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Librarium: Increasing Ocean Literacy

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Author

Hsu, Astrid

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Librarium: Increasing Ocean Literacy



Astrid Hsu
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Scripps Institution of Oceanography
Master of Advanced Studies
Marine Biodiversity and Conservation



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Executive Summary

This Capstone Report for the MAS MBC class of 2015-2016 focuses on the potential for a librarium—a cross between a library and an aquarium. It describes both the need and placement of such a facility/program in its beginning stages. This capstone encompasses a three-pronged approach: background literature to find the past research on learning and aquariums; experimental design to elucidate if books play a role in the aquarium experience; and analysis of library and aquarium distribution to determine potential librarium sites. The following are key results of my Capstone:

Previous Research

- Knowledge pertinent to marine science increased the likelihood of individual action and awareness towards marine issues (Steel, 2005)
- Live animal exhibits allow gains in knowledge, changes in attitude, and contribute to the local economy (Sherwood et al., 1989; Falk and Adelman, 2003; Allen, 2004)
- Visitors of nature facilities see themselves as part of the conservation effort (Falk et al., 2007; Packer et al., 2010; Adelman et al., 2000)
- One day visits [to a facility] are usually far too short of a time period to truly alter the behavior of an individual (Manubay et al., 2002). It is important to have facilities that encourage patrons to return, and to return often.

Experimental Design Findings

- There is a difference in time spent in the Birch aquarium kelp room when visitors pick up books versus those who were not exposed to books or did not pick up books: those who directly interacted with books spent a significantly longer time in the room.
- Books most greatly affected the length of time that adults spent in the room: books also affected the times of children and the elderly.
- Youth were not affected.

Distribution

- Aquariums are found in high population and high educated cities and tend to be along the coast.
- Libraries are found all over the United States, but libraries closer to aquariums also have high population and visitation.
- A good location for a beta-version of a librarium would be a library or an aquarium with these following qualities: relatively high population; low education rate; low visitation; and low cost of entry.

Challenges

- Time constraints and barriers to data access/collection
- Uneven sample sizes
- Limited literature on a librarium

Introduction

According to surveys conducted in 2003, a mere 31% of Americans realize that their actions and behaviors impact the health of the oceans (Steel, 2005). While this statistic may be disheartening, those that do have marine science knowledge, however, are much more likely to support marine conservation efforts. With the ocean constituting over 70% of the world and worth over \$24 trillion dollars in goods and ecosystem services, increasing ocean literacy is a crucial component to sustaining our global economy and livelihood (Hoegh-Guldberg, 2015).

As such, a new method I thought of to increase awareness and ocean literacy is through a **librarium**, a cross between a library and an aquarium. Such a place would blend the aquatic environment with the functionality of a library, presenting a facility where attendees can delve deeper into knowledge about the very organisms and ecosystems that they see. A librarium would aim to be an accessible facility that presents the opportunity for people to frequently interact with marine science through a plethora of methods. My hope is that increased interactions would heighten curiosity and understanding of marine issues, overall increasing marine conservation support and effort as demonstrated by Steel (2005). While this facility may be great in concept, the practicality of it must first be assessed.

This Master in Advanced Studies of Marine Biodiversity and Conservation capstone explores the potential for a librarium and investigates the following questions:

What is the previous research on the benefits of aquariums and libraries?

Do books play a role in the overall aquarium experience?

What is the national distribution of facilities? Where is the best place for a librarium?

Methods

What is the previous research on the benefits of aquariums and libraries?

Using previous peer-reviewed literature, I examined the impact that aquariums can have on visitors' attitudes and actions towards marine science and conservation, as well as the economic impact that these institutes have on the community. The general goal of aquariums is to build knowledge and wonder for the aquatic world, instilling thoughts that may ultimately translate into actions—actions such as financially supporting a conservation projects or getting involved in citizen science. However, whether or not these facilities are successful in these

endeavors has been heavily debated and investigated. I summarized these findings and drew conclusions concerning the social, educational, and economic value that a librarium might have towards the local and marine communities.

Do books play a role in the overall aquarium experience?

To address this question, I conducted in-person observations of conditions that simulate an environment similar to a librarium at the kelp forest room in the Birch Aquarium of Scripps Institution of Oceanography, University of California, San Diego. I compared two environments: one where books were available to visitors and one where the kelp room remained as is. My control was the kelp room as is (No Books), while my experimental environment placed books inside the room (Books). These books were placed on both sides of the seating area (shown in Figure 1) and had an accompanying sign notifying the availability to the public. Literature available ranged from picture books to fish field guides, and were placed upright on small tables.

