QUALITATIVE ANALYSIS OF THE SALTWATER AQUARIUM TRADE: THE PROCESS OF SPECIALIZATION PROMOTES SCIENCE AS A LEISURE ACTIVITY

A Dissertation

by

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ABSTRACT

Aquariums adorning the homes of hobbyists are ecosystems, specifically oriented to add a visual component to the living space. This hobby and trade utilizes animals that humans do not connect with on a regular basis. Home aquarium keeping, specifically the saltwater form of participation, requires daily contact (i.e., care) with the system and the organisms within. The captive environment facilitates contact with aquatic organisms. The main premise of this study was to investigate, using ethnographic methods, the interaction between saltwater aquarium hobbyists and the activity of at-home aquarium keeping.

The serious leisure and specialization frameworks provide a guide to this study. These constructs delineate various forms of participation in other resource-oriented leisure activities such as birdwatching and boating. These hobbies affect wild resources, and when explored using specialization, managerial recommendations become evident. Due to increased focus on the aquarium industry as an under-regulated wildlife trade, these two constructs provided the opportunity to not only understand the participants in the aquarium hobby, but also identify sustainable management techniques.

This study found saltwater aquarists are serious in their hobby from the onset. In addition, the ability to keep aquatic organisms alive requires the hobbyist to continuously gather information in order to maintain participation. Knowledge is obtained through research (i.e., sources) or second-hand information. Both modes rely

heavily on the aquarium keeping social world. Furthermore, this study indicates saltwater aquarists are motivated to continue participation towards the pinnacle of participation, an aesthetically pleasing miniature reef display. A “mini reef” requires perseverance through stages of involvement, each building on the last. Most notably, progression towards a reef aquarium requires the aquarist to increasingly think, and act, like a scientist. In fact, a major result of this study delineated several scientifically oriented niches of specialization in which a hobbyist could demonstrate expertise. Niches provide reef hobbyists to find a place of distinction, and personal identity, within a challenging hobby populated by a number of other capable participants. In many ways, these niches resemble scientific specialties or branches of study.

Further studies should aim to untangle this connection, the potential for aesthetic motivation to mediate the two, and the ability of the hobby to create scientific niches that facilitate scientific careers.

DEDICATION

This dissertation study and its time and energy is dedicated to the Murphy, Marchio, and Powell families. Whatever personality traits, grit, and determination I possess, it was they who supported me in the completion of this work.

ACKNOWLEDGEMENTS

I would like to acknowledge my committee and the mentors who provided personal support through my dissertation journey. Without them, I would surely fail.

I would also like to acknowledge the grit and determination I mined within myself *each day* to overcome feelings of inferiority. This dissertation is the outcome of years of perseverance and work, that which cost me greatly. If you decide to take the Ph.D. journey, I implore you to read two essays I have written in *Science* – one at the start of my degree, one at the end. They lend insight into the uncalculated personal costs associated with this endeavor.

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This work was supported by a dissertation committee consisting of Professor David Scott and Professors C. Scott Shafer and Gerard Kyle of the Department of Recreation, Park, and Tourism Sciences and Professor Jessica Light of Wildlife and Fisheries Sciences. All work for the dissertation was completed independently by the student.

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NOMENCLATURE

Aquarist and **Aquarium-Keeper** are used interchangeably throughout this dissertation. Unless specifically noted, these terms refer to saltwater hobbyists (i.e., not fresh- or brackish water hobbyists). Similarly, **Saltwater** and **Marine** are used interchangeably, both referring to oceanic organisms.

FO	A fish-only saltwater aquarium
FOWLR	A saltwater aquarium fish fish-only with live rocks
LFS	A local fish store; specifically a store close to the person using the term and one that sells only fish and fish-related supplies (i.e., not a pet store)
Science as Leisure	Defined by Marchio (2018) as a leisure activity with an essential scientific component
Serious Leisure	Defined by Stebbins (1992) as the systematic pursuit of an amateur, hobbyist, or volunteer activity that is sufficiently substantial and interesting for the participant to find a career there in the acquisition and expression of its special skills and knowledge.
Specialization	Refers to a continuum of behavior from the general to the particular reflected by equipment and skills used in the sport, and activity-setting preferences. (Bryan, 1977).

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CHAPTER I

INTRODUCTION

Context and Statement of the Problem

I will investigate the various impacts involvement in the home aquarium hobby has on participants. Specifically, the investigation focuses on serious saltwater aquarium keepers. This community is comprised of individuals who maintain at least one marine (i.e., saltwater) aquarium in their home or office space, participate in the hobby while living in the United States, and are active in some aspect of the aquarium keeping the social world. Other aspects of serious aquarium keeping involve science skill, knowledge, and aesthetic interest (Marchio, 2018). This study investigates impacts on participants, such as skill development, identity formation, and scientific outcomes of participation.

The marine aquarium hobby was chosen for investigation due to its close relationship with the freshwater aquarium hobby, a large population of participants that take part in the activity in various ways. This variation is reviewed in Maceda-Veiga, Domínguez-Domínguez, Escribano-Alacid, & Lyons (2014), which also addresses the activity as one with a scientific and conservation element to participation. For example, they state the activity of keeping freshwater aquaria is an "enduring hobby" involving "natural systems" and "serious aquarists and their associations can directly assist and fund scientific research, increase conservation awareness among the general public and even participate in ex situ and in situ conservation programs for native fish species at

national or international levels". My study aims to explore a similar activity – saltwater aquarium keeping – with their results in mind.

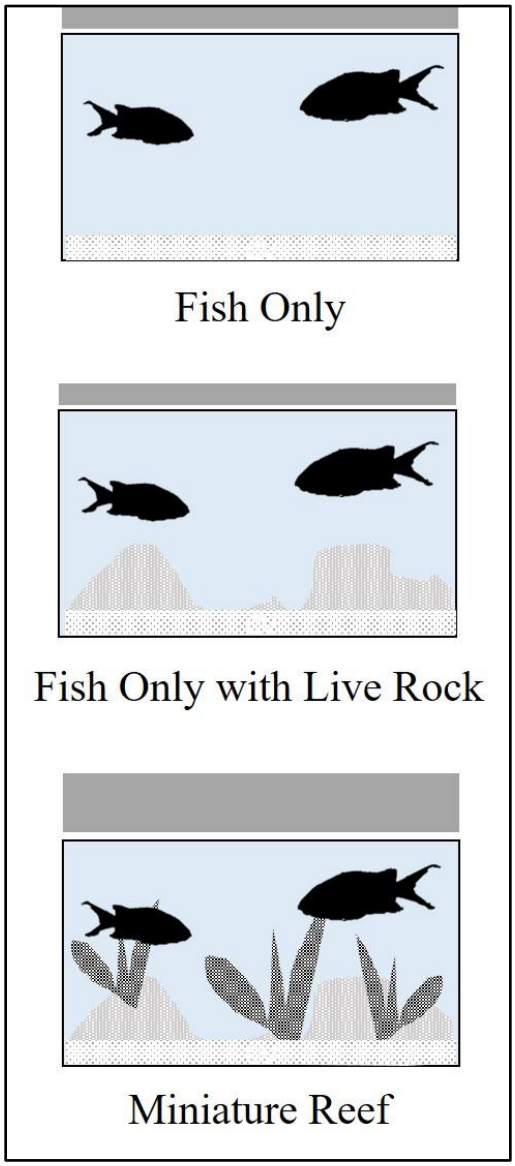


Figure 1: The three marine aquarium types as reported by home aquarium keepers.

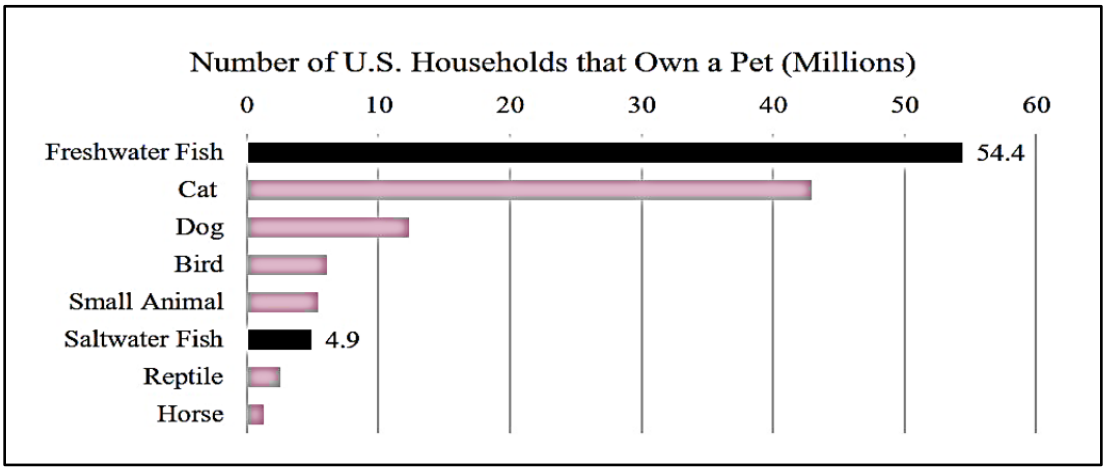


Figure 2: The number of households with a home aquarium in the United States. 2015-2016 National Pet Owners Survey by the American Pet Product Association; data visually adapted by Elizabeth A Marchio.

Conceptual Framework

One of the two conceptual frameworks I used in this study included *serious leisure* as developed by Robert Stebbins. Stebbins (1992) defined serious leisure as "the systematic pursuit of an amateur, hobbyist, or volunteer activity that is sufficiently substantial and interesting for the participant to find a career there in the acquisition and expression of its special skills and knowledge" (p. 3). The serious leisure framework guided this research and demarcated six major characteristics of serious leisure participation. These characteristics are either exclusive to serious leisure and recreation participants, which distinguishes them from other, less serious, participants in the same activity. These characteristics are:

1. A need to persevere at the activity
2. The availability of a leisure career
3. A need to put in effort to gain skill and knowledge
4. The realization of various special benefits
5. A unique ethos and social world
6. An attractive personal and social identity

Serious leisure, as applied to this activity, also integrated the second conceptual framework: *specialization*. Proposed by Bryan in 1977, specialization offers a framework that places participants' behaviors and preferences in the activity along a continuum from a "casual" to "committed". Although there is an ongoing debate as to if progression is a predictable phenomenon (Scott & Shafer, 2001), it is evident that those who progress develop into participants that are more specialized. Increasingly specialized participants have gained more skill and knowledge as well as forming an identity unique to committed participants. This varies from the generalist, or one that is a passing "tourist" in the activity, to the highly specialized and committed devotee.

Purpose of the Study

The purpose of this study was to explore participation in the marine aquarium hobby with the use of the serious leisure and specialization frameworks. Specifically, I aim to: (1) describe the variation that exists across all serious participants, (2) define and understand their development, and (3) delineate and define the specializations they become serious about. Additionally, I was interested in describing the scientific aspects

involved in marine aquarium keeping, from the accumulation of scientific knowledge and skill, to an emergent conservation orientation. These aspects are capable of being studied using the two conceptual frameworks outlined above.

Research Questions

Three research questions guided the data collection and analysis of this investigation.

1. What variation exists across serious marine aquarists?
2. What is the nature of progression among serious marine aquarists?
3. How do serious marine aquarists distinguish themselves (i.e., specialize) from non-serious participants?

Rationale and Significance of the Study

Aquarium hobbies are accessible activities to the public, commercialized in pet stores such as PetCo. As a commercialized activity, marketing to future participants will rely on understanding their interests and consumption habits. Thus, it is rational to pinpoint commercially valuable activities in a study on activity participation. Hobson Bryan chose to look at angling which allowed for the demarcation of four variants of participation. His rationale was to better understand the activity for management specific purposes (Bryan, 1979). The rationale for my study is similar and starts at the exploratory stage of inquiry – assessing the viability of the framework to assess an already serious activity. Further, like angling, saltwater aquarium keeping "uses" wildlife. While anglers may keep the fish they catch for food, or release them back into

the environment, saltwater aquarium hobbyists exclusively remove wildlife. Understanding the participants in this type of activity is not only an extension of the framework and theory associated, it also lays the groundwork for future studies on managing ornamental fisheries from a consumption/commercial perspective.

The rationale of the study stems from the need to assess within activity variation. The marine aquarium-keeping hobby is capable of being differentiated in several ways. Further, little documentation was found regarding saltwater aquarium hobbyists. Their activities in relation to their hobby are entirely unknown to others unless shared by the aquarist or researched specifically by interested parties. The location of the hobby is often private, within the home, so few people but the hobbyist knows what takes place. Further, the specialization and serious leisure frameworks are used to parse out variations within the activity, and is used to describe their attributes and progression towards seriousness. The rationale of this study is to document *how* home aquarists participate in the hobby, particularly since the keeping and trading of live organisms has become an emergent ethical dilemma among aquarists and non-aquarists.

The significance of this study stems from a conservation concern. More than 90% of the live organisms in marine aquaria are *wildlife* (Cato & Brown, 2003; Chapman, Fitz-Coy, Thunberg, & Adams, 1997). Per year, approximately 45 countries export 20–24 million fish, 9–10 million non-coral invertebrates, and an unknown number of individual coral colonies from the wild (Tissot et al., 2010; Wabnitz, Taylor, Green, & Razak, 2003). Developing countries are especially big exporters of wild-sources reef life (Fujita, Thornhill, Karr, Cooper, & Dee, 2014). Due to a lack of

transparency, this highly consumptive hobby is extraordinarily data deficient (Fujita et al., 2014).

Further, making this study significant is that the aquarium trade is integrated into the recreation and leisure markets, thus putting live organisms into the retail environment (i.e., from "reef to retail" (Holthus, 2001, 2007)). Results of this study will divide activity participants into various participation styles which can, in turn, be used for various ends. One end can be to extend and better understand the leisure frameworks (e.g., to assess a serious activity). Another is the applicability of the results to inform consumer and commercial interests. For example, some hobbyists may be pinpointed and marketed to specifically, which may aid in the commercialization of certain products to certain types of aquarium keepers. Another end is to divide the activity into segments that applied to methods of environmental management. For example, similar to Bryan's study on anglers (i.e., a consumptive wildlife activity), saltwater hobbyists can be better understood as a collection of participation styles, each capable of different techniques to better manage the "use" or "take" of aquarium organisms. This study is one step towards understanding an activity with a large number of hobbyists (i.e., 4.9 million in the United States, alone) and has an extraordinarily large impact on wild ecosystems in developing countries.

Assumptions, Limitations, and Delimitations

Assumptions

1. Participants completing in-depth interviews were serious in their hobby orientation.
2. Study participants answered as honestly as possible.

Limitations

1. Informants all had miniature reef aquaria, or propagated marine organisms as a hobby. Other non-reef aquarists may have serious orientations toward the hobby.
2. Participants were initially asked for their duration in the hobby; however, it became clear many aquarists stopped and restarted participation, sometimes numerous times. Thus, age in which they began keeping aquaria was instead used a gauge of participation, and an indicator of perseverance.
3. Asking participants to answer retrospectively presented a certain measurement or response bias.

Delimitations

1. Recruitment for interviews focused on participants at the Marine Aquarium Conference of North America (MACNA).
2. Limited sampling of local and regional social groups was undertaken. This was because some regions of the United States allow aquarium hobbyists to have entire basements full of fish tanks; a benefit for aquarium keepers who desire to keep more than one aquarium.

CHAPTER II

LITERATURE REVIEW

Review

The previous chapter introduced the context and problem, the conceptual frameworks used to explore the problem, and the overall purpose of the study. There I also laid out three research questions informing the dissertation inquiry, as well as the rationale and significance, and limitations of the following work. To answer my research questions, this dissertation lays a qualitative foundation exploring the modern aquarium hobby and its variability, specifically using science as a sensitizing concept.

In this chapter, I review the relevant literature in order to support the rationale, purpose, and significance of this study. Reviewed in five sections, I first give a general review of what leisure and recreation mean in the United States, as the term *leisure* is complex and necessitates unpacking. Second, I review the conceptual frameworks I used for this project, specifically, serious leisure and recreational specialization. Third, I review the aquarium trade, aiming to give the reader a background in its variability and connectivity to science and conservation. Lastly, the fourth section of this chapter ties leisure and science together, and the fifth and final section concludes this literature review.

Leisure and Recreation in the United States

Leisure and recreation encompass a vast array of activities. Activities such as playing bridge (Scott & Godbey, 1994) or watching television (Stebbins, 1997) are relatively straightforward when regarded as a leisure activity. Gelber defined leisure in three fundamental assumptions, (1) it takes place in time free from work obligations, (2) are voluntary, and (3) are pleasurable. Comparatively, recreation involves more action and can be conceptualized the as "re-creation" of the body and mind, often through body movement (e.g., running, kicking, jumping). When conceptualized this way, deciphering the difference between leisure and recreation becomes a bit more straightforward with activities such as backpacking (Lum, 2015), hunting (Bryan, 1979; Kuentzel & Heberlein, 1992), and birdwatching (Lee & Scott, 2004; McFarlane, 1994) mostly defined as a recreation activities. Further, recreation activities are often those outside the home.

This study focuses more tightly on leisure over recreation since aquarium keeping is better defined as a leisure activity. Supporting this, leisure can be conceptualized, or defined, on a contextual basis, including time, activities, and a state of existence/mind (de Grazia, 1962). In a time-based conceptualization, leisure may be delineated from other forms of time as "free time" (Stebbins, 2005c, 2005a) or time that is not work (i.e., a dichotomy; Gelber, 1999; Shen & Yarnal, 2010). In an activity-based conceptualization, leisure is defined based on the activity itself (e.g., project-based leisure; Stebbins, 2005) or based on a certain level of participation (e.g.,, amateur versus professional; Stebbins, 1992). Perhaps the most challenging to quantify is defining

leisure as a state of mind (e.g., Flow; Csikszentmihalyi, 1990). Aquarium keepers (thereafter referred to as aquarists), identity their activity as a hobby. Thus, it makes intuitive sense to explore aquarium keeping from a largely leisure perspective. Regardless of the level of action or re-creation involved in a pastime, both leisure and recreation may be explored similarly using two complementary conceptual frameworks: serious leisure (Stebbins, 1982) and recreation specialization (Bryan, 1977, 1979).

Conceptual Frameworks

Overview

To explore the participatory variation in the aquarium hobby, I utilize both serious leisure (Stebbins, 1982) and recreation specialization (Bryan, 1977, 1979). Coincidentally, these constructs were formed within five years of each other and are capable of exploring similar questions about involvement (Scott, 2012). Stebbins and Bryan constructed ways in which a researcher can delineate various forms of participation along a continuum of involvement.

Generally, these frameworks are used to measure *intensity* of involvement and within-activity *variation* across a spectrum of participation (Scott & Shafer, 2001). Variation led to a classification of different "styles" of participation, which are based on different attitudes, preferences, and motivations (Scott & Shafer, 2001). In this study, for example, I explore variation in involvement within the aquarium hobby. Due to the high level of participation in the aquarium hobby writ large, I focus on one major

participatory variation – the saltwater aquarium hobby. This is further reviewed in the third section of this chapter.

Stebbins and Bryan focused on different aspects of involvement (Bryan, 1977, 1979; Stebbins, 1980; Stebbins & Hartel, 2006), with Stebbins pursuing over 30 years of research on *serious* participation while Bryan chose to formulate his construct as a managerial technique to *categorize* natural resource users and their orientation to the natural resources they use (i.e., anglers; Bryan, 1977, 1979). Specifically, these frameworks differ in that serious leisure focuses on the serious participants across a typology of involvement while specialization offers a way to delineate and describe the heterogeneity within an activity (i.e., not just serious involvement; Scott, 2012; Scott & Shafer, 2001). Arguably, however, these constructs are two sides of the same coin (Scott, 2012). While conceptualized separately, these frameworks are capable of assessing similar phenomena. Empirical studies exemplify this connectivity (S. Lee & Scott, 2013; Tsaur & Liang, 2008).

In addition, subsequent analyses have shown an empirical relationship across serious leisure and recreational specialization dimensions (Lee & Scott, 2013), further supporting their simultaneous use to explore the saltwater aquarium hobby. Lee and Scott used data from birdwatchers and found four dimensions of serious leisure and two dimensions of specialization were strongly correlated. Subsequently, these authors created a single dimension, “seriousness”. These dimensions included identity, perseverance, career, significant effort and personal and behavioral commitment. Their results indicate these two frameworks may be measuring the same phenomena.

Furthermore, specialization allows me to define the existence of *movement* along a continuum of specialization. This is important as it supplements and provides a relationship between the stages of involvement as well as the two constructs. Hobson Bryan described recreation activities as having various styles of participation, and various stages of participation (Bryan, 1977, 1979). For example, he described anglers as existing in four different segments of the angling population (i.e., styles) and these were developmental stages towards a specific end (i.e., trout fishing in specific environments with specific tackle). Thus, specialization and serious leisure can be understood as a *process* of development and not just a typology describing variation in participation.

In his multi-faceted review of the two frameworks, David Scott and colleagues connected the typology of serious leisure and the process of specialization under what he refers to as Seriousness (Scott, 2012). Scott added the missing empirical element to serious leisure by connecting it to specialization (S. Lee & Scott, 2013). This was done by assessing the correlation between four dimensions of serious leisure and two dimensions of specialization. Results found these six characteristics were moderately to strongly correlate with one another. These findings indicate the utilization of serious leisure would be incomplete without including specialization (S. Lee & Scott, 2013; Scott, 2012). For example, the dimensions of each framework overlap, or are conflated, thus showing they are similar in nature.

Leisure and recreation participants are not homogeneous and thus, leisure experiences are complex enough to warrant understanding serious participants along a continuum of involvement (Shen & Yarnal, 2010). Until recently, research on serious

leisure tended to distinguish serious? participants from casual participants. A contribution of the specialization framework, thus, is to place all participants along a continuum from casual to committed, and the continuum includes a myriad of participation styles (Scott & Shafer, 2001).

In this study, I explore participation in the saltwater aquarium hobby, describing different styles of participation. The construct of serious leisure (Stebbins, 1979, 1982) allows me to explore and understand the intensity of involvement in the aquarium hobby and characteristics of participation. For example, the six characteristics of serious leisure have been used to understand serious participation in a multitude of activities, from card games (Scott & Godbey, 1994, 1992) to recreational boating (Kuentzel & Heberlein, 2006). Using recreational specialization (Bryan, 1977, 1979) allows me to describe various participation based on differences across involvement (i.e., delineating among different types of serious aquarists) and focuses on possible outcomes of specialization, namely the construction of a conservation ethic. Involvement has been defined as "an unobservable state of motivation, arousal or interest toward a recreational activity or associated product" (Havitz & Dimanche, 1997, p. 246). Involvement occurs when a stimulus occurs and drive towards a goal is realized (Rothschild, 2001). I then close the conceptual framework section with a clearer description of what I call "science as leisure".

Serious Leisure

Perspective

This conceptual framework focuses on specialized participants in an activity. Participants exist in spectrum of involvement in the activity (Scott, 2012; Scott, Cavin, & Shafer, 2007; Scott & Shafer, 2001), and Stebbins focused on the most specialized participants in this spectrum. I defined specialists in the saltwater aquarium hobby by using this framework, and thus I outline Stebbins' conceptualization, which includes six characteristics used to delineate specialized participation, motivation for serious participation, and the intersectionality of science. Lastly, I put forth a unique conceptualization of the framework to study leisure activities that integrates a scientific component in what I refer to as "science as leisure" activities.

Conceptualization

In 1982, Robert Stebbins coined the term serious leisure as "the systematic pursuit of an amateur, hobbyist, or volunteer activity that is sufficiently substantial and interesting for the participant to find a career there in the acquisition and expression of its special skill and knowledge" (Stebbins, 1982 p. 3). Stebbins stated there are six qualities of serious leisure, including (1) occasional perseverance in the face of challenges, (2) a leisure-to-career trajectory, (3) display of significant effort based on special knowledge and skill, (4) obtaining durable benefits, (5) belonging to a unique social world and ethos, (6) and a tendency to strongly identify with the activity (Stebbins, 1982, 2015). Participants in serious leisure activities gained, expressed, and

searched for rewards unique to their chosen activity (Figure 3; Stebbins, 2001). Stebbins refers to this as the serious leisure perspective (SLP).

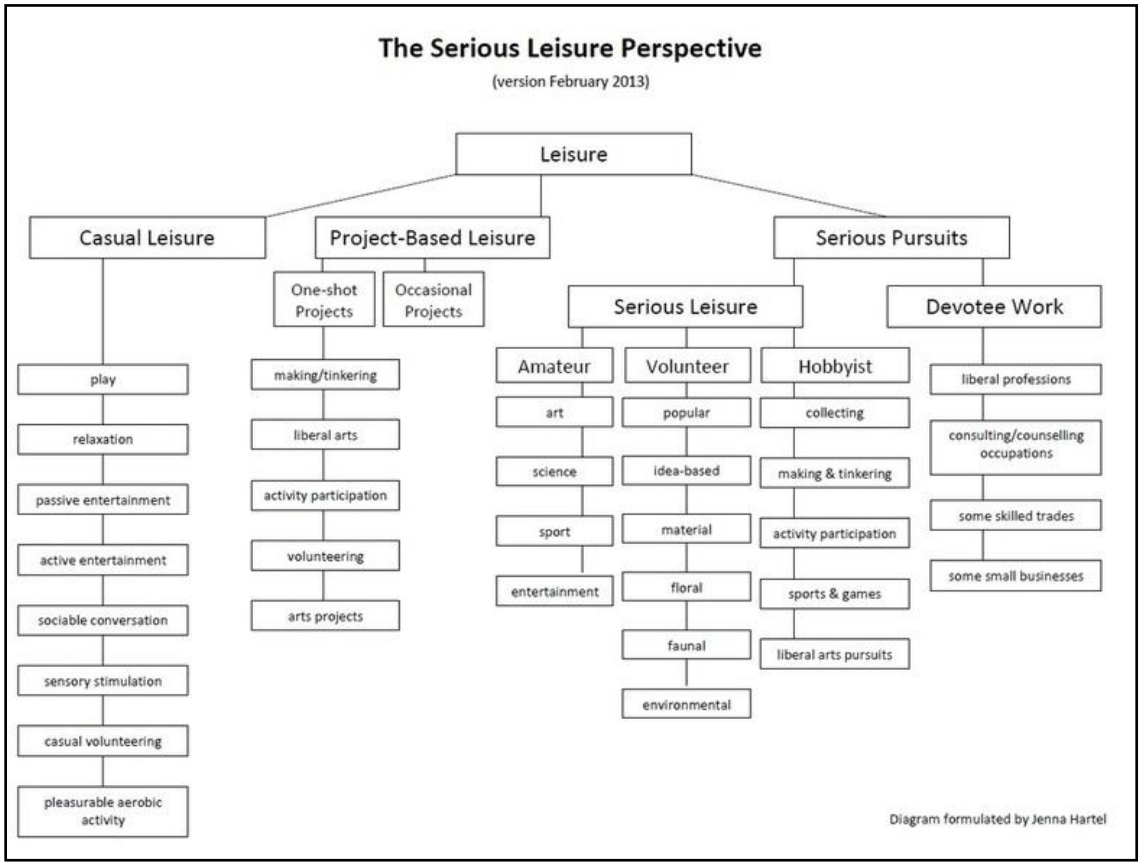


Figure 3: The serious leisure perspective. Adapted from www.seriousleisure.net.

Stebbins spent much of the past 35 years reviewing, recalculating, and reformulating the serious leisure perspective. To date, he uses the SLP hierarchy as a pseudo guideline for unpacking his perspective on leisure. Divided into three forms,

Stebbins conceptualized leisure activity to be either casual, project-based, or serious pursuits (Figure 3). Casual leisure includes passive forms of leisure such as watching television (Stebbins, 1997). Project-based leisure can be "one-shot" or "occasional" projects (Stebbins, 2005c, 2008), and serious pursuits are comprised of serious leisure and devotee work (Gallant, 2016; Stebbins & Hartel, 2006). Shown in Figure 3, Stebbins includes science in serious leisure, thus setting the foundation for my conceptualization of "science as leisure", reviewed in a subsequent section. Next, I review the six characteristics of serious leisure.

Characteristics of Serious Leisure

In his work, Stebbins (1992, 2001) outlined six key qualities of serious leisure. These qualities include a display of significant *effort* built upon skill and knowledge, *perseverance* in the face of challenges, the ability to belong to a social world with a unique *ethos*, and a strong *identification* with the activity, an available *career* trajectory within hobby-related activities, and obtaining *durable benefits* such as self-actualization and enrichment. In Chapter 4, these qualities distinguish types of saltwater aquarists (i.e., sources or sinks).

Displaying Effort, Skill, and Knowledge: The display of effort, skill, and knowledge are commitments measurable in terms of investments of energy, time, and money in the leisure pursuit (Stebbins, 2011). Aquarium hobbyists may use online discussion forums and aquarium club meetings to display their effort via photos, tank logs, and other

information specific to their unique aquarium ecosystem (e.g., “tank specs”; Figure 4). Sharing photos and detailed specifications communicates a commitment to a hobby and doing so online is a relatively easy way to display these facets if the hobby is extremely personal (i.e., taking place in a home setting). Further, the act of display relays serious activity to other hobbyists and sets behavior norms for other participants (Ditton, Loomis, & Choi, 1992). Done socially, the hobbyist may become a source of information for others or categorized as “showing off”. This may be an effort to build status (Taylor, 1995) or communicate participation preference (i.e., niche).

Effort connotes an accumulation of knowledge and skill, both of which are gained over time. Serious participants will have a relatively high level of knowledge and skill in their chosen activity. Aquarium related knowledge is wide ranging, from in-situ experience to expertise in water chemistry. Effort may also be indicated by the aesthetic attractiveness of the participant’s aquarium since selection and maintenance of organisms is a display of skill and knowledge.

Tank Specs

Display: Standard 40g Breeder 36" x 18" x 28" with 29g Display Refugium
Overflow: Eshopps Eclipse S
Lighting: Tek 6 Bulb T5 Fixture with Giessman Bulbs and a Reef Brite Lumi Lite for pop
Heater: 200w Jaeger
Circulation: Tunze Nanostream 6040 and Sicce Syncra return pump
Skimmer: Tunze 9004
Filtration: 20g Sump with floss
Filter Media: Fluval Carbon and Aquaforest Phosphate Minus when needed
Top Off: Tunze Osmolator Nano
Dosing: Few drops of Kent's Iodide by hand every day
Controller: Apex Jr

Figure 4: The "specs" or specifications of an aquarium set-up in an online journal.

Perseverance: The act of persevering in a hobby is one that pushes the participant through challenging times rather than giving up. They overcome obstacles, adversity, and find a way to continue participation. This facet of serious leisure is tightly connected to personal and behavior commitment, two facets of recreation specialization. Commitments that are personal mean the participant has a personal attachment or conviction towards participation (Scott & Shafer, 2001). This may be indicated by

organizing life around the activity (S. Lee & Scott, 2013). Behavioral commitment is one that leads the participant to invest in the activity at the expense of other hobbies or avenues toward building social connections. They end up relying on the activity for social connectivity (i.e., friendships). Among other acts, perseverance in the saltwater aquarium hobby includes restarting an aquarium system after a "tank crash".

Ethos: A unique culture and social world is expected to emerge from serious leisure activities. A social world refers to a social organization with no boundaries in space, time, formality, and membership (Strauss, 1978; Unruh, 1980). Instead, boundaries of social worlds are based on interactions and communications among members, transcending common organizational structure (Unruh, 1980). As an aspect of serious leisure, aquarium keeping is expected to have a unique social world, conforming to the stipulations presented by Unruh, above. In addition, the social world is tied to the culture, or unique ethos if the activity (Stebbins, 1999, 2011). In the aquarium hobby, a unique ethos may include special stipulations for participation and characteristics reflective of a unique culture and spirit.

Implied here, the unique ethos present in an activity is as unique as its social world. This implies diverse, or heterogeneous, participation in an activity. While unique ethos may seem a stable aspect of an activity, it is likely to change, or be a bit different across participation types. If the hobby promotes a scientific or conservation orientation, it could promote participants in the "STEM pipeline" (Blickenstaff, 2005). This does not

connote a complete limitation of upward mobility in a field of interest, but some participants may find science-related durable benefits in this activity.

Identity: One dimension that may motivate aquarists is the emergence, or maintenance, of a personal identity with the hobby. For example, some hobbyists may keep an aquarium because it reflects their personal identity (e.g., SCUBA diver) or it may offer them an identity separate from their paid work (Stebbins, 1979, 1982, 1992). Individuals in North America principally use work-related identity to distinguish themselves from others (Havitz & Mannell, 2005), so an identity separate from work is unique and significant. The activity of aquarium keeping could prop-up or create a personal identification with aquatic resources and or scientific interests.

Identity may be indicated through survey questions as in Lee, McMahan and Scott (2015). There they asked birdwatchers questions regarding their birdwatching identity, including "I am often recognized as one devoted to birding". This indicates others within the social world may be best suited to describe the identity of another participant. Utilizing snowball sampling, or the sampling of activity participants by word of mouth, will return those with a high level of ex situ (not self-classified) identification. Activities that have shown high levels of identification are varied and include participants in collegiate football tailgating and sport tourism (Gibson, Willming, & Holdnak, 2002; Green & Jones, 2005), birdwatching (Lee, McMahan, & Scott, 2015), bicycling (Shafer & Scott, 2013), and even sexual activities such as sadomasochism (Newmahr, 2010).

