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The Art of Aquarium Keeping Communicates Science and Conservation

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In technology-driven societies, scientists, and educators alike flounder in making science interesting and applicable. Communicating science, defined as communicating scientific facts as well as teaching and using the scientific process, can also be done informally though leisure activities. In this qualitative study, I examined the leisure activity of aquarium keeping and its ability to communicate relative aquatic facts and processes. This study examined aquarium keepers across the United States via interviews, participant observation, and an ongoing analysis of aquarium hobby literature. Thus, this study indicates (1) caring for a home aquarium communicates science latently, (2) over time, latent science communication becomes activated, and (3) long-term aquarium keeping leads to a personal response in science, as well as conservation. In addition, artistic expression and innovation intersect with scientific knowledge and application to create beautiful, biodiverse, ecosystems. Through the process of successfully maintaining an aquarium, continued participation leads to a proficiency in applicable scientific facts, a better understanding of scientific processes, and an improved conservation ethic for aquatic resources. Further, this intersectionality motivates participation by providing new challenges and various forms of satisfaction. The human dimensions of the aquarium hobby and the values of aquarists are important to understand for many purposes, most notably because it encompasses an enormous sample of the American population and is extremely lucrative to those along most of the supply chain. Aquarium keeping is not only a hobby, but because of the relationship between science and art, it can communicate, as well as spark conservation efforts in serious aquarists.

Keywords: art, aquarium, fish, science as leisure, captive ecosystem, science, conservation, science communication

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INTRODUCTION

To communicate science, including conservation science, one must elicit a personal response toward science (Burns et al., 2003). A "personal response" includes an awareness, enjoyment, interest, opinion forming experiences, and understanding. These outcomes can be achieved through means defined as formal (e.g., school) or informal (e.g., citizen science; Dickinson and Bonney, 2012). Informal scientific communication includes passive means, often bordering on entertainment. This line, between scientific communication and scientific entertainment, is dense with diverse recreation and leisure activities. One such activity is the hobby of home aquarium keeping.

Aquarium keeping is a global industry worth between 15 and 30 billion U.S. dollars (Hoff, 1996; Wood, 2001; Cato and Brown, 2003; Tlusty et al., 2013). In 2017 there were 12.5 million U.S. households keeping freshwater aquaria and 2.5 million keeping saltwater (American Pet Products Association, 2017) encompassing 139.3 million individual freshwater, 18.8 million saltwater organisms, and approximately 10% of the American population (American Pet Products Association, 2017). Because of these participation levels, home aquaria has huge outreach potential. It is important to understand the past, current, and future effects of the hobby on the aquarists who keep these systems.

Through interviews, content analyses, and participant observation, I found a modern and historical link between art and science in aquarium keepers. Further, this link seems stable, with the aesthetic value of aquatic organisms as one of the key motivators for hobby participation. In addition, the process of keeping a successful aquarium exposes the aquarium keeper to a vast array of scientific information, principles, processes, and methods. I argue the keeping of an aquarium may be motivated, and that motivation maintained, through an aesthetic interest, but the side effect of aquarium keeping is a personal response toward aquatic organisms. Results indicate this response affects scientific *and* conservation awareness, enjoyment, interest, opinion forming experiences, and understanding. This study indicates an aquarium helps link aquarists to an increasingly damaged aquatic world.

Introduction to Home Aquarium Keeping

Home aquarium keeping is an unlikely source of scientific communication due to its highly consumptive past and, to an extent, present. This consumption not only includes the removal of live aquarium specimens for the aquarium hobby, but also encompasses other related practices that detrimentally affect their populations and habitats. This includes the collection of live plants and coral, invertebrates such as shrimp and crabs, as well as abiotic structure (e.g., "*live rock*"). Additionally, the aquarium industry is historically tied to the curio trade (Wood, 2001; Rhyne et al., 2009; Townsend, 2011; Dee et al., 2014; Fujita et al., 2014), likely exacerbating the negative connotation surrounding the hobby.

