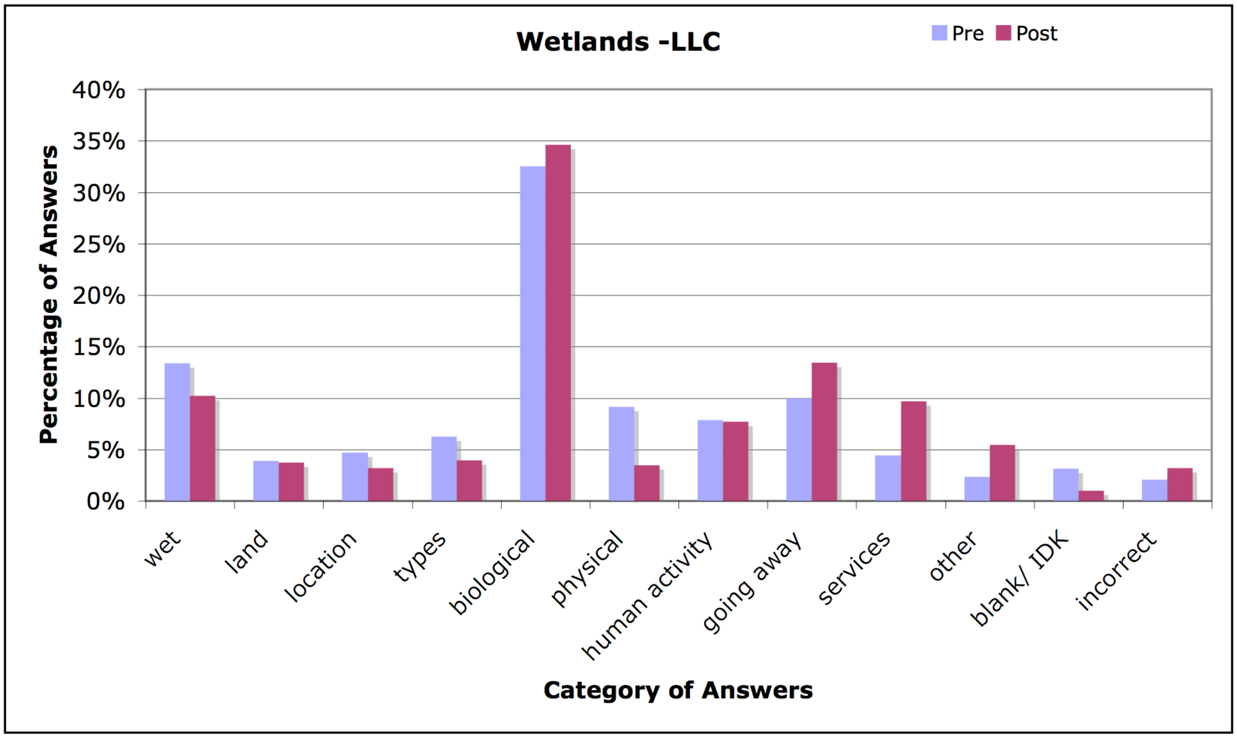
		Pre-test		Post-test			
School	**Categories**	freq.	%	freq.	%	test	
EPR	wet	11	19%	10	22%	0.313	
	land	1	2%	1	2%	0.071	
	location	0	0%	0	0%	0.000	
	type	4	7%	2	4%	0.486	
	biological	22	37%	28	62%	6.248	*
	physical	6	10%	1	2%	5.097	*
	human activity	1	2%	0	0%	1.695	
	going away	1	2%	0	0%	1.695	
	services	3	5%	0	0%	5.085	*
	other	5	8%	0	0%	8.475	*
	blank/don't know	0	0%	1	2%	2.222	
	incorrect	5	8%	2	4%	1.257	
EPJ	wet	44	15%	26	10%	1.272	
	land	11	4%	19	7%	0.980	
	location	14	5%	9	3%	0.282	
	type	10	4%	9	3%	0.002	
	biological	120	42%	112	42%	0.000	
	physical	20	7%	4	2%	3.568	**
	human activity	13	5%	12	5%	0.000	
	going away	16	6%	14	5%	0.011	
	services	11	4%	39	15%	6.300	*
	other	8	3%	8	3%	0.007	
	blank/don't know	5	2%	6	2%	0.063	
	incorrect	13	5%	8	3%	0.319	
LLC	wet	51	13%	41	10%	0.423	
	land	15	4%	15	4%	0.005	
	location	18	5%	13	3%	0.276	
	type	24	6%	16	4%	0.518	
	biological	124	33%	139	35%	0.067	
	physical	35	9%	14	3%	2.558	
	human activity	30	8%	31	8%	0.001	
	going away	38	10%	54	13%	0.520	
	services	17	4%	39	10%	1.953	
	other	9	2%	22	5%	1.244	
	blank/don't know	12	3%	4	1%	1.117	
	incorrect	8	2%	13	3%	0.244	
RUV	wet	19	14%	26	18%	0.542	
	land	14	10%	12	8%	0.186	
	location	3	2%	3	2%	0.002	
	type	9	6%	16	11%	1.147	
	biological	44	31%	44	30%	0.037	
	physical	9	6%	3	2%	2.273	
	human activity	5	4%	3	2%	0.417	
	going away	9	6%	12	8%	0.206	

	services	5	4%	15	10%	3.193	**
	other	4	3%	5	3%	0.047	
	blank/don't know	8	6%	4	3%	1.062	
	incorrect	11	8%	4	3%	2.494	
SMF	wet	12	13%	6	7%	1.356	
	land	1	1%	0	0%	1.042	
	location	3	3%	2	2%	0.085	
	type	8	8%	6	7%	0.066	
	biological	29	30%	25	30%	0.001	
	physical	3	3%	3	4%	0.042	
	human activity	4	4%	1	1%	1.613	
	going away	8	8%	8	10%	0.112	
	services	25	26%	29	35%	1.416	
	other	1	1%	2	2%	0.561	
	blank/don't know	0	0%	0	0%	0.000	
	incorrect	2	2%	0	0%	2.083	
SJP	wet	70	18%	50	12%	1.452	
	land	32	8%	25	6%	0.445	
	location	20	5%	12	3%	0.729	
	type	22	6%	20	5%	0.110	
	biological	135	35%	166	39%	0.169	
	physical	16	4%	11	3%	0.383	
	human activity	9	2%	13	3%	0.088	
	going away	26	7%	43	10%	0.631	
	services	21	5%	60	14%	3.736	**
	other	7	2%	14	3%	0.409	
	blank/don't know	14	4%	3	1%	2.004	
	incorrect	11	3%	11	3%	0.017	
WHL	wet	32	22%	30	20%	0.087	
	land	13	9%	17	11%	0.290	
	location	9	6%	3	2%	2.109	
	type	10	7%	12	8%	0.089	
	biological	57	39%	52	34%	0.257	
	physical	11	7%	6	4%	1.075	
	human activity	3	2%	3	2%	0.001	
	going away	0	0%	7	5%	4.636	*
	services	0	0%	6	4%	3.974	*
	other	2	1%	4	3%	0.414	
	blank/don't know	3	2%	2	1%	0.152	
	incorrect	7	5%	9	6%	0.134	