Career Trajectory: A key contribution of the serious leisure framework is that leisure interest can lead to a career (Gallant, 2016; Stebbins, 1979, 1992; Taylor, 1995). Stebbins touches upon science as a leisure activity in the context of amateur archaeology (Stebbins, 1979), an account later supported by Taylor (1995). This account links science and leisure, a facet I subsequently describe, specifically as a leisure activity that requires science to succeed.

Taylor (1995) explored the professionalization of archaeologists and stated, scientific amateurism is a "self-legitimizing component" of scientific professionalism. Thus, progress from aquarist to professional scientist is a logical career trajectory, with progress a component of the specialization process itself. Further, progress towards professionalism is not straight, nor it a mandatory for continued participation (Kuentzel & Heberlein, 2006; Oh, Sorice, & Ditton, 2010; Scott & Lee, 2010; Shafer & Scott, 2013), however, for those who continue down that path, it is certainly a possible outcome. Further, the career aspect of serious leisure implies progression. For example, Lee, McMahan, and Scott (2013) used indicators that asked if participants progressed or improved over time (e.g., I feel that I have progressed in birding over the years). Career progression in the aquarium hobby will take different forms and connotes progression.

Stebbins (1982) stated serious participants "…launch themselves on a career centered on acquiring and expressing its special skills, knowledge, and experience" (p. 3). It is important to note here that a career trajectory is not limited to one that is amateur

to professional but can take the form of anything expressing special skills, knowledge, or experience. These can be distinct forms of involvement, or specialization "niches".

Durable Benefits: This aspect of serious leisure is one Stebbins states is more prominent than in casual leisure (Stebbins, 1980). Casual leisure tends to have comparatively fleeting outcomes while serious leisure has much more durable, or long-lasting outcomes (Stebbins, 1980). Durable benefits include self-actualization, expression, and enrichment, the re-creation or renewal of self, feelings of accomplishment, an enhancement of self-image, and tangible products (Stebbins, 1980, 1992, 2005b). Additionally, he states that durable benefits increase when there is a relationship between the activity and amateurs (i.e., hobbyists), professionals, and the public (Stebbins, 1992). Simply put, the more social interaction there is between different groups, the more an amateur can obtain long-lasting benefits. Without a public and professional aspect, durable benefits simply are not as durable.

Aquarium hobbyists (i.e., scientific amateurs) may find motivation in these durable benefits. For example, an amateur scientist creates a tangible product at the end of a study (e.g., a research manuscript). Aquarium hobbyists should also show tangible outcomes of participation. These could include written documentation of experience or achievements, awards for "Tank of the Month", sellable-sized fragments of homegrown coral, juvenile fish they bred themselves, and so on. These physical durable benefits are akin to a painting or research paper (Stebbins, 2011) and their existence stems from accomplishment, self-actualization, and expression. Further, tangible outcomes could

encompass, or be a pathway, to an increase in status as it does in scientific fields (i.e., number of manuscripts). Providing tangible outcomes may also alleviate uncomfortable feelings stemming from participation in a highly consumptive activity (i.e., cognitive dissonance).

Becoming Serious

Aesthetic beauty seem to be a facet of motivation for some leisure and recreation activities. In a recent series of studies of boaters on the reservoir lakes on the Colorado River in the Highland Lakes region of Austin, Texas, the top four most cited factors boaters enjoyed most included the “scenic views”, “beauty”, “nature”, and “sunsets” (Kyle, Marchio, Shafer, Bradle, & Richardson, 2017d, 2017a, 2017c, 2017b). These enthusiasts cover a range of involvement (i.e., seriousness) and reflect attitudes towards aesthetics.

In birdwatching, participants become enamored by the organisms they seek (Kaufman, 1997). Birdwatching is vision-based whose participants use binoculars and other sight-aids. Participants invest in having the ability to visually enjoy birds, this connotes an aesthetic value. Further, the durable benefits of the hobby may result in aesthetic goods (e.g., photos). These facets are frequently encountered in serious birders. Considering aquarium keeping is highly observational, it is expected to harbor some aspects of aesthetic value for the participant. Observation-based leisure activities utilize a swath of scientific skills as well. For example, mushroom hunters were visually oriented towards understand the ecological characteristics of wild places, with specific

habitats being best for certain mushroom. Without ecological understanding, through close observation, it was difficult to find mushrooms in a timely, or in any manner whatsoever (Fine, 2003). Aquarium keepers pay very close attention to their aquarium ecosystem, which may allow them to make predictions regarding the environmental conditions and how appropriate they are for the organisms they aim to maintain in captivity.

Further supporting the dimensionality of aesthetics, in his work on amateur archaeologists, Stebbins (1979) explored "pot hunting" which is similar to a treasure hunt for archeological artifacts. He refers to this as a phase of participation, one that is observational, a clear connection to aesthetics. Further, treasure implies some sort of value, whether it be financial, a contribution to status, or for aesthetic value when displayed.

Activities such as boating allows participants to enjoy beautiful scenery, and some whose interest is more serious may try to organize their boating activity to maximize this attribute. For example, they may boat when there are less people on the water or during sunrises and sunsets. Birdwatching and pot hunting, on the other hand, pushes participants to find aesthetically distinct items, such as a new species for their "life list" or to collect various types of artifacts. Activities such as these build collections for the participant.

Stebbins (1979) refers to the hobby archaeologist as a "collector", but, he later stated professionals also collect artifacts. Collecting can be a serious activity with museums and art galleries full of collections. Interestingly, this indicates serious

participants may participate in the very activity they disparage (i.e., over collection, damaging collection activities). After all, Stebbins stated these more serious participants have, and uphold, cultural norms that curb inappropriate treasure hunting behavior (Stebbins, 1979, p. 164). For example, if the specialists, sources, or key social world participants collect, it is likely the inappropriate collecting behavior will continue.

Inappropriate activity may encompass breaking laws that endanger the pastime. For example, amateur archaeologists are presented repetitively with opportunity to touch or remove artifacts they find in the field. Those in the activity may take it upon themselves to police the activities of others, or this policing activity could cause or increase within activity tension (Stebbins, 1979). Norms, standards, and service are tenets of professional participation with those who have a higher status in the hobby setting and upholding the norms of the activity. The aquarium hobby may have a "treasure hunt" mentality, indicating something of value. Further, this mentality may cause tensions across participants and a mix of participants is expected to act in collecting behavior.

While status seeking or a yearning for distinction does not affect all participants, it has close association with aesthetic value and collecting (Gelber, 1999). In stamp collecting, participants are said to go through an "aesthetic phase", which means it is a stage a participant may pass through (Gelber, 1999, p. 115). This is indicative of a process, or development, that happens within an individual as they participate in the activity. Thus, collecting may be a form of distinction for some individuals rather than a definition of serious activity across all participants.

Collectors are a "complicated" type of hobbyist but one that seems strategically placed to progress towards a business-like approach to a hobby. A collector is defined as "someone who accumulates objects in a systematic way requiring the development of specialized knowledge" (Gelber, 1999, p. 78). For example, Gelber stated, "There is a natural progression in the hobby careers of collectors toward specialization and its associated expertise, which leads to a much more rational … business-like approach" (p. 79). Here, he was referring to the collector treating their hobby of collecting as a business with commercial outcomes; however, the act of collecting also creates career contingencies for those who can aid another individual at broadening their collection.

If collections are valuable to activity participants, those who collect these items or experiences create a market for those goods. For example, birdwatchers who aim to list birds (i.e., a collection of bird sightings) may be willing to pay someone to help them broaden their collection (Kaufman, 1997; Scott, Baker, & Kim, 1999). Thus, bird guides are a valid business venture for adept birders because collectors offer career contingencies to serious participants. Outside of collecting, other aspects of serious involvement can also lead to an associated leisure career, such as one in science. Inquiries regarding an individual's career in science are numerous but have not come to an agreed upon conclusion (Blickenstaff, 2005; Cronje, Rohlinger, Crall, & Newman, 2011a; Trumbull, Bonney, Bascom, Cabral, & Trumbull, 2000). Looking at leisure as a source of scientific interest and the beginning of a scientific career is rooted in my personal experience. Literature on the various aspects of leisure that connect to science

emerged during this project (e.g., collecting as a science, citizen science) and is included in this research.

Exploring Science in a Leisure Activity: While saltwater aquarium hobbyists refer to their activity as a "hobby", there is a striking scientific component in serious participation (Burtt, 2015; Maceda-Veiga et al., 2014; Marchio, 2015, 2018; Mayfield, 1979). For example, understanding the nitrogen cycle is required for success in keeping aquatic organisms in captivity (Borneman, 2001; Hunt, 2008; Yan et al., 2017). In fact, this scientific concept is one of the most rudimentary things an aquarist must acquire. The connectivity may slowly build so that the hobbyist, or an outside observer, may not see the hobby as scientifically oriented, but books on professional forms of aquarium keeping (e.g., aquaculture) shed light onto this connection (Figure 5). The figure below provides support for the connectivity between the maintenance and breeding of marine organisms to a career in a scientific field (i.e., aquaculture). Due to the existence of a "genuine professional aspect" (Stebbins, 1980, p. 416), or a scientific career contingency, aquarium hobbyists can be defined as non-professional scientists.

This begs the question, what is a scientist? In this study I define a scientist as (1) someone who utilizes the scientific method as a process of understanding and/or (2) someone who uses scientific fields to explain or understand the world around them. For example, a novice aquarist does not normally have an understanding of water chemistry or the chemical nitrogen cycle of a captive ecosystem. The new aquarist is not a "scientist". However, this may change as indicated by their use of scientific language to

explain aquarium processes, in this case chemical, to others. The qualitative nature of this study enables me to make such assessments. Further, I draw upon philosophical definitions of science, which occurs before the professionalization of science. Thus, a professional in science is not a limitation to who may be called a scientist. Defining a scientist encompasses the gather and application of knowledge (Brossard, Lewenstein, & Bonney, 2005; Cronje, Rohlinger, Crall, & Newman, 2011b; Gieryn, 1983). There is no requirement for this to occur consciously. Thus, those who take part in aquarium keeping may be qualified as scientists if they obtain and utilize science facts or processes.

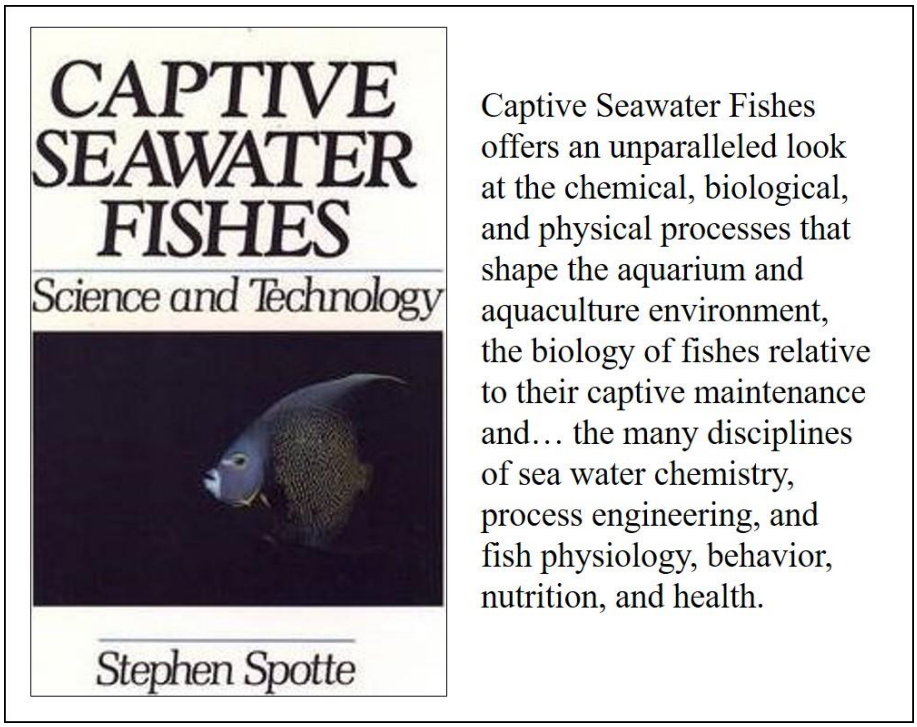


Figure 5: A connection between science and aquaria reprinted from the cover and inside flap of Spotte, 1992.

In his original conceptualization, Stebbins (1979) described non-professionals as amateurs, or "marginal men [sic] of leisure". As such, participants found themselves marginalized by professionals in their field of interest. For example, a professional scientist may delineate their work from hobbyists based on the acquisition of a degree in a scientific field (e.g., biology, chemistry), even if the hobbyist has more experiential skill and knowledge.

Similar to Stebbins, Taylor (1995) noted that non-professionals are on the "fringe" and that professionals may belittle the contribution of hobbyists or amateurs. Maintenance of a boundary between the professional and the non-professional is preserved through "boundary work" (Gieryn, 1983), further pushing to marginalize leisure participants. Gieryn (1983, p. 781) refers to this as the "construction of a boundary between science and varieties of non-science" specifically to demarcate "the acquisition of intellectual authority and career opportunities". Further he supports my use of "science" and "scientist" as a flexible definition that is rather encompassing. He states, "science is no single thing: its boundaries are drawn and redrawn in flexible, historically changing and sometimes ambiguous ways". Thus, motivational drivers for participation by amateurs must be suitably strong to overcome the boundaries placed on them by professional counterparts. Therefore, while an aquarium hobbyist may gather the appropriate knowledge and skill to qualify as a scientist, boundary maintenance or overt intimidation may push them to find distinction elsewhere, perhaps as a source of information within a specialized niche.

Conclusion

Serious leisure is the increasing experience with, and commitment to, a chosen leisure activity, referred to as "the systematic pursuit of an amateur, hobbyist, or volunteer activity that is sufficiently substantial and interesting for the participant to find a career there in the acquisition and expression of its special skill and knowledge" (Stebbins, 1982 p. 3). The literature presented here covers Stebbins' applicable work on serious leisure' connectivity to science. Next, I outline the second conceptual framework, specialization, and its applicability and overlap supporting their tandem use in this study.

Recreation Specialization

Overview

The goal of recreation specialization, hereafter "specialization", was to provide a framework for managers and researchers within natural resources to understand the diversity among recreationists who are all engaged in the same activity (Bryan, 1977, 1979; Scott & Shafer, 2001). Understanding the styles and stages of activity participation has practical value for both the resources and the industry involved in the activity (e.g., McFarlane, 1996; McFarlane & Boxall, 1996; McFarlane, Boxall, & Watson, 1998). Given the use of natural resources for the aquarium trade, and its large global industry, specialization is an appropriate framework to explore the conservation orientations of aquarium keepers. Used in tandem with serious leisure, I can explore serious saltwater aquarium keeping while understanding there are subsequent stages of

involvement and multiple career trajectories. Next, I review specialization to describe its usefulness to this study.

Conceptualization

The concept of specialization is rooted within the idea that within a specific recreation activity, there is heterogeneity in participation (Bryan, 1977, 1979). Using dimensions of specialization (reviewed below), activity participants can reveal heterogeneity, described as different "styles of participation" (Bryan, 1979). In the original conceptualization, Bryan found four stages of angling, from "Occasional" to a "Technique and Settling Specialist" (Table 1). Bryan delineated these different forms of involvement within the activity of fishing. For example, an occasional angler is one who participates on an occasional basis, aims to catch any fish in any water, and who participates with family. In comparison, a Technique and Setting Specialist utilizes specific equipment to catch specific species in specific conditions. These participants also have strict perquisites for setting and natural resources. These anglers take part in the activity with other specialists and may center their lives on the activity (Table 1). Specialization has been described as a robust framework capable of application to leisure activities in general (Scott & Shafer, 2001, p. 322). These activities vary from ultimate Frisbee (Kerins, Scott, & Shafer, 2007) to contract bridge (Scott & Godbey, 1994). Essentially, any heterogeneous activity that can benefit from stylistic delineation can use the specialization construct.

Table 1: The styles and stages of anglers, as described by Bryan (1979; p 45) and recreated by Elizabeth Marchio.

	General ⟷ *Particular*			
	Occasional	Generalist	Technique Specialist	Technique and Setting Specialist
Fishing Orientation	Desire to catch any fish on any tackle	Aim to catch their limit of trout on spincasting lures	Prefer large fish caught on fly-tackle	Aim to catch trout in specific conditions in spring-fed streams with fly-tackle
Resource and Management Orientation	Fish in any water that has fish	Prefers larger lakes and streams; supports the stocking of these water bodies	Prefer streams and supports harvesting policies that maximize size of fish caught	Prefer limestone spring-fed streams and support the preservation of the setting
Social and Leisure Orientation	Fishes with family; few fishing vacations	Fishes with peers; takes short regional vacations to fish	Fishes with peers and takes extended fishing trips	Fishes with fellow specialists and may center their lives around fishing

The specialization framework is largely used as an independent variable to predict facets of participation, including place attachment(Bricker & Kerstetter, 2000; Kainzinger, Arnberger, & Burns, 2018; Mueller & Graefe, 2018), attitudes toward resources (Donnelly, Vaske, & Graefe, 1986; Hyman & McMullin, 2018; McFarlane, 2004; McFarlane & Boxall, 1996; Needham & Vaske, 2013), conservation orientation (Hvenegaard, 2002a; Hyman & McMullin, 2018; Oh & Ditton, 2008; Siemer et al., 2017), physical and social setting preferences (Choi, Loomis, & Ditton, 1994; Kainzinger et al., 2018; Lepp & Herpy, 2016; S. R. Martin, 1997), and so on (Scott,

Cavin, & Shafer, 2007; Scott & Shafer, 2001). Using the specialization framework allows the researcher to measure intensity of involvement, classify participants based on their styles of participation, and attribute the existence of a facet under investigation.

In addition, varying styles of participation developed from specialization can be placed along a continuum that depicts involvement from the "general" to the "particular" (Bryan, 1979). The particular or high end of the spectrum includes individuals who are highly skilled, knowledgeable, advanced in technique and setting preferences, highly committed, have a strong group identification, and display distinctive orientations toward social setting characteristics and natural resources (Bryan, 1979; Scott & Shafer, 2001). For example, Table 1 delineates anglers with a particular style of involvement as those who aim to use their skills and knowledge in the activity to select the best location, bait, and season for catching specific fish (i.e., trout). These people qualify as serious or hardcore participants (Scott, 2012; Scott & McMahan, 2017; Stebbins, 1979, 1992, 2001; Stebbins & Hartel, 2006). The general or low end of the continuum includes novices, newcomers, or simply individuals who have little attachment to the activity (Gelber, 1999; Stebbins, 1979, 1997; Stebbins & Hartel, 2006).

After Bryan conceptualized specialization, he almost immediately stopped publishing on the topic. Since that time, many authors have conceptualized and measured specialization differently. Some dimensions used to understand the classification of participants include experience, skill and ability, centrality of that activity one's lifestyle, commitment, involvement, economic commitment, preferences, attraction, and self-expression (Table 2 & 3). Experience has been measured as time

spent in the activity over a lifetime, skill and ability are specific to each activity and can be self-classified or assessed by others within the social world (e.g., a "guru"), and centrality is the choice of participating in the activity at the expense of others. Table 2 and 3 display a tabulated form of some of the literature reviewed, including the authors, activity under investigation, their classification method for delineating homogeneous styles/stages of participation, the dimensions they utilized, the dependent variable, and the analysis utilized to text the connectivity between the specialization and the dependent variable. In Table 2, for example, Donnelly et al. (1986) assessed sail and motor boating activities and used an additive index to classify each participant's specialization level. To do this, they utilized four dimensions of specialization, including participation type, equipment, skill, and activity related interests. They analyzed the data using cross-tabulation with activity types (i.e., boating types) as the dependent variable. Table 3 is a continuation of Table 2 with no differences delineated between the two.

Table 2: Examples of the literature reviewed in this study.

Author(s)	Activity	Classification Method	Specialization Dimensions	Dependent Variable(s)	Analysis
Donnelly, Vaske, & Graefe, 1986	Sail and motor boating	Additive index	1. Participation 2. Equipment 3. Skill 4. Activity-related interests	Activity types	Cross-tabulation
Bricker & Kerstetter, 2000	Whitewater recreationists	Additive index	1. Experience 2. Skill and ability 3. Centrality of lifestyle 4. Enduring involvement 5. Equipment investment	Place attachment	ANOVA
Chipman & Helfrich, 1988	Fishing	Cluster analysis	1. Resource use 2. Experience 3. Investment 4. Centrality to lifestyle	1. Motivations 2. Attitudes toward resource management	Cross-tabulation
Bryan, 1977	Fishing	Cross- tabulation	1. Preferences 2. Resource orientation 3. Interest and activity 4. Centrality to lifestyle	Activity types	Cross-tabulation

Table 3: Examples of the literature reviewed in this study.

Virden & Schreyer, 1988	Hiking	Additive index	1. Experience 2. Recent Experience 3. Economic equipment 4. Centrality to lifestyle	Preferences: 1. Social 2. Physical 3. Managerial	Pearson correlation coefficient
Kuentzel & Heberlein, 1992	Hunting	No delineation of styles of participation*	1. Past experience 2. Commitment 3. Media involvement 4. Hunting organization 5. Hunting style	1. Behavioral choice 2. Quality of setting judgements	Correlation coefficient
Wellman, Roggenbuck, & Smith, 1982	Canoeing	Additive index	1. Investment 2. Past experience 3. Centrality to lifestyle	Depreciative behaviors	unclear
McIntyre & Pigram, 1992	Vehicle-based camping	Cluster analysis	1. Past experience 2. Familiarity 3. Attraction 4. Self-expression 5. Centrality	Attitudes toward resource management	Kruskal-Wallis analysis of variance
Kuentzel & McDonald, 1992	White water kayaking and canoeing	No delineation of styles of participation*	1. Past Experience 2. Commitment 3. Centrality	1. Motives for participation 2. Perceptions of crowding 3. Attitudes toward resource management	Zero-order correlation and regression analysis
Kuentzel & Heberlein, 1997	Sailing	No delineation of styles of participation*	1. Experience and freq. of participation 2. Boating behaviors 3. Evaluations of experiences 4. Commitment	1. Social status 2. Self-development	ANOVA

Based on personal communication with Bryan, Scott and Shafer (2001) formulated a conceptualization based on three overarching dimensions: (a) a focusing of behavior, (b) skill development, and (c) personal and behavioral commitment. Furthermore, these dimensions have been empirically confirmed in a study of birdwatchers (Lee & Scott, 2004), thus supporting their utility. Lastly, focused behavior, skill development, and commitment are sensitizing concepts used in this study to support the use of the specialization construct to explore conservation.

Sensitizing Concepts

Sensitizing concepts are abstract and thematic rather than hard and definite; according to Blumer (1954) they provide "a general sense of reference", "guidance in approaching empirical instances" and "merely suggest directions along which to look". Using these concepts helps ground my exploratory research in the specialization theory. The sensitizing concepts chosen are those from Scott and Shafer's (2001) critical review of the specialization construct, which deconstructed the conceptualization of specialization into three general dimensions: a focusing of behavior, skill development, and personal and behavioral commitment.

Deconstruction aided in making specialization more consistent (McFarlane, 2001) and conceptually clear (Kuentzel & McDonald, 1992). Sensitizing concepts guided my initial interviews and participant observation with saltwater aquarists, thus providing a place to start an inductive scientific method. There, observations are made with general concepts in mind and theory emerges from these observations and

descriptions. The links between conservation (a sensitizing concept) and leisure have already been documented in the literature (Bryan, 1977, 1979; Oh & Ditton, 2008) but have yet to be explored in the context of the aquarium keeping hobby.

Progression and Stages of Involvement

In addition to describing the styles of participation within an activity, specialization was initially used to segment an activity and its participants into different "stages" of involvement Bryan, 1977, 1979; Scott et al., 2007; Scott & Shafer, 2001). Specialization is not only a way to look at discrete styles of participation in the activity under study; it is conceptualized as a phenomenon that unfolds over time.

Focusing of Behavior: The first dimension that provides evidence of progression is a focusing of behavior. When participants do this, they emphasize one leisure activity at the expense of others (Scott & Shafer, 2001, p. 326). This narrowing of interest correlates with an increase in commitment. Commitment can be divided into subsets, including financial, intensive, and extensive (Kuentzel & Heberlein, 1997). In Kuentzel and Heberlein (1997; p 310) they measured commitment intensively, via emotional ties and lifestyle identification, as well as extensive commitment which was measured by asked people how many of their a) friends and b) relatives took part in the activity. While informative, a commitment or focusing of behavior does not alone constitute progression. In addition, other dimensions have been used, including behavioral

indicators such as cost, type, and number of pieces of equipment owned, as well as years of experience, distance travelled to participate, frequency of participation (Table 2 & 3).

In the saltwater aquarium hobby, this character may be evident as participation in this aquarium hobby over the freshwater hobby. This focuses the aquarist on behavior specific to marine ecosystems (e.g., reflected in equipment, frequency of participation, costs). Participants may also choose to focus on a certain aspect of the hobby they find appealing or can distinguish themselves in (i.e., niche). They may also progress from a fish-only aquarium to a more complex, natural ecosystem (i.e., a miniature reef).

Skill Development: According to Scott and Shafer (2001), the development of skills and the acquisition of knowledge are equally good indicators of progression in an activity. People who participate in an activity over an extended period increase their knowledge of setting attributes and the environment (Table 2; Williams, Schreyer, & Knopf, 1990). They also have a greater specificity for preferred outcomes (Table 2; Bryan, 1979; McFarlane, Boxall, & Watson, 1998) and show higher levels of conservation-oriented behaviors and management preferences (Table 2.; Bryan, 1979; Hvenegaard, 2002; McFarlane & Boxall, 1996; Oh & Ditton, 2008).

The implication here is a positive correlation between amounts of time spent participating in a leisure activity and skill and knowledge levels; however, this is not always the case. For example, some participants in the game of contract bridge have participated for an extended period of time but refuse to hone their skills to a "more specialized" mode of participation (Scott, 1991; Scott & Godbey, 1994). This lack of

skill would qualify these participants as less specialized, even though that may not be the case. Much of skill and knowledge is tied to desire (Scott & Shafer, 2001, p. 328); thus, skill and knowledge acquisition should be used in tandem with other indicators of specialization.

Commitment: At their highest level, commitments constitute a "central life interest" (Scott & Shafer, 2001) and can include a strong level of attachment and identity to the activity. In fact, personal commitment specifically refers to the development of an identity linking the individual to the hobby (Yair, 1990) and a strong emotional attachment (Buchanan, 1985). Personal commitment also increases dedication to the activity, its norms, values, social world, and potentially the resources utilized during participation. Indicative of this is McFarlane and Boxall's (1996) study on conservation orientations in birdwatchers where they found a positive relationship between specialized birdwatchers and wildlife conservation. Increasing levels of personal commitment may correlate to a greater conservation orientation in other nature-based activities as well.

Behavioral commitment, on the other hand, involves expectations and costs that make cessation of participation difficult (Scott, Baker, & Kim, 1999). Other names for behavioral commitment include external commitment (Shamir, 1992), side bets (Becker, 1960), and structural commitment (Yair, 1990). A high level of behavioral commitment to an activity involves placing the activity in a central life role. This commitment, over time, envelops or develops a participant's social network; ceasing to participate may

mean a loss of social connectivity. Furthermore, some activities require a high monetary investment (e.g., boating); a participant cannot simply put the activity aside.

Significance in Understanding Natural Resource Orientation

Bryan (1979) originally showed that anglers in different stages and style of participation have different perspectives on fisheries conservation and management. He stated, "The more specialized the fisherman, the more his [sic] enjoyment and pursuit of the activity are inextricably linked to the nature and setting of the resource he fishes" (p. 39). The orientation of recreationists towards natural resources has been a common reason to use the specialization framework. This research encompasses a multitude of natural resource-related activities (Table 2 & 3), including all types of boating (Bricker & Kerstetter, 2000; Cottrell, Graefe, & Confer, 2004; Donnelly et al., 1986; Kuentzel & Heberlein, 2008), hiking and backpacking (Shafer & Hammitt, 1995; Virden & Schreyer, 1988; Watson et al., 1994), camping (McIntyre & Pigram, 1992), and hunting (Kuentzel & Heberlein, 1992). It also includes birdwatching (Cole & Scott, 1999; Martin, 1997; McFarlane, 1996; McFarlane & Boxall, 1996; Scott, Ditton, Stoll, & Eubanks, 2005) and fishing (Bryan, 1977, 1979; Chipman & Helfrich, 1988; Choi, Loomis, & Ditton, 1994; Ditton, Loomis, & Choi, 1992).

Further, the utility of the specialization construct to understand consumption- and preservation-based styles of involvement is robust and important. In leisure and recreation activities involving wildlife and natural resources, there is a trade-off: participants remove organisms from the natural environment (i.e., "consume") but they also receive something from that experience. Consumption of organisms or other natural

resources has costs, benefits, and these not only need to be monitored, but understood. My research will set the foundation for understanding the orientations of hobby aquarists have towards their consumption of a wildlife resource. By doing so, behavioral and policy changes can be altered to better conserve the natural resources while maintaining a lucrative economic activity. This builds on work by Bryan (1979) who stated there are different attitudes towards natural resources in each type or style of participation, specifically moving from consumption-oriented to preservation-oriented as the styles of participation becomes increasingly specialized.

Lastly, Bryan's (1979) work shows that recreational anglers go from a consumption-orientation towards natural resources to a more intrinsic orientation focused on preservation. For example, the second least specialized group of anglers, the "generalists", tend to try to catch their limit on fish and they thus support the stocking of fish in order to increase their own take. On the other end of the specialization spectrum, the most specialized participants focus on fishing in natural settings, perform catch-and-release, and seek to preserve the resource as is. The specialization construct allows researchers to explore the conservation orientation of leisure participants and this study aims to delineate different saltwater aquarists and their associated conservation orientations. Next, I review a well-studied activity that has an integrated conservation ethic, birdwatching.

Birdwatching: Probably the largest body of literature to use the specialization framework to define variation in conservation-orientation is on the activity of birdwatching. This

popular pastime has participants that range from Casual to Advanced/Committed (McFarlane, 1994, 1996). Groups were delineated based on participants past experience, centrality of the activity to their lifestyle, and the commitments they made to the hobby in equipment (i.e., economic commitment).

McFarlane (1994) found that birdwatchers contribute to the conservation of birds in a fashion that varies across style of participation. Interestingly, it was the novice and intermediate birdwatchers that were motivated most by a conservation ethic, not casual or advanced birders. Later, in her work following up on these findings, McFarlane and Boxall (1996) showed the casual and intermediate birdwatchers did not contribute as much to wildlife conservation compared to advanced birders. These conclusions are noteworthy. Conservation is an ethic and a motivation for birdwatchers; however, not all those who hold a conservation ethic contribute to conservation. These findings indicate serious aquarists may have a conservation ethic, but it may not be found in all serious participants or have correlated behavior.

Another study by Hvenegaard (2002) looked specifically at conservation involvement in birdwatchers. He found that conservation involvement was positively related to specialization level; two-thirds of birdwatchers in his sample were members of wildlife conservation groups, 84.9% were willing to donate to conservation efforts at a rate of $26.94 per person, and 60% donated to wildlife causes in the last year.

Conclusions

This section outlines the two frameworks in which this study is situated, specifically serious leisure and specialization. Described therein, I outline these in light of aquarium keeping, which I argue is a systematic pursuit of a non-professional that offers compelling involvement for long-term and diverse styles of participation. Further, the hobby has diverse outlets for career contingencies where they can express special skill and knowledge. In addition, specialization can produce distinct styles of participation by parsing activities across a continuum of behavior from the general to the particular. These discrete groups are stages of involvement that reflect a progression from general to specialized participation. Further, these are reflected by skills and equipment, among other preferences. The next section further connects science to leisure activities, and is reframed as “science as leisure”.

Science as Leisure

Overview and Conceptualization

Science as leisure is a reframing of science as a leisure activity rather than its current conceptualization as a profession. For example, modern parlance indicates the term "science" as a professional field (i.e., work), but the activity of science was not always a profession. Aristotle, in his work *Politics*, stated leisure is not mere amusement; it involves pleasure, happiness, and spirituality. Pieper, in his work studying leisure as a basis for culture, similarly stated, "it must be clearly understood, [leisure] is a mental and spiritual attitude" (Pieper, 1963, p. 40). It is unplanned; free of "total labor" (i.e., work; 1963, p. 20). He agreed with Aristotle in that leisure is the antithesis of work, quoting "we are unleisurely in order to have leisure" (p. 21). Thus, the outcome of pleasure, happiness and spirituality are not possible in people who are occupied with work. An occupation has a means to an end. Leisure does not.

Science was a leisure activity, grounded in high thinking and intellectual interests. These characteristics are aligned with those of leisure's mental and spiritual attitude. Day to day life in antiquity did not rely on intellectual thought, nor did work (de Grazia, 1962; Pieper, 1963). Leisurely science activity, including thoughtful processes as well as behaviors, is the origin of professional science (Daniels, 1967). Scientific inquiry started as an "open-access" discipline which was made up of, and relied upon, non-professional leisure participants to observe, describe, and categorize the natural world (Miller-Rushing, Primack, & Bonney, 2012; Vetter, 2011).

Not only are these leisurely experiences with scientific principles and concepts able to promote science understanding in an informal manner, participants also take part in aspects of the scientific process. In Marchio, 2018, I outlined the success as an aquarist as one tightly contingent on the participant's willingness to expend energy and effort to understand scientific mechanisms involved in the hobby (e.g., the nitrogen cycle, photosynthesis, respiration). Further, the ways in which they obtain a better understanding of their aquarium utilizes the scientific method. Similarly, work studying volunteer scientists (citizen scientists) aims to understand a citizen's interest in science as well as scientifically oriented behaviors (Bonney, Cooper, et al., 2009a; J. Dickinson, Zuckerberg, & Bonter, 2010).