A vast array of literature exists on the aquarium hobby, eliciting over 8,000 Google Scholar hits; however, it is primarily focused on understanding the aquarium industry's effects on the environment at both ends of its supply chain. For example, there are numerous studies on the impacts of removing aquatic organisms from the wild (Parks et al., 2003; Jones et al., 2008), the impacts of aquaculture (Tlusty, 2002; Parks et al., 2003; Rhyne and Tlusty, 2012; Bush and Marschke, 2017; Duggan and Pullan, 2017; Lorenzen et al., 2017), and the capture and care of organisms (Wood, 2001; Jones et al., 2008; Bell et al., 2009; Militz et al., 2016).

Once ornamental organisms are collected other factors are studied. This includes diseases associated with aquatic organisms (Whittington and Chong, 2007; Lawson et al., 2015), invasive species release (Padilla and Williams, 2004; Delaney et al., 2008; Howeth et al., 2016; Bandaranayake and Chandrasekara, 2017; Magalhães et al., 2017; Selwyn et al., 2017; Tuckett et al., 2017) and use for popular aquarium species for breeding and scientific research (Hoff, 1996; Moe, 2003; Moorhead and Zeng, 2010; Olivotto et al., 2011; Domínguez and Botella, 2014; Tehrani et al., 2014). Another, far less common focus for research includes the human dimensions of the aquarium trade and hobby. Instead of studying the organisms, the stakeholders are analyzed. Here, the aquarium hobby literature is increasing (e.g., Maceda-Veiga et al., 2014), but generally overlooks the aquarium hobbyist as a population of research interest.

LINKAGES BETWEEN ART AND SCIENCE COMMUNICATION

A captive ecosystem is a malleable canvas reliant upon science. James Shirley Hibberd, a nineteenth century part-time naturalist, documented the link between aquaria, art, and science in this quote: "The aquarium has become established as a triumph of art acting as the handmaid of science" Hibberd (1860). This link between art and science is evident in modern successful aquarium keeping; beautiful and creative ecosystems are created with a detailed understanding of the science working behind the scenes (**Figure 1**).

Behind the scenes, scientific facts, processes, and methods are slowly learned and mastered. For example, the goal of every aquarist is to keep aquatic organisms alive in captivity. Arguably, the major hurdle for all new aquarists is applying their knowledge of the nitrogen cycle (Paletta, 2002; Delbeek and Sprung, 2005; Fenner, 2008). During the nitrogen cycle, a new aquatic ecosystems must be *"cycled."* During this time, aquarists test their scientific knowledge, and patience, by monitoring the water chemistry and nutrient input as their *"beneficial bacteria colonizes."* Then, once this occurs, they can slowly add new organisms to their system (Paletta, 2002; Delbeek and Sprung, 2005; Fenner, 2008). Aquariums allow non-scientific people a place to observe aquatic organisms, and master relative scientific facts and ecological processes via a hands-on learning experience.

Aquaria have long acted as both formal and informal modes of educating the public; "Nor is it only for amusement that such parlor oceans [home aquaria] and lakes [ponds] are prepared and stocked; they are invaluable as a means of instruction" (Sowerby, 1857). Aquaria used as instructive devices are found in schools today (Rutherford, 2015a,b; Quality Marine, 2017). The link between science and aquarium care is not lost on teachers who aim to please students who ask, "When will I ever need to know or use scientific facts and knowledge?" Formal instruction with an aquarium communicates science, while informal learning through home aquarium care elicits a more personal response due to taking responsibility for those organisms.

Science communication suffers from several issues, with one being a failure to go where the people are, not where they want them to be. For example, instead of studying how to get more participants into places of science communication (e.g., museums), I suggest we go to participants at their hobbies to explore the informal educational potential of those activities. Previous research has shown hobbies act as early careers, with a

FIGURE 1 | A challenging and unconventional miniature 1.5-gallon reef aquarium can be grown in a glass vase. Home aquaria offers the home aquarist a chance to get close to oceanic organisms, appreciate their natural beauty, and even propagate them for sale and trade. Photo reproduced with the permission of the copyright holder [Matt Pederson].

potential to lead to professionalism (Stebbins, 1979, 1980, 1992). In his extensive body of work, Stebbins explores the different participation levels within hobbies (i.e., amateur, professional), focused on describing the different types of leisure (e.g., serious leisure; Stebbins, 1979, 1982). Results indicate an additional leisure type, science as leisure, where science and conservation may be communicated thorough leisure activities.