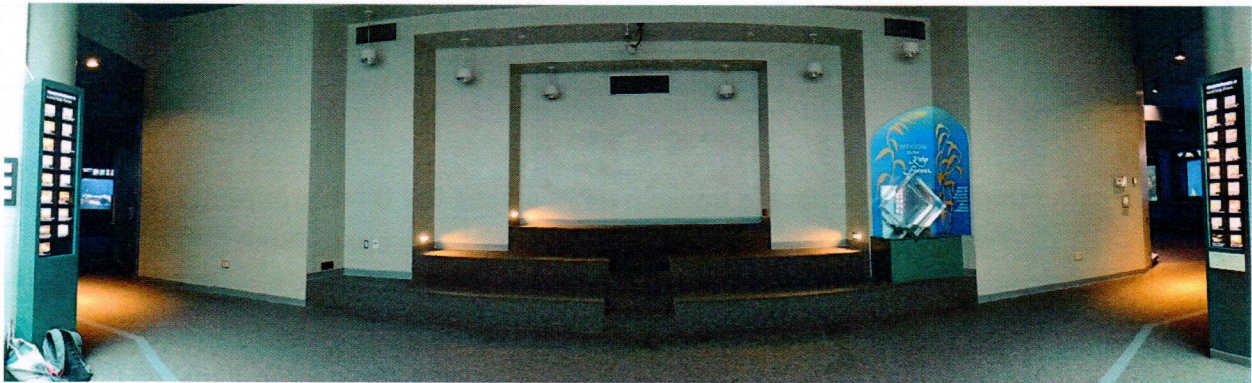


Figure 1: Study site at Birch Aquarium. Start and stop times were entrance and exit of the kelp room. The seating area was flanked by books on either side with signs in the experimental treatment.

Sitting at the back of the kelp room, I observed the following behaviors/characteristics exhibited by the visitors: total time spent in the kelp forest room, gender, age category (Child, Youth, Adult, Elderly), time spent looking at books, and how many books were picked up. Start and End times were captured when people stepped in or out of the kelp room while Book times were noted by how long an individual held onto the book. Observed individuals were chosen at random: only one individual was observed at a single time, and as soon as they left, the next individual to enter the room was chosen. However, if an individual spent longer than 5 minutes in the kelp room on a slow day or 3 minutes on a busy day, the next individual to enter the kelp room after this time mark was also recorded. This was to ensure a large enough sample size. This experiment ran for a total of four weeks (Table 1). Experiments ran on Sundays and Wednesdays to attain a comprehensive sample of weekend and weekday visitors. Prior to my experiment, I consulted with Birch aquarium staff who described the aquarium audience: while

visitors can be unpredictable, generally there were different groups on weekends (out of towners) versus weekdays (locals). Likewise, different demographics come throughout the day—mornings tend to be mothers and toddlers, noontime brings school groups, and afternoons attract older people and lone visitors. As such, each sampling day was observed during the hours listed in Table 1 to capture this variety.

Table 1: Schedule of observation dates for the experiment at the Kelp room in Birch Aquarium.

Date	Day of the week	9:15 AM – 10:15 AM	1:00 PM – 2:00 PM	3:45 PM – 4:45 PM
March 6	Sunday	No Books		
March 9	Wednesday			
March 13	Sunday	Books		
March 16	Wednesday			
April 10	Sunday	No Books		
April 13	Wednesday			
April 17	Sunday	Books		
April 20	Wednesday			

I then compared the total time spent in the kelp room among the three groups of people: those who were not exposed to books (No Books); those who picked up books (Books-Pickup); and those who were exposed to books, but did not pick them up (Books-No Pickup). Using one way ANOVA, I tested the significance using the null hypothesis that there are no differences between the mean total times spent in the kelp room among the three groups against the alpha value of 0.05. Significant results were followed up with post-hoc tests (Tukey Kramer HSD and Welch's t-test) for further details on if books affected the total kelp room times of each age category (Ruxton, 2006).

What is the national distribution of facilities? Where is the best place for a librarium?