In this section, I further described science as leisure as an informal scientific endeavor – with a review of citizen science I outline other activities that qualify as scientific, the outcomes of including leisure participants as scientists, and the connection between leisure and conservation.

Leisure: Informal Science and Citizen Science

Modern scientific inquiry in western civilization essentially began as leisure activities. One of the earliest leisure scientists was the Milesian philosopher Thales who, around 600 BC, used his leisure time to search for evidence-based explanations regarding the natural world and humanity's place in it (Barr, 2006; Lloyd, 1974). For centuries, the field of science was advanced by people who observed, described, and categorized the natural world (Barr, 2006; Miller-Rushing, Primack, & Bonney, 2012;

Vetter, 2011).

As science became professionalized during the Age of Enlightenment and as universities formalized their research programs throughout the 19th and 20th centuries, individuals continued to explore and make new discoveries in their leisure time (Barr, 2006; D. C. Martin, 2008). The professionalization of science, arguably, completed the continuum of scientific involvement; today, the spectrum of involvement runs from casual to professional. This continuum linking leisure and science also includes hobbies, and research has shown participation within an activity varies in intensity and that variation that can be explained by a focusing behavior, increasing skill and knowledge, and increasing commitment (Scott & Lee, 2010; Scott & Shafer, 2001). 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 (Quality Marine, 2017; Rutherford, 2015a, 2015b). The link between science and aquarium care is not lost on teachers who aimed to please students who asked, “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.

Furthermore, there are practical reasons to promote science as leisure, including the integration of a younger generation (Champaign Urbana Schools Foundation, 2017; Lafond, 2014) and the ability to push our collective boundaries in both knowledge and

skill. Integrating the young as well as the old is citizen science. Citizen science is a term used to describe involving non-professionals in a scientific endeavor. Much research has been done on this type of leisure participation, specifically aimed to understand (1) its ability to aid in large scale scientific research (Connors, Lei, & Kelly, 2012; Cooper, Shirk, & Zuckerberg, 2014; Couvet & Prevot, 2015; Davies, Stevens, Meekan, Struve, & Rowcliffe, 2012; Devictor, Whittaker, & Beltrame, 2010; Johnson et al., 2014; Scyphers et al., 2015), (2) the collection of useful, valid scientific data (Bird et al., 2014; Bonter & Cooper, 2012; Crall et al., 2011; Delaney, Sperling, Adams, & Leung, 2008; Foster-Smith & Evans, 2003; Wiggins, Newman, & Stevenson, 2011), and (3) quantifying the impact citizen science has on those who participate (Bonney, Cooper, et al., 2009a; Branchini et al., 2015; Ganzevoort, Riyan, Van Den Born, Halffman, & Turnhout, 2017; Jordan, Gray, Howe, Brooks, & Ehrenfeld, 2011; Marshall, Kleine, & Dean, 2012; Tulloch, Possingham, Joseph, Szabo, & Martin, 2013).

Utilizing citizens in science has large-scale ecological outcomes. For example, taken collectively, data from birdwatchers across the United States has been collected for over 100 years during the Christmas Bird Count (Lepczyk, 2005). Observations by these non-professionals include both a temporal and geographical piece of data for individual bird species (B.L. Sullivan et al., 2009; Brian L. Sullivan et al., 2014; Andrea Wiggins, 2011). These data are capable of tracking bird populations across the United States.

The collection of useful and valid scientific data via a citizen's involvement in specialized hobby activities have helped the scientific community. Professional scientists have assessed the usefulness and validity of these data and found citizen science to be an

acceptable data collection method Citizens are also useful because they have a wide range of interest and leisure time to pursue interesting projects professional scientists may not be able to complete. For example, citizens have identified and classified new galaxies (Cardamone et al., 2009; Lintott et al., 2010; Willett et al., 2013), discovered of over 40 new fly species (Hartop, Brown, & Disney, 2015; Hartop, Brown, & Disney, 2016) and a new species of a poison dart frog (Amézquita et al., 2013), and a peacock jumping spider (Hoye & McQuillan, 2014). When science is done as a leisure activity they, at times, contribute to professional scientific endeavors.

The impact of scientific inquiry on citizens has also been explored. Bonney et al., (2009) are among the top researchers in understanding the impact citizen science programming has on the participants. Their findings indicate the accumulation of activity-specific skill and knowledge can lead to opportunities to contribute to science in a variety of ways. They outline the variation under three types: contributory, collaborative, or co-created with professionals (Bonney, Ballard, McCallie, & Phillips, 2009). The connection between citizen science and science as a leisure activity – the conceptual basis of my study – is that science done as a leisure activity may be a precursor to citizen science. Specifically, if aquarium keepers accumulate skills, knowledge, and connectivity to scientific studies, they may become citizen scientists in a future endeavor.

One example of a science as leisure activity is birdwatching. This activity is an established hobby that is popular throughout the United States and has significantly

contributed to our understanding of birds and the environment (Cole & Scott, 1999; J. Lee & Scott, 2004; S. Lee & Scott, 2013; McFarlane, 1994; McFarlane & Boxall, 1996; Scott, Ditton, Stoll, & Eubanks, 2005). Birdwatching has been shown to exist on a continuum of involvement from the casual participant to those who become as skilled and knowledgeable as a professional ornithologist (Burtt, 2015; Mayfield, 1979). Thus, birdwatchers are a heterogeneous group of leisure enthusiasts that can be further delineated into sub-groups based on their seriousness in the hobby (Cole & Scott, 1999; J. Lee & Scott, 2004).

Further, many participants are recognized for their knowledge of bird behavior and habitat conservation as well as their participation in citizen science activities (Bonney, Cooper, et al., 2009b; Brossard et al., 2005; J. L. Dickinson & Bonney, 2012; Miller-Rushing et al., 2012). These science-oriented attributes have been placed on a continuum of involvement from casual to serious participation (Hvenegaard, 2002b; McFarlane & Boxall, 1996). I argue aquarium keeping works similarly and that continued participation and the growth of the hobby could provide opportunities for citizen science programming and involvement.

To elaborate on the science of aquarium keeping, aquariums require frequent maintenance, caring for and observing aquaria increases knowledge of organisms and ecosystems (Maceda-Veiga et al., 2014). This is especially true for miniature reef aquariums, as they require weekly, if not daily, diligence (Delbeek & Sprung, 2005). As a collector of scientific knowledge, especially if done in a systematic and easily understood manner (Gelber, 1999), these aquarists become specialized. Further, if they

communicate with others in the social world, they may find themselves as a source of scientific knowledge, making them an opinion leader (or what I will refer to as a "go-to person"). Further, scientific skills may allow them to find distinction in ecosystems, organisms, or aquarium equipment – all scientific in their own way.

As aquarists interact with their aquariums, they become hobby-driven experts on a complex ecosystem and come up with inventive strategies for increasing their success (Maceda-Veiga et al., 2014). This hobby-induced knowledge and skill not only aids in maintaining their own aquaria, they are pushing the limits of scientific knowledge in a range of fields (Maceda-Veiga et al., 2014). Because of this, aquarium-keeping skills are practical for scientists to promote; in addition, without self-funded hobbyists to improve designs, innovate, and take risks, scientific research involving aquatic ecosystems and organisms would move much slower (Maceda-Veiga et al., 2014). As described above, leisure can have a scientific component leading to the development of scientific skill and knowledge. For example, collecting is a leisure activity and a part of the scientific method (i.e., collecting data). Further, according to Gebler (1999), the definition of a collector could also describe a scientist as "someone who accumulates objects in a systematic way requiring the development of specialized knowledge". Theoretically, science and leisure are interconnected in this regard.

Examples of Scientific Leisure Activities

Science as a leisure activity is not limited to birdwatching or the aquarium hobby. A notable example of is Stebbins' (1979) seminal work studying non-professional scientists in the field of archaeology. When people are first interested in archaeology, they collect artifacts such as arrowheads or bone fragments they find on their free time. This, he states, may begin in childhood; it is not until they are introduced to the scientific significance of these artifacts that these "pot hunters" begin to formalize their interest in archaeology and progress in their leisure career.

Further, while their identity may remain at the amateur level, some archaeology aficionados participate in much, if not all, of the scientific method (Stebbins, 1979). Pushing past the marginalization of non-professionalism, a scientific oriented leisure hobbyist also needs to overcome a feeling of imposter syndrome (Cohen et al., 2009). Imposter syndrome is a misalignment of identity with skill. Aligning these facets may well be a turning point in the life of an amateur. Stebbins found that some amateur archaeologists suffer from this imposter syndrome, a well-known phenomenon in students of academia (i.e., scientists) where participants feel inadequate and lack confidence in their professional skills (Cohen, Kay, & Youakim, 2009; Cope-Watson & Betts, 2010; Sherman, 2013). Here, effort and perseverance are key; without these attributes, an amateur in any field will be constrained to casual or non-professional participation. However, along with an increased level of perseverance, effort, and career progression is an increase in identity towards the activity. In addition, non-professionals who are skilled in science as a leisure activity may find themselves along a trajectory, or

career contingency, of the hobby projecting them towards a more professional participation (Burtt, 2015; Marchio, 2015; Mayfield, 1979).

The connection between leisure and science is clearly linked, and science as leisure covers each of the six characteristics of serious leisure (i.e., perseverance, career trajectory, effort based on special knowledge and skill, durable benefits, unique social world and ethos, and identity). Implications of studying science as a leisure activity could be a better understanding of the limits imposed upon participation, specifically, a lack of diversity in the sciences (Blickenstaff, 2005). For example, leisure constructs have characteristics capable of better understanding continued participation, or lack thereof (e.g., perseverance, identity commitment). Next, I review the practical use of aquarists as scientists, namely their interest and ability to fund their own scientific endeavors.

Practical Outcomes

The hobby of aquarium keeping may be where conservationists and scientists obtain new insight and understanding of the natural history, husbandry, and basic science information on aquatic species. This is important; these fields of study are starting points for beginning scientists (Agrawal, 2014; Burtt, 2015; Marchio, 2015; Mayfield, 1979) and have an valuable place in science (Tewksbury et al., 2014). Aquarium keepers not only have the capacity to aid in science and conservation, many also have the political will to take part in both activities.

Furthermore, scientific progress in captive breeding both fresh- and marine ornamentals is highly dependent on understanding the natural and life history of each species (Callan, 2016; Moorhead & Zeng, 2010). Natural and life history knowledge can, and is collectively gained by aquarists through participation. This information is no longer regularly researched by professionals, likely due to the low funding rate for basic science by the nation's largest scientific funding agencies (National Science Foundation, NSF, and National Institute of Health, NIH). Any natural history knowledge obtained through volunteers, in this case aquarium keepers, is done so by people who are committed to obtaining practical knowledge they can use for their own hobby. In a sense, this type of contribution to basic science is a "recreation sensitive" activity (Porter, Murphy, & Eagles, 2000) thus allowing participants to engage on their own terms and in their own space. Effectively, these hobbyists use their own money to do their own "research" (Bonney, Cooper, et al., 2009; Cohn, 2008; Theobald et al., 2015).

This informal scientific research is also called "free choice learning" (Brossard, Lewenstein, & Bonney, 2005; Cronje, Rohlinger, Crall, & Newman, 2011; Falk, 2005; Povey & Rios, 2002). If utilized appropriately, this could be an unexpected and inexpensive way to supplement lagging natural and life history knowledge when basic science has been dealt such drastic funding cuts (Dalton, 2003; Kemp, 2015). Another potentially important connection is that to conservation science and applied conservation. Specialized participants, such as those in angling (Blicharska & Rönnbäck, 2018; Bryan, 1979; Schroeder et al., 1007), develop a conservation ethic thought leisure participation. Leisure and conservation science is reviewed next.

Leisure and Conservation

The former chairman of the Great Barrier Reef Marine Park Authority, Dr. Graeme Kelleher, opened an education center off the coast of the Reef in Townsville, Queensland Australia. His aim was "to create the Great Barrier Reef on land, making the reef accessible and affordable while at the same time spreading the reef conservation message and gaining public support for the protection of the 'real thing'" (Reef HQ, 2013). Interpretive reefs in public aquariums are a cornerstone to conservation outreach and education, specifically aimed at people who cannot visit a wild reef ecosystem.

Not only do interpretive organisms increase science and conservation messages to the public, when people take a more active, experiential role, research has shown a drastic increase in conservation engagement (Lewandowski & Oberhauser, 2015). While these messages are aimed at educating the public, experience with wild animals and ecosystems can help formulate a conservation ethic across all types of stakeholders (Chao & Prang, 1997). For example, local people in the Brazilian Amazon rely on catching and selling live ornamental freshwater fishes as a source of income (Figure 6). Recent studies have shown this area is the epicenter for the diversification of important ornamental species (Fitzgerald et al., 2018; Lujan, Cramer, Covain, Fisch-Muller, & López-Fernández, 2017). Thus, collecting ornamental aquarium organisms is a highly productive livelihood resource (Chao & Prang, 1997; Coomes, Takasaki, Abizaid, & Arroyo-Mora, 2016; Moreau & Coomes, 2007; Ruffino, 2014). Threats to the ornamental fishery threatens their livelihood, thus, some fish collectors engage in conservation of their aquatic resources (Campos-Silva & Peres, 2016; Inomata,

Gonzalez, Román, de Souza, & de Carvalho Freitas, 2018).Findings by Lee (2011, p. 895) suggested an attachment to place, recreation involvement and conservation commitment "*critically impact environmentally responsible behavior*". He found a commitment to conservation was simultaneous between place attachment and environmentally responsible behavior, and mediated the two. Conservation commitment was also related to the variation in involvement as well as responsible environmental behavior. These findings indicate a need to promote and maintain an attachment to place to aid in responsible behaviors and conservation.

Figure 6: Local people rely on ornamental fish for their livelihoods. Photo by M.J. Tuccinardi

Conclusion

Research explicitly designed to explore the benefits of natural resource-related experiential activities, specifically private home aquaria, is warranted. Additionally, aquarium keeping is a "recreation-sensitive conservation" activity (Porter et al., 2000) which allows people to learn on their own time, at their own pace, and not forfeit their leisure enjoyment. By putting leisure first, participants do not feel pressured or educated through an activity. Instead, the activity is done for its own sake; the benefits for science literacy and conservation emerge from this informal participation. Science as a leisure activity is a prudent reconceptualization of science, allowing research to be done on informal science activities that could lead to careers in scientific fields.

Aquarium Trade

Examination

Although the aquarium hobby is a very popular activity, it is prudent to first explain the activity. Usually constructed of transparent glass or acrylic, aquaria or "tanks", allow aquatic animals to be viewed from the side rather than from the top, as would a pond. This may be the most alluring part of the activity since the aquatic realm is otherwise only viewable from looking down into water or from swimming with head submerged. Further, aquaria bring aquatic organisms to people who would otherwise be unable to see them (i.e., landlocked individuals). Organisms kept in aquaria encompass a large number of species, with fish being the most popular. People who take part in this activity refer to it as "the hobby", and refer to themselves as "aquarium keepers" or "aquarists". Some clubs use terms such as aficionados and enthusiasts. It is a leisure hobby that utilizes live organisms for display purposes.

This section reviews aspects of the aquarium hobby, specifically aiming to define the saltwater aquarium hobby, pertinent trade statistics, and the peer-reviewed literature comprising the previous research foci surrounding the hobby. Trade statistics are an important aspect to review since the activity involves wildlife, which is of conservation concern (Prakash et al., 2017; Raghavan et al., 2013; Rhyne, Tlusty, & Kaufman, 2014). A review of the previous literature is also outlined, showing there is a great deal of trade information but little on participation.

Saltwater

I focus on the saltwater trade and saltwater aquarists because they rely heavily on wild-caught organisms to adorn their home aquaria (Chapman et al., 1997; Livengood & Chapman, 2007). These organisms are mainly captured in Indonesia and the Philippines with Brazil, Maldives, Vietnam, Sri Lanka, and in the U.S. Hawaii is also exporting a high volume (Rhyne et al., 2009; Wood, 2001). Furthermore, saltwater organisms are valuable display organisms (Murray, Watson, Giangrande, Licciano, & Bentley, 2012), often coveted for color and pattern over other factors such as appropriateness for captivity, adult size, compatibility with other organisms, origin, etc. These often-overlooked attributes make saltwater aquarium keeping a conservation concern. The specialization framework involves conservation in its participant classification methods and has been used by other researchers to study wildlife-oriented activities (Hvenegaard, 2002b; McFarlane & Boxall, 1996) thus making conservation an interesting point of research in this study.

Statistics

Trade statistics are an important aspect to keep in mind when studying the aquarium hobby. Shown in Figure 7, the United States spends a predicable amount of money on the pet trade, increasing each year. Further, aquarium organisms make up a large number of these expenditures. Since saltwater hobbyists utilize wildlife, it is important to review the aquarium trade and its potential impacts on wild ecosystems.

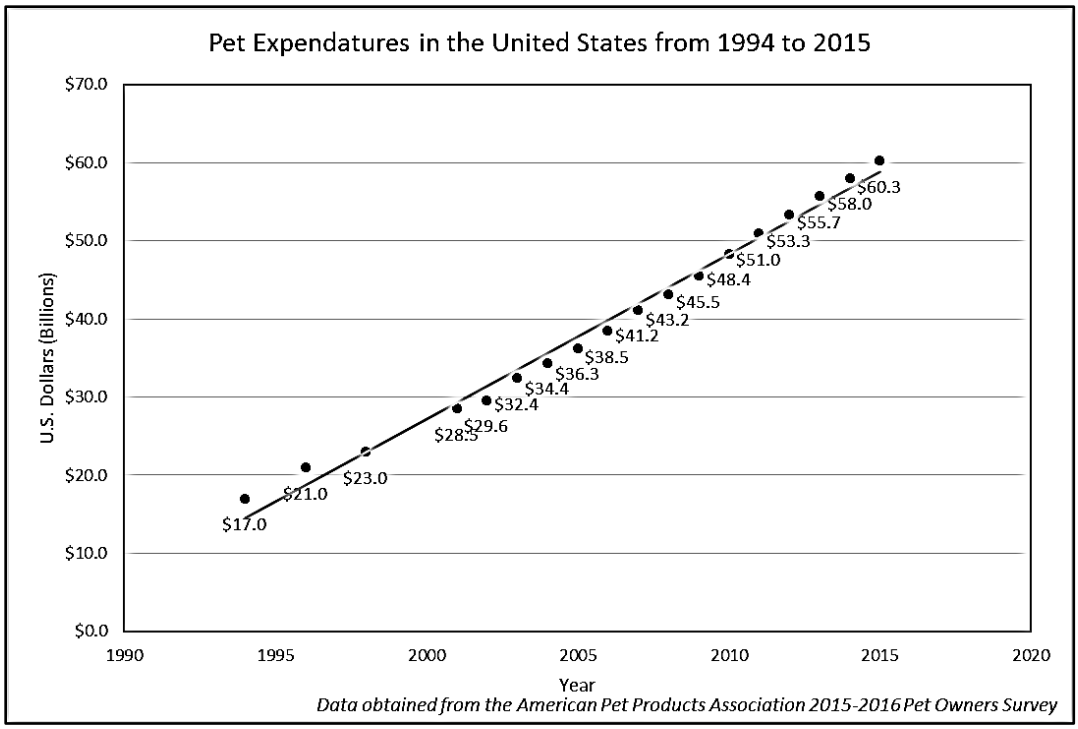


Figure 7: Predictable annual growth of pet owners in the United States.

The aquatic ornamental industry, a multi-billion dollar trade, includes live aquatic organisms and the equipment used to house them (Larkin, 2003; Pelicice & Agostinho, 2005; Prang, 2008; Wabnitz et al., 2003). Recent estimates value the trade at 15 billion US dollars (Hoff, 1996). Furthermore, nearly half of the total number of species traded, 1,500-1,600, are ornamental saltwater fish (Livengood & Chapman, 2007; Olivier, 2003; Whittington & Chong, 2007), and the vast majority of these fish are wild-caught (90-99%; Calado, 2006; Chapman, Fitz-Coy, Thunberg, & Adams, 1997; M. A. Moe, 2003; Ostrowski & Laidley, 2001; Tissot & Hallacher, 2003; Tlusty, 2002;

Wilson, Osenberg, St. Mary, Watson, & Lindberg, 2001). The freshwater side of the trade is the opposite, with approximately 90% of fish species bred and raised in captivity (Chapman et al., 1997; Tissot & Hallacher, 2003; Tlusty, 2002). While making up only 10% of the total number of organisms destined for captive aquaria, saltwater fish are, on a unit basis, the most valuable fisheries in the world (Hardy, 2003)

The United States, alone, imports both the highest number of aquatic organisms and the highest value organisms totaling over $80 billion US dollars for fresh and saltwater aquarium species and other live materials (e.g., “live rock”). This level of consumption is followed by European markets and Japan (Wood, 2001). Due to mismanagement (e.g., Hawaii; Tissot & Hallacher, 2003) as well as lack of any management whatsoever (e.g., the Philippines and Indonesia; Lunn & Moreau, 2004) much of the wild marine fisheries is increasingly under intense scrutiny.

Consumption for the hobby not only includes the removal of live aquarium specimens but also encompasses other related practices that detrimentally affect their populations and habitats (Bailey & Sumaila, 2015; Dee, Horii, & Thornhill, 2014; Vaz, Esteves, & Calado, 2017). These issues also encompass the collection of live plants and coral, invertebrates such as shrimp and crabs, as well as abiotic structure. Additionally, the aquarium industry is historically tied to the curio trade (Dee et al., 2014; Fujita et al., 2014; Rhyne, Rotjan, Bruckner, & Tlusty, 2009; Townsend, 2011; Wood, 2001), likely exacerbating the negative connotation surrounding the hobby.

Previous Studies

A vast array of literature exists on the aquarium hobby, eliciting over 8000 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 (Jones, Gardner, & Sinclair, 2008; Parks, Pomeroy, & Balboa, 2003), the impacts of aquaculture (Bush & Marschke, 2017; Duggan & Pullan, 2017; Lorenzen et al., 2017; Parks et al., 2003; Rhyne & Tlusty, 2012; Tlusty, 2002), and the capture and care of organisms (Bell, Clua, Hair, Galzin, & Doherty, 2009; Jones et al., 2008; Militz, Kinch, Foale, & Southgate, 2016; Wood, 2001).

Once ornamental organisms are collected, other factors are studied. This includes diseases associated with aquatic organisms (Lawson, Petrovan, & Cunningham, 2015; Whittington & Chong, 2007), invasive species release (Bandaranayake & Chandrasekara, 2017; Delaney et al., 2008; Howeth et al., 2016; Magalhães et al., 2017; Padilla & Williams, 2004; Selwyn et al., 2017; Tuckett, Ritch, Lawson, & Hill, 2017) and use for popular aquarium species for breeding and scientific research (Domínguez & Botella, 2014; Hoff, 1996; Moe, 2003; Moorhead & Zeng, 2010; Olivotto et al., 2011; Tehrani, Dorche, Goli, & Akbary, 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, Domínguez-Domínguez, Escribano-Alacid, & Lyons,

2014), but generally overlooks the aquarium hobbyist as a population of research interest.

Conclusion

The capture and selling of aquatic wildlife has ecological and social costs as well as benefits; however, only the ecological and monetary costs of the trade have garnered attention (Calado, Araújo, Narciso, Lin, & Rhyne, 2003; Raghavan et al., 2013; Rhyne et al., 2012, 2009; Rhyne, Tlusty, & Kaufman, 2014; Rhyne & Tlusty, 2012; Tissot et al., 2010). Looking at the aquarium trade in any way other than economical or ecological will be unique. Interestingly, driving the change to ornamental fisheries management seems to be the aquarium keepers themselves (Maceda-Veiga et al., 2014; Shuman, Hodgson, & Ambrose, 2004; Wabnitz et al., 2003). However, the attitudes, beliefs, knowledge, and behaviors across any or all aquarists is currently unknown. If even a portion of conservation-oriented change comes from hobbyists, it is important to understand aquarists' attitudes and behaviors.

Summary

Home aquarium fish and invertebrates are often afterthoughts for many consumers and even in commercial agencies within the United States. Saltwater fish are collected in the wild, done so in staggering numbers with little to no natural history and population data, and flown to countries half the world away. Perhaps due to the focus on food fish species and their depletion, aquarium fish are not often thought of as wildlife

and thus have not felt the hand of regulation as much as other pet industries (e.g., reptiles and amphibians). The ornamental aquarium fish industry is global, economically huge, maligned with conservation issues and thus ripe for regulation. In addition, saltwater aquarists are diverse participants that span various styles of involvement and they have globally important management and policy issues that affect their participation. My study will add to the body of leisure and recreation literature by utilizing leisure frameworks in a novel, and broad, fashion.

The construct of serious leisure (Stebbins, 1979, 1982) the construct of recreational specialization (Bryan, 1977, 1979) can be used in tandem to understand diverse participation styles, their developmental processes, and the various career outcomes or contingencies. Further, these have been used to understand how different styles of participation impact the management of natural resources (e.g., Bryan, 1977; Mcfarlane, 1994) which is an emerging issue in the aquarium trade. The series of studies I propose will aid in understanding each of these in saltwater aquarium hobbyists.

In addition, I reconstruct leisure as a scientific endeavor as "science as leisure" activities (Marchio, 2018). This concept sensitizes this research towards understanding the scientific aspect of aquarium keeping and how it may passively engage participants in science and conservation. This series of studies stems from accounts of serious leisure participants who became scientists (Burtt, 2015; Marchio, 2015; Mayfield, 1979). This occurred across a variety of activities including birding, (Burtt, 2015; Mayfield, 1979) and collecting and keeping tadpoles (Marchio, 2015). This dissertation is one step in understanding the connectivity of science and leisure, and the variability of participation

in the aquarium hobby. It will contribute to the leisure sciences in a novel way through this reconceptualization and focus.

CHAPTER III

METHODS

Review

In the previous chapter, I reviewed the pertinent literature involved in researching the conceptual frameworks utilized in this study as well as the links between the aquarium hobby and science done as leisure. Topics reviewed include leisure and recreation in American society, the frameworks of serious leisure and recreation specialization, connectivity of leisure and science-based leisure activities, and a review of the aquarium trade.

In the following chapter, I will review the methodological frameworks I utilized for this research. Included in the scope of this examination is a review of qualitative research methods including grounded theory and ethnographic research, an outline of the research design (e.g., sampling and data collection methods), analyses used, and limitation to the research. First, I review the researcher lens in which I conducted data collection and analysis.

Researcher Lens

When conducting qualitative research, including the use and interpretation of data, it is useful to understand the position of the researcher. Merriam (2007) refers to this as a "researcher lens", effectively describing the lens in which the researcher sees the world. For example, researcher and climbing accident victim, McMahan (2015) used her involvement, her lens, to explore what she experienced. She later described intense

participation as “hardcore leisure” (Scott & McMahan, 2017), a term likely influenced by her experience in the activity under study. This account shows the back and forth between the lens and the research.

Much of my interest in aquatic life involved freshwater organisms. This is an important aspect of aquarium keeping- the entire aquarium must be either fresh-, brackish-, or salt-water. This limits the aquarist to the organisms that can be maintained in each type of ecosystem, a base knowledge that similarly delineates aquarists as well as aquaria. For example, those that keep freshwater organisms have different facets to consider than those that keep saltwater, the most obvious being saltwater contains salts and different ionic levels of sodium, chloride, magnesium, and calcium (Figure 8). As a previous freshwater aquarist with less experience in saltwater, I decided to pursue a better understanding of the saltwater aquarium hobby.

Across fifteen years of participation as an aquarium hobbyist, I found indication of an emergent theory linking aquarium keeping and science communication (Marchio, 2018). After much reflection, I attributed obtaining my Master’s Degree in fish phylogenetics to my past history as an aquarium hobbyist (Marchio, 2015). During my experience as an aquarium hobbyist, I experienced science in a way that lead me to a professional career.

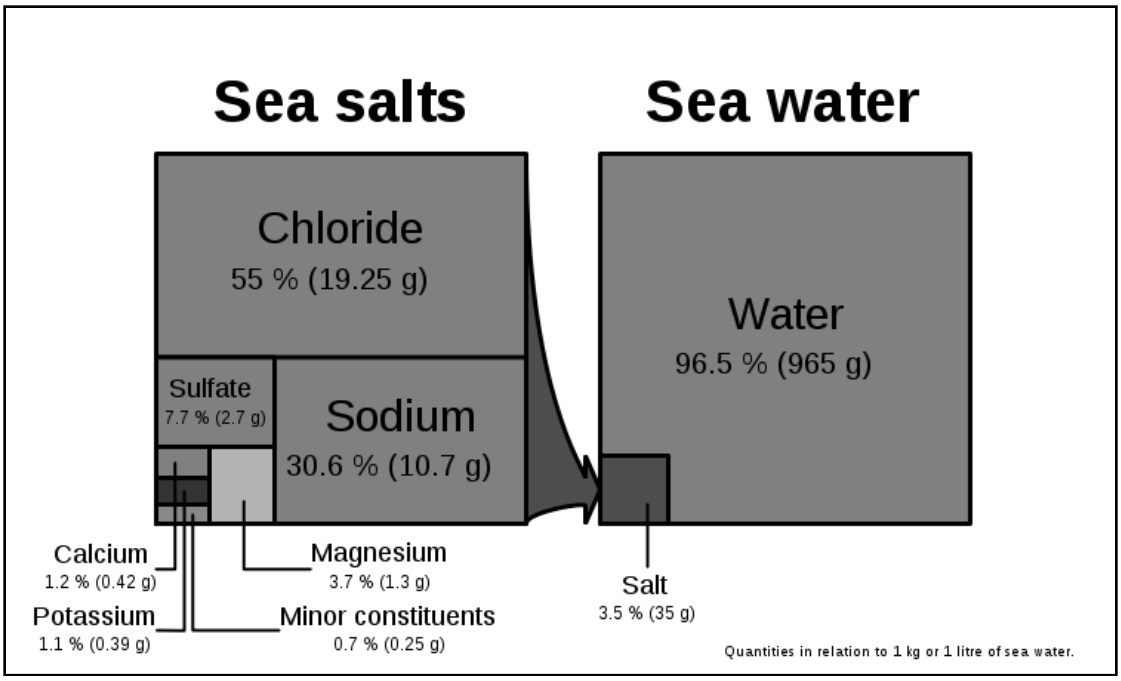


Figure 8: Sea water contains salts, which is comprised of various concentrations of ions. Figure is open source.

Methodological Design

My interpretation of the behavior of aquarium keepers is based on observations and is thus inductive reasoning. The overall design of this research is to explore and flesh out science done as a leisure activity. Stebbins mentioned science can be done as a leisure activity, but does not elaborate (Stebbins, 1979, 1992). Here, I elaborate and extend his work in an attempt to create a foundation of inquiry involving science and leisure. This foundation is a novel addition as well as an extension of theory, offering both inductive and deductive aspects of inquiry to this research.

The design of this study is emergent and flexible, core qualities of qualitative research (Charmaz, 2006; Glaser & Strauss, 1967; C. Marshall & Rossman, 2011; Spradley, 1980). Qualitative methods, reviewed in turn below, have allowed me to gain a robust and detailed understanding of the culture of saltwater aquarium keeping. In this, I explore the emergent scientific and conservation-oriented human dimensions of those who participate.

I chose ethnographic and grounded theory methodologies to immerse myself in the social context of the aquarium hobby (Agar, 1996; Charmaz, 2006; Glaser & Strauss, 1967; Spradley, 1980). These methods are umbrella of methods, allowing a reflexive analysis of aquarists where they are able 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 different forms of grounded theory and ethnography are reviewed below; first I overview the sampling procedure across all methods.

Sampling

In order to make this study representative of the U.S. population of aquarists, the sampling regime needed to cover a nationwide scale. Sampling for qualitative research does not involve statistical significance and thus does not require numerically large sample sizes. Sample size is important, but not necessarily numerically important. For example, in a quantitative study statistically significant results require a certain sample size. If the sample is too small, significance is not possible. Qualitative research uses no

numerical calculations of this sort, which means there is no specific number of informants required. This means the sample is subjective, and relies on the researcher to use recursive and cyclical methods to ensure they have come upon the answers to the topics under question (Charmaz, 2006; Glaser & Strauss, 1967; Kathy Charmaz, 1996).

Instead, what is gained through qualitative methods are rich descriptions and foundational theoretical information that can later be built upon through quantitative methods (Glaser & Strauss, 1967; Merriam, 2009; Saldaña, 2011). Further, choosing qualitative methods allowed me to focus on theoretical sampling, aimed to take me where the most interesting and pertinent data lay. Theoretical sampling is the method of sampling theoretically – following a specific trail of inquiry to extract information on a specific theory or topic of interest. I focused on understanding the integration of scientific thoughts and processes. Without theoretical sampling, I found interviews to focus on a vast array of topics. While informative, I used questioning methods to extract details about one topic rather than shallow information on several. I focused on serious individuals within the aquarium hobby and pursued participants across the United States.