METHODOLOGICAL FRAMEWORK

Previous personal experience in aquarium keeping, from 2000 to 2015, indicated an emergent theory linking aquarium keeping and science communication. In fact, I attribute obtaining my Master's Degree in fish phylogenetics to my past history as an aquarium keeper (Marchio, 2015). More specifically, I chose ethnographic methodologies to immerse myself in the social context of the aquarium hobby (Glaser and Strauss, 1967; Spradley, 1980; Agar, 1996; Charmaz, 2006). This method allows aquarists to help me interpret situations and events. By contextualizing the topic, I can further explore the importance of science to aquarium keeping as a sensitizing concept (Bowen, 2006). The framework for this study draws from previous experience, participant observation, semi-structured interviews, and analyses of aquarium hobby content. Due to the lack of hobbyist-specific peer-reviewed research, grounded theory allowed me to discover and explore the interconnectivity between leisure and science.

Previous experience and participant observations were keys to this study. While many interviewees were open and willing to talk about the hobby, participants spoke more candidly outside a formal setting and much of the data comes from informal conversations. For example, at a *"frag swap"* I participated by shopping and *"swapping"* live coral fragments alongside other aquarists. There, I could be a "professional stranger" (Agar, 1996), listening to aquarists ask questions and comment on things important to them. Moreover, I attended the Marine Aquarium Conference of North America (MACNA) over 3 years (2015–2017) where a large vendor and conference room let me blend in and participate authentically.

Additionally, participant observation helped to triangulate the emergent data and themes (Spradley, 1980). This consisted of maintaining both salt- and freshwater aquaria in my own home. I documented the majority of my experience in a notebook. The notebook consisted mostly of water quality measurements and observations of the inhabitants and the system. Both systems were set up for at least 1 year.

To triangulate these data, I conducted twelve interviews. The interview protocol was semi-structured, providing a guide for the conversation. This allowed participants to go toward the most important topics to them, allowing emergence of theory. I carried out interviews in accordance with the recommendations of the Texas A&M University Institutional Review Board with informed verbal consent from all subjects. Aquarists interviewed were mainly saltwater aquarium keepers but some kept both saltwater and freshwater aquaria concurrently. A few maintained only freshwater at the time of the interview. It is important to note aquarium keepers often switch styles of involvement but usually begin their hobby with a freshwater bowl or aquarium.

I choose interviewees that represented different stages of participation—from novice to advanced. In the leisure sciences, studies have shown there are different stages and styles of involvement in a leisure activity, and these can reflect different values, motivations, and experiences (Bryan, 1977, 1979; Chipman, 1986; Chipman and Helfrich, 1988; Scott et al., 1999; Scott and Shafer, 2001; Waight and Bath, 2014). Aquarium keeping seems no different.

Novice aquarists were challenging to interview; they felt they had little information to offer which often lead to a decline for a conversation. Serious aquarists were the opposite. To supplement, online forum data were easy to obtain with new aquarium keepers seeming most comfortable talking behind a computer screen. Additionally, this study includes content from online forums, aquarium books and literature, and content of several aquarium conferences. Online forums included www.reefcentral.com and www.nano-reef.com.

In addition, personal correspondence with aquarists online allowed for constant comparison and on-demand participant validation (Bowen, 2006). This is important since my previous experience could bias analyses (Agar, 1996). Additionally, I was able to connect with several important people, or "gatekeepers," in the hobby. This includes two editors of major aquarium magazines, speakers at the national MACNA, speakers at freshwater aquarium club meetings, professional researchers in aquaculture, scientists from the California Academy of Sciences, aquarium club members across the United States, aquarium technicians and local fish store, or *"LFS,"* workers, as well as other leaders in the hobby. Using these connections, I made a network of individuals that I ask to comment on my conclusions of the hobby. Online discussions aided in receiving critical reviews.

Lastly, the results below follow an internal documentation system used to describe the data. Data from participant observation and content analyses are "Field notes" while interview quotations have a pseudonym attributed. Terms italicized throughout are community-applied terminology (Ritchie et al., 2014, p. 193). The Texas A&M University Institutional Review Board, IRB2017-0405 D, approved all protocol. All interview data and contact information are stored in accordance with the IRB protocol.