* $p < 0.05$ **$p < 0.1$


Wetlands -EPR
Pre
Post
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percentage of Answers
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers


Wetlands -EPJ
Pre
Post
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percentage of Answers
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers


Wetlands -LLC
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
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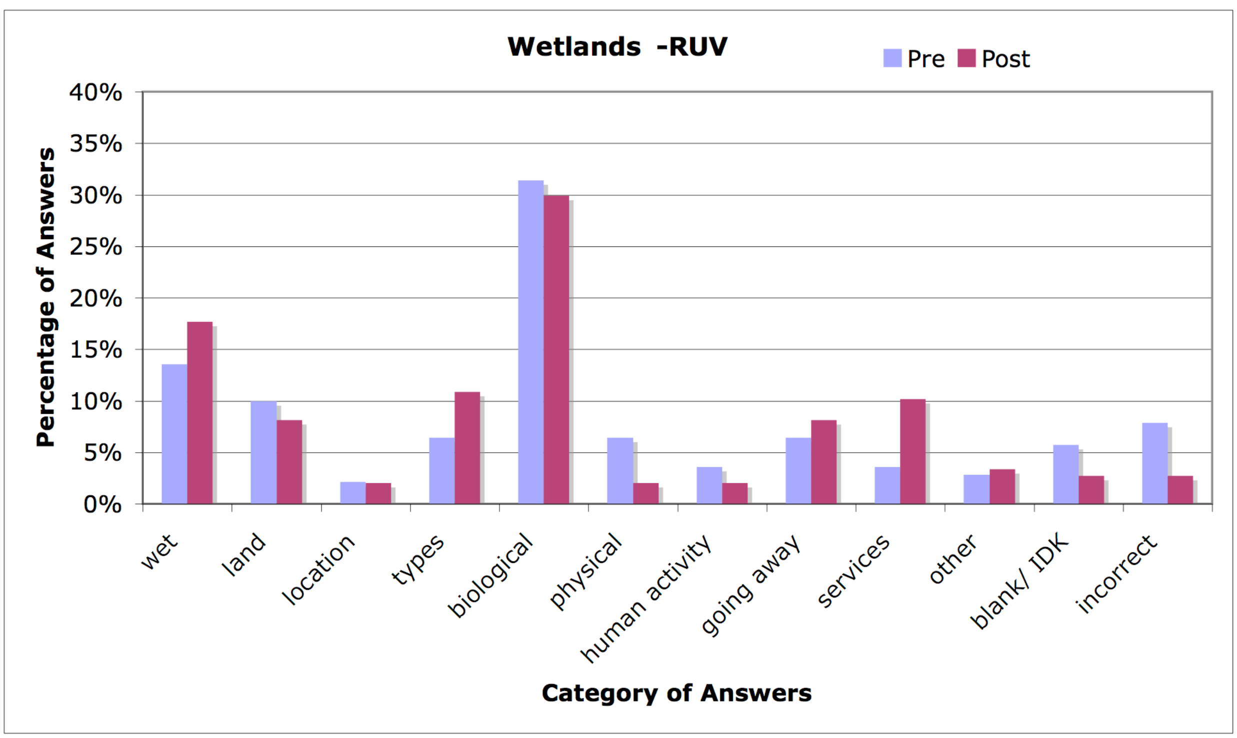
0%
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers


Wetlands -RUV
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
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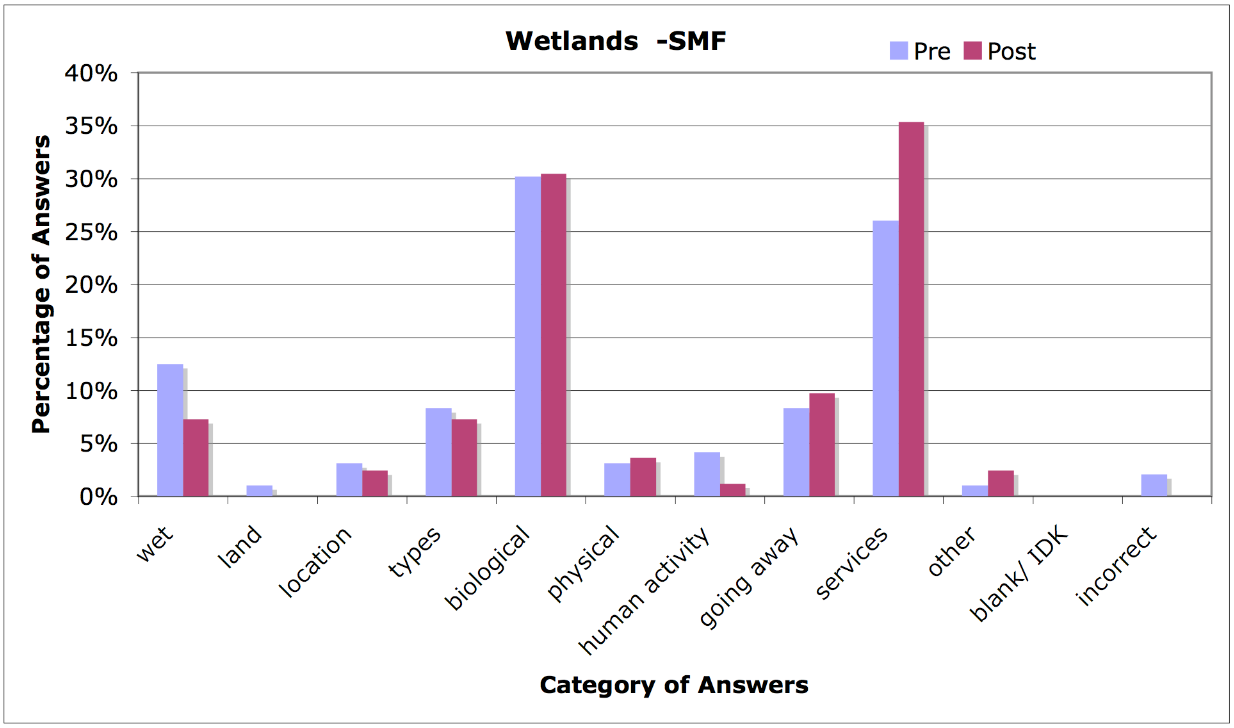
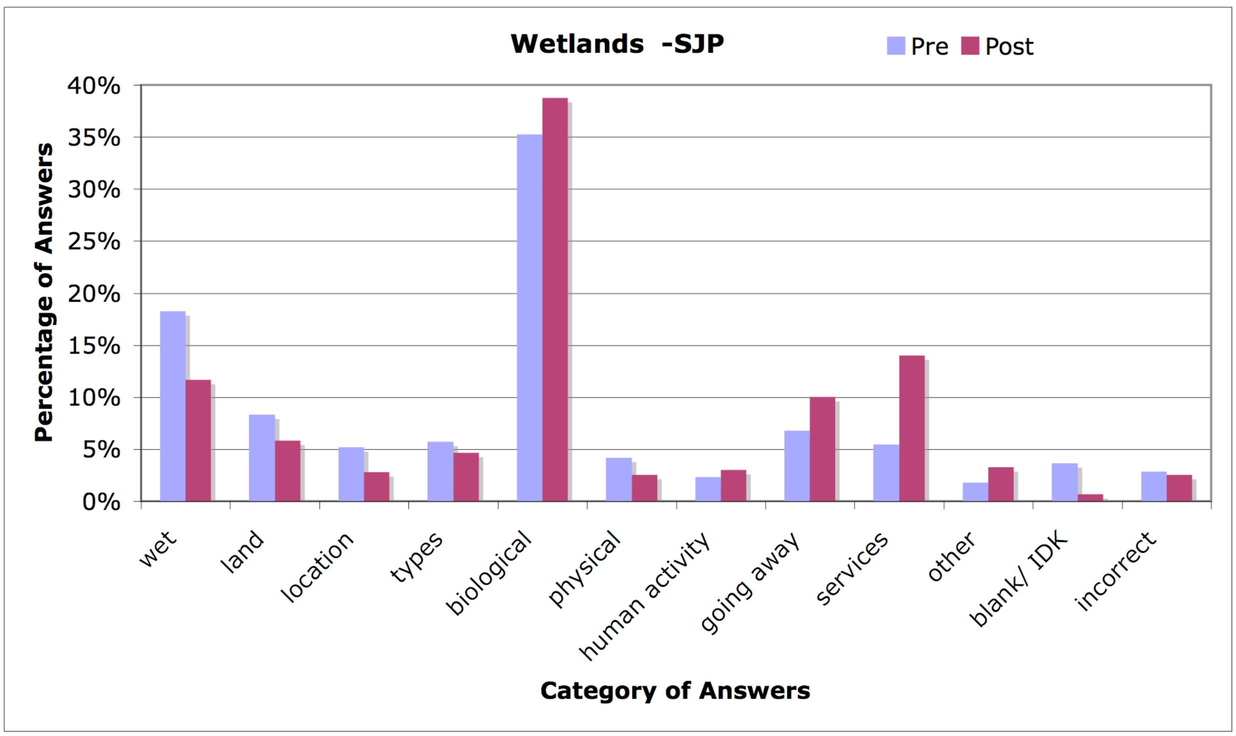
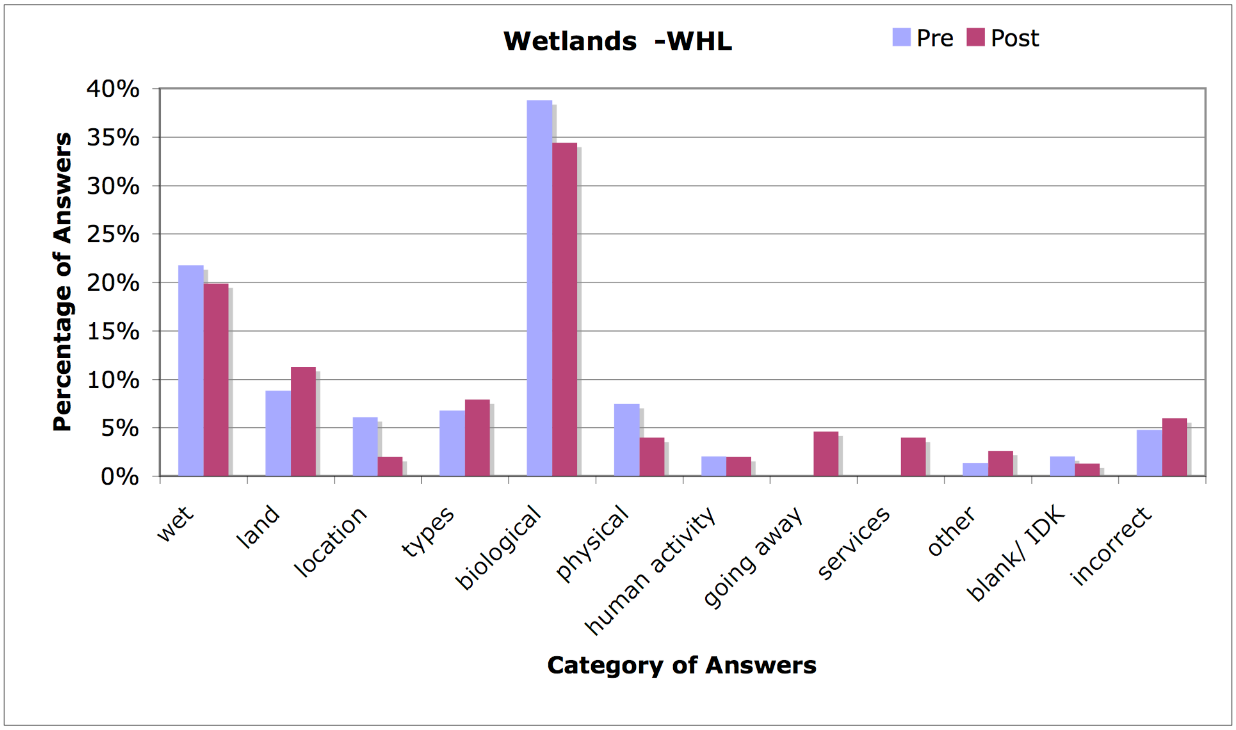
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers


Wetlands -SMF
Pre
Post
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percentage of Answers
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers


Wetlands -SJP
Pre
Post
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percentage of Answers
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers


Wetlands -WHL
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
5%
0%
wet
land
location
types
biological
physical
human activity
going away
services
other
blank/ IDK
incorrect
Category of Answers

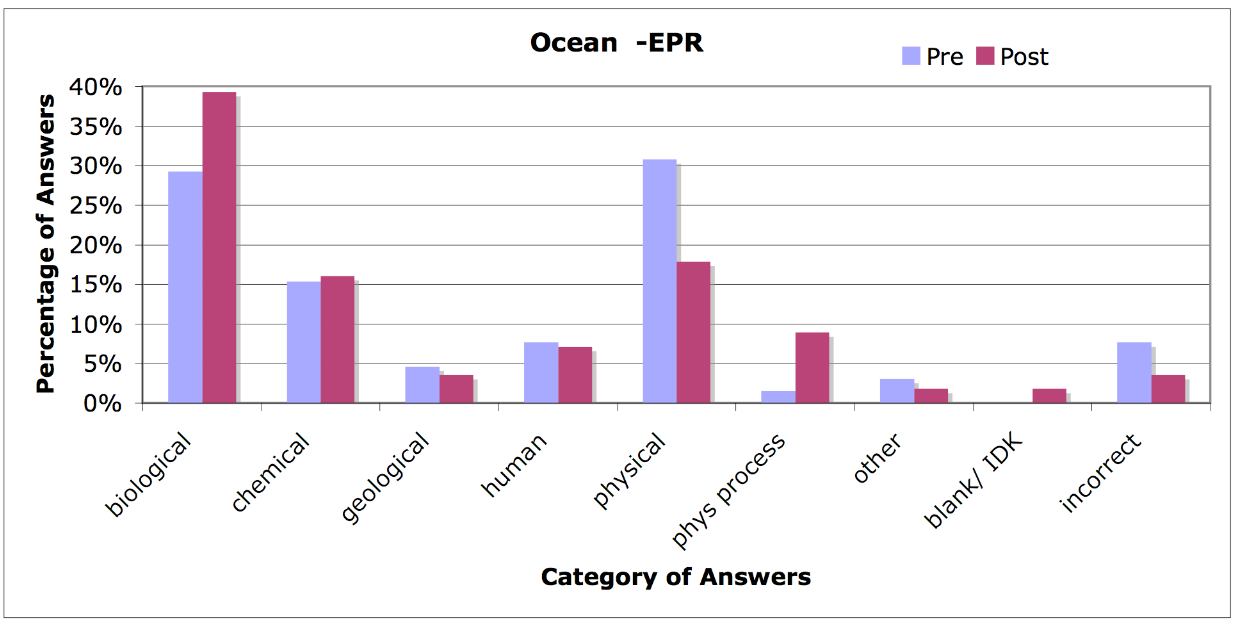
Question: List at least five (5) things you know about the ocean.

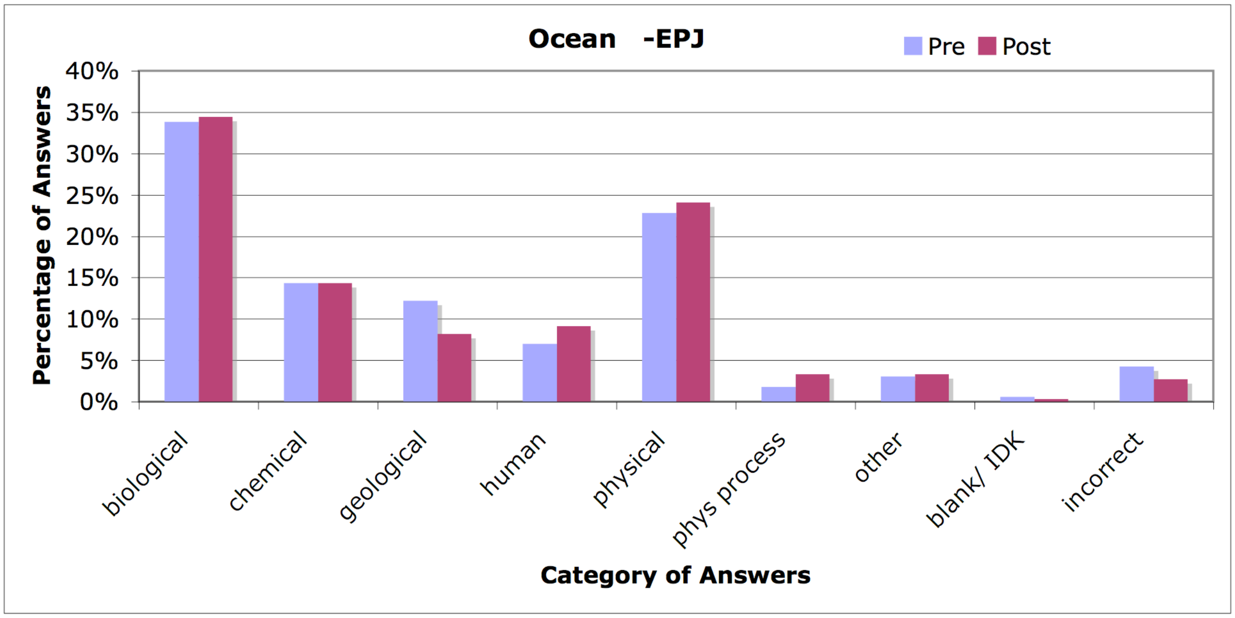
T-Test on Answers to "What do you know about the ocean?"