Participation in the saltwater aquarium hobby is a rather serious endeavor, as it is expensive and time intensive. However, there are still gradations on involvement, which I found to involve a social aspect of participation. For example, each informant for this study was obtained from one or more of the sources in Table 4. Likewise, these sources are indicators of serious participation. Included in this are (1) a large-scale, national hobby conventions, (2) a local hobby clubs, (3) online saltwater-specific aquarium forums, (4) social media specialist groups, (5) local pet and fish stores, (6) online

purchases through various distributors, and (7) saltwater-specific periodicals. These types of participation were chosen for their reflection of serious participation as they were the highest form of participation in the saltwater aquarium hobby. Only two segments of aquarium keepers were found outside of these sources: novice saltwater hobbyists and professional aquarists at public and private zoos and aquariums. Each of these segments were not the focus of the research undertaken. In Table 4, I outline the participation types listed above, the specifics of the sampling location, and the mode of data collection. I used grounded theory and ethnographic methods, also attributed to each participation type and sampling location. These include participant observation (the participation and viewing of participants taking part in each activity), content analyses (assessing the content of the source in question), and interviews. Subsequently, I review why each of these participation types are valuable resources for collecting data on serious saltwater aquarium keepers

Table 4: Sample of the population included in the study. Shaded area denotes the method used.

Sample	Mode of Data Collection: Participant Observation	Content Analysis	Interview
Category 1: National Conventions			
MACNA 2015, Washington D.C.	■	■	
MACNA 2016, San Diego, CA.	■	■	
MACNA 2017, New Orleans, LA	■	■	■
Aquatic Experience 2016, Chicago, IL	■	■	
Category 2: Local Conventions and Clubs			
Reef Currents 2016, Houston, TX	■	■	
Reef Currents 2017, Houston, TX	■	■	
Aggie Aquarium Association	■	■	
Brazos Valley Aquarium Club	■	■	
Brooklyn Aquarium Society	■	■	
Columbus Area Fish Enthusiasts	■	■	■
Dallas Ft. Worth Marine Aquarium Society	■	■	
Greater Cincinnati Aquarium Society	■	■	■
Greater Houston Aquarium Club	■	■	■
Greater Pittsburgh Aquarium Society	■	■	■
Greater Portland Aquarium Society	■	■	
Houston Saltwater Aquarium Club	■	■	
Louisville Tropical Fish Fanciers	■	■	
Madison Area Aquatic Hobbyists	■	■	
Milwaukee Aquarium Society	■	■	
Missouri Aquarium Society	■	■	
Category 3: Online Forums			
www.nano-reef.com	■	■	
www.reefcentral.com	■	■	
www.reef2reef.com	■	■	
Category 4: Social Media Specialty Groups			
Addicted to Fish Keeping	■		
Addictive Reefkeeping	■		

Table 4: *Continued*

Sample	Mode of Data Collection: Participant Observation	Content Analysis	Interview
Aquarium hobby Historical Society	■		
C.A.R.E.S. Preservation	■	■	
Club Fraghouse	■		
East Texas Marine Aquarium Society	■		
Fish Rooms and Breeding	■		
Frags Auction Place	■		
High-End Coral Auctions	■		
Macroalgaes in the Reef Tank	■		
Official SPS Frag Swap Page	■		
Saltwater Aquarium & Reef Keepers	■	■	
Saltwater Aquarium Forum and Sales	■		
Saltwater Buy Sell and Trade	■		
Saltwater Maniacs	■		
Seahorses & Pipefish	■		
Texas Freshwater / Saltwater Aquarium Hobbyist	■		
Zoanthid Fanatics	■		
Category 5: Aquarium Stores			
Oceanlife Aquariums (Houston, TX)	■		
Rivers to Reefs (Columbus, OH)	■		
PetCo (Misc. Locations)	■		
Austin AquaDome (Austin, TX)	■		
AquaTek (Austin, TX)	■		
Houston Aq. Warehouse (Houston, TX)	■		
Fish Gallery (Houston and Austin locations)	■		
Aquarium Design Group (Houston, TX)	■		■
FJW Aquarium (Houston, TX)	■		
Fish-N-Pets Unlimited (Houston, TX)	■		
Aquarium World (Houston, TX)	■		
Inwood Aquarium (Houston, TX)	■		
Xtreme Fish & Pets (Houston, TX)	■		
That Aquarium Place (Houston, TX)	■		
T&T Fish and Reef (Houston, TX)	■		
Austin Aqua Farms (Austin, TX)	■		
Fishland (Houston, TX)	■		
50 Fathoms Pet Shop (New Orleans, LA)	■		
N. Waco Tropical Fish, LLC (Waco, TX)	■		

Table 4: *Continued*

Sample	Mode of Data Collection: Participant Observation	Content Analysis	Interview
Category 6: Online Distributors			
LiveAquaria.com PremiumAquatics.com FragHouseCorals.com JasonFoxSignatureCorals.com HouseofSticks.com WorldWideCorals.com	■	■	
Category 7: Hobby Periodicals			
Coral Magazine Reef Hobbyist Magazine	■	■	

The seven categories listed above constrain my sample to serious participants for various reasons. I review these in turn. For example, large-scale conventions (Table 4. Category 1) require financial and personal commitment to attend. A full conference pass at the 2018 MACNA at the Westgate Resort and Casino in Las Vegas is $159 per person. This cost does not include travel or boarding costs, both of which increase the price dramatically. Further, conferences for aquarium hobbyists always have a vendor room where aquarists can purchase live organisms for their aquaria. Stebbins (2001) among others (Scott et al., 1999; Yair, 1990), state serious participants are often highly committed, and attending a national conference is an example of high commitment in saltwater aquarium keepers.

Smaller conventions and local clubs (Table 4. Category 2, above) are also appropriate places to sample serious participants. While national conventions support seriousness with financial commitment, local groups are comprised of serious individuals who show a personal and social commitment to their geographically specific social world. Their seriousness is similar but much more localized in participation scope. Methodologically, the local conventions and clubs allowed me to compare and contrast seriousness, and as stated these seem to be similar enough to be grouped together in this study.

Online aquarium forums (Table 4. Category 3) showed the largest variation in participation, with forums specifically for new aquarium keepers as well as more advanced. Forums are open to anyone with an internet connection, thus offer a global community of participants a way to socialize and exchange information about the hobby. Further, the open access nature allows new and experienced aquarists the ability to interact, indicated by a unidirectional conversation. In fact, online forums depend on transmission from advanced to new hobbyists, as a free service there are no known paid members who are paid to dispense information. It is voluntary. These facets indicate online forums may be comprised on diverse participants, but serious hobbyists exist and are relatively easy to identify. In addition, two of these forums have monthly "Tank of the Month" winners, which reflect serious participation in the hobby.

Social media specialist groups (Table 4. Category 4) were comprised of Facebook groups for selling hobby-related items and hobby-related information sharing.

Over the duration of the study, I followed over 20 different groups from Addicted to Fishkeeping to Zoanthid Fanatics. Participation in these groups is often strictly limited to specialists in the hobby. For example, people that keep *Zoanthid sp.* are keeping one genera of coral species unnecessarily[1], thus they have chosen to take one piece of the hobby and specialize in it. This is an aspect of serious participation.

Another aspect of participation is shopping at pet and aquarium specific stores for hobby-related accoutrements (Table 4. Categories 5 & 6). These take two general forms, local pet and fish stores (LPS and LFS, respectively) or online stores. The only local pet store (LPS) I sampled was the national pet store chain, Petco. I also visited 19 fish-only stores (LFS). The difference between pet and fish stores is significant. Pet stores sell fish and other pets while fish stores sell *only* fish. Fish-only stores are specialized offering fish-specific pet owners a place to shop for unique or specialized items. It is for these reasons I sampled more fish-specific stores than pet stores.

I also joined the mailing lists of online distributors, including liveaqaria.com. This website is a major distributor for saltwater organisms in the United States. They offer "bread and butter" stock as well as organisms that are hard to keep and require very specific care. On a weekly basis I checked the "Diver's Den", a specific part of liveaquaria.com that offers unusual organisms or "what you see is what you get". Not all

[1] It is important to note that some species require species-specific aquaria. This may indicate seriousness as most aquarists strive to keep a highly biodiverse aquarium. In the saltwater hobby, species specific aquarium keepers were often breeders of those organisms.

aquarists understand the importance of seeing the live organism before purchase, so any online distributor that offers "WYSIWYG" is considered to cater to advanced aquarists.

Lastly, I reviewed two hobby periodicals, including Coral magazine and Reef Hobbyist Magazine (Table 4. Category 7). Coral Magazine is a subscription-based bi-monthly periodical and Reef Hobbyist is a free, short, monthly periodical. Both are saltwater specific with articles for all levels of aquarium owners. They are also comprised of advertisements attempting to increase sales by offering the products aquarists want.

The next section review the specific methods used to obtain data for this study. These sections review grounded theory, ethnography, the analyses I used, and the limitations of the study. These sections conclude Chapter 3.

Grounded Theory

Grounded theory is the systematic but flexible guide for conducting qualitative studies aimed at constructing theories "grounded" in the data (Charmaz, 2006; Glaser & Strauss, 1967). It asks the researcher to participate in the social world, or milieu, for a sustained period of time (Charmaz, 2006, p. 21). Further, supplementary data can be used to provide detail about the social environment under investigation. In addition, Stebbins (1982, 2015) stipulated that a social world meets one of the six characteristics of serious leisure, connecting theory to method.

This method of inquiry, or "genre" (Saldaña, 2011), can and was used in conjunction with participant observation and ethnography (Charmaz, 2006, p. 21). The

focus of grounded theory is to learn what occurs in the research setting of choice, in this case the saltwater aquarium keeping social world, and what the participant's lives are like. This is done by paying close attention to the details in which they speak and the actions they make (Charmaz, 2006, pp. 2–3) and these are the data points in which this method is built. As Glaser (2002) stated, "All is data".

I conducted grounded theory by beginning on a small scale (i.e., individuals and individual cases) and progressively developed more generalizable characteristics and themes. These categories, reviewed in the Results Chapter, synthesized small-scale incidents into general, or abstract, characterizations. Grounded theory allowed me to stay close to the data, continually reviewing from various perspectives over time. During this time, I built the foundation of *science as leisure* around the social world of aquarium keeping. The immense size of the aquarium hobby is paralleled by the amount of data available. Grounded theory allowed me to rigorously review thick, Jimmy descriptions by checking, refining and developing theory, it also allowed me to analyze large amounts of data (Charmaz, 2006; Kathy Charmaz, 1996).

Ethnography

Ethnography is a cyclical research process (Spradley, 1980, pp. 26–29) and it is this cycle of inquiry that includes (a) asking ethnographic questions, (b) collecting ethnographic data, (c) making an ethnographic record, (d) analyzing ethnographic data, and then repeating the cycle until triangulation or crystallization of findings occurs

(Figure 9). Ethnographic data are thick, rich, detailed descriptions of human groups "seeking to understand how they collectively form and maintain culture" (Denzin, 2001; C. Marshall & Rossman, 2011, p. 19). Thus, the central focus of ethnographic research is the culture of a group, including the actions and interactions of the group members.

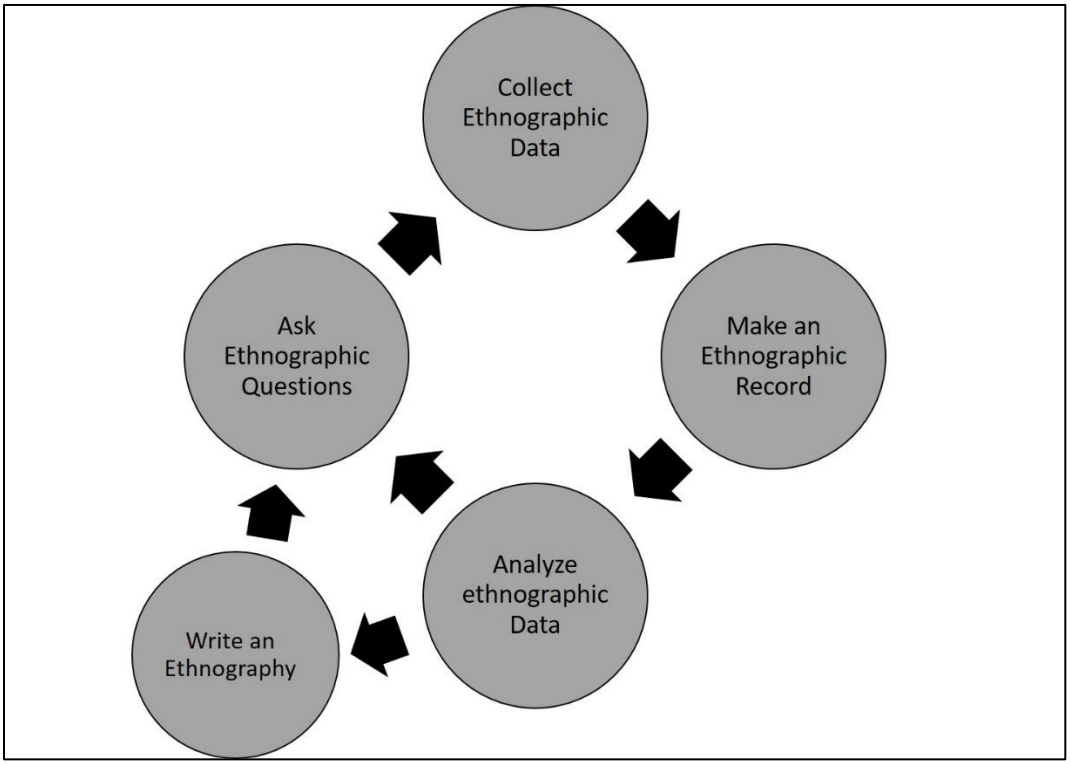


Figure 9: The cyclic research cycle of ethnography. Adapted from Spradley, 1980.

This method relies heavily on participant observation as the means for data collection. Through ethnographic interviews with saltwater aquarists, this process was continually recycled until theoretical saturation occurs. In addition, this process also

allows for new theory to emerge through the process of grounded theory (Glaser & Strauss, 1967). Ethnographic studies cover a wide range of topics stemming from Stebbins' foundational work on serious leisure included archaeology and astronomy amateurs and various types of entertainment-related activities (singers, thespians). Other activities explored via ethnography include contract bridge (Scott & Godbey, 1994, 1992), marijuana use (Moffat, Johnson, & Shoveller, 2009), street corner societies (Whyte, 1993), and hikers along the Pacific Crest Trail (Lum, 2015).

Ethnographic techniques utilized in this study include grounded theory with participant observation and thick description, in-depth interviews, and content analyses (Table 4). All techniques, omitting interviews, were done recursively from 2014-2018. Interviews took place between 2016 and 2018 and were included in the recursive analyses post-transcription. Each technique and detailed methods are reviewed below.

Participant Observation

Observation is a central facet to qualitative research (Marshall & Rossman, 2011); it is used to discover, in situ, the complex interactions that occur in social groups (2011). This method puts the researcher in a position of "observer as participant" and this participation can occur at varying degrees of involvement, from passive to complete participation (Spradley, 1980, p. 58). Complete participation is sometimes conducted when the researcher is already a participant in the activity under investigation (1980, p. 61). Further, I needed to become a "socially acceptable incompetent" (Babbie, 2007, p. 308). Participant observation also lends validity and credibility to the qualitative

research; through prolonged and reflexive engagement with the social group under study (Marshall & Rossman, 2011).

Qualitative studies can suffer from issues of reliability, but during the cyclical collection of ethnographic data (Figure 9), credibility, confirmability, and validity are increased through member checks, peer debriefing, and triangulation (reviewed below; Marshall & Rossman, 2011). The ethnographic approach also requires a degree of self-assessment, an important facet when prolonged engagement could alter objectivity (Bowen, 2009).

Previous experience and participant observation builds the foundations of 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. There, I could be a "professional stranger" (Agar, 1996), listening to aquarists ask questions and comment on things important to them. This is especially true in social media interest groups and online forums where questions may be posed anonymously.

From 2015-2017 I participated in the saltwater aquarium hobby by maintaining a mini-reef aquarium (Figure 10). My miniature reef aquarium cost approximately US$1000 to set-up and was funded by the Marine Aquarium Society of North America (MASNA). During this time, I maintained the system with a few major issues. For one, I chose to set up a "nano" aquarium – one that is under 10 U.S. gallons. As reviewed in the results, small aquaria are unstable and elicit many problems for aquarists. These problems were noted in my logbook where I kept notes specific to the system, including

water chemistry analyses (as suggested by the social world community) and observations of organisms (Figure 11).

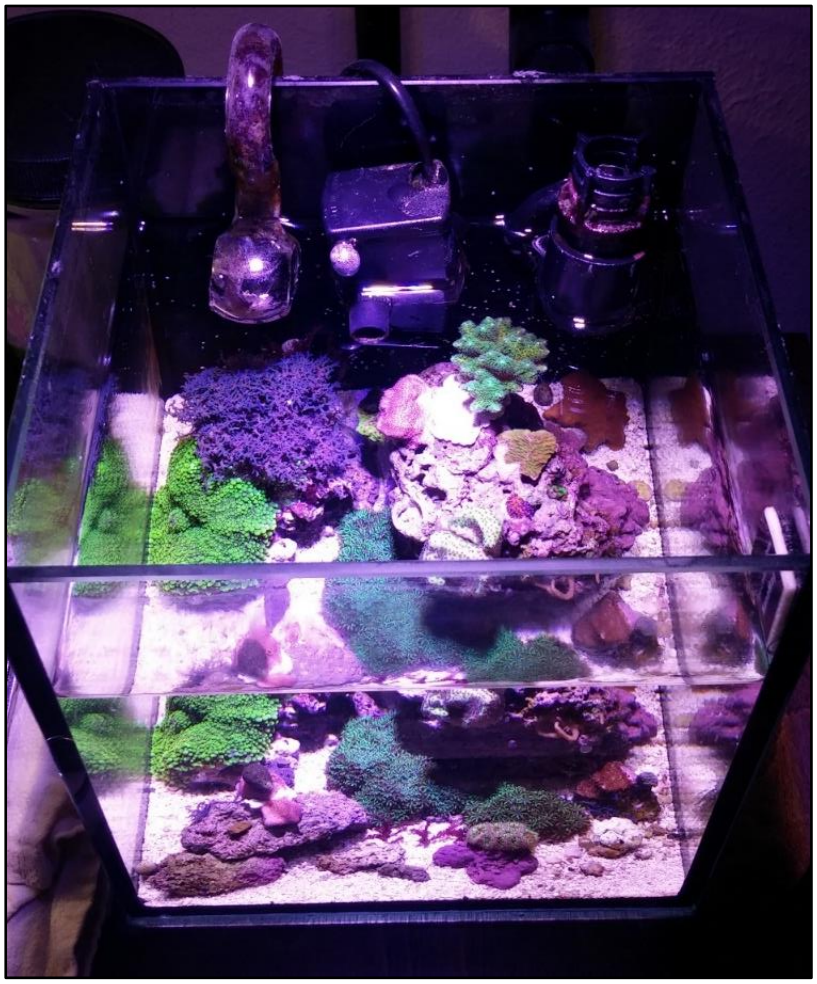


Figure 10: A top-down photo displaying the equipment and organisms in my 2.5 gallon, 8" x 8" x 8" miniature reef aquarium. Photo by Elizabeth Marchio, 2016.

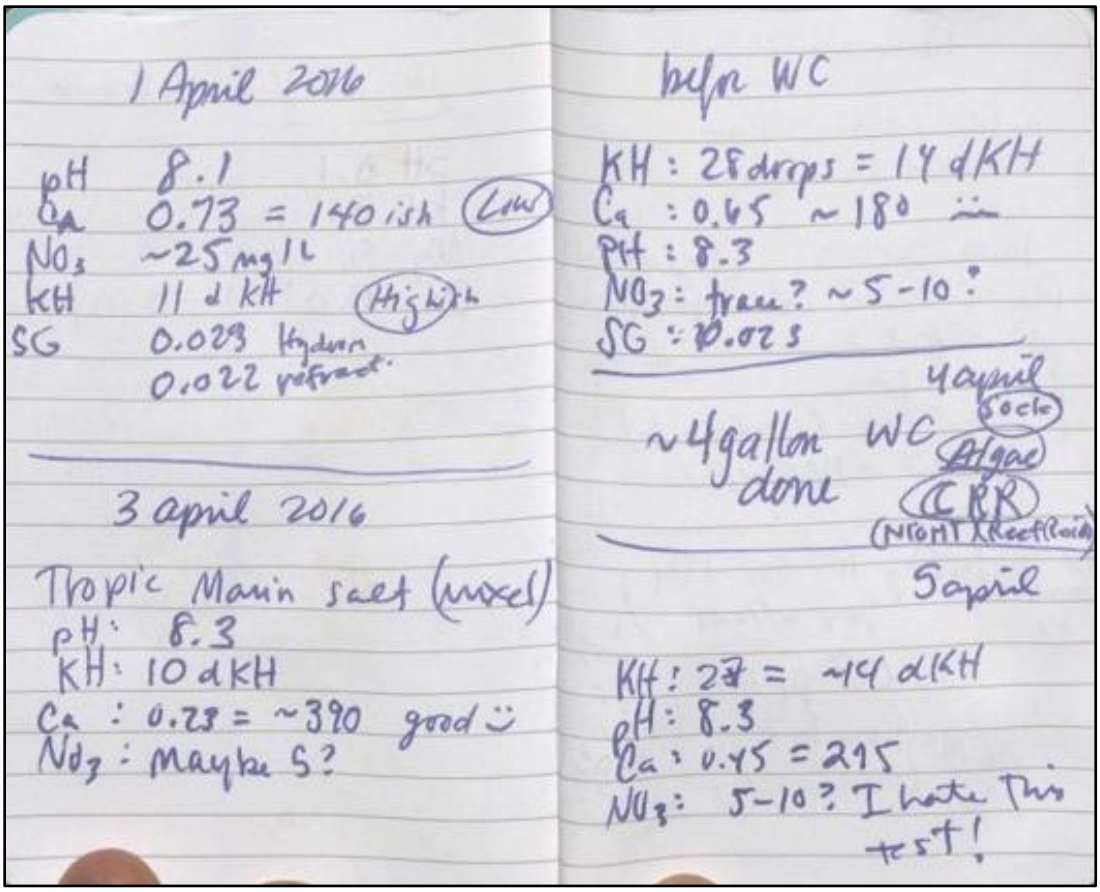


Figure 11: Tank journal .

The aquaria, a 2.5-gallon reef display (Figure 10), has allowed me to not only experience what a hobbyist experiences (Figure 11), but gives me fodder for conversations with them. These conversations have proven essential to my ability to communicate with and understand aquarium hobbyists. This has also increased trust between me and other aquarists, an essential element for my research. Further, I have gained an insider's perspective on the hobby through being a participant as observer

(Gold, 1969). For example, during the study I had to I judge the accuracy of unsolicited and solicited information I gained while participating. Specifically, when I shopped through the vendor hall at the 2017 Marine Aquarium Conference, I listened to the conversations of others (unsolicited) and asked my own questions (solicited). It was evident there were specialists in coral identification, but some, such as coral vendors, focused on color morphs over species. I also listened to the conference seminar talks and the information they provided to the audience (again, unsolicited). Overall, participation and observation has been an integral part of my work in understanding specialization among aquarists and the connections I made during that time have been essential for my sampling and confirmation procedure.

Content Analyses

The aquarium hobby is popular and much more complex than first glace. The set-up, maintenance, and long-term success of an aquarium is highly involved and detailed, thus resulting in large amounts of hobby-related accoutrements. Here I considered "content" to encompass everything, from hobby conference 'swag bag' contents, to magazine, online forum, and social media content. As Glaser states, "All is data" (2002), thus all content associated with the hobby was data. Content analyzed for this study includes that from (1) national saltwater aquarium hobby conventions, (2) local conventions and club gatherings, (3) online forums and communities, (4) social media specialty groups, (5) aquarium stores, (6) online distributors, and (7) hobby periodicals (Table 4, above).

Data collected from conventions and clubs (Table 4. Categories 1 & 2) was varied, and ranged from free conference "swag" (i.e., hobby-related promotional flyers and advertisements, accoutrements, and coupons; Figure 12) to analyzing the science and conservation-related language and content of the vendor room (Figure 13). The focus of my analyses is on recent convention content, i.e., Figures 12 & 13, collected during the IRB data collection period in 2016-2018. Content from previous experience in the hobby (i.e., before the IRB application) are historical documents (IRB2017-0405D). Irrespective of my research agenda, I obtained all content in a similar fashion as other aquarists. For example, every conference attendee of a MACNA received a 'swag bag', which encompassed approximately 4985 daily conference tickets purchased at the New Orleans, Louisiana conference in 2017 (Figure 14; www.macna.com/exhibits).

Figure 12: The contents of the 2017 Marine Aquarium Conference of North America 'swag bag'.

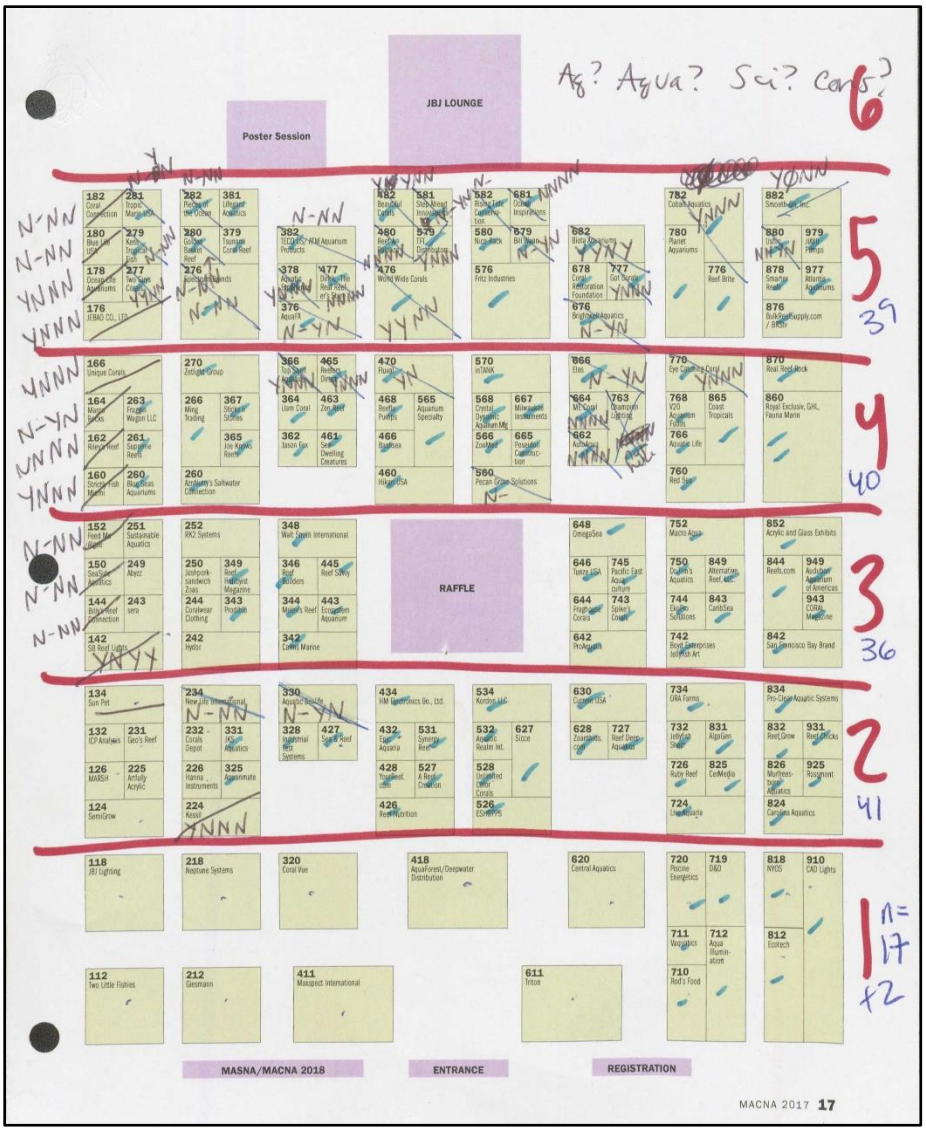


Figure 13: The 2017 MACNA vendor map with memos.

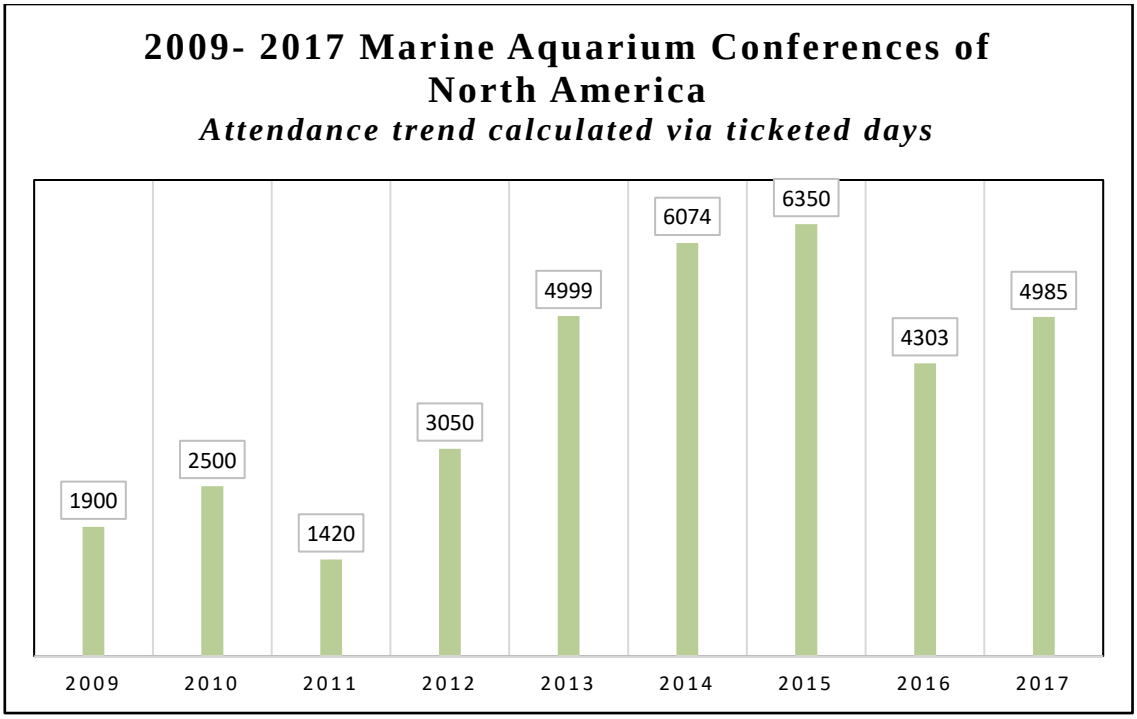
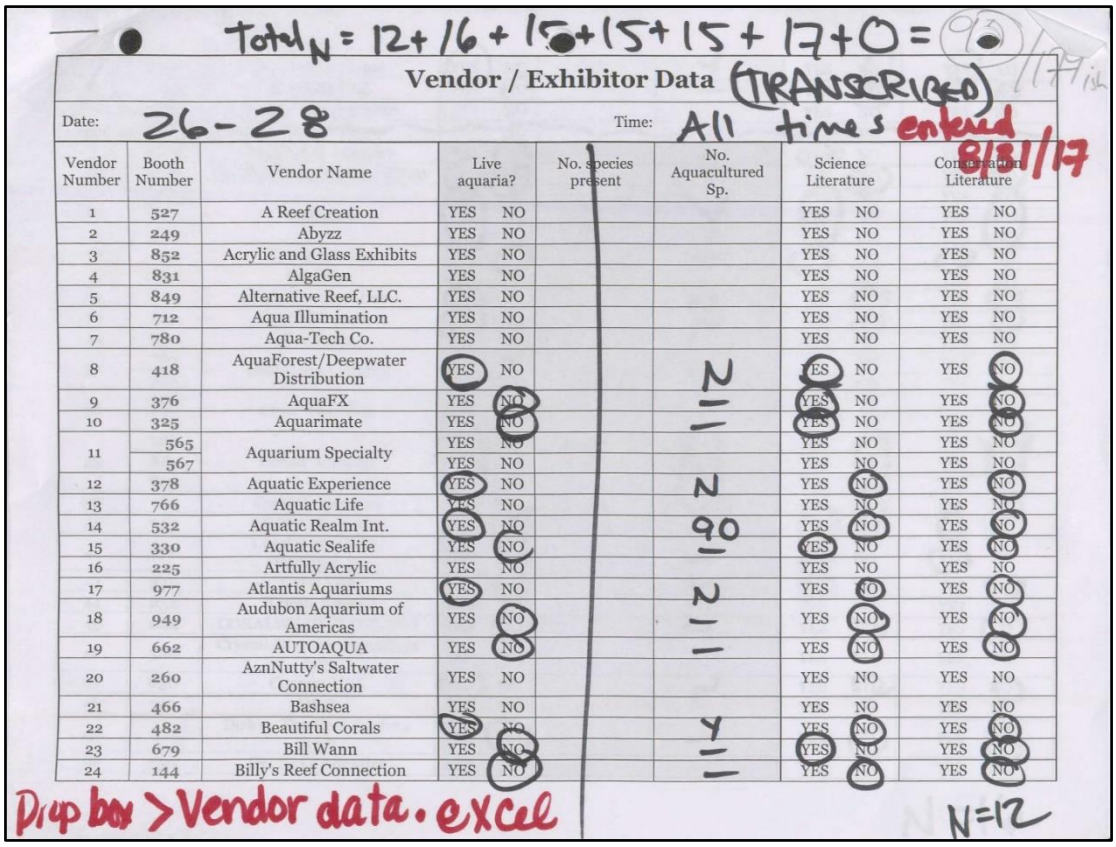


Figure 14: Attendance trends, via daily ticketed sales, for the multi-day Marine Aquarium Confernce of North America from 2009-2017.