RESULTS

In this study, I discovered caring for a home aquarium (1) is largely motivated by aesthetic reasons, but (2) communicates science latently, over time, (3) and long-term aquarium keeping leads to a personal response in science, as well as conservation. Reviewed below, these findings are first situated within the context of the hobby—one that relies heavily on aesthetics.

Aesthetic Value of the Hobby

The following data exemplify the importance of aesthetics in aquarium keeping. Aesthetic value not only comes from the organisms themselves (i.e., color, movement), but also from the ecosystem as a whole including the display of the system itself. For example, serious aquarium keepers maintain large systems housed within a wall of their home:

> *"In my opinion, all the technical equipment should be unobtrusive, hidden and quiet (at least if not used to make sound), and simply should work. There was no choice, then; the new system would have to be an in-wall design." (TOTM Aug 2006)*

> *"For purely aesthetic purposes, the aquarium also needed to have no visible pumps and equipment." (Field notes)*

These quotes show the importance of a sleek, professional look with life-sustaining equipment hidden from view. Many regard this as reminiscent of a photograph hanging on a wall. In fact, some aquarists identify aquaria as "moving pictures," akin to colorful, moving photographs. Previous experience in the aquarium hobby also supports these data; many new aquarists pick organisms based on color and completely disregard compatibility. In fact, unless explicitly told, new aquarists mainly learn to keep aquatic organisms though trial and error. Supporting these points are the following quotes:

> *"And a lot of people… it's a picture on a wall. I'm gonna set it up and I'm gonna forget about it. Well, it doesn't work like that." (Mike, 40+ years in the hobby)*

> *"I find the aquarium to be an amazing medium of expression… You can paint a beautiful picture with your wood, rocks, plants, and fish. In addition to that, your work of art is constantly moving, evolving, growing, and changing. I see this comparable to the transition from still art on paper and canvas to the modern art of film and cinematography. Aquascaping is a living, breathing, work of art." (John, 5 years in the hobby)*

> *"I'm most interested in movement" (Leslie, Less than one year in the hobby).*

> *"I selected these particular fish based on their different color, shape, and patterns." (Beginner Forums)*

> *"A variety of corals that offer just about every color and shape imaginable." (TOTM May 2002)*

> *"I am new to the hobby and just bought a 75 g tank. I was hoping to get some advice on some cool looking reef safe fish" (Beginner Forums)*

> *"I think I am drawn toward [stony coral] species because of the seemly endless variations of colors and shapes." (TOTM Sept 2015)*

> *"The colors and growth of each coral is what has flourished my love for them." (TOTM Feb 2010).*

> *"When setting up the tank, I was more concerned with color than growth. My experience showed me that corals will grow with patience, but selecting a few choice corals and placing them in optimal places really can make a difference." (TOTM Feb 2010).*

These data reflect the aesthetic values involved in aquarium keeping; they also connote scientific communication. For example, different colored fish and invertebrates usually belonging to different species. Essentially, the new aquarist is most interested in biodiversity, reflected in words such as "variety," "endless variations" sometimes specifying this as "color," "shape," "movement," or "pattern". One of the hardest things for new aquarists is identification of species and compatibility within and across species. Similarly, this includes behavior and growth.

Latent to Active Scientific Communication

By focusing on an individual organism's attributes, a non-scientific aquarist is introduced to scientific concepts such as "species" and "biodiversity." In fact, driven to increase various forms of color and movement, many aquarists unwittingly strive to keep a biodiverse tank. Further, within the confines of a captive ecosystem there are stocking limitations and compatibility issues that push aquarists to obtain more information on each organism they keep.

"In the years that followed I became more and more accustomed to the tank's requirements, and more information on stony corals became available to me." (TOTM Aug 2006)

Some aquarists identify joining an aquarium club or online forum as a turning point in their hobby; within that community, they can obtain accessible, increasingly specific knowledge and share their own. Here, the forum ReefCentral.com elicited such a response:

"While browsing on the internet I came across Reef Central. This was the turning moment for me. With the wealth of information that is freely shared among the great reefers throughout the world and with a little tweaking on my system I was able to keep fishes, corals (mainly LPS[1] and Softies[2]) and anemones alive." (TOTM May 2014)

"There is no end to learning, trying to optimize the environment for the animals while still having fun looking at them and sharing the knowledge." (TOTM Aug 2006)