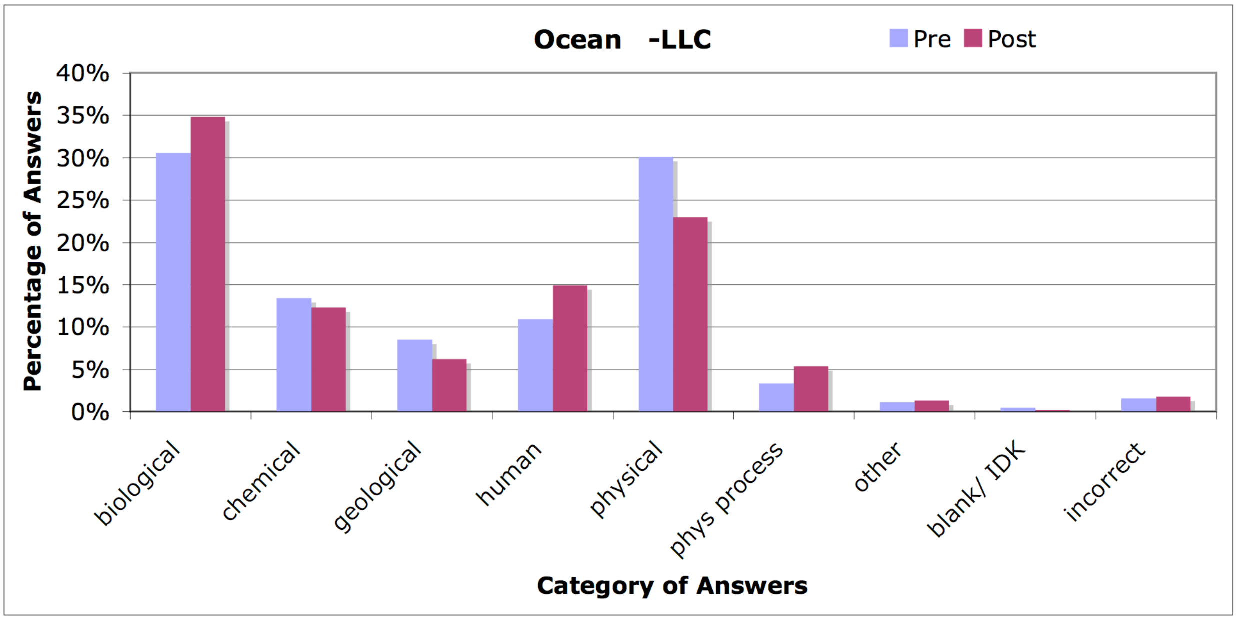
School	Categories	Pre-test freq.	Pre-test %	Post-test freq.	Post-test %	test	
EPR	biological	19	29%	22	39%	1.399	
	chemical	10	15%	9	16%	0.012	
	geological	3	5%	2	4%	0.044	
	physical	20	31%	10	18%	3.343	**
	physical process	1	2%	5	9%	5.283	*
	human related	5	8%	4	7%	0.020	
	other	2	3%	1	2%	0.343	
	blank/don't know	0	0%	1	2%	1.786	
	incorrect	5	8%	2	4%	1.508	
EPJ	biological	111	34%	113	34%	0.005	
	chemical	47	14%	47	14%	0.000	
	geological	40	12%	27	8%	0.769	
	physical	75	23%	79	24%	0.032	
	physical process	6	2%	11	3%	0.448	
	human related	23	7%	30	9%	0.282	
	other	10	3%	11	3%	0.015	
	blank/don't know	2	1%	1	0%	0.102	
	incorrect	14	4%	9	3%	0.331	
LLC	biological	137	31%	156	35%	0.275	
	chemical	60	13%	55	12%	0.049	
	geological	38	8%	28	6%	0.338	
	physical	135	30%	103	23%	0.960	
	physical process	15	3%	24	5%	0.464	
	human related	49	11%	67	15%	0.623	
	other	5	1%	6	1%	0.020	
	blank/don't know	2	0%	1	0%	0.000	
	incorrect	7	2%	8	2%	0.015	
RUV	biological	40	23%	49	28%	0.529	
	chemical	25	15%	28	16%	0.099	
	geological	1	1%	0	0%	0.581	
	physical	77	45%	49	28%	3.618	**
	physical process	4	2%	14	8%	3.230	**
	human related	13	8%	14	8%	0.022	
	other	4	2%	4	2%	0.000	
	blank/don't know	0	0%	3	2%	1.744	
	incorrect	8	5%	11	6%	0.275	
SMF	biological	16	16%	20	23%	0.990	
	chemical	19	20%	15	17%	0.176	
	geological	2	2%	5	6%	1.692	
	physical	18	19%	20	23%	0.421	
	physical process	22	23%	17	19%	0.269	
	human related	11	11%	5	6%	1.881	
	other	3	3%	2	2%	0.125	
	blank/don't know	0	0%	0	0%	0.000	
	incorrect	6	6%	4	5%	0.251	

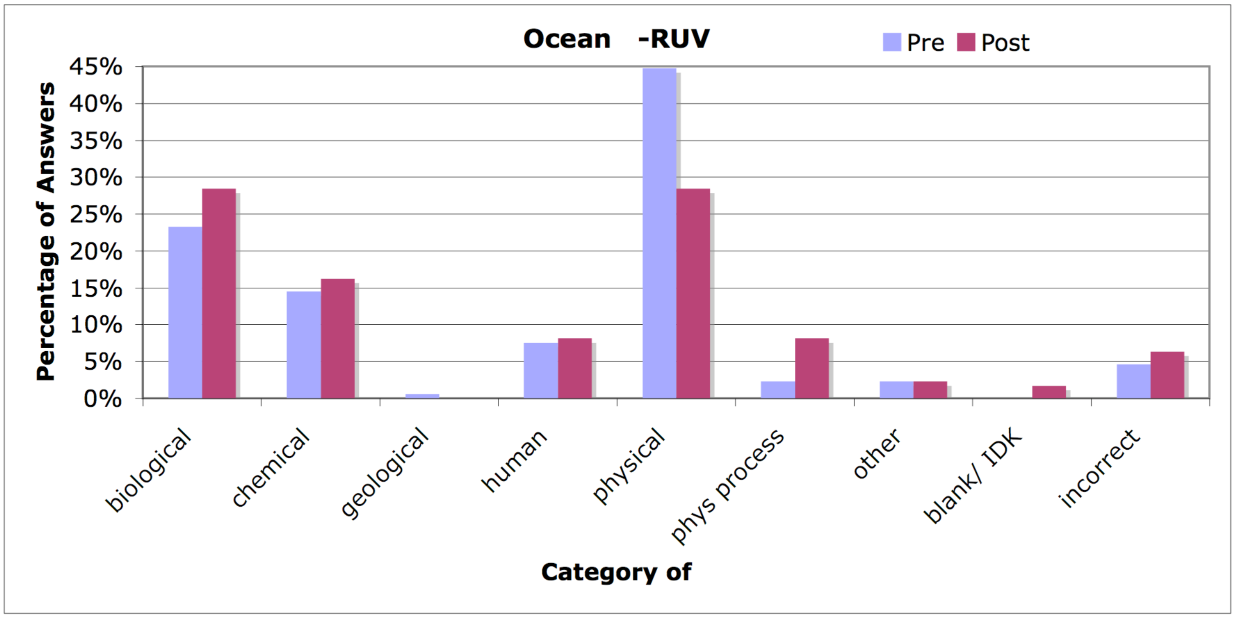
SJP	biological	159	32%	174	35%	0.092
	chemical	81	17%	81	16%	0.002
	geological	49	10%	41	8%	0.171
	physical	136	28%	114	23%	0.467
	physical process	10	2%	27	5%	1.532
	human related	34	7%	44	9%	0.228
	other	5	1%	4	1%	0.026
	blank/don't know	2	0%	0	0%	0.000
	incorrect	14	3%	13	3%	0.011
WHL	biological	64	40%	62	37%	0.143
	chemical	19	12%	25	15%	0.319
	geological	13	8%	14	8%	0.002
	physical	40	25%	39	23%	0.077
	physical process	5	3%	12	7%	1.546
	human related	10	6%	11	7%	0.005
	other	2	1%	0	0%	1.250
	blank/don't know	2	1%	0	0%	1.250
	incorrect	5	3%	6	4%	0.027