Along with assessing the content of the 'swag bag', I assessed the science and conservation content of the vendors in the vendor room for the 2017 MACNA. To accomplish this, I took the vendor map (Figure 13) and randomly selected vendors to walk past (Figure 15) and assess their display(s) for science and conservation themes as well as live, cultured organisms. Science themes include: (a) the use of scientific language (e.g., "nutrition", Figure 16), (b) associated applications of science (i.e., technology), (c) or through conveying a sense of scientific knowledge, skill, or orientation. Conservation themes included those that outwardly displayed promotional

conservation material to materials that use conservation-charged language, such as Piscine Energetics' use of the word "sustainable" to describe their focus in collecting live shrimp for fish food (Figure 16).



Total$_N$ = 12+16+15+15+15+17+0 = 90

Vendor / Exhibitor Data (TRANSCRIBED)

Date: 26-28 Time: All times entered 8/31/17

Vendor Number	Booth Number	Vendor Name	Live aquaria?	No. species present	No. Aquacultured Sp.	Science Literature	Conservation Literature
1	527	A Reef Creation	YES NO			YES NO	YES NO
2	249	Abyzz	YES NO			YES NO	YES NO
3	852	Acrylic and Glass Exhibits	YES NO			YES NO	YES NO
4	831	AlgaGen	YES NO			YES NO	YES NO
5	849	Alternative Reef, LLC.	YES NO			YES NO	YES NO
6	712	Aqua Illumination	YES NO			YES NO	YES NO
7	780	Aqua-Tech Co.	YES NO			YES NO	YES NO
8	418	AquaForest/Deepwater Distribution	YES NO		N	YES NO	YES NO
9	376	AquaFX	YES NO		—	YES NO	YES NO
10	325	Aquarimate	YES NO		—	YES NO	YES NO
11	565	Aquarium Specialty	YES NO			YES NO	YES NO
	567		YES NO			YES NO	YES NO
12	378	Aquatic Experience	YES NO		N	YES NO	YES NO
13	766	Aquatic Life	YES NO			YES NO	YES NO
14	532	Aquatic Realm Int.	YES NO		90	YES NO	YES NO
15	330	Aquatic Sealife	YES NO		—	YES NO	YES NO
16	225	Artfully Acrylic	YES NO			YES NO	YES NO
17	977	Atlantis Aquariums	YES NO		N	YES NO	YES NO
18	949	Audubon Aquarium of Americas	YES NO		—	YES NO	YES NO
19	662	AUTOAQUA	YES NO		—	YES NO	YES NO
20	260	AznNutty's Saltwater Connection	YES NO			YES NO	YES NO
21	466	Bashsea	YES NO			YES NO	YES NO
22	482	Beautiful Corals	YES NO		Y	YES NO	YES NO
23	679	Bill Wann	YES NO		—	YES NO	YES NO
24	144	Billy's Reef Connection	YES NO		—	YES NO	YES NO

Drop box > Vendor data. excel

N=12

Figure 15: Vendor data sheet with memos.

Figure 16: A tri-fold flyer evokes science and conservation themes, denoted by notes.

For vendors with live organisms, I assessed the "content" of the aquaria, identifying each species present[2]. I was assumed a customer, alleviating contact with

[2] Aquaculture is the captive propagation of organisms, and in the aquarium hobby, an aquacultured organism is not a wild organism. Selling or purchasing wild organisms connotes a lack of conservation orientation.

vendors unless species identification was required. The identification process required previous taxonomic experience identifying common aquarium species and each individual organism's likelihood of being aquacultured. While challenging, shortcuts made this rather straightforward. For example, there are very few saltwater fish cultured for the aquarium hobby (so far), so all fish on display at a MACNA are wild-caught unless they are of a known aquacultured species[3].

While fish seem to be a focus of aquarium keeping, the display and sale of live coral seemed to be the focus of the vendor room and throughout much of the marine aquarium hobby. Randomly selected vendors, who displayed live coral, for sale or display only, were assessed using the following characteristics: (1) species identification, (2) size of each individual specimen for sale, (3) attachment structure (e.g., "frag plug" or "live rock"), (4) color, and (5) collection location. Coral species are not always easily identifiable; however, captivity selects for certain, colorful, hardy species that are commonly seen in the aquarium trade. For example, *Anacropora sp.* is extremely rare but a similar genus, *Acropora sp.*, is commonly traded. However, if I saw an *Acropora* larger than 2" (i.e., 4 cm) in any dimension, I would need to assess it further as aquacultured. Some coral species are maricultured, which means they are grown in the ocean for the aquarium trade. Aquacultured corals are grown in captive conditions but both it and maricultured corals are considered sustainable.

[3] Advances in aquaculture are regularly shared on social media and in hobby periodicals (e.g., Coral Magazine).

Live coral is often sold or traded in small sizes, sometimes as small as possible (Figure 17). Further, the vendors were asked for clarification regarding the source of the organism, if necessary. In addition to size, the color and attachment source are evaluated. Attachment source refers to the base structure a coral has been grown on. Coral larvae "settle" on a substrate, mainly rock, so coral fragments on "plugs" or artificial structure are likely aqua- or maricultured. Wild specimens of non-stony coral and some stony coral are collected with substrate attached, a clear indicator of wild collection, and potentially an unsustainable source of coral as well as substrate.

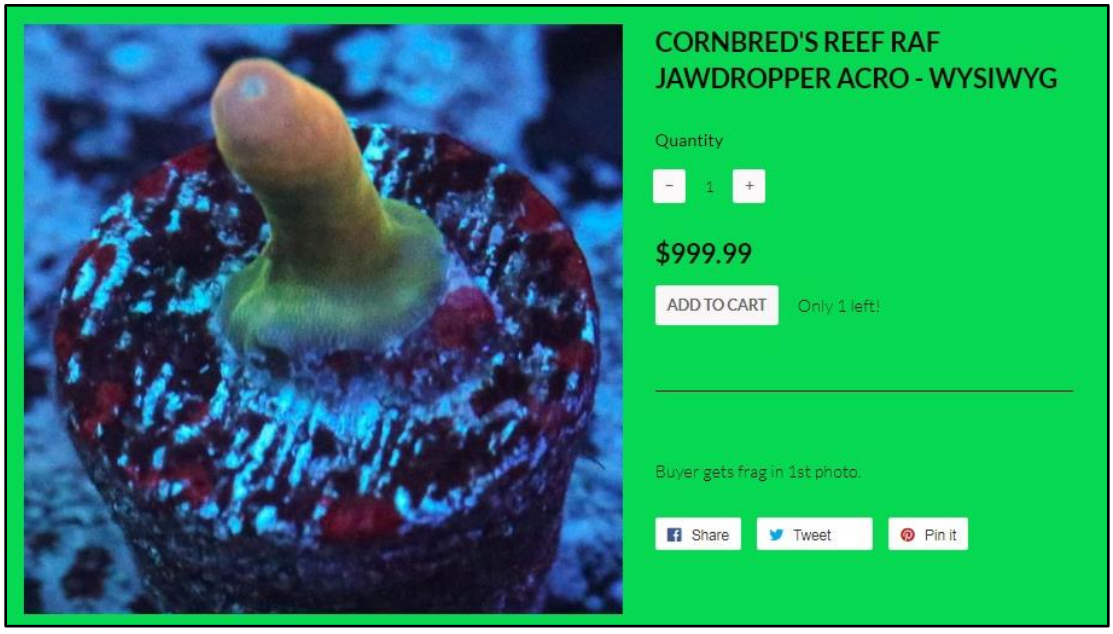


Figure 17: An *Acropora* coral fragment consisting of one polyp and measuring less than 1". Image from the www.cornbreadcorals.com.

Outside of the evaluation of live specimens, analyses of hobby accoutrements were done recursively. As I participated in the hobby and analyzed content, I noticed various themes that paralleled those found in interviews as well as themes from my own experience (i.e., researched reached theoretical saturation). Content was collected over 2014-2018 and analyses were done by hand. Detailed analyses are given in the Analysis section below.

In-depth Interviews

In-depth interviewing is a dependable ethnographic method for collecting reliable data in a qualitative context (Haig, n.d.; Ritchie, Lewis, McNaughton Nicholls, & Ormston, 2014; Spradley, 1979; see section on Reliability, below). Interviewing involves the solicitation of participants from the social world under investigation and the procedure of conducting and transcribing an interview. Done in-person, over the internet, or via- phone, interviews may take the form of a formal, structured event, a semi-structured procedure with guiding questions, or unstructured interviews with little to no interview organization.

This research is based partly on interview data gather through 17 in-depth, semi-structured interviews with individuals who were currently caring for at least one saltwater aquarium in their home. I sampled individuals based on theory, i.e., purposive sampling. Purposive sampling is a selective sampling process by which informants are picked based on their ability to provide the most information (Merriam, 2009). To be

included in an interview, informants had to identify as a currently participating saltwater aquarist, be serious about their avocation, and provide verbal consent.

Interviews were done in accordance with the recommendations of the Texas A&M University Institutional Review Board with informed verbal consent from all subjects. Subjects include key informants and gatekeepers of the hobby (Merriam, 2009). Reviewed in Table 5, informants include an editor of a major aquarium magazine, speakers at the national Marine Aquarium Conference of North America (MACNA), professional researchers in aquaculture, scientists from the California Academy of Sciences, aquarium club members across the United States, as well as aquarium technicians and "*local fish store*" workers. Using these connections, I made a network of individuals that I ask to comment on my conclusions of the hobby. I also used these connections to gather interviews from less serious aquarium keepers; however, the vast majority of the research presented here is based on serious participation. Online discussions also aided in receiving critical reviews.

Interviews were completed in-person and through telephone interviews. I treated these as "guided conversations" (Babbie, 2007, p. 307) or "conversations with a purpose" (Burgess, 1984). This is best described as an interaction between the interviewer and interviewee that is semi-structured with a general plan of inquiry and includes topics to be covered. Interviewing in this manner proceeded in natural and smooth manner (Babbie, 2007). Interview protocol and guiding questions under IRB2017-0405D appear in Appendix A. I concluded the interviews in accordance with

Creswell and Plano Clark (2006) where conclusion occurs when no new information is discovered.

The age of informants ranged from 18 to 55 and their start in the hobby ranged from age six to age 31. Of the 16 informants, five were female. Solicitation of interviews was done through word of mouth, snowball sampling, scientific poster presentations, social media, and e-mail. The duration of each interview was between 30 minutes and 90 minutes

While I desired to know exactly how long each person has been in the aquarium hobby, it was not possible to calculate an accurate duration in the hobby. To do so, aquarists would need to calculate the number of years they maintained a saltwater aquarium during the entire duration of their life. While informants were capable of remembering when they may have taken a break from the hobby, it was not possible to calculate an accurate an accurate duration of that break. In addition, this research shows that much of the hobby is reliant on knowledge gained through the hobby; thus, firsthand experience caring for their own aquarium was used as a starting point for hobby activity.

Table 5: Characteristics of key informants

Key Informant	Demographic, Aquarium, and Interview Information
1 Nikki	Nikki is a female aged 26-35 who works in a science or conservation field, making between $20,001-$35,000/annually. She began keeping saltwater aquaria at age 22 with a 10-gallon aquarium. The most water volume she has maintained is 400 gallons and the largest number of tanks cared for at one time 8. Her single largest aquarium was 135 gallons, and smallest was 2.5 gallons. She stated he spends approximately $10/month on the hobby and in a single purchase, spent $60 on one star polyp coral (*Pachyclavularia spp*.). She does not collect specific color morphs of corals. Her most expensive fish purchase was Frank, a cowfish (*Lactoria cornuta).* Nikki is highly invested in the husbandry of specialized individual organisms, such as her cowfish, which was a wedding gift from her husband.
2 Jessica	Demographic and Aquarium Information: Jessica is a female aged 46-55 who works in a science or conservation field. She makes $85,001-$100,000 a year. She began at age 19 but does not recollect the tank size. The most water volume she has maintained is 120 gallons and the largest number of tanks cared for at one time was 1. Her single largest aquarium was 120 gallons, and did not share the size of her smallest aquarium. She stated he spends approximately $60/month on the hobby and in a single purchase, spent the most on a *Duncanopsammia axifuga* coral. She does not collect specific color morphs of corals. Her most expensive fish purchases were two $500 (wholesale) fish: A Japanese angelfish (*Centropyge interupta*) and a Gem Tang (*Zebrasoma gemmatum*). These animals sell for $4,999.99 and $2,995.99, respectively (prices obtained from www.bluezooaquatics.com on 7June2018). Jessica is highly invested in the husbandry of specialized individual organisms.

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
4 Adrian	Adrian is a male aged 18-25 who works in a science or conservation field making between $20,001-$35,000/annually. He began keeping saltwater aquaria at age 12 with a 29-gallon aquarium. The most water volume he has maintained is 299 gallons and the largest number of tanks cared for at one time is 6. His single largest aquarium was 150 gallons, and smallest was 6 gallons. He stated he spends approximately $250/month on the hobby and in a single purchase, spent $300 on one 'Chalice' coral (*Echinophyllia spp*.). He collects specific color morphs of corals, which this may have been. His most expensive fish purchase was a Majestic angelfish (*Pomacanthus nevarchus*). Adrian was interviewed individually at MACNA 2017 in New Orleans Louisiana. He was employed at a major fish distributor in Florida.
5 Carl	Carl is a male aged 18-25 who does not work in a science or conservation field making under $20,000 annually. He began keeping saltwater aquaria at age 12 with a 45-gallon aquarium. The most water volume he has maintained is 110 gallons and the largest number of tanks cared for at one time is 3. His single largest aquarium was 110 gallons, and smallest was 14 gallons. He stated he spends approximately $100/month on the hobby and in a single purchase, spent $70 on a fragment of Jason Fox's Grafted Monti (a chimeric *Montipora sp*.). He collects specific color morphs of corals, which this was. His most expensive fish purchase was a $150 Metallic/Magnificent Foxface (*Lo magnifica*). Carl was interviewed in a 3-person focus group at MACNA 2017 in New Orleans, Louisiana. Carl was with a female, showing her around the conference and helping her set up her new aquarium with the equipment, information, and organisms obtained at the show.

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
6 David	David is a male aged 46-55 who works in a science or conservation field. He makes $100,000+ a year. He began keeping saltwater aquaria at age 6 with a 40-gallon aquarium. The most water volume he has maintained is 600 gallons and the largest number of tanks cared for at one time is 15. His single largest aquarium was 600 gallons, and smallest was 4 gallons. He stated he spends approximately $400/month on the hobby and in a single purchase, spent $500 on one coral (*unidentified*). He does not collect specific color morphs of corals. His most expensive fish was a $250 basslet (*Liopropoma collettei*). David was interviewed in a 3-person focus group at MACNA 2017 in New Orleans Louisiana. David held the Secretary General positon on the Marine Aquarium Societies of North America at the time of the interview.
7 Jared	Jared is a male aged 35-46, was, and is currently the President of the Marine Aquarium Societies of North America. He spent time, on and off, speaking with me during the 2017 MACNA as well as the 2015 and 2016 conferences. We remain connected via social media as he was a major source of verification and an information source of all things hobby related. His time and support as a gatekeeper made this research possible. Jared does not keep an aquarium now as he has been completing his Ph.D. and is now a Marine Biosecurity Specialist in Australia. He is originally from the United States.
8 Jimmy	Jimmy is a male aged 46-55 and was a major source of verification for several facets of the marine aquarium hobby. We met at MACNA 2015 and spoke at MACNA 2016 and 2017 in between his responsibilities as a speaker and host/entertainer at the conference dinner. Jimmy's favorite marine organisms are Cephalopods, such as octopus, which he has a tattoo of on his arm. Jimmy has kept aquaria professionally and as a hobbyist.

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
9 Daniel	Daniel is a male aged 46-55 who works as a freelance writer for aquarium-related publications. Daniel and I met in 2015 and we have communicated about the hobby since then. Daniel is another source of verification for my research findings and his work emphasizes the importance of data to the aquarium industry. He does not keep an aquarium at the time of this research.
10 Robert	Robert is a male aged 26-35 who works in the aquarium hobby as local fish storeowner. He opened his store in 2014 and set each aquarium up himself (with help from his now husband and several club members and friends). The store currently houses approximately 4,500 gallons of water. I met Robert in 2002 while working at an aquarium store; we have remained in contact over social media. He currently has several aquaria set up, the number that changes regularly. As of 8June2018, he runs 350 total gallons of freshwater aquaria and 300 salt. Plus, a 90-gallon pauldarium coming in the next week. Robert has acted as an information source for all thing trade related, from importing fish and coral to policy-related information.
11 Richard	Richard is a male aged 26-35 and works at a local fish store in Texas. There he is an aquarium technician-, which means his job is to go out and take care of aquaria in homes, offices, hospitals, elderly facilities, among many other places. I met Richard through social media where I solicited interviews from several social groups. His interview is the result of snowball sampling; another interviewee suggested I talk with him. He was called the “go-to guy” for aquarium information. Upon talking with Richard over the phone, they were right.

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
12 Jasper	Jasper is a male aged 18-25 and makes $20,000-$35,000 annually. He is a student as well. Jasper started keeping aquaria at age 18 and the largest aquarium he has ever cared for, as well as his first aquarium, was 65 gallons. The largest volume of saltwater aquaria he has kept at one time is 230 gallons and he has kept a maximum of 4 saltwater aquaria at one time. The smallest tank he has maintained was a 10 gallon. Jasper collects specific color morph of corals, and seems to be interested in "designer" clownfish. For example, the most expensive fish he has ever purchased was a 'Da Vinci' clownfish, which is a captive bred clownfish that has a lineage and was selected for a specific color and pattern. Choice in coral does, and does not, parallel. his interest in selected-for coral color and pattern. He lists his most expensive coral as an Open Brain coral, which he spent $400. This species of coral is currently incapable of being reproduced in captivity. Designer corals have a lineage and /or are capable of having one. At this time, Open Brain coral (*Trachyphyllia geoffroyi*) are not capable. I did not ask him if he knew this, but would like to follow up in future, more specific, manuscripts. Further, he stated he collects coral morphs, so it seems likely he does so at a lesser price. This is reasonable, as $400 is a fair amount, even for a designer frag. Jasper had a perspective from an aquarium store worker as well as a home hobbyist. He was a part of a 2-person focus group with Malori, who is his stepmother. The interview was at the 2017 MACNA in New Orleans. He moved in with her at one point and she had a 55-gallon aquarium with a max of 3 aquaria at one time. He was interested in African cichlids and saltwater aquaria and learned about more specific fish tank parameters and fish from her. He has since moved out and at the time of the interview, had 7 aquaria set up. Jasper had a lot of insight information about aquarists he sees come into the aquarium store and trends across time.

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
13 Malori	Malori is a female aged 36-45, works in a science and/or conservation field, and makes $45,001-$55,000 annually. As an undergraduate, she studied Wildlife Ecology and Conservation when she began keeping an aquarium. She wasn't into conservation of aquatic resources until she began working at a fish store and got into the reefs, saltwater, African cichlids and became super interested in that aspect of ecology and conservation. She began keeping aquaria at a relatively older age, at 31 years old with a 45-gallon aquarium. The largest total volume of saltwater kept at one time was stated to be 110 gallons in a 110-gallon aquarium. Her single smallest saltwater tank was 37 gallons. Malori does not collect specific color morphs, nor does she know the "specific" (scientific) name of coral but "notices color pattern" on coral. The average they spend on the aquarium hobby, per month is $100, which is also the total value of her most expensive coral purchase (*Zoanthid sp*.; which she wrote as "zooanthid", a common misspelling). Her most expensive fish was a Blonde Nano Tang. Malori was interviewed in a 2-person focus group at MACNA 2017 in New Orleans Louisiana. She was with her stepson, Jasper. Both of them have worked at aquarium stores. She had insight into conservation, specifically how people look at saltwater organisms in a conservation orientation.

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
14 Hunter	Time was aged 20-30 and was working in a science/ conservation field at the time of the interview. Hunter was a previous scholarship winner for the Marine Aquarium Conference and was somewhat of an honorary attendee in 2017. I knew Hunter from previous MACNA events and we talked a great deal at the 2017 conference. There, he accepted an invitation to interview him over the phone. Hunter and I talked over the phone for about an hour, unrecorded. I took notes over the course of the interview. He stated that he was most interested in finding a coral species he would excel at maintaining, enough that he could propagate it. Once he was able to propagate that species, he began collecting different color morphs. For example, he started with Zoanthid coral, mastered it, collected and traded specimens, and then moved to another species of interest once Zoanthids became too easy. Hunter was always looking for a challenge and a coral that could be propagated to support his hobby.
15 Jai	Jai was between 29-39 years old and was relatively less serious. She seemed to do things by a shoestring, saving money where she could. Specifically, she mentioned an unwillingness to upgrade her lighting system (her significant other wanted to upgrade). She said they did not have any coral that needed such a high end lighting system. She admitted to being a "jeans a t-shirt kinda girl" and stated several inaccurate concepts about the hobby, specifically scientific in nature. Jai was interviewed over the phone in an unrecorded conversation. We talked for 1-1.25 hours and I took notes during the conversation.
16 Scott	Demographic and Aquarium Information: Jai had suggested I talked to Scott, a leader and "go-to" person in her local aquarium club. Scott and I spoke over the phone for 1.25-1.5 hours, a conversation encompassing a lot of information about the local participants as well as himself. He said he was patient and willing to help others, he spoke rather disparagingly about some of the local aquarists who seemed to want to show off. He admitted not being interested in the hobby until captive raised organisms were available, although it is unlikely he limited himself to only those organisms – there simply is not enough to create a true reef tank (yet).

Table 5: *Continued*

Key Informant	Demographic, Aquarium, and Interview Information
17 Wilber	Wilber was aged 45-59 and was interviewed over the phone in a recorded conversation. He had several interesting stories about his fish, some of which negated each other a bit. For example, he said he did not name his fish but later told a story about a lionfish he had named after a hitman. The fish was passed along to several aquarists who wanted to get rid of a specific fish in their tank, so they would borrow the lionfish and let him hunt and eat them. Wilber used to be intimately involved in his local aquarium club until it obtained non-profit status. He said after that it was no longer fun so he and his wife quit the club board membership and just enjoyed their hobby as they felt they wanted – no other people involved.

Analysis

In order to analyze the data, I followed the methods suggested by Spradley (1980), Glaser and Strauss (1967), Marshall and Rossman (2011), and Charmaz (2006). All work was done by hand, including the transcription and coding of interviews, content, and other related materials.

Coding and Constant Comparison

According to Charmaz (2006), coding consists of extracting categories in a summarization of the data. By breaking-up large pieces of data (e.g., interview transcripts), I was able to move beyond the concrete and towards an analytic interpretation of the data. Coding can be thought of as a distillation process where large pieces of data are systematically reduced to categories or themes (Coffey & Atkinson, 1996). Done continually, across two phases (Charmaz, 2006), unrelated themes remain. Further, theoretical coding extends the themes towards an articulation of a theory and an analytic story (Charmaz, 2006).

This reductive technique also creates increasingly abstract themes and categories from the data (Charmaz, 2006). Along with the constant comparison method (Glaser & Strauss, 1967), a mode of analysis that compares data within and between scales (i.e., initial data, categories, and concepts). These are successive stages of analysis.

Across the three data collection methods, I processed the data similarly. The initial step, or phase, was general coding of data collected via interviews, participant observation, and content analyses. Recurrent analyses supported some of these themes

more than others. At this point, I reflected on the data and codes in light of the theoretical frameworks and my previous experience in the aquarium hobby. I took the codes I created and dissected them. There I reassembled the data into a different story, one that not only integrates theory, but also extends and add robustness. This focused coding aided in theoretical coding (Charmaz, 2006). As a recursive process, this continued until not only theoretical saturation, but also a cohesive and understandable set of stories emerged. This method of analysis also constantly compared outcomes (Glaser & Strauss, 1967).

An example of coding can be seen in Figure 16. There, I analyzed the written content of the Piscine Energetics ad, and three themes emerged, including nutrition, sustainability, and invasive species. These themes were the first round of analysis for coding. Along with constant comparisons across all content, interviews, and experience, two overarching themes emerged: science and conservation. Nutrition is a scientifically oriented theme, where aquarists emphasize the importance of a proper diet for their captive animals. In addition, Piscine Energetics' tri-told ad (Figure 16) uses conservation-laden language including "sustainability" and "invasive species" an important emerging issue (Bandaranayake & Chandrasekara, 2017; Bax, Williamson, Aguero, Gonzalez, & Geeves, 2003; Chucholl & Wendler, 2017; Duggan & Pullan, 2017; Li, Chen, Wang, & Copp, 2017; Magalhães et al., 2017; Mendoza, Luna, & Aguilera, 2015; Moorhouse & Macdonald, 2015; Tuckett et al., 2017; Warwick et al., 2018). These papers are specifically over invasive species in aquatic environments, most with an emphasis on the ornamental trade.

Memo Writing

Another mode of analysis used in this research project is memo writing. This is a method of pausing to analyze codes, categories, and constructs (Charmaz, 2006). Continuous memo writing encourages reflection and reassessment of the data. With each recursive phase, more information is added to the body of knowledge I gathered, so constant comparisons were necessary.

Researchers use memo writing as a way to keep notes during quick informal gatherings or in formal structured ways. Formal methods include clustering and freewriting (Charmaz, 2006). Clustering clusters similar ideas and experiences together to form a cohesive "cloud" of interconnected terms and ideas. In the coding section above, an example is given regarding the elicitation of science and conservation as overarching themes. These were categorized using the "cloud" method, above. I also utilized freewriting- as stream-of-consciousness writing aiming to flesh out internalized ideas and experiences. This was akin to a diary where I took notes at conferences, club meetings, aquarium stores, and any social event.

For my research, I reflected on my position as a researcher studying aquarium hobbyists (i.e., reflexivity; Berger, 2015) and the emergent data and themes. Usually freewriting was done on scrap paper but I kept several notebooks of memos detailing social situation and themes I saw and experienced. Notes included, who was present at the event (e.g., number, gender, age), if they interacted with each other and how, the behaviors and actions of the social group, the interaction of the people and the

organisms, and what these organisms represented to the aquarists. I further performed clustering to align my data with theory in order to understand the interconnectivity and to create a cohesive, understandable story.

Theoretical Saturation

Because ethnography involves continual data collection and constant comparisons across methods, ending data collection involves reaching a data saturation point, or theoretical saturation. Theoretical saturation is "the phase of qualitative data analysis in which the researcher has continued sampling and analyzing data until no new data appear and all concepts in the theory are well-developed" (Morse, 2004). This method is normally used with grounded theory methods (Morse, 2004) where theory emerges from the data.

At each round of data collection, coding, and analysis, the theory is reformulated. This reformulation occurs through purposive sampling of participants and other cultural materials (e.g., documents, magazines). For example, in studying the social world of contract bridge, Scott found a delineation between two dissimilar sets of players, social and serious (Scott & Godbey, 1994). This emerged after rounds of data collection and purposive sampling to characterize these two groups. It was not a characteristic intended to be studied; it emerged from the data collection methods (Per. Comm., David Scott, 2017).

Participant observation has remained the most continuous method in my research project, where my link to the social world via personal connectivity, remains. Continuous participation in social situations is a powerful tool for data collection, elaboration (i.e., procuring examples), as well as member checks and other sources that increase reliability. Continued data collection has also aided in identifying the point of theoretical saturation. Once I received similar outcomes of my recurrent analyses, it was appropriate to stop data collection. Saturation for interviews was my highest priority since interviews elicit a good amount of reliable data. Saturation occurred after 17 interviews.

Limitations

Largely based on my previous knowledge of the aquarium hobby it is a concern that I hold preconceived notions about the activity. These notions are founded in experience and thus are valid; thus exemplifying a high level of validity for fieldwork (Babbie, 2007, p. 315). The cost is the expense of reliability and generalizability. Compared to a quantitative approach to research, in the qualitative sciences reliability, validity, and generalizability are not as easily discernable. Each are reviewed in turn below.

Reliability

Reliability is a recurring conclusion stemming from repetitively applying a particular technique (Babbie, 2007). To increase reliability, I completed this study over a

long period of time and across several different locations and contexts. In the content analyses, six undergraduate students at Texas A&M helped me gather and analyze themes across two internet forums. At each of the ten weekly meetings, we discussed, distilled, and retested the emergent themes (Babbie, 2007, p. 145). For themes to emerge as reliable, we essentially test-retested them each week. I further tested them by crosschecking results with participant observation and interviews. With seven total researchers, the content analyses had methodological variation, but it remains a reliable source of information after recursive analyzes over a 10-week study period in Fall 2017. I personally completed interviews and Participant Observation methods.

Generalizability

Generalizability is the ability of the sample data to be generalizable to a larger population. In qualitative studies, sample size is often relatively small but data rich (Agar, 1996; Spradley, 1979). Generalizability to a larger population is problematic, especially if the population is diverse. While small sample studies have limitations in this regard, inclusion of other methods (i.e., content analyses along with interviews) help to increase generalizability (Spradley, 1979, 1980).

In my study, I sampled saltwater aquarists across the United States. During the study duration, the aquarists I interviewed connected me with increasingly involved participants, thus snowball sampling towards advanced participants. Snowball sampling involves the continuous accumulation of informants by asking the previous for suggested individuals. This enabled me to remain focused on serious participants and informed my

understanding of what "serious" means within the social world. Information from novice aquarists, or those less involved in the hobby, was gleaned from content analyses of online forums and social media social interest groups for saltwater aquarists. It is for these reasons this study is generalizable to U.S. saltwater aquarists who are social-media/computer savvy, and intermediate to advanced participants.

Trustworthiness, Reflexivity, and Validity

Much of trustworthiness comes from the data collection methodology. Creswell and Miller (2000) list nine procedures that ensure rigor and usefulness. These include having a prolonged engagement in the field, a continued search for disconfirming evidence, triangulation, reflexivity, performing member checks, collaboration, maintaining an audit trail, and peer debriefing. The design of this study took advantage of my prolonged experience in the aquarium hobby, which in turn aided a search for disconfirming evidence. Validity is the reflection of reality (Babbie, 2007, p. 146) and in qualitative research methods, high validity stems from real-world experience, such as those in the field.

In addition, I used multiple methods to triangulate the data (reviewed above). Lastly, social media and online discussion forums provided a source of member checks, collaboration, and peer debriefing. Accumulation and recursive analyses of data improved reflexivity and maintained a paper trail.

Conclusion

This chapter reviews the methodological foundation of my research study. I included an overview of each technique, its use in other studies, and its use this research. Included in this methodological overview is the researcher lens, methodological design (including sampling, ethnography, and grounded theory), and analytical methods such as coding and constant comparison, memo-writing, and reaching theoretical saturation. I also review the limitations of the study, with a review of reliability, validity, generalizability, trustworthiness, and reflexivity. The methods and analyses have results that are presented in Chapter 4.

CHAPTER IV

RESULTS

Review

The purpose of this dissertation is to describe the social world of saltwater aquarium keeping, specifically among serious participants. In Chapter 1, I introduced the purpose, rationale, significance and limitations of the study. Chapter 2 outlined the primary literature including leisure and recreation in the United States, the conceptual framework of serious leisure and specialization, a reconceptualization of science *as* leisure, the aquarium hobby and trade, and conservation implications of the activity under investigation. Chapter 3 outlined the methodological and analytical frameworks, their utility, benefits, and limitations.

This Chapter describes the results of the study. I first review the characteristics of the informants. Second, I outline three research questions that provide an organization to what follows. In Section 1 describes the different participation styles as sources or sinks, Section 2 explores the development of a serious hobbyist and its links to aesthetics, and Section 3 describes the various niches or career trajectories a serious aquarist can find in the activity. These sections provide grounding and evidence for "science as a leisure", an activity postulated by Stebbins and fleshed out here. I begin with an overview of the background and characteristics of the research informants.

Background and Characteristics of the Informants

I attempted to gain background information from each informant I interviewed, encompassing 17 different aquarists (Table 6). At 17 interviews, data saturation was complete. Of these informants, I concluded that 12 of 17 were highly invested, serious participants. The other four were invested but less serious. Data were augmented by posing questions on internet forums and social media specialty groups. This allowed me to obtain valuable insight from several more participants that are serious. These participants were serious participants as well, as reflected participation in an online social world for the aquarium hobby. Although these other participants were not considered "formal" informants, the information I gleaned from them was indispensable in my analysis.

Specific characteristics used to identify and describe serious participants included (a) age at initial participation (proxy for duration in the hobby), (b) investment type, (c) the extent to which relied on information from other participants (categorized here as a source, sink, or neutral), and (d) if they participate in the social world (e.g., clubs and conferences). Each of these is reviewed in turn.