These data support time in the hobby, including repetitive trial and error, leads to an increased knowledge of biology, ecology, animal physiology, zoology, and other natural science fields. Moreover, with specific organismal knowledge some aquarists begin to specialize in the organisms they can keep, or simply prefer. This continues an aquarist's informal scientific education and can spur specialization in one area or species, shown here:

"Due to the shallow depth of the tank and demanding requirements of the Acropora, I found myself forced to make a choice and decided to dedicate the tank entirely to SPS[3]." (TOTM Oct 2013)

In the data above, science communication is informal and thus sensitive to the true motivations of the hobbyist—through aesthetics. Additionally, as time progresses, aquarists strive to keep challenging themselves and the sensitivity to aesthetics gives way to other motivation. For example, an aquarist may change from fresh- to saltwater or back again, follow a specific artistic style (e.g., Iwagumi aquascaping style, Dutch Synthetic Reefing, Jungle Style; **Figure 2**), engineer their ecosystem by bypassing all-in-one aquarium kits and doing it themselves (i.e., "*DIY*."), or they may recreate a wild ecosystem in exacting detail (i.e., "*biotope*"). Increased attention is paid to the organisms as well as the "*aquascape*" (Figure 2; Amano, 1996; Veganbrian., 2012; Brenner, 2017). This further embeds non-science oriented aquarists to the biology and ecology of aquatic organisms and these organisms are not limited to fish.

Aquarists also challenge themselves to replicate wild ecosystems in exacting detail, a system called a "*biotope*." In a biotope, only organisms that are found together in the wild are housed together in the same captive system (Stawikowski, 1993). Creating a biotope requires a large amount of research to accurately replicate natural conditions and house the appropriate organisms and aquarium décor (Stawikowski, 1993). A rather general biotope, a "*miniature reef*," is often set up to display the oceanic biotope, or a "*slice of the ocean*," in their home (**Figure 1**; Pederson, 2018).

FIGURE 2 | Houston's Hiep Hong's "Jungle Style" 54 gallon aquarium, *Aqueous Reflection*, placed 116th at the 2017 International Aquatic Plants Layout Contest (IAPLC) (Brenner, 2017). He used specific species and his knowledge of them to create a living piece of art. Photo reproduced with the permission of the copyright holder [Hiep Hong].

Another aquarium keeping style similar to a biotope is a "species-only" system. A species only system is one that houses only one species of interest. Usually species-only aquaria house challenging or dangerous species such as electric eel, seahorse, mantis shrimp, or octopus. One of the most sought after organisms to challenge the skill of an aquarist are cephalopods; for example:

"[I] have the smaller Dwarf Octopus.… Life span can be short but wouldn't trade the experience with this one. Arrived unannounced at local pet shop, unable to resist." (Field notes)

"I have an A. aculeatus in one of my office tanks… and I spent almost a year prepping the tank for his arrival, with the understanding that I'd likely only have a few months with him." (Field notes)

"About 10 years ago I got a bimac and within a few day it laid eggs. Stopped eating and died a few weeks later. Second one was the most amazing pet I've ever had. I had him for 8 months." (Field notes)

Octopus are intriguing animals and aquarists appreciate them for their engrossing behavior, amazing ability to change color, shape, and movement, and their ephemeral nature. These attributes makes them one of the pinnacle species for the home aquarist and one that truly communicates to people who may not be as interested in aquarium fish, plants, or coral.

Personal Response Increases Conservation Ethic

Research on wildlife-oriented recreation (e.g., fishing) show participants may shift their focus from a consumption orientation to one that is conservation orientated toward

[1]LPS is an antonym for Large Polyp Scleractinian coral species such as *Acanthastrea* and *Favia* species.
[2]Softies is a term used for soft corals such as *Sarcophyton* and *Lobophytum* species.
[3]SPS is an antonym for Small Polyp Scleractinian coral species such as *Acropora* and *Montipora* species.

the wildlife in which they interact (Bryan, 1977, 1979; Oh and Ditton, 2008; Oh et al., 2013). For example, in a study across all angler types, anglers were initially motivated to participate for the consumption of the organisms (i.e., the removal of them from the wild). As the participant continuously interacts with the environment and the organisms, a conservation ethic emerges. A personal response was elicited by continued participation in a leisure activity and lead to an increase in conservation orientation (Bryan, 1977, 1979; Oh and Ditton, 2008; Oh et al., 2013).