My hope is that a librarium can reach a wide range of audience, encourage revisits, educate the local community, and be an accessible facility. To make a librarium, there are three options: add an aquarium to a library; add books to an aquarium; or construct a stand alone facility. In order to pinpoint where a librarium would be able to fulfill these goals, I analyzed the national spatial distribution of public libraries and aquariums. The main factors I looked at were high school and college education, local population, median household income, and aquarium ticket price of cities that host aquariums and libraries. All this data was collected from the US Census and from aquarium websites and subsequently compared to the national average using 95% confidence intervals. They were Tableau (platform for organizing and visualizing data) and GIS (program for organizing and visualizing geographic related information) were then used to

display and store this data. I mapped 9,290 libraries and 72 aquariums. For ArcGIS, the inputs for included the longitude and latitude of libraries (US Census2, 2014) and aquariums (Google Maps, 2016) and the population sizes of those cities (US Census1, 2014).

Libraries were further categorized based on distance: libraries within a 40-mile radius of an aquarium were considered "Near", while libraries outside this radius are considered "Far". This radius was chosen because it is the maximum distance that constitutes a "local trip" (Andereck and Caldwell, 1994; Hall and Lew, 2009). One-way ANOVAs (Welch's t-test) were conducted between libraries associated with aquariums and libraries not associated with aquariums comparing population and annual visits. The null hypothesis was that there is no difference between the socioeconomic factors of Near and Far libraries.

Results

What is the previous research on the benefits of aquariums and libraries?

As previously mentioned, studies demonstrate that knowledge pertinent to marine science increases the likelihood of individual action and awareness towards marine issues (Steel, 2005). Aquariums prove to be an effective vector for such dissemination of information. Live animal exhibits provide a wealth of benefits: gains in knowledge, positive changes in attitude, and economic contribution to the local community (Sherwood et al., 1989; Falk and Adelman, 2003; Allen, 2004). Not only do visitors better retain information, but they also change their outlook towards wildlife and better grasp conservation issues. One of the greatest gains of these nature facilities is that visitors see themselves as part of the conservation effort (Falk et al., 2007; Packer et al., 2010; Adelman et al., 2000). Simply identifying as part of the solution to marine issues is a critical step to actually solving a marine issue. For example, if people identify themselves as part of the solution to marine litter, they are more likely to participate in beach clean-ups and to advocate against dumping. Thus, increased exposure and education of the underwater world seems to increase support for the marine sciences.

Moreover, zoos and aquariums are also economic drivers, employing over 193,000 people and generating over 19 billion USD in the United States alone (AZA, 2013). These facilities bring visitors from around the world, boosting both the local and regional economies. Not only is money directly pumped into the local region through wages (employment), but the visiting tourists also spend significant amounts on local stores, restaurants, lodging, and transportation businesses (MAN, 2008; AZA, 2013). However, several of the studies conducted at aquariums and zoos mention that patrons typically visit for only a day and do not return often. One day is usually far too short of a time period to truly alter the behavior of an individual (Manubay et al., 2002). As such, it is important to have facilities that encourage patrons to not only return, but to also return often. The librarium would need to offer affordable prices and the atmosphere

would be similar to that of a library/café with “regulars”. Likewise, the librarium, with qualities derived from both a library and an aquarium, would ultimately aim to benefit the local community educationally and economically as libraries and aquariums do (McClure et al., 2000; Barron et al., 2005; BL, 2004; MAN, 2008; AZA, 2013). At the same time, it would boost conservation appreciation, awareness, and engagement of the marine sciences.

Do books play a role in the overall aquarium experience?

A total of 327 subjects were observed: 39 Children, 39 Youth, 40 Elderly, and 209 Adults.

Among the three categories of books interactions (Books-Pickup, Books-No Pickup, and No Books), the ANOVA test returned a significant value of < 0.0001 , much lower than the alpha value of 0.05 (Figure 2). This allows the null hypothesis to be rejected, indicating that the mean duration of time spent in the kelp room is different for at least two of the groups. This difference is further examined in post-hoc tests: Student’s t-test and Tukey-Kramer HSD.