Table 6: Specific characteristics of informants

Name of Informant	Age at Initial Participation	Investment Type	Knowledge Type	Social World
1 Nikki	22	Highly invested in the husbandry of specialized, individual organisms (i.e., cowfish)	Sink	National
2 Jessica	19	Highly invested in the husbandry of specialized, individual organisms (i.e., Gem Tang, Japanese Angelfish)	Source	National
3 Lauren	19	Highly focused on knowledge investment prior to procuring live organisms (i.e., seahorses)	Sink	National
4 Adrian	12	Focused on collecting color morphs of coral; potentially interested in biodiversity.	Source	National
5 Carl	12	Invests in obtaining rare color morphs (i.e., Jason Fox's Grafted Monti (a chimeric *Montipora sp*.). He is less discriminating with fish, choosing uncommon species but not rare.	Sink	National
6 David	6	Invests in whatever species he finds interesting; is not concerned about remembering scientific or hobby names. Focused on the ecosystem as a whole over the individual specimens.	Source	National

Table 6: *Continued*

Name of Informant	Age at Initial Participation	Investment Type	Knowledge Type	Social World
7 Jared	Unknown	Invested in the social world of the marine aquarium hobby.	Source	National
8 Jimmy	Unknown	Highly invested in the social world and scientific aspects of the aquarium hobby	Source	National
9 Daniel	Unknown	Highly invested in the accumulation of trade and hobby data.	Source	National
10 Robert	Unknown	Highly invested in the trade and hobby as a whole.	Source	Local/ Regional
11 Richard	Unknown	Highly invested in accumulating and passing along information.	Source	Local/ Regional
12 Jasper	18	Moderately invested in obtaining specifically patterned and colored “designer” clownfish.	Sink	National
13 Malori	31	Low investment in obtaining specific color morphs or species. Low investment in knowledge; more invested in socializing with her step-son, Jasper.	Sink	National
14 Hunter	14	Invested in unique looking coral; collects named frags within one genera and switches once he masters their propagation.	Source	National

Table 6: *Continued*

Name of Informant	Age at Initial Participation	Investment Type	Knowledge Type	Social World
15 Jai	17	Self-proclaimed “jeans and t-shirt type of girl”; invests in knowing about the organisms she is interested in at the time.	Sink	Local
16 Scott	9	Invested in the social world, a “go-to guy”, scientifically minded, interested in breeding designer clownfish.	Source	Local
17 Wilber	Unknown	Previously highly invested in his local club, enjoys keeping his tank running as-is. No frills.	Sink	National

Duration of participation was assessed by asking informants how long they had been involved in the saltwater aquarium hobby. Initial participation age was easier to recollect as opposed to calculating actual participation time, which included tabulating every participatory start and stop across the entire lifespan of the participant. Previous participation and experience concluded the initial start of participation to be a proxy measure of aquarium knowledge, as the accumulation of knowledge plateaus or remains continuous, even if participation is not.

Age at initial participation ranged from 6 to 31 years of age. The seriousness of the five "unknown" participants is assumed to be within this broad age range. Participants included in the study had to have a minimum of one year of experience to qualify as a serious participant. Other facets, such as investment, knowledge type, and social world participation were also taken into account.

Investment was assessed by asking probing questions about informant's aquarium set-up, including equipment, organisms, and other hobby related items (e.g., furniture for the aquarium to sit upon). Results indicated aquarists had discrete investment interests, with some preferring to invest in single, charismatic organisms (e.g., Nikki keeps a Longhorn Cowfish, *Lactoria cornuta*), while others invested in acquiring numerous specifically colored, captively grown coral fragments.

Participants such as Richard, Jimmy, Jared, and to a degree, David and Wilber, found the social investment to be highly rewarding. Richard was highly involved in his local aquarium club, Jimmy gave lectures and presented information to other aquarists at the national aquarium conference, Jared was the current president of the Marine

Aquarium Societies of North America, and David was on the board of that same social group. Wilber was highly involved in his local club until they became non-profit, which made leadership less fun. Other aquarists, such as Malori, were more focused on intimate socialization efforts, aiming to find common ground with her stepson Jasper. One aquarist, Jai, admitted she used the hobby as a way to facilitate socialization with other people in general. In her interview, Jai stated she found it "hard to make friends as a grown up" and she enjoyed socializing with her local club and allowing, "fish people to come over and admire my tank". Socialization was a major attribute of serious hobbyists. In fact, it was challenging to keep interviews within the allotted timeframe (1 to 1.5 hours) due to the openness of the informants.

Another characteristic of informants pertained to their ability to impart knowledge. For summary purposes, I have identified three types of participants: "source", "neutral", or "sink". A source is a participant who has accumulated enough hobby-related knowledge that s/he is sought out by other aquarists for information. It became evident that skill and knowledge of aquaria was in high demand by the social group members, with two of the informants referred to as "go-to guys" for anything aquarium related. Richard, an aquarium technician, held an important role in his local club since he was well versed in aquaria and worked for a reputable local store recognized across the country. His knowledge stemmed from maintaining 6 to 8 a day for various clients across the city. The other go-to person was Scott, who was suggested as an informant by Jai. She stated he "knows everything, is not a know it all, and just has a lot of experience". I found Scott very forward in his interview, stating his usefulness to

the local club was his “patience”. He stated the club atmosphere was comprised of “good people” who were “not condescending” and “more adult”. This was in comparison to online webpages and forums that have “lots of rude people” who “think they’re an expert and don’t want to listen to others”.

A second group of informants may have aquarium-related knowledge but lack either the confidence or the interest in sharing. These people were labeled “neutral” participants. Nikki epitomized a neutral source of information. During her interview, she was with another interviewee, Jessica, and seemed wary to make claims or statements that would reflect her knowledge. Interestingly, both she and Jessica has similarly scientific jobs, indicating a potential uniformity in knowledge. However, Nikki would not stand firm and came across as a neutral source of information about the hobby. Another informant, Carl, came across similarly.

The third group, labeled as “sinks,” were reliant on others for aquarium-related information. A sink could indicate non-serious participation, although accomplished aquarists (i.e., Tank of the Month winners; referred to as TOTM) stated knowledge accumulation is a challenge and requires time, effort, and study. For example, a TOTM winner from August 2006 Reefkeeping Magazine stated, “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." In support of this lifetime learning phenomenon are statements from several informants, including Jai, who was motivated to keep learning because she “really wanted to be careful with my selection [of livestock]”. She also stated she “joined the Facebook club where I can get good information”, adding

support to her qualification as a “sink”. Other aquarists play off the need for information sources, such as Scott who said “the best thing about the hobby is problem solving”. With a regular influx of “sink” aquarists, those who qualify as a “source” can have a lifetime of learning and helping others.

Lastly, I made an effort to categorized informants in terms of their level of social world participation. It is important to note that many freshwater aquarists delineate themselves from other freshwater aquarists by taxa (i.e., organisms they keep, such as killifish). This method of categorizing saltwater aquarium keeping has little currency. Thus, I decided to simply categorize informants based on whether they participated locally, regionally, or nationally. In general, Seriousness in the marine aquarium hobby is associated with the tendency to participate nationally. An online example of this is the tendency for aquarists to join large, national or global social groups, as they seem to have the best sources of information. Reefkeeping Magazine’s February 2009 TOTM winner stated, “My main source of information was the Reef Central community as a whole, followed closely by my local club, the Greater Iowa Reef Society.” Likewise, the May 2014 winner stated,

> 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 and Softies) and anemones alive.

Additionally, those who participated in MACNA conferences invested money to travel and stay multiple days for hobby-related events. This is a relatively high investment compared to participation in a local or regional social group. However, there were serious aquarists, such as Jai, Richard, and Scott, who were deeply invested in their local clubs. Further, TOTM winners also gave accolades to their local clubs. A winner from 2006 noted, "Just prior to this, I made the best move of all: joining the Pittsburgh Marine Aquarium Society (PMAS.org). The many friendships support and knowledge base proved invaluable." A 2008 winner reflected, "Joining the local aquarium society has proven to be the most important lesson."

Meaning and Identity

The saltwater aquarium hobby acted as a strict hobby for 11 of 17 informants. While some informants showed an interest in science as a field of study, many were invested in other fields, including having long-term jobs in vastly dissimilar topics. For example, David was employed in information technology and Wilber was a realtor. The other six informants were aquarists with scientific jobs. For example, Nikki worked for a wildlife agency, Jessica was a director of aquatic husbandry, Adrian worked for a large fish distributor, Daniel was a data scientist, and Jimmy worked at a large science institution. Malori and Jasper were two informants who had yet to differentiate themselves professionally.

In general, few saltwater aquarists are professionals or earn money in the hobby. It is true that early experiences keeping fish (fresh water or salt water) may provide an

impetus to science-based careers or interests. For example, my career as a scientist stemmed from my interest in aquatic life, specifically life I kept in aquaria. However, the vast majority of aquarists, particularly, those who join the hobby after choosing some other career, rarely become (or evolve into) career scientists. Nevertheless, several informants stated "biological interest" as a motivator for participation in the aquarium hobby. Thus, the hobby may act as an outlet for interests they cannot obtain elsewhere. Stated differently, the activity may act as a way to engage in science without having the formal education of a scientist.

Research Themes

Findings are organized around three overlapping themes: (1) various characteristics delineating styles of participation in the hobby, (2) the development of a serious aquarist and the connectivity of aesthetics in the activity of keeping a saltwater aquarium, and (3) finding distinction in the saltwater aquarium hobby.

Characters Delineating Saltwater Aquarium Keepers: Sources and Sinks

Synopsis

Resulting from this study, marine aquarists display an assortment of lifestyles and across rural, urban, and suburban settings in the United States. There are men and women of varying age and occupations. Participants participated in the broader social world of aquarium keeping; some even formed their own groups, while others preferred to go it alone. Enjoyment seemed to vary with success although many appreciated the opportunity and challenges their failures permitted. By its very nature, participation in the saltwater hobby requires being serious—to keep saltwater fish and invertebrates requires commitment, time, and effort. Indeed, saltwater aquarium keeping does not lend itself to a casual style of participation. That said, there is variability among participants and at the apex of participation are those keep "full blown" reef aquariums.

The continuum of hobby involvement was delineated into two different styles of participation. The goal of this section is to contrast these styles. These styles of participation are referred to here as "sources" and "sinks" of hobby-related information. Sources are defined as participants who have garnered enough experience and respect to be listened to and followed by aquarists in the social world. As the term suggests, they are sources of information. Aquarists who function as sinks are those who drain information from other activity participants. They have not developed the same level of skill and knowledge as sources and their progression is dependent on learning from them.

Native terms for these two groups varied, with sources referred to as “expert”, “go-to person”, “pro”, “professional”, and “source”. The term sink is not a native term, but described the group in a way that does not necessarily connote negativity or value. Native terms for sinks were sometimes negative, especially if the participant was identified as a repeat offender. Sinks who were simply untested in the hobby included, “noob”, “newb”, “noobie”, and “novice”. Value laden terms included “moron”, “idiot”, “parasite”, and in the retail industry, “mind rapist”. The latter was documented during my participation as a retail worker, which employees used to describe a specific set of customers who came into the store to “pick the minds” of the employees, but then make all their purchases elsewhere (e.g., online). There were other “mind rapists” who were good customers (i.e., they purchased many fish), but did so only because they took advice they did not apply and their fish repetitively perished under their care.

I begin by presenting various attributes, or characteristics, I used to differentiate between sources and sinks (Table 7). These stem from three types of information I collected in the study: participant observation in the reef aquarium hobby, content analyses of hobby periodicals and internet forums, and in-depth interviews across 17 informants. Specifically, I delineated informants into two groups based on their proclivity to develop and obtain new skill and knowledge, if the hobby was a central life interest (e.g., national club participation), if they have found a specialized niche, and their awareness and behavior surrounding conservation issues in the hobby and trade. The table outlines the resultant characterizations, which are then explained in a general sense. Subsequently, sources and sinks are parsed out and reviewed using these

attributes. This section concludes with a description of what it means to be a source or sink in the serious aquarium hobby.

The characteristics provided in Table 7 maximize the differences I observed among marine aquarists in this study. The attribute of orientation to skill development indicated a difference across hobbyists regarding their patience and interest in developing skill and knowledge related to the hobby. Centrality of the hobby was the level of long-term interest in a participant's life and participation in the social world. This was subject to the individual's perseverance when presented with challenges in participation.

As the term suggests, intensity of identification involved the degree to which participants identified as a saltwater aquarist. A high degree of identification came at the cost of other hobbies. Careers choice also distinguished sources from sinks. Conservation orientation was looked at as two variations: as an aquarists' understanding of aquatic conservation and the conservation-oriented behaviors they displayed. Knowledge and behavior were parsed because these did not always correlate positively; specifically, a conservation-based understanding did not mean behaviors were conservation oriented.

Table 7: Characters and character states across sources and sinks in the marine aquarium hobby.

Characteristics of Participation	**Styles of Participation**	
	Source	***Sink***
Orientation to Skill Development	Highly interested in developing skills and knowledge; patient	Not interested in developing skills or knowledge; impulsive
Centrality to Lifestyle	Long-term participant; active social world member; appreciates and perseveres through challenges	Ephemeral participant; may participate in social world; circumvents challenge and quits easily
Intensity of Identification	Strongly identifies as a reef aquarist; focuses on this hobby at cost of others; aquatic careers	Identifies as a reef aquarist but has other (more) important hobbies or job-related limitations
Conservation Orientation	Medium to high understanding; low to medium behavior	Low understanding; low behavior

Contrasting Characteristics

Table 7 summarizes two participation styles. These styles are Sources and Sinks. Sources are those who are highly interested in developing skills and knowledge, they are often long-term participants who are active social world members, and they tend to have an appreciation for challenges in the activity. Furthermore, they often identify strongly as a reef aquarist and have a career orientation towards the hobby. Lastly, Sources have a medium to high understanding of aquatic conservation and low to medium conservation-oriented behavior patterns. Sinks are much of the opposite. For example, a sink is not usually interested in developing skills or knowledge and they tend to be ephemeral participants. Many sinks strive to circumvent challenge or may quit easily. Further, while they may identify as an aquarist, it is not as strong of an identification as a Source – Sinks have other hobbies to occupy them. Lastly, sinks often show both a low understanding and behavior orientation to conservation. These attributes of Sources and Sinks are supported with data in the next sections.

Orientation to Skill Development

Skill development was a prominent character delineating sources from sinks. Sources had a positive orientation towards skill development. They put forth effort to refine their skills in order to reach the epitome of marine aquarium keeping, which is a beautiful reef tank. For example, Jessica developed husbandry skills, which enabled her to keep rare species of fish and coral. She was highly skilled and was regarded as a

source by MACNA members. In 2018, she was asked to give an educational lecture at the annual conference.

Other aquarists were regarded as sources of scientific knowledge due to their well-developed understanding and scientific skills. One of these, Daniel, specialized in trade statistics. Daniel was the go-to person in this field, primarily because he was one of the only people working in that area. This seemed to aid in motivating him as no one else was doing what he thought was “really important work.” Additionally, Daniel was a freelance journalist so he wrote articles on the subject, which simultaneously developed his skills and a public persona in the hobby. Daniel produced many articles for periodicals and numerous talks for clubs and conferences.

In contrast, sinks were less interested in developing their skills. Some admitted that they found a participation level that they felt was adequate. For example, David “likes to sit back and watch the tank rather than fiddle with it”. Wilber felt similarly. He no longer yearned to shop for the next fish or coral for his aquarium. Instead, he enjoyed watching it for what it was and stated,

> As the aquarium hobby changed into the electronics, every MACNA I have gone to I have come back and wanted to change things around from the way I'm doing it. But I have found the way I have been doing it has worked for 20 years. If it works don't fix it, ya know?

This statement from Wilber showed that he had plateaued in his interest to develop skills that could potentially improve his hobby. He was satisfied with his level of participation and felt no improvements were necessary (although the temptation was there). Jai also mentioned feeling she was motivated to, "just enjoy what she had in the tank" rather than developing skills.

Other sinks included Carl, who admitted he was impulsive in his purchases. For example, in his interview he stated,

> When I first got into the hobby I just jumped into it. I actually took over someone else's tank and they had two anemones and a shark. It was a 2-foot shark and I had a 65-gallon tank. I took just the animals. I knew nothing about it… I had them for a couple months and they died. I was planning on getting a bigger tank. I eventually did buy a 165-gallon but I couldn't set it up [as saltwater] because I lost the shark, so then I stuck with my 65. I impulse bought a bunch of wrasse and a bunch of corals off the [club]. I threw those in the tank and everything died. That was a [6-month period] of being in the club and people giving me advice and me just being ignorant and doing what I wanted to do. I just continued to do it anyways.

Carl's recollection of his first aquarium experiences epitomizes a sink mentality. While he may have mostly grown out of that style of participation, he outlines several facets sinks do until they quit. For example, they tend to be more impulsive than sources, who are, as David noted, more inclined "to be smart and go into something with a book". Instead of performing research, sinks often make purchases impulsively. Further, sinks

ask a number of questions of other, more experienced aquarists (i.e., sources); however, they often ignore this advice. Sinks also ask many questions after the fact. For example, Carl could have easily found out a 2-foot long shark does not belong in a 3-foot long aquarium.

An orientation to skill development provides clues about participants' experiential preferences. Sources tended to have an individualistic view of their hobby, going it alone in some instances. They enjoy investing time to research or solve a problem. Scott identified himself as a "problem solver", who seemed to enjoy it enough that he searched for others to help when he had few aquarium-related problems of his own. Richard said he enjoyed "sharing information". Sinks, such as Jai, did not have this drive to do their own homework. She was more inclined to ask questions of anyone and everyone, which seemed to be her definition of "doing research". In support of this, she recollected some of the key informants in her aquarium club, including Scott, but she did not seem to have much knowledge of pertinent books or authors. Carl was of similar ilk— in his account above, he asked for a lot of information but did not follow it very well.

Sources, such as Scott and Richard, enjoyed researching and being recognized as go-to people. Both could recite books and authors as sources of information, with Richard going so far as to "find crazy old books in Latin… and textbooks to gain more information on how to keep fish better and replicate their environment." When I observed aquarium club members and online forum discussions, many aquarists encouraged "noobs" to read books, such as a "reefkeeping bible" before starting an

aquarium; sometimes suggesting they read before asking questions of the group. For example, nano-reef.com has the following rules for the Beginners Forum (2005): "The purpose of the beginner's forum is to provide a friendly atmosphere in which new reefers can get their questions answered and learn how to keep a happy, healthy reef. With that in mind, please observe the following:

> 1. If you're new to reefkeeping, chances are your question has already been asked and answered. Before asking again, we strongly recommend you do a quick search. There's already a wealth of information out there.
> 2. If, after searching, you can't find an answer or still don't quite understand something, ask away! There are many users more than happy to point a newcomer in the right direction.
> 3. To the more experienced reef keepers - remember that at one time you had no idea what you were doing either. Be kind, and if you don't have the patience to help with the basics, don't bother with the beginner's forum.
>
> Flaming in the beginner's forum WILL NOT be tolerated!"

These rules showed several important points. First, source aquarists do get annoyed with sinks since the rules requested the beginner's forum be "a friendly atmosphere" and "remember… you had no idea what you were doing either. Be kind" and "Flaming … WILL NOT be tolerated". Additionally, beginners are a normally occurring sink of information across the hobby. Further, the rules showed sinks were

asking the same questions and doing no research beforehand. The rules also provided two characteristics of sources, “the patience to help with the basics” and a willingness to help answer questions in the first place.

Centrality to Lifestyle

Centrality to a reefkeeping lifestyle and time investment were closely related. Specifically, sources were long-term, continuous participants who participated in hobby-related clubs/activities and persevered through challenges. These individuals also invested a good deal of time on their hobby, which seemed to form an intimate connection towards it and the organisms they kept. Continuous monitoring of an aquarium system usually leads to long-term success. As may be expected, sources spent a great deal of time on their hobby. Time investment was unequivocally maintenance based, where some, like Wilber, suggested checking the aquarium daily for “at least 10-15 minutes”. Some went to far as to have phone “apps” connected to specialized equipment which allowed them to get regular alerts or to check the aquarium at their leisure.

Closely linked to centrality was the challenge and perseverance of aquarium keeping. Richard stated he has crashed “thousands of aquaria” but has continued his work as a technician. Hunter also crashed a tank, which he said “really upset him, but after a week” he was “back at it”. Social participation also seemed to encourage long-term participation and centrality since there was always help from someone and many clubs acted like communities of like-minded individuals. Hunter took centrality to the

extreme when stated he would “give frags away to other aquarists” to make sure he “could get that coral back if his tank crashed.” By doing this, he was able to help others and help himself persevere through hard times.

Sinks, on the other hand, were more ephemeral in their participation and did not invest a lot of time into the hobby relative to sources. Jai found a number of ways to participate in the hobby without investing a lot of time, including the procurement of second-hand ecosystems that others were selling. Buying a set-up circumvented the need to research (i.e., a major time investment). It is important to note the acquisition of second-hand equipment and “rescued organisms” is not entirely indicative of a sink, but it is a cost and time cutting measure used by them.

Jai provided an additional account of an ephemeral participant. Her main display tank was purchased from Craisglist.com from someone who “went to college so [they] could not take the tank”. This was “a 90-gallon aquarium for $400, including the tank, stand, sump, skimmer, and light”. Further, under her care this tank “was set up on and off over many years”, which indicated a lack of centrality. While challenges to participation are common in the hobby, sinks are relatively less interested in persevering through them.

Intensity of Identification

Likewise, intensity of identity varied across the two styles. Source-styled participants identified strongly with the hobby, reflected in a great deal of social world participation. Richard and Scott were avid club members and identified very strongly as

aquarists and as resources for others. For example, Scott seemed inclined to help others because many of the sources of information are “rude people, impatient with new aquarists”, and that he “enjoyed the problem solving aspect”. As a well-known, patient source of information, who liked solving problems, these statements indicate he enjoyed being a source and went out of his way to help people solve their problems.

Further, some aquarists put their hobby before everything else, even the wishes of their significant other. Personal observation across all aquarium hobbies showed a disproportionate number of single men. This could be due to conflict with their partners in regards to the identification and centrality towards the hobby (i.e., woman may not like a singularly focused partner). Taken to the extreme, a strong identity with the hobby has led some informants to pursue a career related to aquariums. For example, Jessica became a director at a public aquarium, Adrian a manager of a live animal importer, and David maintained his IT job but spent a great deal of time on MACNA events and his local club. Others pursued a similar field in a more formal manner, such as scientists studying aquatic resources. Those who were sinks had outside hobbies and careers, which limited their involvement and identity as a reef aquarist.

Conservation Orientation

The last characteristic delineating sources versus sinks was a conservation orientation. This character had two parts: conservation knowledge and conservation behavior. Across source participants, conservation knowledge was medium to high. This means sources were well aware of conservation issues surrounding the aquarium hobby.

None that I interviewed or interacted with was oblivious. However, sources showed medium to low conservation behavior. Essentially, while knowledgeable and aware of conservation issues across the hobby, they would not, or could not, engage in more conservation behaviors.

Compared to conservation knowledge, conservation behavior was low. I attribute this to the consumption-orientation of the hobby. Consumption refers to the removal of the organisms from their environment. In contrast, a non-consumptive wildlife hobby, like birdwatching, does not typically remove organisms from their ecosystems. Moreover, having access to captive raised specimens was not always satisfactory. Informants noted that sometimes the selection was poor. This is reflected in a comment by Lauren, who said, "…many of the captive raised fish are similar". Instead of quitting this highly consumptive hobby or omitting wild-caught organisms (e.g., snails), source participants tried to keep the fewest possible number while still maintaining a viable reef aquarium.

Sinks did not have much of a conservation orientation in either knowledge or behavior. His or her focus was on unravelling the complexity of captive ecosystem care, not understanding where each organism or piece of rock was sourced. Many assumed these resources were sustainable when some of the most common species in the hobby were critically endangered and specimens available are sometimes wild caught (e.g., the Banggai Cardinalfish; *Pterapogon kauderni*).

Conclusion

Sources and sinks differed across four different orientations or dimensions of seriousness: orientation to skill development, centrality to lifestyle, intensity of identification, and conservation attitudes. Sources accumulated and shared knowledge and skill while sinks preferred to participate in loose fashion, adhering to few social norms (e.g., reading for research), and sometimes causing strife in the hobby with their laziness and lack of concern for wildlife. As noted at the beginning of this section, the range of the continuum of saltwater aquarists tends to be narrow given the complexity of keeping marine fish and invertebrates alive. Still, there is variation. This section provides insight into major differences among saltwater aquarists. The implications of these results are covered in detail in the Discussion (Chapter 5).

Aesthetics

Synopsis

Results indicate a major motivating factor for participation in the saltwater aquarium hobby is the aesthetic value of the captive organisms and the ecosystem. While other aesthetic characteristics are present and may initially motivate hobbyists, results indicate hobbyists focus on visual attributes such as color, pattern, and movement. For example, an appealing aesthetic for an aquarium includes multiple colorful fish in a multitude of colors. Exemplary captive marine ecosystems are viewable in online forums as a "tank of the month" (TOTM, Figure 18). Although initially drawn in by the aesthetic value of a marine aquarium, specifically large colorful fishes, marine aquarium keepers overtime develop an attraction to the challenge of replicating a wild reef environment.

Figure 18: The epitome of hobby participation is displaying a colorful reef ecosystem.

This development from an aesthetic focus (Figure 19, A and B) to a more complete ecosystem focus (Figure 19, B to C) are major results of this study. Further, once a marine aquarist has accomplished the feat of keeping a natural ecosystem, some seek further rewards and benefits, often correlated to finding a new challenge in the hobby. These rewards include finding the most colorful and uniquely shaped coral fragments, growing fragments into large colonies and propagating them, and displaying vivid and elaborate systems (Figure 19, D).

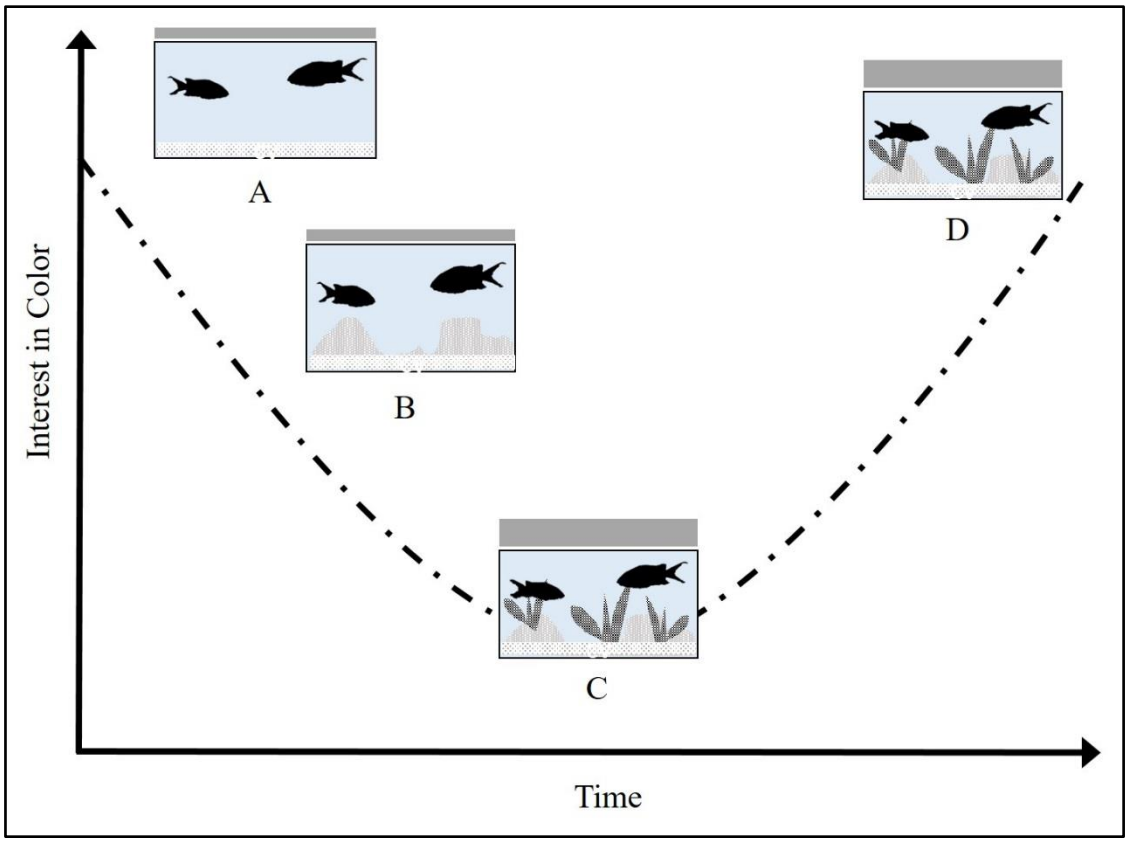


Figure 19: The development of a marine aquarist can be seen in over time.

Interest in color does not disappear as the marine aquarist progress. Instead, that interest is focused on the particularity of the organisms and the system being kept, namely color and the accentuation of color through technology and equipment (Figure 19, D). Further, success with these facets enables the aquarist to take advantage of the retail environment of the hobby, specifically regarding the acquisition, display, and propagation of their coral collections.

In this part of the results, I review each of these developmental steps using data from interviews, online forums, and conversations with serious hobbyists during participant observations. Many of the informants were capable of retroactively reflecting on their motivations for acquiring colorful organisms, however, much of their information was focused on judging others' participation style. This connotes a sense of competition between styles, which contests the meaning of authenticity across the marine aquarium hobby. While there may be some truth to this, my focus in this section is to explain how progression occurs among saltwater aquarists. Central to progression is moving beyond simply the *display* of a beautiful, moving picture.

A Moving Picture

The motivation for starting a marine aquarium varies, but this research has found it is largely aesthetically driven. Aesthetics of the aquarium focus on the organisms and the ecosystem with the initial incarnation focused largely on striving to display a replica of a photograph of a reef system. Informants described this as creating a "moving picture[4]". Essentially, the initial stage of marine aquarium keeping is to replicate what aquarists' *thinks* a reef should look like although most aquarists have never been to a wild reef. Thus, they aim to replicate photographs or videos of the aesthetics, often disregarding the challenge of actually creating a simulated reef. Additionally, it is the *display* of an incarnation of a reef that motivates rather than the *creation* or *maintenance* of the

[4] A moving picture is not a movie.

system. This section reviews the conception of a moving picture effect and the associated focus on diversity over compatibility. The turning points toward a more natural captive ecosystem and conservation concerns are indicated, but further described in subsequent sections are reviewed in Chapter 5.

Definition and Creation

When referring to an aquarium, "moving picture" is a literal term. This term is not intuitive since an aquarium has length, width, and depth while a picture has only two of these dimensions (i.e., length and width[5]). The aquarist can transform a three-dimensional aquarium to two-dimensions by removing the view ability of the third dimension (i.e., depth: from the front to the back of the aquarium). Adding to the two-dimensional effect is that all aquaria have at least one transparent, often rectangular, viewing pane. Transparency allows the viewer to see inside the aquarium without noticing the existence of the viewing pane. Further promoting the effect is the shape of the viewing pane, which is normally rectangular, which is similar to a landscape-oriented photograph.

To accentuate this effect, an aquarist might install the aquarium inside a wall of his/her home, setting the viewing pane flush with the wall just like a hanging photograph. A less effective, but similar effect can be created by using a cabinet and canopy for the aquarium, framing two or three of the dimensions. These set-ups have

[5] It is worth noting a 2-D object has length and width but these terms are altered in 3-D. for example, the width of a photograph becomes depth in an aquarium.

similar functions: they create a picturesque view of the aquarium and can hide the plethora of equipment used to maintain the system. It is important to note that not all novice aquarium keepers create such a stunning effect, oftentimes limited by frugality at starting a hew hobby. Further, advanced aquarists may choose the wall installation or a nice cabinet, but seem more motivated to hide the increasing pieces of equipment they accumulate during participation[6]. My data revealed that when an aquarist is at the moving picture stage of involvement, s/he disregard all else for a polaroid-type of outcome: quick, picturesque results.

Interview data from Wilber provided insight into the aquarium as a moving picture[7]. Wilber was an active member of his local marine aquarium club that involves a good deal of information sharing and helping new hobbyists achieve success. However, giving advice led to an accumulation of generalizations, sometimes negative, that he used to describe newcomers. The term "picture" described the focus of new aquarists, and done so with a negative connotation. Wilber stated that this aim was over all other, including the health and lives of the organisms used to create the effect:

> Anyhow, 40 years I've been doing it. I don't have wipeouts like some new people in the [hobby] have, I don't ... that's what pushes people out. Total wipeouts or... or, they just don't realize it's not like a picture you buy and put on a wall. A lot of

[6] New aquarists do not purchase equipment more advanced aquarists end up accumulating (e.g., calcium reactor).
[7] The context was not referring to their own motivation, but rather that of others.

> people, especially people who like to throw money at things to fix it, think it's a picture on a wall, ya know? I'm gonna set it up and I'm gonna forget about it. Well, it doesn't work like that.

Here, Wilber described the mentality of newer aquarists as participants interested in the display aesthetics of the aquarium set-up *at the detriment of the lives of the organisms* within. Specifically, he uses the term "wipeout" to refer to all the organisms dying at one time. Further, the wipeout, or "tank crash", may be caused by the aquarist's outlook of the aquarium as a thing to "put on a wall" and forget about, not a living ecosystem with requirements and responsibilities. Essentially, those with a moving picture mentality do not see an aquarium as a living system, with lives of intrinsic value confined within. The value is the display aesthetic and its associated benefits (e.g., status), not its care. Wilber's negative attitude towards this aesthetic indicates he was uncomfortable, even angry, at the outcome of the behavior, i.e., the death of the organisms.

Wilber's information laid the groundwork for differentiating those with a moving picture mentality versus those who construct a carefully executed system aimed at long-term care. The differences between the two states are indicated by a turning point towards maintaining the lives of the organisms as fully as possible. Next, I review the other facets of the moving picture mentality. These provide insight into turning points that drive salt-water aquarists to create a more natural reef aquarium system.

Wilber's statement above points to ignorance of the complexity and systematic nature of an aquarium, problems *every* aquarist faces at one time or another. While the marine aquarium hobby is a more recent incarnation of the aquarium hobby, Wilber indicates problems such as wipeouts are common and reoccur across all types of aquarium keepers. However, he further indicates these mistakes can be circumvented with research and perseverance over quick fixes. Instead of researching, asking for advice, or fixing it themselves, those who think of aquaria merely as moving pictures attempt to fix their problems by throwing money at them. He alluded to this being part of why people quit the hobby – their "fixes" do not work and they wipeout their entire tank. Similarly, Jai felt marine aquaria deserved more attention to detail because it required more precision and was a more expensive hobby than other aquarium types (e.g., freshwater). Thus, money can help set one up a successful system, but it is not a cure-all.