Data collected for this study indicate aquarium hobbyists act similarly over time. New aquarists, and those with a casual orientation, are unaware of conservation implications stemming from the trade and undesirable behavior of aquarists. Undesirable behavior includes purchasing species that grow too large for captivity, purchasing animals without researching their requirements first, overstocking an aquarium, etc. Forums on the internet have regularly occurring conversations, and passionate debates, on these subjects. This is because long-term aquarists understand the importance of imparting a conservation ethic to new aquarists (Borneman, 2001; Tullock, 2001; Paletta, 2002; Delbeek and Sprung, 2005; Fenner, 2008). It seems it is up to the aquarium community to "*police*" the consumption and behavior of other aquarists, shown here:

> "*I think it's important that people reading the thread hear at least one person mention the fact that these are not animals that should be sought out. I hear they had a Wonderpus on the most recent episode of "Tanked!" and we all know that's not going to help anything.*" (Field notes)

> "*…I have to come out and say I am an advocate of tangs, however not a member of the tang police. In this sense I am interested in what is best for the fish.*" (Field notes)

According to Burns et al. personal significance of science and conservation facts is influenced by cultural, social, and political conditions in which they are produced and/or promoted (2003). Further, it is critical to involve all aquarists in scientific communication in order to contextualize and frame their interactions with the captive ecosystem and its inhabitants. Aquarium social groups, such as clubs and conferences, are ideal places to improve a science and conservation ethic.

Examples of an Embedded Scientific and Conservation Ethic in Aquarists

Perhaps due to the integration of professional scientists in the aquarium hobby (i.e., social and cultural conditions), some aquarists decide to follow advice from scientists or attempt to use the scientific method. An aquarist's understanding of the scientific method varies but a scientific ethic remains present in some aquarium keepers. For example:

> "*I tend to lean towards applying techniques to my reef by using proven data provided by the scientific method." (Field notes)*

> "*I'm just curious really of the science/method on it and what kind of factors affect it working vs them killing each other off" (Field notes)*

Due to aquarium keeping's massive participation levels and available biodiversity, some aquarists specialize in certain species. Specialization lead to the creation of species-specific clubs and societies within the hobby. Using money from club members and other donations, these clubs fund research on their species of interest. For example, the American Cichlid Association offers the Guy Jordan Research Fund ($600–1500), which specifically targets cichlid research. Other U.S. clubs have similar funds (Marine Aquarium Society of North America, 2016; American Cichlid Association, 2018; American Livebearer Association, 2018; Ohio Cichlid Association, 2018). Moreover, the Marine Aquarium Societies of North America has made it a point to incorporate science in their mission by offering publication funding for scientists (Dr. Junda Lin Memorial Fund), two $4,000 scholarships for undergraduate and graduate students, and a scientific poster presentation at their annual conference.

Again, seemingly motivated by passion for specific species, clubs and social groups also have "*species maintenance programs*" run by the aquarium community. These programs identify species in need and put captive individuals of that species in the hands of interested, and capable, home aquarists. Species maintenance programs are possible through the sharing of technical information about the species, often written up by aquarists as species reports. These have enough detail for aquaculture and laboratory use. Dr. Paul V. Loiselle, whose 50 years of experience as an aquarist turned into a scientific career studying fish in the Family *Cichlidae*, inspired programs such as CARES Preservation Program:

> *"The purpose of the CARES Preservation Program is to create a base stock of conservation priority species through encouraging hobbyists worldwide to devote tank space to one or more species at risk and distribute offspring to fellow qualified hobbyists, while forming an information network where possible between aquarists, scientists, and conservationists."*

Lastly, conservation is not only limited to species. Serious aquarists can become attached to the places their aquatic pet's live, or an *ex-situ* attachment to geographic place. This attachment motivates aquarists to take international trips to see, and potentially collect, organisms in their wild habitat. In conclusion, aquarium keeping has the potential to bond caregiver, organism, and wild ecosystem.