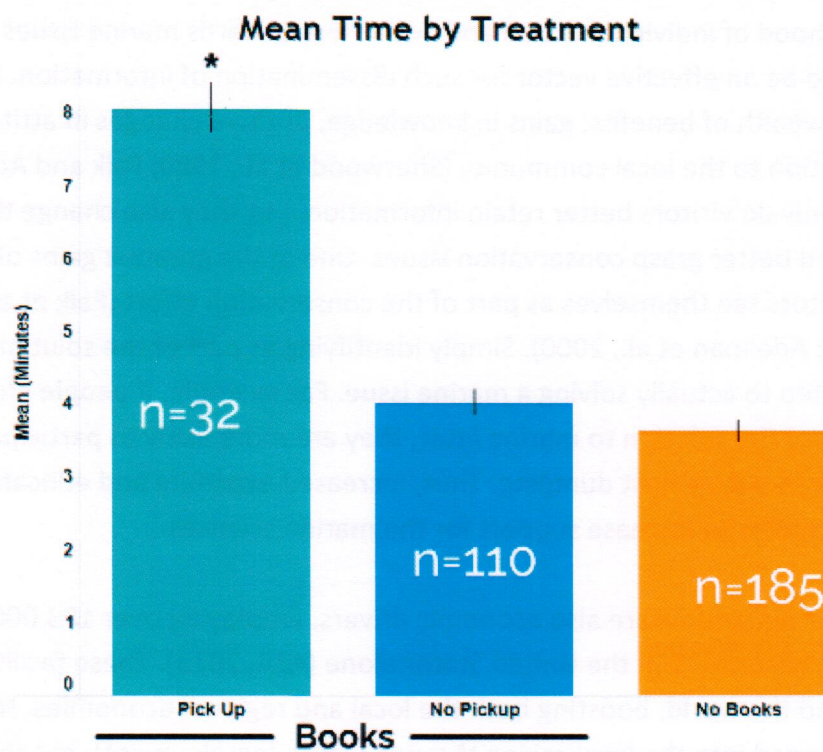


Figure 2: The average total time that the general public spent in the kelp room depending on whether their book interaction. Asterisks indicate significant difference.

After completing the statistical analysis (Student’s t-test and Tukey-Kramer HSD), I found that the average time spent in the kelp room is significantly different between the Books-Pickup and

Books-No Pickup as well as No Books. However, there were no significant differences between the times spent in the kelp room between people who did not pick up the books and visitors in the control group (Table 2).

Table 2: Results of statistical tests demonstrating that Books-Pickup average total time spent in the kelp room is significantly different from Books-No Pickup and No Book.

	p-value: Student's T-Test	p-value: Tukey-Kramer HSD
Books-Pickup and Books-No Pickup	<0.0001**	<0.0001**
Books-Pickup and No Books	<0.0001**	<0.0001**
Books-No Pickup and No Books	0.482	0.6858

Thus, books do play a role in the overall experience of visiting an aquarium: if people pick up books, they are more likely to stay longer in the exhibit. This excess of time demonstrates that people are willing to give up their time to engage in the books and (hopefully) learn more about marine related items.

Table 3: One-Way ANOVA tests to compare of the average time spent in the kelp room among treatments and age groups.

Null Hypothesis	Sample Size	p-Value	df
There is no difference between the mean total time among all age groups spent in the kelp room among all treatments (No Books, Books-No Pickup, and Books).	329	<.0001**	326
There is no difference in the mean total time Children spent in the kelp room among all the treatments.	39	0.0107*	36
There is no difference in the mean total time Youth spent in the kelp room among all the treatments.	40	0.7271	37
There is no difference in the mean total time Adults spent in the kelp room among all the treatments.	209	<.0001**	206
There is no difference in the mean total time Elderly spent in the kelp room among all the treatments.	39	0.1127	36

*significant at α -level of 0.05

**significant at α -level of 0.01

However, whether or not the direct interaction with books affects the total time an individual spends in the room depends on the age category (Table 3). This difference in time is most strongly seen in Adults: the time spent in the kelp room is significantly higher in Books-Pickup individuals compared to Books-No Pickup and No Books individuals (Table 4 and Figure 3). Children and Elderly subjects also spent a significant increase in time when they directly interacted with books. However, youth did not see a change in time with respect to books.

Table 4: Results of Tukey-Kramer Tests in comparing the average time spent in the kelp room among age groups.