Further, no aquarist is safe from a tank crash. Across all interviews, I asked if the informant ever had a tank crash, and everyone, outside of Lauren who was still researching her purchases, said yes. Richard, the aquarium technician, actually said he has experienced "hundreds" of wipeouts – likely due to his frequency in setting up new systems for clients. Hunter, on the other hand, recollected a recent crash, stating he was "devastated", but he did not quit. It seems crashes are considered a part of the hobby. It seems, regardless of stage or style of marine aquarium keeping, organisms are expected to die sometimes – it is the frequency that varies.

Frequency of crashes diminish over time as aquarists learn scientifically charged concepts, such as nitrification. Wilber has been an aquarist for 40 years and has not

admitted to *recently* wiping out a tank. Similarly, David stated he maintains his current set-up, without adding much new to the aquarium, and has for years. He is more focused on the health and growth of the organisms rather than displaying something quickly. These data lean into the next facet of a moving picture, the desire to maintain certain types of organisms – some poorly chosen for their system, added to the system too quickly, or are inappropriate as a whole. These data also hint at another turning point for aquarists - creating a healthy, natural system. Before getting into this, I review the organismal focus of moving picture displays, and the unfortunate problems associated.

Diversity over Compatibility

Results indicated all aquarists appreciate diversity. Diversity, as used here, has two interconnected varieties. One is the focus on creating a colorful reef-looking display (i.e., the ecosystem as a whole). The second is choosing diverse organisms, referred to as "biodiversity", which means "life-diversity". As noted by Richard, newcomers are focused on keeping a diverse group of organisms because they were attractive to them rather than compatible with each other. Specifically, informants noted less serious aquarists want "one of this and one of that", focused on keeping a diverse group of organisms "because they were pretty, not compatible", as stated by Richard. Jai, a less serious reef aquarist, supported this stating she got into the hobby because she "visually liked the corals" and marine aquaria "are pretty and I like that". Again, these data support the aesthetic appeal of an aquarium, sometimes at the detriment of the organisms within.

Detrimental behaviors stemming from a motivation for biodiversity and aesthetics include the choice of incompatible organisms. Compatible organisms vary across every single system, largely based on who will eat whom. As noted by one informant, “fish will eat anything that can fit in its mouth”. For example, a predatory eel may cohabitate with prey fishes if the volume of the aquarium, and its shape, allows the organisms enough space to stay away from each other. However, the motivation for a colorful aquarium, and interesting organisms, overrides this seemingly obvious predator-prey interaction. During my personal observations as an aquarium retail worker, there were times when a new aquarist would purchase predatory fish and unwittingly add prey fish to the same system, then ask for a refund. Similarly, Wilber gives a rather laughable account of his friend adding an expensive fish to his tank, in grandiose fashion, only to have it eaten within thirty seconds (covered more in Section 4.2).

Accordingly, there seems to be a pervasive attraction to display aesthetics so powerful, aquarists omit compatibility research. Further, they will purchase an organism without seeking advice, add it to the tank and see a problem, *then* ask or seek help (or a refund). The lack of before-purchase research is extremely problematic as it commonly ends in premature death of the organism and a financial loss for the aquarist. This raises major conservation and sustainability concerns for the hobby. As Wilber stated above, total wipeouts deter hobbyists from persevering and progressing to a more advanced stage of involvement.

Scott adds another layer to the compatibility issues above. As a member of a local aquarium club, and the “go-to guy” for aquarium related information, he noticed,

"novices don't care about fish lives". Unfortunately, data indicated very few marine aquarists start researching their purchases before making them. There are exceptions, such as Lauren, who compiled 59 pages of research on organisms and aquarium products (viewable at www.lizmarchio.com). Lauren was a student at the time of the interview, who proclaimed she was limited in financial means, which contributed to her research desire. Thus, financially strapped individuals may be more careful in selecting compatible organisms. Other variables, such as biological knowledge or conservation concern, may also play a role in researching compatibility before purchases.

Supporting the purchase-then-research dogma of the hobby are comments from informants that indicate, at least partially, they enjoy the trial and error of this activity. For example, many aquarists refer to their hobby as a scientific endeavor where they can freely experiment. For example, Jai stated, "I'm learning at all times". Further, aquarists I spoke with in passing at the 2016 MACNA stated they are "learning something new every day". Integrating the science and research aspect are comments such as the motivation to keep aquatic wildlife as a "research opportunity with captive animals", for "biological curiosity", "education", "observational studies of captive ecosystems", and "the ability to do science". These comments indicate serious marine aquarists certainly do learn as they go, as most of these informants were not initially scientifically oriented proceeding hobby involvement.

Shifting Focus

As noted above, there are three major variations of a marine aquarium: a fish-only (FO) system, a fish-only-with-live-rock (FOWLR) system, and a reef system. Movement between a FO system and a FOWLR *and* reef system reflect two important changes in focus. One change is physical and easily viewed: an organismal focus from fish to invertebrate life. A second change, occurring simultaneously, is an attitudinal or mental shift from a display, (i.e., moving picture) toward the creation and maintenance of a functional, natural reef system. Although aquarists retain an interest in aesthetics, they increasingly make purchases and seek to create and display *scientifically* sound reef environments. Reviewed in turn below, these two facets are interconnected and describe a general shift in participation across the marine aquarium hobby.

First Fish, then Invertebrates

As noted, the mentality of many novice marine aquarists rests upon the replication of a moving picture of a reef environment. A fish-only system focuses on fish and contains *replications* of coral and rock. There are few, if any, invertebrate life in FO systems. Invertebrates are organisms without a backbone, and include aquatic snails, crabs, shrimp, starfish, and other non-charismatic species. Coral species are also invertebrates, but their inclusion is exclusive to a reef system (covered below). As a whole, a FO system poses less of a challenge in creation than a FOWLR and reef systems because they lack invertebrates. Invertebrates require much more specific and consistent conditions than most reef fishes and their inclusion in aquaria reflect a

progression in skill and understanding. For example, Hunter stated he maintained Harlequin Shrimp in their own aquarium because they were “very unique”, “difficult”, and “had very specific requirements” that were not compatible with fish. Nikki, on the other hand, was keeping a cowfish, stating, “he was in a tank by himself” referring to the fish’s propensity to eat ornamental shrimp and other crustaceans.

Adding invertebrates to a reef, and aiming to maintain them, increases the complexity of the system since they impose strict limits on the aquarist. For example, an aquarium with invertebrates cannot be medicated with commonly available remedies (e.g., copper, erythromycin) so an aquarist must set up a “quarantine tank”. A quarantine tank *must* be separate from the display, with no water exchange. Essentially, when keeping invertebrates and fish together, the aquarist should set up *an entirely new aquarium* just to treat sick fish. This means keeping invertebrates promotes the acquisition and set-up of multiple aquaria.

In addition, fish are relatively less demanding than invertebrates and are better equipped, physiologically, to survive captive conditions. Due to their evolutionary history, fish such as damselfish and clownfish, can deal with fluctuations in specific gravity (i.e., the salt concentration of water). Even short-term tolerance to such different conditions increases the “hardiness” of the species in the eyes of an aquarist. Hardiness is an organism’s ability to deal with environmental fluctuations. Hardy fishes are important first fish for a new aquarist, especially in marine aquaria.

According to several informants, new marine aquarists do not understand the physics of evaporation, which leads to major stress on both fish and invertebrates.

Specifically, novices make the mistake of "topping off" evaporated water with saltwater, therefore increasing the concentration of salt in the water. This is stressful physiologically for all organisms, but fish are better adapted to variation in environmental conditions. In contrast, invertebrates such as coral "will die if you look at them wrong". It is much more complex to maintain an aquarium with invertebrates and fish, thus FOWLR and reef aquaria are limited to relatively scientifically knowledgeable individuals than those who keep a FO system.

Scientific knowledge and skills are gained over time and can indicate seriousness in the aquarium hobby. Novices, for example, may not realize invertebrates can be kept for beauty as well as function. Outside of their beauty, coral does not necessarily perform a function in a captive reef environment. Other reef invertebrates such as snails, crabs, starfish, and worms "have a job" in a captive reef. It is common, if not required, to keep functional reef invertebrates as a "clean-up crew". These organisms are not especially aesthetically pleasing and are sometimes referred to as "reef janitors", which seems to help new aquarists understand their utility. Although often unattractive clean-up crews *help maintain an aquarium aesthetic* by consuming nuisance species, such as algae. While algae occur in fish-only systems, the addition of live rocks increase the likelihood of various outbreaks of these, and other, nuisance species, further increasing the utility of "reef janitors".

The first step towards the pinnacle of involvement in the hobby, a miniature reef, is the addition of live rock. Live rock and fish characterize a FOWLR system, which literally stands for fish-only with live rock. Essentially, this type of system incorporates

any reef invertebrate *except* live coral. Harvested from the ocean, or inoculated by long-term captivity, live rock is more natural than décor commonly found in FO aquaria. In fact, the "live" part of the name refers to the bacteria colonies than act beneficially to break down waste produced by the fish. This is a major step towards a healthier, natural reef system. It is also a major facet of knowledge that that underscores the movement from a FO to FOWLR system. Again, this indicates a FOWLR system is a stepping-stone towards creating and maintaining an authentic reef aquarium.

To conclude, a FOWLR aquarium has a higher level of complexity than a FO system. This is mainly due to the inclusion of invertebrates. These organisms limit aquarists and force them to hone their skill and knowledge, specifically their scientific understanding of physics, physiology, and ecology of a reef ecosystem. As a stepping stone towards an authentic reef a FORLR system projects the aquarist into the challenging world of reef keeping.

Attitude Adjustment towards Authenticity

The second shift, occurring almost seamlessly with the functional changes occurring within the aquarium, is an attitudinal from a moving picture toward the creation and maintenance of a functional, natural reef system. This shift relies on an additional facet, striving to create a system rather than just display one. The moving picture mentality is largely comprised of participants yearning to display a *rendering* of a reef ecosystem. Success in the hobby depends on the ability and interest of the aquarist to *learn about and care* for the aquarium. Essentially, as time progresses and

involvement continues, the aquarist learns about the functionality of a captive reef system and its care.

Live rock seems to be a major component, leading to both better success and a better understanding of an authentic reef. Adding live rock is indicative of an attitude change, one attentive to unattractive, but useful, organisms. Further, the attitude of an aquarist changes towards valuing scientific knowledge and application. For example, it takes time for a participant to understand the use of live rock. The science behind it indicates its use is not just for creating a nice reef scene, but it has bacteria capable of nitrification. This requires the aquarist to understand a reef ecosystem, not just the purchase and display of one.

While a fish-only system contains these "beneficial bacteria[8]", they must be cultivated over a longer period (i.e., no live rock is used) and are easily killed with medications aimed at maintaining the health of the fishes. Focused on fish, a FO aquarium keeper underestimates, or is ignorant of, the function of bacteria. The relative difficulty between a FO and FOWLR system is understanding, and maintaining, the beneficial bacteria[9], again reflecting the acquisition of scientific knowledge. It is worth noting that the use of live rock actually aids in aquarium care, but the overall complexity is so high, even an aquarium with live rock may be more difficult than a fish-only system.

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[8] This is a native term, likely used to prod new aquarists to shed their colloquial understanding of bacteria as "bad" organisms.

[9] Categorizing bacteria as an invertebrate will aid in understanding the difference between the three systems, specifically the difference between a FO and a FOWLR and reef (Figure 3).

The hobbyist benefits from the use of live rocks as they seem to increase the success of long-term fish keeping. However, even if live rocks are suggested to new aquarists, essentially suggesting a FOWLR over a FO system, it can be a major added expense. These rocks can cost up to, or more than, $10 per pound. Online forums and marine keeping social media pages advise aquarists to keep a minimum of a "pound per gallon" of live rock. Thus, a 30-gallon aquarium would house $300 in rock, alone. Paying this much for "live rocks" seems like a ploy, and is certainly an added expense to an already expensive hobby.

Online forums are replete with complaints about the cost of these rocks, and as such, they may be the first cost cutting measure by new, or frugal, hobbyists. Jai is a less serious aquarist than the other informants in the study, indicated by the cutting costs by incorporating "dry rock[10] and live rock from others" to complete her system. Jai's seriousness is also indicated by her lack of overall scientific knowledge. She justified keeping fish in aquaria because "fish stay in a relatively small area anyway", which is true for some species, but certainly not the vast majority. While these data indicate live rocks are an integral, and expensive, part the replication of an authentic reef aquarium, scientific knowledge and application is integral as well.

An aesthetically pleasing aquarium remains a lingering objective in the desire to create an authentic and healthy reef. In fact, live rocks add a completely new dimension

[10] Just rocks. Literally any kind of rock capable of being used in a reef aquarium.

to marine aquarium keeping. A hobbyist on reef2reef.com posted the following about setting up a natural aquascape using live rocks,

> I got my tank all set up etc. and I'm not too sure if I like how I stacked my live rock, I did at first but now I want some ideas before I start stacking my tank post your set-ups please! for some ideas I'm interested in the lined up stacked type kinda like what I done with mini caves etc. or the live rock all stacked up the middle of the tank but I feel as if the sides would be bare? but then adding fish and creatures would take them areas up so might be okay. whatcha think?... bear in mind I'm still a big noob at this!!!

Here, the hobbyist is focused on producing an attractive rock-scape (via "stacking" the rock), attempting to orient the live rocks in a natural but pleasing way. He is focused on the orientation of the rocks within the tank and how the dimensions will work together. He is even paying attention to the negative space. Other hobbyists focus on the shape of the rocks themselves, as some locations in which live rocks are collected have vastly different natural shapes. The beginner's forums have many hobbyists asking what kind of rocks they should purchase. On www.nano-reef.com the following information was posted:

> **Fiji-** This is the most commonly available live rock on the market. It is very porous, providing good biological filtration and a lot of rock for the money.

(Because it is not very dense!) Fiji rock is also usually rather inexpensive, although the quality varies a LOT from one vendor to the next. (wholesalers included.) Premium Fiji is quite beautiful once cured and encrusted with the purple coralline algae this rock is known for- but if you order the cheapest online Fiji, don't expect much!

Tonga Branch- Extremely dense branched coral skeletons that add a very nice look and natural appearance to a mixed reef structure. It can be very heavy and usually carries less "life" than most types of LR. I like small amount of Tonga Branch for a diverse appearance, but do not use it as the only rock in a tank.

Kaileni- WOW! Deep-water Tonga rock that has a wide range of shapes, sizes, and densities. Some Tonga branch-like rock is usually mixed in small amounts, but most pieces are the huge caves and arches that make aquascapers drool. Many foraminifera's, fire corals, and a wide range of wildlife is found throughout the rock. Some of it is porous like Fiji, other pieces are hard, flat shelves or branches. This is my personal favorite Live Rock. The rock was originally named after importer Walt Smith's daughter- pronounced in the tongue of the people who collected the rock. Just a tidbit of LR trivia for you.

Caribbean- Very cool shelves and big, flat branchy pieces. Has a lot of the characteristics of Tonga branch, but not as dense. The Caribbean rock I have handled has been Haitian (I think), and is absolutely FULL of worms. Spaghetti worms, bristle worms, feather dusters, I don't know why, but there are always dozens of worms in the bag the rock comes in, so I dump them in the Live Sand vats.

Experienced reef aquarists, specifically sources of information, are prone to giving detailed responses such as this. It is evident something as simple as a rock can have various important attributes. Here, the aquarist focuses on shape, density, and the hitchhikers (e.g., worms) as he feels they are the key attributes of good quality live rocks. These rocks vary in type and quality because it is a product harvested from the ocean. The fact that there are several oceans and even more specific reef ecosystems, live rocks come in different shapes, sizes, costs, and qualities. For example, there are several sources of live rock, hailing from various reefs all over the world (Table 8).

Table 8: Live rock collection locations.

Ocean	Specific Location and Trade Names
Arctic	
Antarctic	
North Atlantic	Caribbean, Punta Cana, Gulf of Mexico, Florida
South Atlantic	
North Pacific	
South Pacific	Fiji, Buna, Tonga, Kaileni, Marshall Islands, Vanuatu, Solomon Islands
Indian	Jakarta, Java, Bali

Trade names reflect the diversity of live rock available to aquarium hobbyists, often delineated by location, but also are a reflection of variation in density and shape. These attributes stem from their origin as coral skeletons. Coral are "reef building" organisms, essentially repeating the process of growing, dying, and growing again atop of their predecessors. Thus, different locations have different species of coral, and after death, they become live rock. Tonga live rocks, for example, are comprised of branches. This is a unique attribute, reflecting the location and the species of coral within. In the end, the variation in live rocks available to the home hobbyist is also a variation in aesthetics.

As with most live marine "products", live rock is commonly collected from wild resources. This not only allows for aesthetic variation, organisms from the collection location can "hitchhike" on the rock and into the aquarium. Aquarists have even found small octopus, snapping shrimp, and fireworms in their live rocks. These "free" organisms are of great interest to the serious aquarists I interviewed. Scott stated hitchhikers were "the number one most interesting aspect" of the hobby for him. He described these organisms as "cool". Further, Jai stated she enjoyed seeing what creatures come out of the rock. These statements show the addition of live rocks for better aquarium functionality and authenticity promotes a keen eye for detail. The ability to see what others do not indicate a turning point in the hobby.

Hunter's eye for detail took this behavior to another level. He, too, liked hitchhikers but instead of waiting to see what came out of his own live rocks, he searched through the aquaria of local aquarium shops to look for hitchhikers.

Specifically, he like to "look for stuff they don't know they have, like macro-algae". During my experience in the hobby, it was fun to test my knowledge of hitchhikers and to identify organisms that others don't pay attention to. It seems if there is not a price tag on the item, it often goes unnoticed[11]. This adds an achievement aspect, and game-like effect to the hobby, which may promote participation as it adds novelty and complexity to the hobby. Hunter had admitted to setting up an entire tank for macro-algae, often found as hitchhikers. Increased value attributed to hitchhikers is indicative of a movement away from a fixation on a FO system and progression in aquarium keeping in general.

Scott also set up an entire system for a hitchhiker, this time a mantis shrimp. Mantis shrimp are predatory and will kill fish and invertebrates, thus they are best maintained outside of a "community[12]" aquarium. While commonly referred to as nuisance species, mantis shrimp are intriguing organisms[13]. Scott had maintained his hitchhiking mantis shrimp for three years and managed to get it to eat frozen food (e.g., silversides, shrimp). Feeding frozen food to a wild caught fish, let alone a shrimp, showed a great deal of effort and accomplishment since the organism was "trained" to eat something it has never seen before. The feeling of accomplishment stems from a unique skill, as assessed by the social world.

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[11] In the freshwater hobby, these organisms are referred to as "contaminants" and are often a different fish species found within a shipment of a specific species. This mainly occurs in wild caught fish shipments.
[12] A community aquarium is a term used to describe a display tank of compatible aquatic organisms. Predators, such as mantis shrimp, do not qualify since they aim to eat the other inhabitants.
[13] Featured in cartoons by The Oatmeal.

The care of hitchhikers “freaks people out”, as Scott put it, although he might have meant the mantis shrimp, specifically. Mantis shrimp can “punch” hard enough to break glass, which has given them a reputation. Regardless of their reputation, Scott’s retort was there is “no punishing animals for being animals”. Viewing hitchhikers as valuable organisms, specifically intrinsic value, is again an indication of progression s among aquarium keepers. This statement points towards an increased understanding of biology and ecology of this species, furthering the seriousness of Scott’s hobby.

An Authentic Reef Aquarium

In this section, I outline what I argue is the pinnacle of participation in saltwater aquarium keeping: Maintaining a reef aquarium. This transition to keeping a reef aquarium is accompanied by changes in meaning and identity. Progression to this stage of involvement is reflected by (1) a movement toward the creation of a fully functional reef ecosystem; (2) the propagation of species; and (3) a shift toward the acquisition of captive bred specimens and an overall conservation ethic. Although not all aquarist reaches this stage of participation, many serious participants regard this stage as desirable and laudable. Furthermore, progression to this stage entails the acquisition of scientifically sound knowledge about keeping saltwater fish in captivity.

The Pinnacle of Participation

A reef aquarium is a term used by aquarists to refer to the creation of a fully-functional reef, in miniature. Some aquarists omit the term *miniature* as it thought to be

redundant. Interestingly, there are actual miniature aquaria that have their own set of terminology to denote their size, including “nano” and “pico”. Nano aquaria are small (10-30 U.S. gallons) while pico aquaria are the smallest (under 10 U.S. gallons). In fact, there are entire sub worlds of specialized aquarists who are committed to keeping these very small reef aquaria (e.g., nano-reef.com). Nano and pico reef aquaria are facets of the hobby that allow a decently experienced reef aquarist to test their skill (Figure 20). The smaller the captive ecosystem, the more challenging it is to take care of it. Regardless of size, a home reef tank is a miniature version of a natural, authentic wild reef.

Figure 20: A hobbyist’s reef aquarium can come in all shapes and sizes. Photo and permission given by the photographer, and father, Matt Pederson.

Keeping coral *alive* in captivity is the cornerstone of an authentic reef aquarium. The name "reef aquarium" is defined by the maintenance of live coral. It is highly frowned upon for a participant to purchase coral, kill it, and repurchase. To assess the authenticity of a participant, an assessment must be made of long-term maintenance of the species held captive in the aquarium. Assessing authentic participation is problematic, especially when replacement specimens are easily available[14]. A hobbyist can now order and have a new, similar looking specimen shipped directly to their doorstep the next day[15]. Thus, it is relatively easy to fake authentic participation in the aquarium hobby. Remarkably, the internet allowed participants to fake authentic participation, although there are now online social worlds capable of judging and rewarding authenticity. Assessing authenticity required assessment of long-term species maintenance success and long-term social world participation.

Meaning and Identity

While FO and FOWLR participants may get out of the hobby after tank crashes or other failures, serious aquarists appreciated the challenge and risks of reef keeping. The term "challenging" was used repetitively to describe the hobby in statements from serious participants at the Marine Aquarium Conference of North America. These results showed serious marine aquarists are *motivated* to continue participation even though of

[14] Individual fish specimens are much more difficult to tell apart than coral, so covert replacement of coral is a bit more difficult to spot.
[15] During my experience, it was a common occurrence for participants, parents especially, to repurchase a specimen of the same species in order to circumvent having to explain death to their children.

the inherent challenges in keeping fishing alive. Marlin noted, “I learn something new every day.” Another aquarist observed she enjoyed “the ability to ‘do’ science”.

The aesthetics of the natural world motivates and epitomizes serious reef aquarium hobbyists. The examples from above suggests that advanced aquarists have a deep connection to the reef ecosystem and a desire to mimic or replicate the ocean in captivity. Dory noted “I have lived near the ocean my entire life.” Likewise, informant James, “It’s my little piece of the ocean.” These statements from serious aquarists indicate strongly held motivations as well as shifts experienced during participation in the marine aquarium hobby.

Movement to a Fully Functional Reef System

When the aquarist develops a reef aquarium, s/he has developed cognitive and scientific skills to keep fish alive. One skill on display is undertaking extensive research before making purchases. It is rational to follow this reasoning since a lack of research leaves the aquarist with an incompatible organism with no place to live.

Several quotes display the development of reason and problem solving skills, including one from Jai: “I watched the snails eat other snails. I didn’t know they were predatory”. She also stated these snails “had a periscope tube thing” which may have later helped her identify these organisms as mud whelks. These quotes illustrate an increased attention to detail, specifically ecological and biological knowledge, towards aquatic organisms. Further, she was paying close attention to the least aesthetic organisms in her tank – the clean-up crew. These results illustrate the hobby increased

her interest in non-charismatic fauna and promoted a curiosity that resulted in a better understanding of ecology and biology. These details also helped the aquarist create a fully-functional ecosystem.

Another example of an eye opening experience regarding ecosystem function came from Richard. During his participation, he realized the entire tank was his responsibility. Once realized, he better understood and took responsibility for the control he had over the system. His creation of a fully functional ecosystem was one that "mirrored nature, trying to craft [a] serene world and mimic nature – achieving that level, you're literally a God of this little world". These data showed that the functionality of a reef ecosystem relied on cognitive changes, a better understanding of science, and the realization that the aquarist is the sole caregiver for the lives of the organisms in captivity.

Propagating Species

An advanced stage of participation was also reflected by a growing interest in propagating captive species. To propagate and breed aquatic organisms connotes skill and knowledge, as well as the ability to persevere through setbacks and challenges. Not all attempts to breed or propagate an organism are successful. Those who propagate species have an increased understanding of the biology and ecology of the organisms. For example, Hunter became interested in propagating coral species once he was able to maintain them in captivity long-term. Coral will propagate under the right conditions, so

if cared for long-term, the organisms are likely to reproduce asexually. Success in caring for a species leads to successful propagation, at least among coral.

These successes spurred an attitude change in Hunter. Once he had some success with a species, he started to specialize in their propagation. Once he was sufficiently able to succeed with specimens of a particular species, he then began to collect numerous specimens that varied in color. For example, Hunter recollected his first species of interest saying "I began collecting zoanthids because they did well in my system. I geared my next purchases towards what did well in my tank". It was not until he identified a species that did well in his aquarium that he began to collect the various color forms of that species.

Variations in color across a single species are "color morphs". Unlike fish, one species of coral may come in a naturally occurring variety of colors and patterns, a natural history aspect serious aquarists key into. This variation allowed the aquarist to specialize in one species, but collect and propagate several different looking color strains[16].

Some serious aquarists were more interested in propagating fish than coral. Due to the lack of information regarding the husbandry and natural history of marine fishes, they are an even higher challenge for enterprising marine aquarists. Further, they are capable of adding important scientific information in regards to the successful aquaculture of ornamental species (see Section 4.2 for more details). Those who breed

[16] It may be helpful to think of these color strains as "breeds". They are the same species, but look very different.

fish are no longer *solely* focused on maintaining coral but shifted towards a different, but similarly particular specialization. Similar to the development of a fish-only system to a reef contingent on success at keeping fish alive, those who have mastered coral begin to search for meaning in other aspects of the hobby. These participants ended up maintaining concurrent systems, one a reef, another a propagation tank or brood stock tank. One of the key facets, regardless of mobility across participation types, is that their scientific acumen does not decrease. Many reef keepers on reef2reef.com shared their experiences in having to step away from the hobby. For example, one participant state, "I quit the hobby in 2009 (after 22 years) due to a combination of very young children and not enough time or frankly interest in keeping my tanks in good shape." While serious aquarists may take a break due to family or work obligations and become out of date on new technology, they do unlearn their accumulated skills and knowledge.

While a natural reef is a pinnacle of success, once achieved participants seek out other rewards or special benefits. These rewards and benefits include the successful selection of unique color morphs for propagation efforts in coral species, or achieving a never before seen breakthrough in breeding ornamental marine fishes. These results additionally showed biodiversity plays a role in driving specialization as well as a motivation to participate in the hobby. Participants who propagate species may not be trying to recreate a wild, authentic reef scene since they are selecting specific colors or breeding certain species. Instead, they strive for accomplishments that push the hobby to new and interesting specializations.

Shifting towards Conservation

Evidence from this study show a change in consumption occurred during the shift from a FO to a reef aquarist. Specifically, novice aquarists tended to overconsume organisms as they learn about the care of a captive aquarium (i.e., the killing and replacing of specimens). However, along with skill and knowledge of the organisms and the system comes knowledge about the reef aquarium trade and industry – specifically its reliance on wild caught organisms. This knowledge shifts the aquarist towards a more ethical consumption of live organisms and toward a conservation ethic.

To circumvent consuming wildlife, the aquarist changes towards consuming captive raised specimens. This behavior change seemed to be due, at least partly, to understanding the implications of the trial and error learning process, which is a key reason for overconsumption. As the aquarist fails (i.e., kills organisms) but continues participation, s/he take notice of the number of organisms they have personally consumed. They also notice the number of organisms others consume. Online forums show aquarists arguing about this. Increasingly, opinion leaders sanction the behavior of others towards a conservation ethic (Figure 21). Thus, duration in the hobby and seriousness seem to be related to an increased conservation ethic.

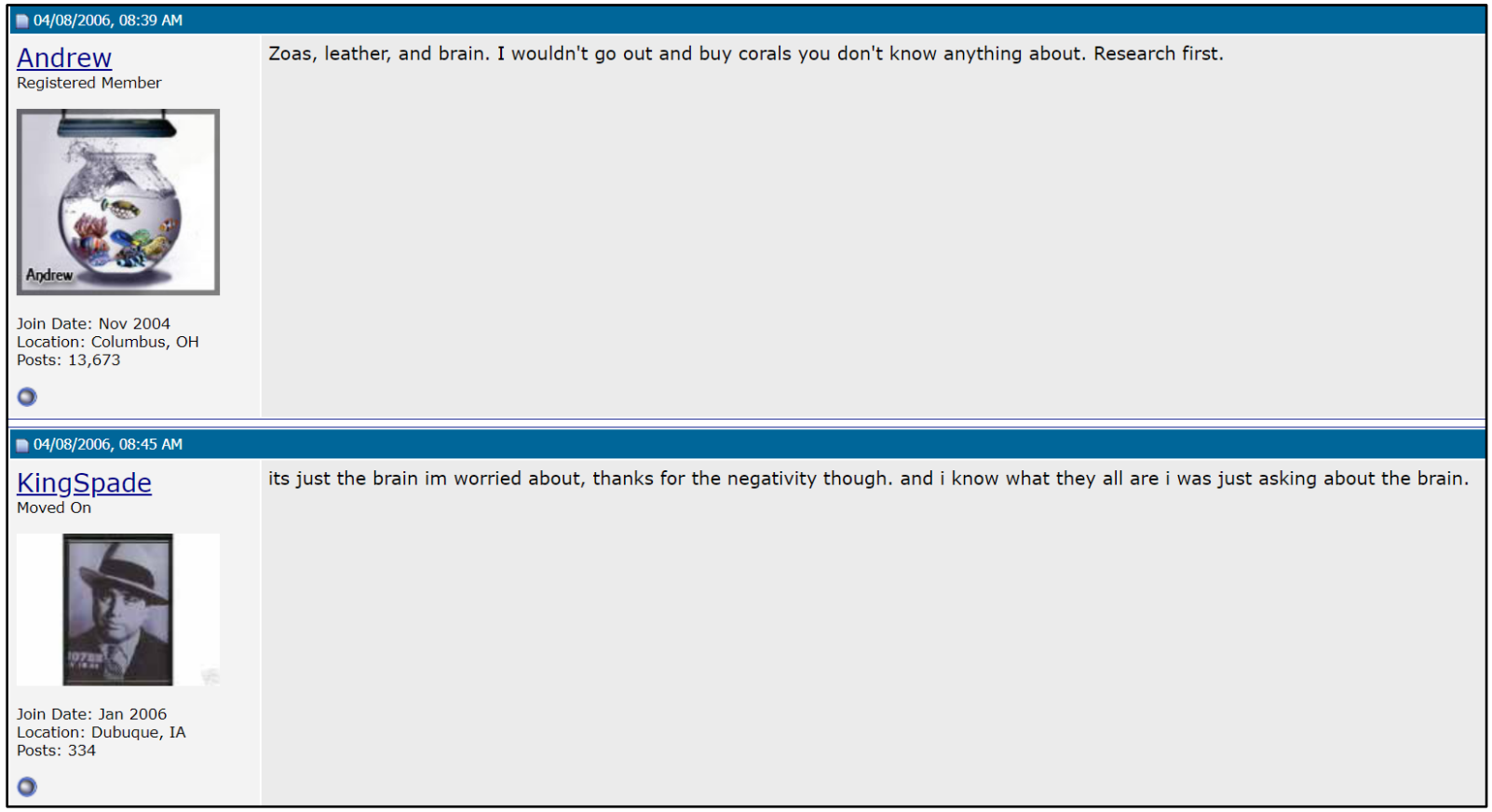

Figure 21: Social sanctioning on www.reefcentral.com.

Aesthetics, There and Back Again

Color and pattern are major foci for marine aquarium keepers; characteristics improved with artificial selection and good marketing. For example, aquarists such as Jason Fox select and propagate only the most colorful coral specimens, which markets the organism well on its own. However, due to the popularity of the internet, coral frags are often for sale online, "sight unseen". Thus, representations of the coral (i.e., photos) must be done ex-situ. Normally, this is though photographs of the coral fragment and the "mother colony" as proof of color.

However, color changes across each captive ecosystem, so a $999 fragment may not look the same, or be worth the same amount, if the conditions to recreate the color are not exact. Caring for colorful corals relies on the successful care *and* growth of the coral itself. In the excitement of obtaining a live specimen, some aquarists forget to make sure they can keep the coral alive long enough to propagate it for their own interests.

Aesthetically pleasing aquaria are not only associated with the number of different species in a reef tank (i.e., biodiversity), but also the number of color variants, or "morphs", *within* each species. Color variation in coral may not be obvious to a new reef aquarist as the details are rather minuscule. For example, "zoas" or "zoos", which is hobby nomenclature for *Zoanthus* species (Figures 22 and 23), have three physical attributes that may have different color combinations. This particularity further qualifies the reef hobby, and coral aficionados, as serious leisure participants.