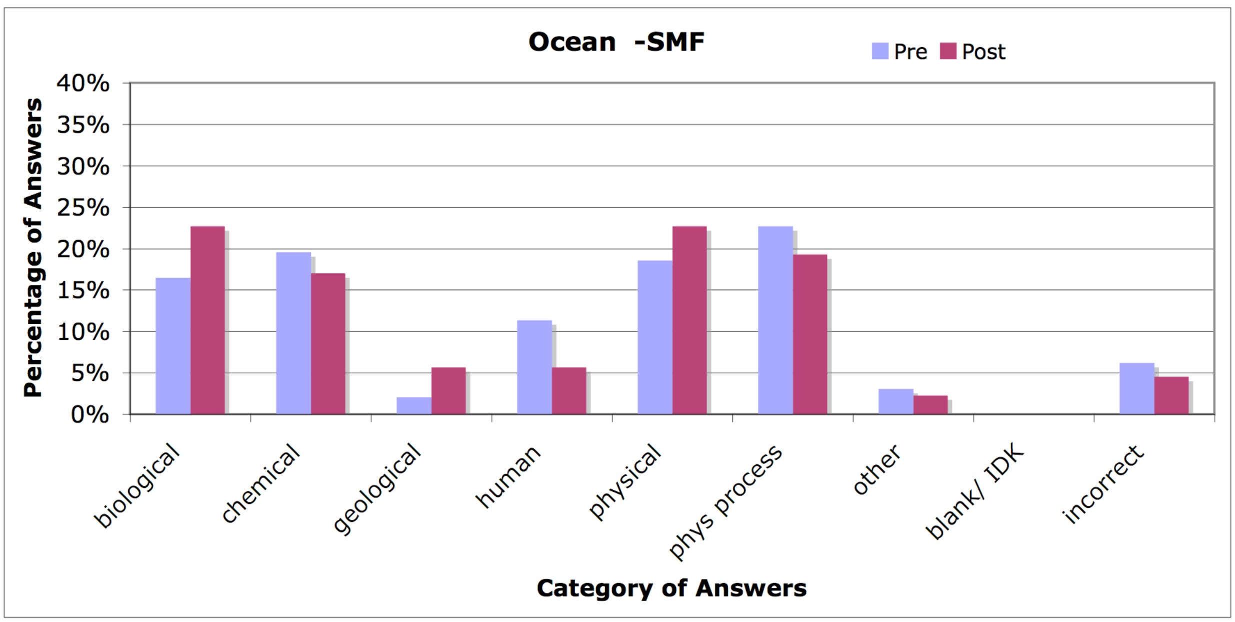
* $p < 0.05$ **$p < 0.1$

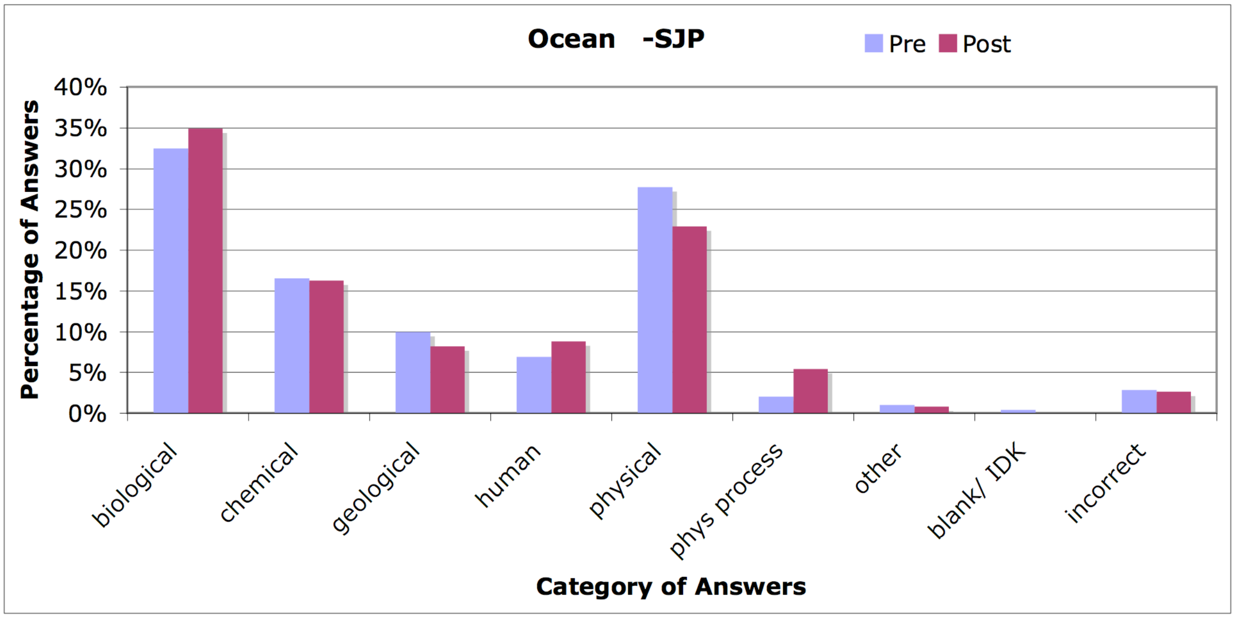


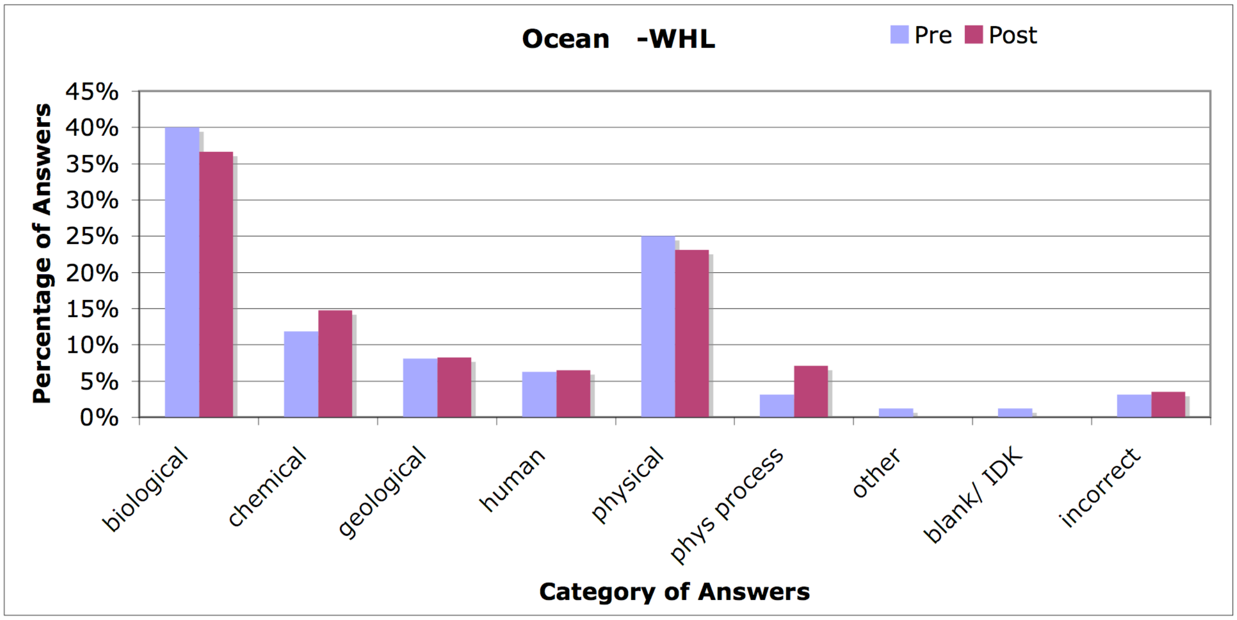

Ocean -EPJ
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
5%
0%
biological
chemical
geological
human
physical
phys process
other
blank/ IDK
incorrect
Category of Answers


Ocean -LLC
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
5%
0%
biological
chemical
geological
human
physical
phys process
other
blank/ IDK