	Treatment Comparisons using Tukey-Kramer HSD		
Age Category	Books-Pickup and No Books	Books-Pick Up and Books-No Pickup	Books-No Pickup and No Books
All	<.0001**	<.0001**	0.4082
Child	0.0379*	0.0336*	0.8569
Youth	0.9943	0.9666	0.7055
Adult	<.0001**	<.0001**	0.8008
Elderly	0.0387*	0.0614	0.9640

*significant at α -level of 0.05

**significant at α -level of 0.01

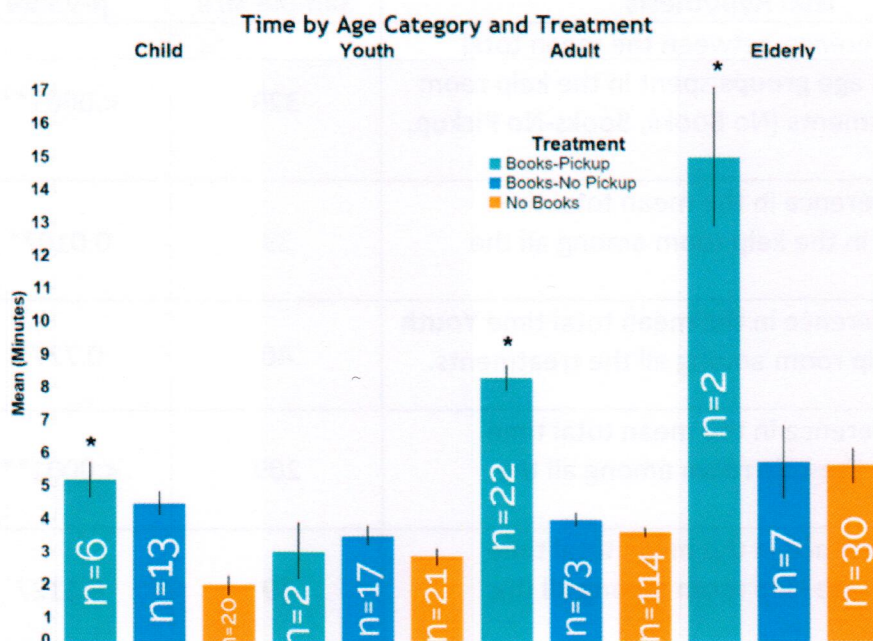


Figure 3: The mean total time that individuals spent in the kelp room based on age category and interaction with books. Asterisks indicate significance difference.

To understand the exact impact that books had on each age, a breakdown of time spent looking at a book and total time spent in the kelp room is shown in Table 5. On average, visitors spend 37% of their time in the kelp room looking at books. Youth spend by far the greatest percentage of their time looking at books (80%), followed up by Children, Elderly, and Adults. This is a unique and surprising find, considering that the experience of Youth was not significantly affected by the books. However, it should be noted that sample sizes are relatively small, especially for Youth and Elderly, so these results should be taken with caution and demands retesting to increase their reliability.

Table 5: Average total time people spent looking at books, average total time spent in the kelp room, and the average ratio of the two factors.

Age Category	Average Total Book Time (minutes)	Average Total Time In Kelp Room (minutes)	Average Ratio (Book:Kelp Room)
Child	3	5.166666667	0.472222222
Youth	2	3	0.8
Adult	2.636363636	7.818181818	0.309272924
Elderly	6.5	15	0.325
Total Average	2.90625	7.46875	0.371479302

What is the distribution of facilities? Where is the best place for a librarium?