DISCUSSION

Understanding the human dimensions of the aquarium hobby is increasingly important. Due to previous mismanagement (i.e., Hawai'i; Tissot and Hallacher, 2003) as well as lack of any management whatsoever (e.g., the Philippines and Indonesia; Lunn and Moreau, 2004) wild ornamental fisheries are under intense scrutiny. In 2017, the state of Hawai'i closed its marine ornamental aquarium collection (McAvoy, 2017) and Fiji followed suit directly after on December 28, 2017 (Lacanivalu, 2018). Closing the aquarium trade to wild collection of organisms may be dutiful in the face of climate change; however, the positive

short- and long-term effects of aquarium keeping on the home aquarist will be altered.

In this study, I discovered caring for a home aquarium is largely motivated by aesthetic reasons. In addition, aquarium keeping latently communicates science and long-term aquarium keeping may lead to a personal response in science and conservation. Aquarium keeping depends on the aquarist to be responsible for the organisms under their care. That is the point of the hobby. As one aquarist puts it:

> *"Little did I know what started off as a free tank and a couple clown fish would have developed into a lifelong passion." (TOTM Oct 2013)*

Finally, this research indicates ichthyologists and natural scientists may be encouraged to study science and conservation through latent scientific activities such as aquarium keeping (Maceda-Veiga et al., 2014; Marchio, 2015). These results indicate aquarium keeping may offer people the ability to informally increase their science and conservation ethic in a way that is creative, challenging, and always changing.

IMPLICATIONS AND FUTURE DIRECTIONS

Due to the consumptive nature of aquarium keeping and its reliance on wild caught organisms to maintain and invigorate the hobby, it is necessary to explain where an increase in science and conservation orientation breaks down. As shown above, serious aquarists may become more science and conservation oriented as they participate in the hobby, but not all follow this path. In fact, they may decide to do things that are not scientific nor conservationally aligned. Motivated by other factors, some aquarists are willing to break the law to keep threatened or endangered species. For example, in 2006 when one person turned in another for keeping what they thought, or what may have been an illegal coral species, the marine aquarium community debated. This conversation is not uncommon; here it took part on www.reefcentral.com, one of the post popular reef aquarium websites and community forum. While many had conservation-oriented views such as this:

> *"I think that the problem with posting illegal corals is that it may promote the collection of them." (Field notes)*

> *"Illegal coral collection is all of "our business," coral reefs are for all of us to enjoy and are all of our responsibility. I am not going to let someone else take a rare and illegal coral from the ocean for his personal enjoyment, resulting in the fact that I and everyone else will never be able to publically enjoy the benefits of that coral through a recreational dive or the general economic an recreational benefits that coral provides by being in the wild." (Field notes)*

Other aquarists feel much differently and do not appreciate other aquarists policing the actions of fellow hobbyists, even at the potential detriment of their hobby. Within the same online thread as the quotes above, fellow hobbyists dissented with the actions of the whistleblower rather than the illegal activity:

> *"I can understand why one should not endorse the collection of illegal corals. However, I think we can all agree that collection of Carib[4]corals for the aquarium industry will never mean the Atlantic reef's destruction. It is not [Dr. Eric] Borneman's place to play reef police by covertly turning someone in." (Field notes)*

> *"Still [Dr. Eric] Borneman actually narced out Bomber for his Carib coral. My opinion of Borneman has definately taken a hit.… You just don't go dropping the dime on fellow reefers. I mean it is not like Bomber poaches coral for a living. Not cool at all." (Field notes)*

Conservation issues seem more prolific in the saltwater aquarium community. The freshwater hobby is overall less expensive, older, more specialized, and it is currently not as reliant on wild caught organisms as it was in the past. These attributes must have meaning since there are 10 million more freshwater aquarium keepers (American Pet Products Association, 2017) with a seemingly higher conservation ethic. Further, antecedents to participation in the hobby should be studied; for example, brand new aquarists may already interested in science and conservation. Future research is required to unpack these major points.

In conclusion, it is important to understand the human dimensions of aquarium keepers across the United States, and globally, to continue understanding the human effect of home aquarium keeping. With 10% of the U.S. population *already invested* in keeping an aquarium, developing and facilitating scientific and conservation communication may aid in increasing a science and conservation ethic.

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The author confirms being the sole contributor of this work and approved it for publication.

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[4]In 2006, Caribbean corals had limitations on take for the aquarium hobby.

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