incorrect
Category of Answers

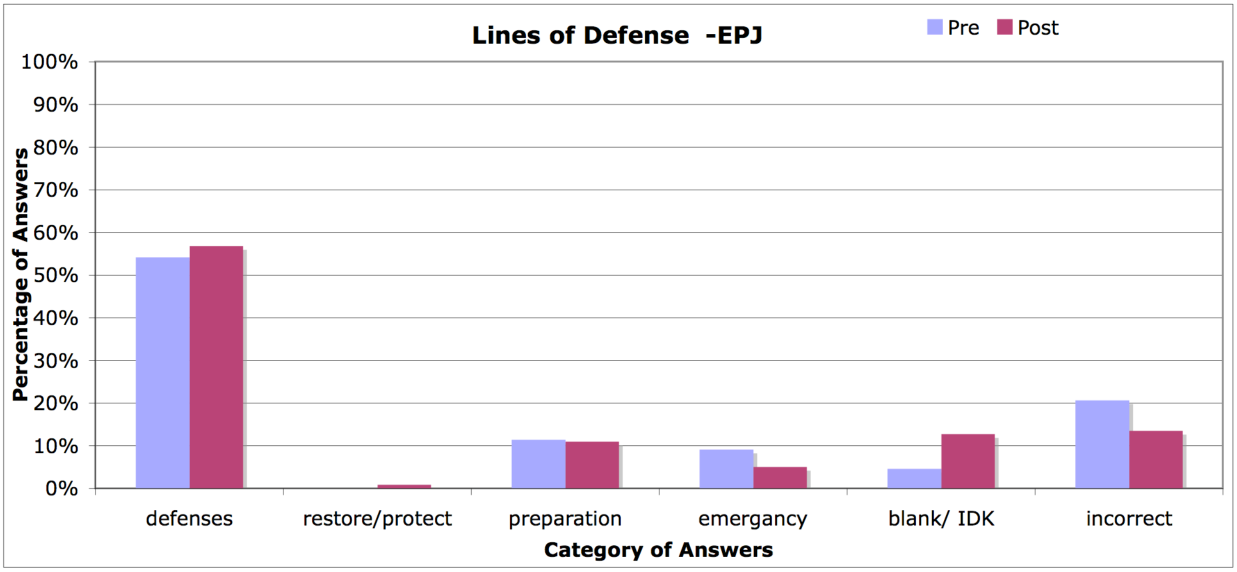

Ocean -RUV
Pre
Post
Percentage of Answers
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
biological
chemical
geological
human
physical
phys process
other
blank/ IDK
incorrect
Category of

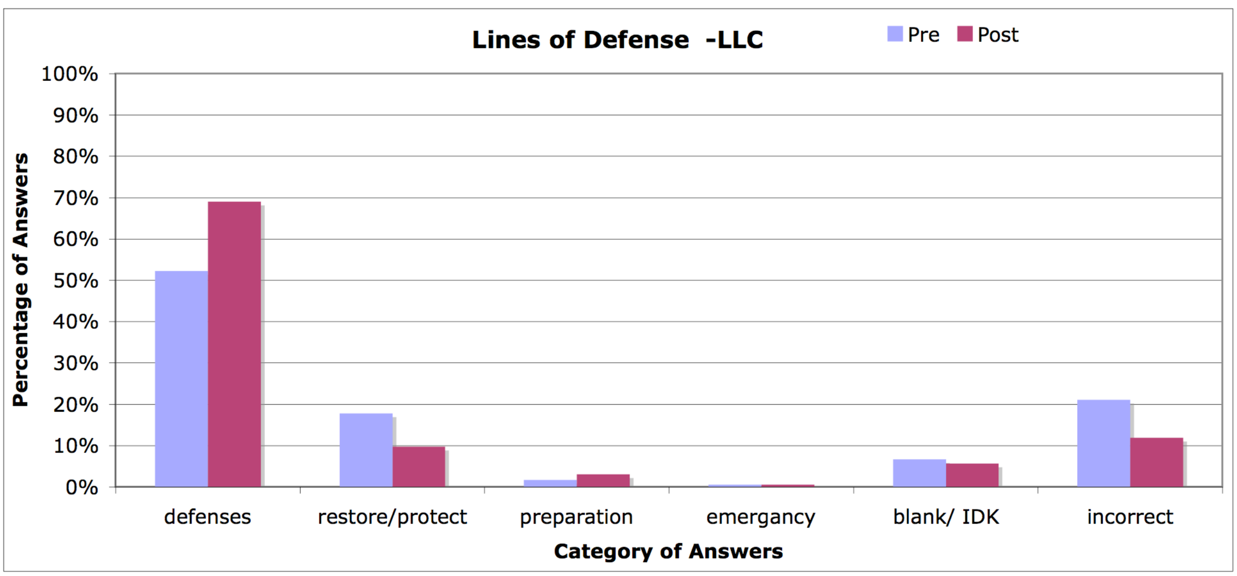

Ocean -SMF
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
5%
0%
biological
chemical
geological
human
physical
phys process
other
blank/ IDK
incorrect
Category of Answers