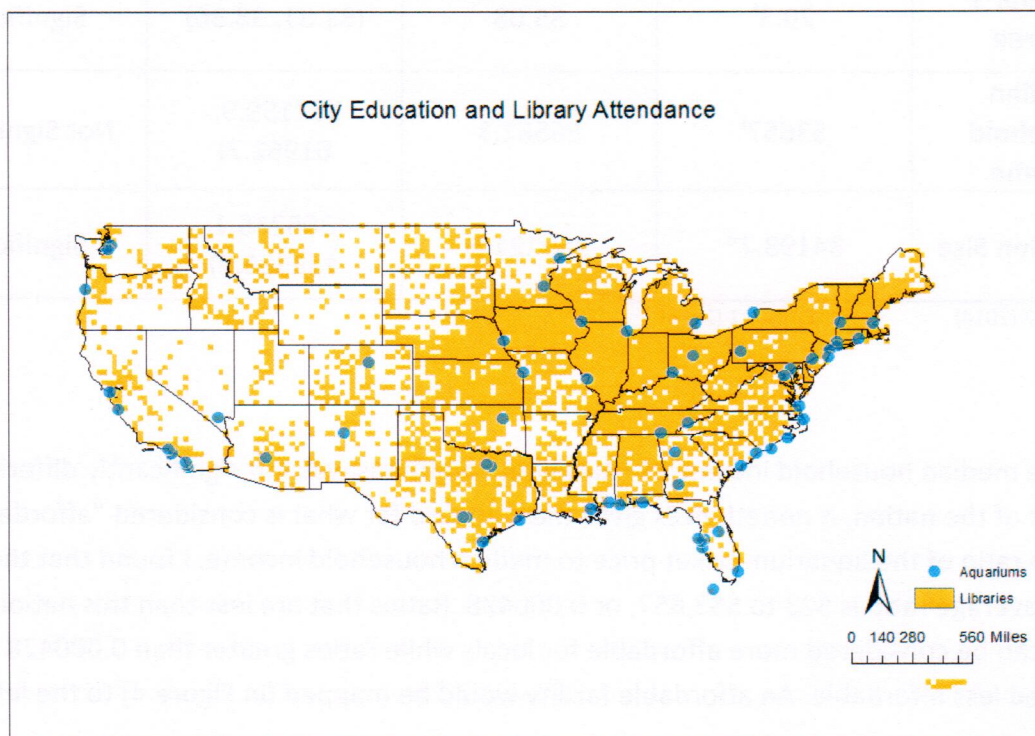


Figure 4: Distribution of Libraries and Aquariums in the United States. The blue circles represent aquariums, which are generally found near bodies of water. Libraries, represented by the orange, are found throughout the nation (including Alaska and Hawaii, not pictured).

By mapping the facilities, it is evident that libraries are found throughout the United States, while aquariums tend to be concentrate along the coasts. When statistically looking at the socioeconomic factors of aquariums and how they compare to the rest of the nation, I found that cities with aquariums had significantly higher percentage of people (aged over 25) with a college degree and higher population density at a 95% confidence interval (Table 5). However, they were not significantly different from national averages in high school education or median household income. As such, cities with aquariums are more educated and host a larger number of people.

Table 5: Results of 95% confidence intervals of the mean of selected factors in cities with aquariums compared with the national average. Aquariums are found in cities with higher population and education levels than the national average.

Factor	National Average	Sample Mean	Confidence Interval	Significance
High School Diploma	86.3 [†]	87.24	(85.51, 88.95)	Not Significant
Bachelor's Degree	29.3 [†]	35.08	(31.81, 38.36)	Significant
Median Household Income	53657 [†]	56561.3	(51159.9, 61962.7)	Not Significant
Population Size	34198.2 [*]	369121.5	(305216.1, 433026.9)	Significant

*US Census 2 (2014)

[†]US Census 1 (2014)

While the median household income of cities with aquariums was not significantly different from that of the nation, it nonetheless gives the standard for what is considered “affordable”. Using the ratio of the aquarium ticket price to median household income, I found that the national average ratio is \$23 to \$53,657, or 0.000428. Ratios that are less than this national average can be considered more affordable for locals while ratios greater than 0.000428 can be considered less affordable. An affordable facility would be mapped (in Figure 4) to the left of

the average ticket price, while a city with lower socioeconomic levels is likely to be mapped under the national average.