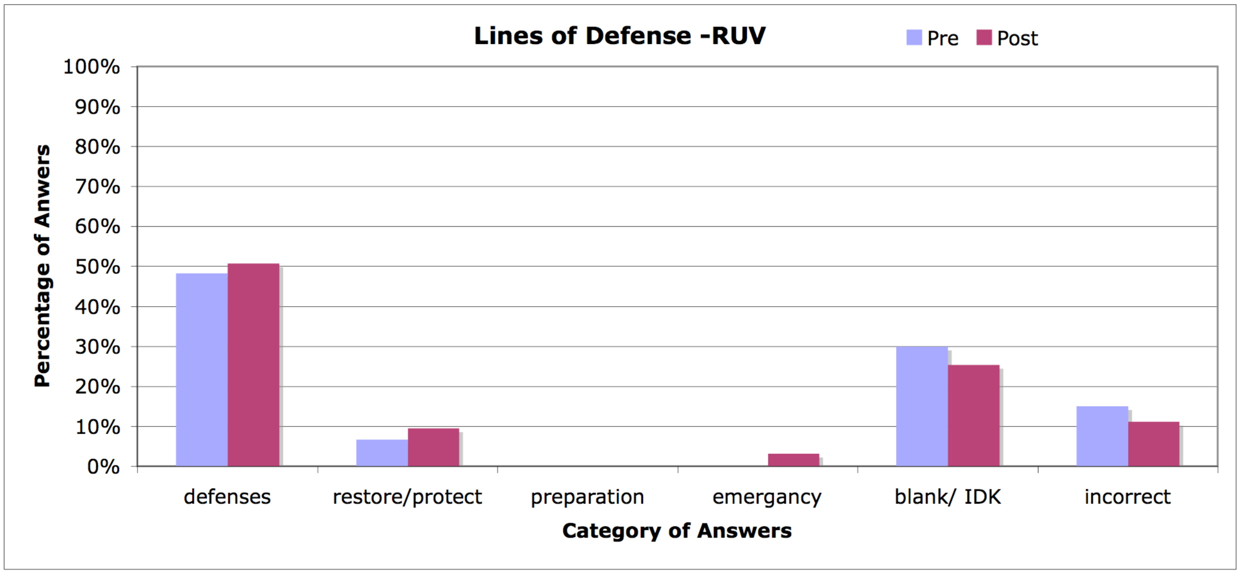

Ocean -SJP
Pre
Post
Percentage of Answers
40%
35%
30%
25%
20%
15%
10%
5%
0%
biological
chemical
geological
human
physical
phys process
other
blank/ IDK
incorrect
Category of Answers

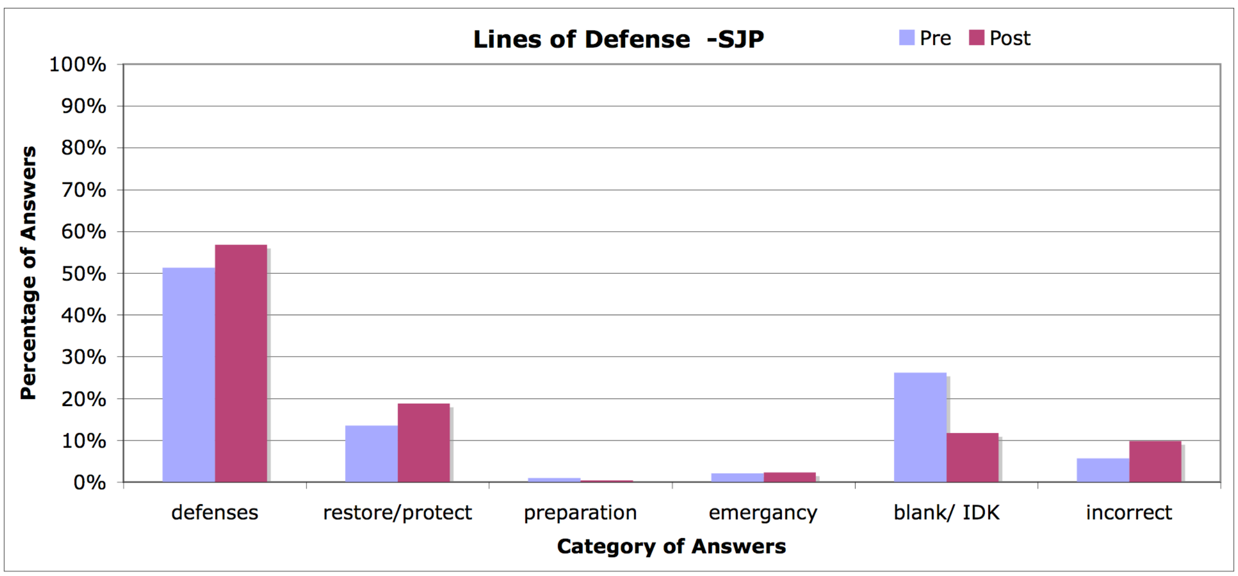

Ocean -WHL
Pre
Post
Percentage of Answers
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
biological
chemical
geological
human
physical
phys process
other
blank/ IDK
incorrect
Category of Answers

Question: List some of the natural and human-made lines of defense for coastal restoration and hurricane protection in Louisiana.






Lines of Defense -RUV
Pre
Post
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Anwers
defenses
restore/protect
preparation
emergancy
blank/ IDK
incorrect
Category of Answers


Lines of Defense -SJP
Pre
Post
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Answers
defenses
restore/protect
preparation
emergancy
blank/ IDK
incorrect
Category of Answers

VITA

Catherine Angela Sutera was born in Metairie, Louisiana in October 1982. She received her Bachelors of Science in biology and a minor in geology from Louisiana State University Agricultural and Mechanical College in December 2005. During this time she participated in the National Student Exchange program and spent a year at the University of North Carolina at Wilmington. She re-entered Louisiana State University in August 2007 and is a candidate for the Master of Natural Science. After eighteen months working in the Education Department at Louisiana Sea Grant, she hopes to continue working in the field of informal science education and outreach education.