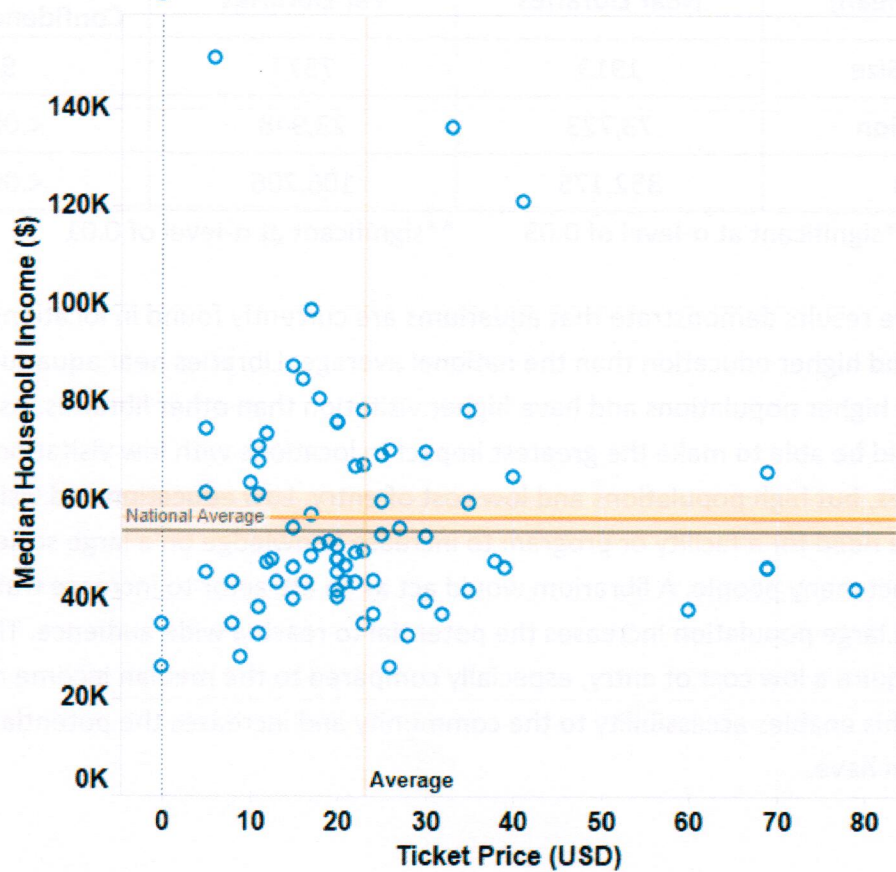


Figure 4: Ticket price and Median Household Income of each aquarium in the nation, averages of the data in orange (band of orange is the 95% confidence interval) while the national average is lined in gray. A ratio of ticket price to median household income can act as a proxy for affordability. Aquariums in the lower left quadrant are generally good candidates for a librarium because they represent cities of lower socioeconomic levels but have affordable aquariums.

Libraries are also found all over the nation, so by isolating libraries that are within a 40-mile radius from aquariums, it can be determined whether or not libraries near aquariums have distinct socioeconomic characteristics from libraries far from an aquarium. In terms of looking at whether cities with libraries within a 40-mile radius of an aquarium (Near) are different from libraries that are outside this radius (Far), I found that libraries near aquariums are in cities that have much larger populations and host more visits into their facility. As such, cities surrounding aquariums tend to have more educated residents, attract more educated visitors into their libraries, and serve larger communities.

Table 6: Welch's test analyzing the difference between *Near* libraries and *Far* libraries for city population and library annual visits.

Factors (Mean)	Near Libraries	Far Libraries	p-value at 95% Confidence (Welch's)
Sample Size	1913	7377	9290
Population	73,723	23,948	<.0001**
Visits	352,175	106,706	<.0001**

*significant at α -level of 0.05

**significant at α -level of 0.01

The summative results demonstrate that aquariums are currently found in locations with higher populations and higher education than the national average. Libraries near aquariums are in locations with higher populations and have higher visitation than other libraries. As such, a librarium would be able to make the greatest impact in locations with low visitation and education rates, but high populations and low cost of entry. Low education and visitation rates demonstrate a need for a facility or program to increase knowledge on a large scale with the ability to impact many people. A librarium would act as an attractor to increase traffic and reading, and a large population increases the potential to reach a wide audience. The librarium would also require a low cost of entry, especially compared to the median income of the local community. This enables accessibility to the community and increases the potential impact that a librarium can have.

Case Studies

To get a better grasp of what facility would constitute as a good candidate for a librarium, two case studies were analyzed. Again, to make a librarium, there are three options: to convert a library by putting in an aquarium; convert an aquarium by putting in books; or to create a stand alone facility. A library and an aquarium were considered: Kern County Public Library and Cabrillo Marine Aquarium.

Kern County Public Library of Bakersfield, California, is considered a great candidate due to a collection of factors (Table 7). First, the population of Bakersfield is greater than the national average, allowing for a wide reach of audiences. The number of Kern County visitation rates is low relative to the total population number. This low visitation rate, as well as the low percentage of college and high school graduates compared to the national average, is considered a good indication because a librarium would hopefully increase these local statistics. Cost of entry is also low: as all public libraries are, Kern County is free to enter. This allows the facility to be accessible to the local community.

Table 7: Statistics showing the potential for Kern County Public Library to be the foundation for a librarium on the basis of population, visitation rates, education, and cost.

	Bakersfield, CA	Average
Population	857,882	34,198*
Annual Visits	831,636	157,253*
High School Degree	79.7%	86.3% [†]
Bachelor Degree	20.7%	29.3% [†]
Cost of Entry	\$0	\$0

*US Census 2 (2014)

[†]US Census 1 (2014)

However, putting an aquarium inside an library can be logistically difficult and incredibly expensive. As such, a second case study was analyzed: Cabrillo Marine Aquarium in San Pedro, California. Cabrillo Aquarium (Table 8) is considered a promising aquarium for a librarium because it has a higher population than the national average, has a lower high school and college graduation rate than the national average, and also has a low ticket price. This ticket price is considered cheap not only relative to the national average, but also in proportion to the median household income of San Pedro. This displays local accessibility to the Cabrillo Aquarium. Visitation records for aquariums were unable to be attained because of facility privacy (see *Challenges*), therefore I was unable to gauge the visitation rates with the aquarium network and compare relative to the local populations.

Table 8: Statistics showing the potential for Cabrillo Marine Aquarium to be the foundation for a librarium on the basis of population, education, and cost.

	Cabrillo Marine Aquarium in San Pedro	National Average[†]
Population	86,012	34,198.2
High School Degree	61.7%	86.3%
Bachelor's Degree	24.6%	29.3%
Ticket Price	\$5	\$23
Median Household Income	\$61,507	\$53,482

[†]US Census 1 (2014)

Challenges, Recommendations, and Conclusion

Challenges

This three-pronged approach took great effort to both collect and analyze the data. While lack of background literature of a librarium obviously was a hindrance, my greatest challenge was designing the experiment to conduct the librarium stimulations. Originally, I had wished to record individuals in the kelp room and to be able to capture a greater number of factors. However, this proved to be an obstacle for the time frame given for this capstone: as such, factors such as whether people were visiting alone or in a group and what books were picked up were not recorded and taken into account. Additionally, many elements affected the length of time that people spent in the kelp room. There were quite a number of incidents that caused people to leave early or stay later than they usually would, affecting both the time spent in the kelp room as well as the time looking at books (i.e. sea turtle swimming in adjacent tank, another member of the party not allowing book interaction, etc.). While this may be considered normal behavior, it nonetheless influenced my experiment. However, such observation details can be used to design a librarium (i.e. turtles can be used as an attractor) in the future.

I also initially planned to include and analyze various data from all US aquariums (number of visitors, revenue, etc.), but those points proved difficult to attain due to many of the facilities being privately owned and the potentially sensitive nature of the information. Having this data would reveal patterns within the aquarium network and allow identification of which facilities are most “successful”. This can better answer whether or not a librarium would integrate well into an aquarium and provide further insight on how aquariums serve their community. Despite these challenges, I am confident that this study lays a sturdy foundation delineating the potential of a librarium.

Further Research and Conclusion

The results of this study not only demonstrate how a librarium may impact the local and marine communities, but also reveal where a librarium could be established. It should be made clear that a librarium does not have to be a stand-alone institute: this applies to aquariums and libraries that are already existing and hints at the potential to design programs and features similar to a librarium. Though it is easier to put books in an aquarium than to put an aquarium into a library, libraries can achieve the same effect of an aquarium through use of electronic screens and monitors, a much more cost-effective way. Regardless, to turn a standing facility (aquarium or library) into a librarium requires resources to execute such a program and demands a case-by-case study. As a preliminary study, using total funding of facilities can help assess the feasibility of implementing such a program.

Additional next steps include retesting of this design in libraries and aquariums that fit the above criteria and advertising the librarium feature. In addition, and if possible, setting up a workplace area (i.e. seating area, tables) would be a wonderful addition to test. This would more closely mirror a librarium, as a place for people to be able to study, do work, and explore the marine sciences. In conjunction, analyzing for changes in knowledge (from the books) or increased curiosity (aquatic animals), as well as changes in visit frequency and the motives behind visitation would lend additional insight to a librarium's effectiveness. These trials would provide the opportunity to watch for changes in the listed factors and provide insight as to whether or not a librarium can make tangible impacts.

Marine science is still a relatively novel sector: we know more about outer space than the deep ocean. As such, I believe that effective education is key: marine sciences need to engage the general public to advance conservation knowledge and action. I believe that the librarium will not only be very attractive in terms of entertainment, but also holds the potential to increase ocean literacy as well as make a difference socially, economically, and educationally.

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