To elaborate, hobby *Zoanthus* species are historically attributed to one species, *Zoanthus sociatus*, but the species is extremely variable in color. Interestingly, fish species are described by their morphology, including color, but coral are not. For example, *Zoanthus* are in "taxonomic chaos" (Khushali, 2015), which means marine scientists believe there are many species, but have not been able to figure out how to best decipher them. In a twist of fate, non-professionals have found it quite easy to describe different *Zoanthus*, and largely do so according to color (Figure 23). While naming coral color variants is not taxonomically valid, it is a way for a serious reef hobbyist to advance their interest in aesthetics and literally make a name for themselves in the social world.

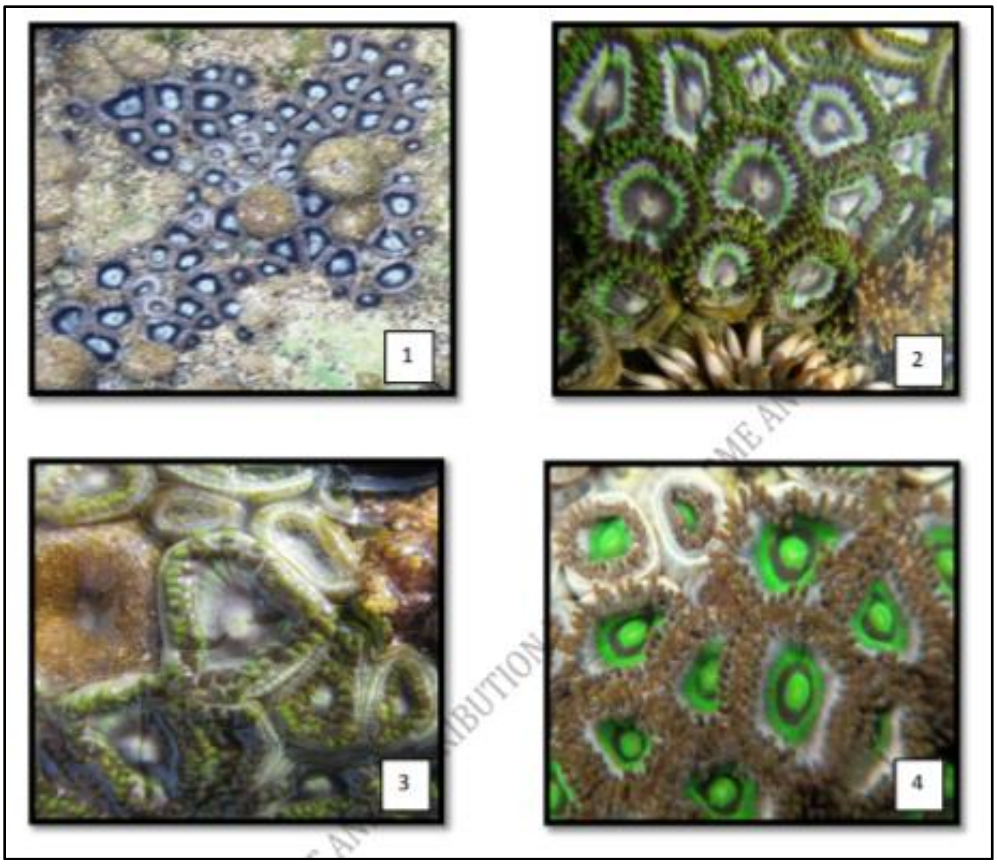

Figure 22: Color variation in zoanthids, through the eyes of scientists.

Figure 23: Color variation in Zoanthus, through the eyes of serious reef aquarists. Image is a partial scan of a flyer from the 2016 MACNA.

From these data, it is evident colorful systems are some of the most impressive. Interestingly, coral colors have become increasingly impressive over time due to improvements in technology and equipment. For example, small-polyp Scleractinian (SPS) corals such as *Acropora* species look like "brown sticks" under inadequate conditions. For example, Dan, an online forum user stated one of his "unimpressive" corals became "worthy of attention" once it had started to develop yellow and blue pigments. Further, he states it is important to have patience and that he will use this coral to propagate his collection:

> You just never know when you will find a gem. This coral is a prime example of this premise when speaking about corals in captivity. This *Acropora tenius* started out very different then it appears today. Even with the couple decades of keeping corals under my belt I did not see the potential in this specimen. It was a small seed fragment I acquired from a hobbyist at one of the many frag swaps I attended. The coloration was quite unimpressive so I did not give it much attention or prime real estate in any of my systems until recently. After a few months in the original location it was placed I saw the yellow pigments and a hint of blue on the axial coralites. I promptly decided it was worthy of some attention and better placement. I positioned it to receive strong light and random flow in one of my most mature reef aquariums. After several months in the new location the pigments began to develop into what you see now. As each month passes the coral becomes more vibrant although is not adding mass as quickly as I would anticipate. The polyp extension and new active growth tips tell me I did the right thing. Now I must have patience and watch my new gem grow into a mature colony with hopes of propagating this coral in the future. I believe it has the

> genetics to be a worthy addition to my brood stock and only time will tell if I made the proper decision. The moral of the story is you just never know. Never assume a certain specimen will not become your next diamond in the rough.

This quote epitomizes the thought process of someone who is focused on the aesthetics and return on investment in the saltwater aquarium hobby. Specifically, the return on investment stems from propagating aesthetically pleasing coral fragments for sale to other reef aquarists. This individual is also a likely source of propagation information as well as answering questions about the proper care of the species/morph he sells. Further, this quote is laden with scientific jargon – and this individual is not a scientist. While focused on aesthetics and even financial reward, science still infiltrates the hobby.

Summary of Aesthetics

Across multiple modes of data collection, these results indicate an overall, and ongoing, focus on aesthetics in the marine aquarium hobby. Yet, it is evident some aquarists shift from a core aesthetic orientation, largely focused on acquiring colorful fish, towards developing a *scientifically* sound ecosystem. The previous section outlined this development as one reflected in participation style, from fish-only aquaria to increasingly complex systems complete with invertebrate life. The middle point development was the use of live rocks to aid in ecosystem function. Once functionality is understood, scientifically, aquarists have dabbled with keeping live coral. The

incorporation of live coral qualifies the participant as a reef aquarist. However, it is the long-term success at keeping these organisms in a system with fish and other invertebrates that is considered the pinnacle of participation.

The most serious marine aquarists maintained reef aquaria. As with other serious pastimes, some of these participants search for additional meaning and challenge in their hobby through other, more specific, practices. In the marine aquarium hobby, these practices included behaviors related to status seeking and those of an emergent conservation ethic (discussed in Chapter 5).

Niches: Searching for Distinction in the Marine Aquarium Hobby

Overview

In Section 2, I outlined the central motivation for keeping a marine aquarium: the aesthetic draw of colorful, tropical marine life. Further, I outlined the development of a serious marine aquarist from an interest in replicating a picture of a reef to the creation and maintenance of one. Due to the centrality of aesthetics, some serious hobbyists focus on the maximization of aesthetic appeal. In contrast, new reef aquarists display more effort towards maintaining live coral. Simultaneously, serious reef aquarists excel at keeping live coral and thus focus on keeping the most pleasing coral they can find. Often this refers to eye-catching, colorful specimens. Fish are still a major facet of the system, and some serious aquarists focus on their acquisition, care, and breeding, but success in the latter is extremely difficult due to the life history strategies of reef fishes (i.e., pelagic) and finding distinction in the former is contingent on financial means. Regardless, marine aquarists find distinct ways to participate in a serious, specialized manner. These distinctions aid in the delineation of specialized niches.

Niches are specializations, or trajectories (Scott & Shafer, 2001b), that correspond to the interests, availability of resources, and the aquarist's own unique skills and knowledge. These specializations facilitate the maximization of an eye-catching reef system. For example, a mechanically inclined aquarist may use his or her skill to create a lighting system with specifically chosen light emitting diodes (L.E.D.'s) that make the color of their corals "pop". In turn, this participant distinguishes himself or herself in the

hobby at large. This is just one of a multitude of trajectories that aquarists can distinguish themselves in, and thereby, achieve status among their fellow participants.

This section outlines some of the realized niches that had emerged from the data on serious reef aquarists. It is important to note that there are some realized niches that were so specialized they blurred the lines between hobby and profession. As a hobby that grows and changes with technology and scientific discoveries, the numbers of trajectories and niches, as well as their delimitations, also change over time. At the time of this study, there were three main types of serious participation: (1) ecosystem, (2) the organisms, and (3) the equipment (Figure 24).

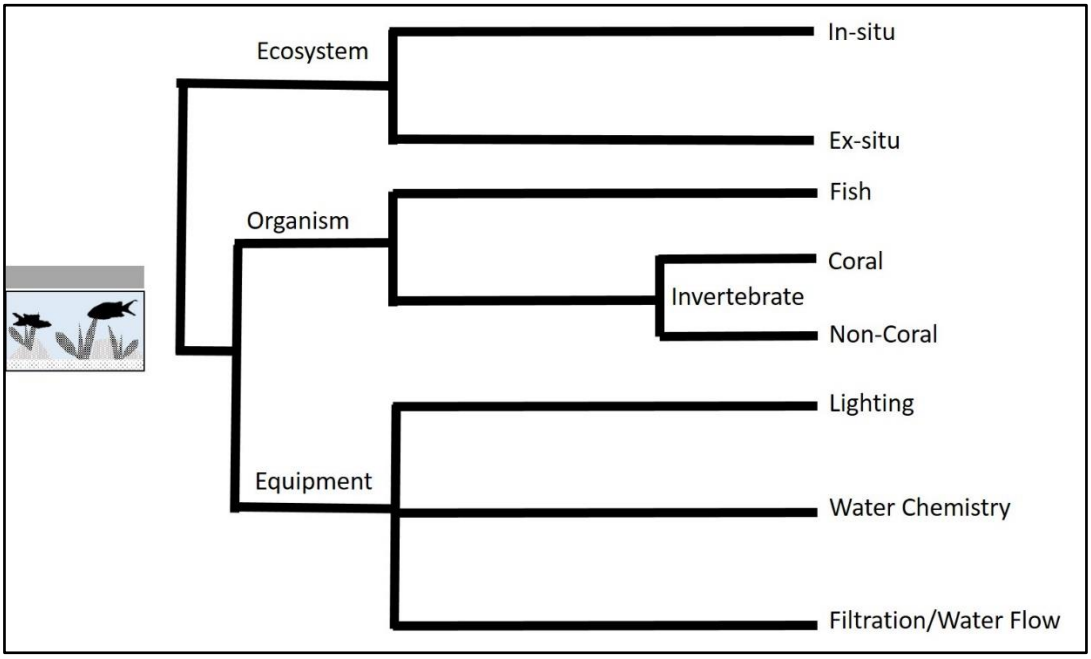

Figure 24: Different trajectories or niches within serious marine aquarists depicted as a cladogram.

These three overarching niches are reviewed in turn. In addition, several of the more specialized trajectories are similarly described and are presented in order along the far right of Figure 24. Specifically, I touch upon the formation of such niches, their participants, and delimiting characteristics. Lastly, this section reviews how an aquarist can make use of their specialization. To elaborate, participation in any of these niches opens up several tracts, from starting their own business to becoming a club leader, or "go-to" person. Indeed, many of the informants in this study were "go-to" people within the hobby, which not only allowed them to distinguish themselves, they were also able to achieve status among their fellow participants. The following sections characterize several of the niches in the marine aquarium hobby and the participants who have realized these niches.

Ecosystem Niche

In the context of this study, the term *ecosystem* refers to a wild, tropical reef[17]. Serious aquarists who specialized in an ecosystem did so in two ways: (1) as a specialist in a wild ecosystem or (2) as a specialist in a captive ecosystem. I refer to these two variations as in-situ and ex-situ, respectively (Figure 2).

[17] There are temperate reef ecosystems but these are much less common in the hobby.

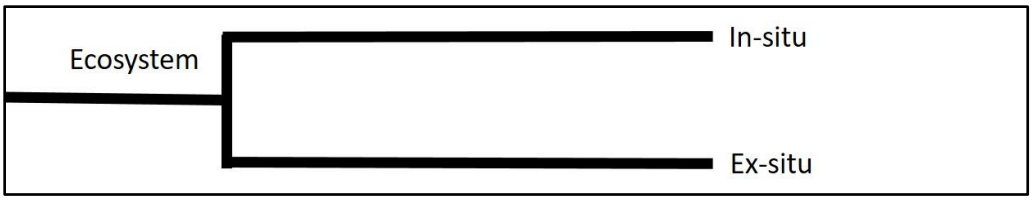

Figure 25: Ecosystem clade for serious reef aquarists includes two specializations, in- and ex-situ reef ecology.

In-situ Characterizations and Participants

In- situ specialization in reef ecology was identified by both knowledge and skill in the *wild* reef systems. This niche was one of the least common seen throughout this study. Much of what characterized this niche was an accumulation of scientific information and the application of that knowledge to non-hobby aspects. For example, some of the people I included in this group were (1) science-oriented individuals who (2) understood wild systems, and (3) *could* keep a reef aquarium and perhaps did so at one time, but did not always have a currently running captive system of their own. Instead, they used their skill across in-situ applications such as collecting data on wild coral populations, describing new fish species, or communicating conservation-oriented messaging. For example, three speakers at the 2015 MACNA showed very specialized in-situ knowledge but did seem to maintain a home aquarium. The titles of their talks were as follows: (1) Into the Twilight Zone: A Collector's Perspective, (2) A Journey through the World's Coral Reefs and Their Fishes, and (3) Gorgonian Corals in the Twilight Zone. These participants could keep a home aquarium but chose to focus on in-

situ reefs. While activities such as collecting, diving, and delineating species are intimately linked to the hobby, in-situ specialists were an uncommon group in this study.

The accumulation of scientific information was one characterization of in-situ specialists (one, above). Specifically, these aquarists were able to identify marine species, especially those uncommon to the aquarium trade (e.g., *Anacropora* versus *Acropora* or hybrid fish specimens). The last indicator of in-situ specialization was a conservation ethic. Specifically, they knew how human actions affected the wild reef ecosystems, which seemed to run counter to the consumptive mentality of the hobby. Across all characterizations for this niche, the conservation indicator was weakest.

Ex-situ Characterizations and Participants

Throughout this study, there were indications that the ex-situ ecosystem specialization was one of the most common niches. For example, multiple informants had reached an expert level of captive ecosystem knowledge and skill. Since the aquarium hobby relies on the aquarist accumulating a broad spectrum of scientific knowledge as well as their interconnected nature with organisms and abiotic parameters (e.g., pH, NO_3), it makes sense that many participants in the hobby are ex-situ specialists.

In addition to club involvement, there were four indicators defining participants as specialists in captive reef ecosystems. Specifically, they (1) had long term success (i.e., multiple years) at maintaining the same fish specimens in the same system. Further, these aquarists also (2) maintained live coral specimens along with fish. Coral were

either solitary organisms who had lived long term or colonial corals that not only lived long-term but also propagated themselves within the system. Coral specimens were also (3) maintained in the same system over the duration of their lives; however, propagated fragments were sometimes passed along to other aquarists. The interaction of passing along information as a go-to person and/or as the supplier of captive raised coral fragments worked to increase the reputation of an ex-situ specialist. Thus, (4) a social world characterization delineated this group from others. Further, the realization of these attributes may have caused participants to form, or move towards, a coral-specific niche in the hobby (Figure 26; further covered below).

Interviews elicited several ex-situ ecosystem specialists. For example, Jessica covered all four characters for ex-situ specialists because she was charged with maintaining one captive ecosystem as a part of her job. This defined her as a go-to person for the care of a captive reef. Jimmy also had a job maintaining aquaria, although he did so on a much larger scale (i.e., several aquaria at a science museum). Richard, as an aquarium technician, was the only source of ex-situ ecosystem success for clients who paid him to maintain their aquaria. Robert owned an aquarium shop, which meant he not only cared for captive ecosystems, he was a major source of aquarium-related information for customers from all over the local area. In some form or another, these informants were ex-situ specialists and provided services to others in making a successful captive reef.

Other informants preferred to remain relatively informal in this niche. They maintained their own ecosystems, accumulated specialized knowledge, and were happy

to share with others. These hobbyists were involved in their local aquarium clubs, often reef specific social groups[18]. Scott, for example, was a well-known aquarist in one club, indicated by being called a "go-to person for anything aquarium related". Wilber had been a board member of his club, and David was currently holding a positon in his local and national clubs. While there are also online versions of aquarium clubs (e.g., Club Zoa on nano-reef.com, Facebook groups), these are not included since they were not a topic touched upon by informants.

Conclusion

While both of these niches are ecosystem specialists, there are differences between them. For example, in-situ specialists were generally better at recognizing species, especially those uncommon in the aquarium hobby. These participants were also delineated from others by their activity in-situ, or within wild ecosystems. Further, due to this intense interest, while capable marine aquarists, they chose to their time understanding wild reef ecosystems. In contrast, other ecosystem specialists chose to specialize in captive, or ex-situ ecosystems. There they kept the same specimens long-term within the same ecosystem. In addition, they were tightly integrated into the social world of the hobby. Both groups found a unique source of meaning and enjoyment through these specializations.

[18] Not all localities could successfully maintain enough members for reef-specific aquarium clubs. Instead, reef aquarists participated in general aquarium clubs, which were largely comprised of freshwater aquarists.

Organism Niche

Organisms provide another niche for serious marine aquarists. While fish are the main draw for those viewing a marine aquarium, coral has the largest contingent of serious participants. Thus, two main specializations emerged from the data, those focused on fish and those on invertebrates (Figure 26) with the vast majority of all participants focused on coral. Non-coral invertebrates are simultaneously common and uncommon, since some are used as "reef janitors" while others are categorized as pests. For example, crabs are often used as janitors while octopus may be purchased, but are also relatively rare hitchhikers on live rocks.

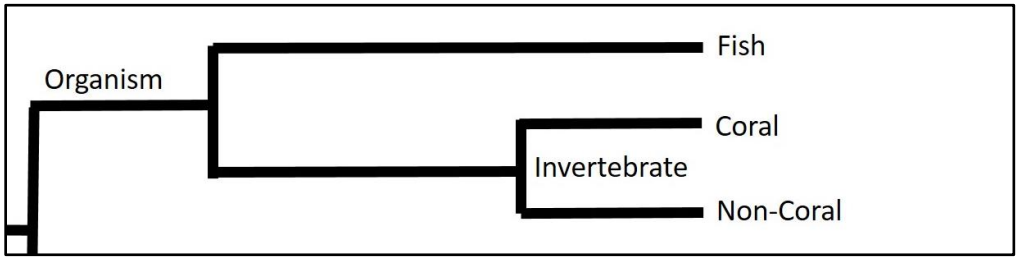

Figure 26: Organism clade for serious reef aquarists is divided into fish and invertebrate specializations with invertebrates further divided between coral and non-coral species.

By far, organismal specialists shared a key characteristic – the interest in *reproducing* marine organisms in a captive environment. This activity was called "captive breeding", "propagation", or "culturing". Notably, these aquarists are assumed

to have the ability to maintain these organisms. In order to reproduce, the organism needed to be "thriving, not just surviving". This qualification seemed to indicate that organismal specialists were also capable ex-situ hobbyists.

Fish Niche Characterizations and Participants

Participants who comprised the fish niche were, as stated above, mainly interested in the *captive breeding* marine fish, not just keeping them in an aquarium. Thus, the main characterization of this niche is an interest and skill in reproducing fish. An interest in breeding fish seemed to stem from the recognition that the hobby is almost entirely comprised of wild caught fish specimens. Hobbyists in this niche found meaning in reducing the hobby's reliance on wild populations by applying their skill towards understanding and replicating a species' life history in captivity. This motivation stems from collaborative efforts, such as the Marine Breeding Initiative (MBI) which has a mission to "reduce the need for wild caught specimens" and this activity "is one way we as hobbyists can reduce those pressures".

An interesting facet of this niche was a reliance on other aquarists for success. This facet may mean participants found meaning in working together towards a common goal. For example, at the 2016 Marine Aquarium Conference, a great deal of celebration occurred due to the success of the Tropical Aquaculture Laboratory at the University of Florida in not only breeding, but also raising larval Blue Hepatus Tang (*Paracanthurus hepatus*). The complexity and challenge of this achievement is illustrated in Figure 27.

Each of these stages of development had unique requirements that needed to be achieved successively in order to raise the fish larvae through metamorphosis.

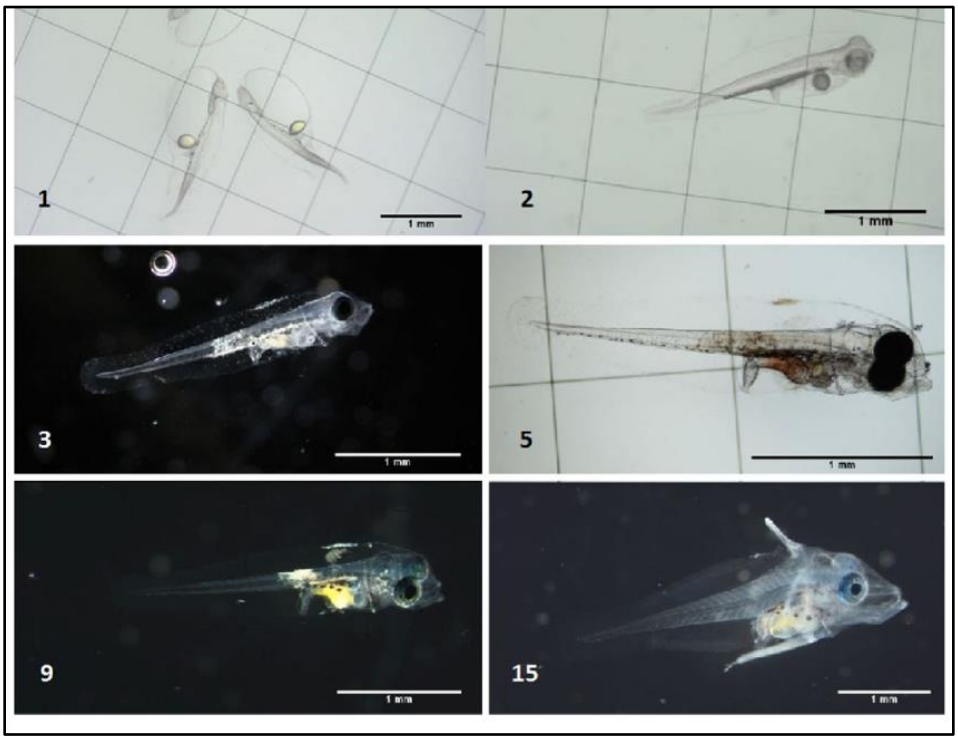

Figure 27: Several stages of development (i.e., success) are illustrated in the culture of Blue Hepatus Tang. Image from Cassiano et al. (2014).

The difficulty of raising marine fish also requires a financial commitment as well as a reliance on several stages of achievement. Success meant building on previous failures, and collaborative efforts across individuals enabled aquarists to push ahead toward a common goal. As noted on their website, www.mbisite.org, for example:

"The MBI creates a standardized model that uses a central database to share information between all MBI sites while rewarding and encouraging hobbyists to begin breeding and existing breeders to tackle more difficult species and try new techniques". The results of this study have shown aquaculture laboratories of numerous aquarists comprised much of the fish niche.

There were, however, single aquarists who had successfully bred fish on their own. One aquarist was known to have bred and raised *Centropyge bispinosa,* the extremely popular Coral Beauty angelfish. She had successfully raised other marine species (e.g., clownfish) and built upon her skills to breed a more challenging species. She moved from clownfish because she became "weary of the same breeding regimen and started to try to raise other kinds of ornamental fish[19]". Besides boredom, this aquarist appreciated "the challenge" of unlocking the techniques to breeding and raising marine fishes.

Built upon previous personal failures and successes this aquarist also had help from other aquarists. At a local fish store, another aquarist overheard of her success raising marine fishes from egg to adult, so he offered her eggs of three species that were naturally breeding in his aquarium. In her account of raising the Coral Beauty, she credited several sources of knowledge that helped her succeed. It seems she too was a part of a collaborative effort, although the participants were not a part of a physical laboratory. It is unknown whether or not success in the successful captive breeding of

[19] https://reefs.com/magazine/raising-coral-beauties-landlocked-hobbyists-basement/

marine fishes is higher in laboratories versus individuals, but it seems individuals have created their own laboratories through social media and other means of communication. Regardless, I found sufficient reasons to delineate serious aquarists into a niche of fish specialists who are interested and able, to raise marine fish species.

Coral Niche Characterizations and Participants

Another organismal niche in serious aquarists was comprised those who specialized in coral. Similar to fish breeders, this niche focused on replicating the organisms, not just maintaining them in captivity. Perhaps due to the lack of informants within the fish niche, coral propagators seemed more interested in using their captive propagation success to reinvest into their personal hobby. Further, these aquarists did not collaborate in order to succeed. Essentially, these aquarists focused on propagating colorful coral to sell to other aquarists in order to finance their own infatuation, and a general self-centered motivation for participation.

Participants in this niche aimed to maximize their return on investment by critically selecting certain coral species and color morphs for propagation. During his interview, Hunter described his interest in coral as a “collector’s mentality”, and walked through his coral selection process. Specifically, he was up to date with the current interests of other aquarium hobbyists and used that to his advantage by weighing the resale value of the fragments he purchased. His keen eye for detail was evident in his memorization of the unique color characteristics and hobby names for each coral in his

collection. Hunter collected 40 different color morphs of *Zoanthus*, including those named “Utter Chaos” and “Bloodshot” (Figure 28).

Figure 28: Utter Chaos and Bloodshot zoanthid color morphs. Photos from zoanthids.com and jasonfox.com, respectively.

Further, Hunter described the *lineage* of the coral fragments as an important attribute and enjoyed talking about sources of his frags. He spoke about “knock offs”, or coral frags that looked similar to popular named variants, “but were easily 1/3 the size of the original polyps”. Memorizing these attributes was extremely important because he was collecting numerous color morphs, maintaining them in the same system, and then selling them with a rather amazing amount of specificity to other aquarists. The specificity was required to maximize the return on his “investment”. Hunter, who was very aware of the popularity and trends of each of the color morphs he maintained,

would sell frags as close to the height of their popularity – all to fund his next coral propagation interest.

Hunter's interest in coral species changed over time, contingent on what he referred to as his "mastery of a species". When I interviewed him, he was on at least his third species, moving from zoanthids to "acans" (*Acanthastrea sp*.), to mushroom corals. I originally met Hunter at the 2015 MACNA where he placed in the scientific poster contest and won $500. As with many serious hobbyists, he immediately used that money to purchase hobby-related items in the conference vendor room. Specifically, he used his winnings to purchase *one specimen* of strangely shaped coral he had been wanting, a "Bounce" mushroom coral. During the 2017 interview, I asked why he used his entire winnings to purchase one individual specimen. The purchase, he stated, acted as both a personal propagation challenge and an investment.

Due to the ever present interest in aesthetics (i.e., color), coral propagators pinpointed, and took advantage, of that desire by offering color coral for sale or trade. For example, the Bounce mushroom coral Hunter purchased had a unique coloration and shape, with "bubbles" that "bounced" in the water current (Figure 29). A specimen without these traits may be a "knock off", or at the very least an investment with poor return. As Hunter noted, the trendiness of specific corals was found to wax and wane. This was evident in that he spent $500 for one Bounce specimen in 2015, and two years later other Bounce mushrooms sold for $6000.

Figure 29: A Google Image search for "Bounce mushroom" displays the intense coloration and shape of the coral specimens that elicit up to $6,000 each.

Do to the potential to make money off coral propagation, aquarists specializing in coral spent a great deal of time considering how to design their aquariums accordingly. For example, Dan, an online informant stated, "The coloration [of the coral fragment] was quite unimpressive so I did not give it much attention or prime real estate in any of my systems… After a few months … I saw the yellow pigments and a hint of blue... I promptly decided it was worthy of some attention and better placement". Here, the aquarist ignored a coral in his aquarium until it had increased its value.

Some aquarists went so far as to set up entirely separate "frag" tanks just for the colorful frags they would find and subsequently produce. This was because "real estate" in their main display would shrink due to the growth of the corals within. A frag tank added another aquarium to the original, which seemed to start "multiple tank syndrome", or MTS. This "syndrome" was characterized by one major symptom - the imperceptible accumulation of multiple aquaria by a hobbyist. Essentially, MTS indicated an increasing level of seriousness, or at the least, an increasing level of interest in

incompatible aquatic species. MTS became a point of conflict for families of aquarists as evidence showed significant others, specifically wives, found the hobby to be too time and financially consuming for their husbands. Some hobbyists hid their purchases (e.g., receipts and even the frags themselves) in an attempt to continue unabated participation (Figure 30). This tendency seemed to occur among a small number of saltwater aquarists

Figure 30: Online forums offer a way for aquarists to share their true experiences.

Lastly, one of the underlying characterizations for this niche was a self-centered motivation for coral propagation, a trait displayed in a few ways. Compared to fish

breeders, coral propagators were not particularly collaborative. They also aimed to have their achievements memorialized with their name attributed to a lineage of coral fragments. Memorialization by the naming of coral lineages seemed to start as a way to communicate the fact that the coral was captively propagated, meaning it was an easier specimen to maintain compared to wild collected fragments. For example, when I was participating as an aquarist I had local stores suggest certain coral lineages as "easy" or "beginner friendly" (e.g., Green Slimer *Acropora*).

Interestingly, some coral propagators appropriated this trend in order to memorialize themselves. This behavior seemed limited to those who propagated corals as a business venture. For example, Hunter did not name corals after himself. While naming, and remembering, a coral's lineage connotes a great deal of information, it is frowned upon to name organisms after oneself. For example, scientists do not name species after themselves, it must be ascribed to them by others in order to memorialize their efforts[20]. Memorizing a high achiever is sometimes acceptable, but memorializing one self's achievements is self-aggrandizing.

Non-Coral Characterizations and Participants

The least common trajectory for a marine aquarist interested in organisms, specifically their propagation, was the non-coral niche. Organisms represented here included shrimp, crabs, worms, cuttlefish and any other non-coral invertebrates. As one

[20] Similar to the peer-review process.

may expect, non-coral invertebrates are not highly sought after for ornamental purposes, and as outlined in Section 2. Characterizing the limited number of participants in this niche was an interest in propagating these animals for food for other captive reef organisms and for display in public aquaria. It appeared this niche provided opportunities for hobbyists to explore a new frontier in propagating organisms, but most seemed focused on propagating them for food and display.

Non-coral invertebrates are some of the most numerous organisms found in a reef aquarium. Some of these are "hitchhikers" that come into the system with live rocks, while others are purchased as "clean-up crews". It is important to note that hitchhikers are *free* and species comprising a clean-up crew are *cheap* (e.g., Blue Legged hermit crabs; Figure 31). Since the organism niche is characterized by a strong interest in propagation, with accomplishments in fish receiving high praise and coral propagators achieving monetary feedback, propagating hermit crabs may not be as rewarding. Non-coral invertebrates are not the focus of a reef aquarium, and thus seem to be overlooked as organisms to propagate (i.e., specialize in).

Blue Leg Hermit Crab - Clibanarius tricolor

Quantity	Price
1 – 11	$0.99
12 – 24	$0.94
25 – 49	$0.89
50 – 99	$0.84

Figure 31: A quick Google.com search elicited the cost for varying quantities of a common, wild-collected, non-coral invertebrate.

Those who propagated these organisms were focused on providing them as a source of food for fish or corals. For example, mysid shrimp were bred by hobbyists for food, or as a supplement to their clean-up crew. However, no informants did this at the exclusion of other aquarium related activities. It was a means to an end in meeting loftier goals.

During my own participation in the hobby, I came across one professional aquarist who had bred cuttlefish. Cuttlefish are related to octopus, both of which do not perform a practical function in a reef aquarium; however, they make spectacular organisms to display at public aquaria. Likewise, this aquarist spoke about breeding these animals for display purposes at their public aquarium. Unfortunately, I could not

locate any hobbyists who specialized in non-coral invertebrates, thus I conclude this niche is rudimentary but needs to be categorized separately from the coral specialists.

Conclusion

The overall niche specific to reef organisms was varied in participatory characteristics. Fish specialists were collaborative and focused on raising fish as a personal challenge. The lack of ego associated with this group seemed to morph into a conservation ethic – specifically breeding these organisms to reduce collection pressures on wild populations. Diametrically opposed to these attributes are those in the coral niche. Specifically, these hobbyists were more territorial and aimed to memorialize their efforts by appropriating a naming convention previously used to convey husbandry information. There was also seemingly an underlying lack of conservation orientation due to the competition-like nature of finding, naming, and selling the newest coral trend. This behavior may lead to more pressure to collect corals from wild populations.

Coral niche participants were also interested in reinvesting their propagation skills back into their own hobby. This was done opportunistically, as evident from Hunter. Other aquarists started coral propagation businesses that provided more than enough funds to make up for their hobby participation. At the time of data collection, coral maintenance, as well as propagation, was a very popular activity across all reef aquarium hobbyists, with some specializing in it. This niche has a large number of participants, which seemed to help spur smaller, specific-specific niches (e.g., *Zoanthus*, *Acropora*, *Montipora*).

Lastly, the non-coral specialist niche was limited to those who cultured these organisms for practical purposes, either as food or as display organisms for non-hobby aquarium displays. However, these organisms are distinct enough to have their own niche, especially since organismal niches are characterized by propagation of species.

Equipment Niche

Separate of ecosystem and organism specialists, there are niches of equipment savvy aquarium keepers. Equipment specialists were particularly evident online and at the annual national conference (MACNA). Specifically, these participants were focused in one of three subgroups: Lighting, Water Chemistry, and Filtration and Water Flow (Figure 32).

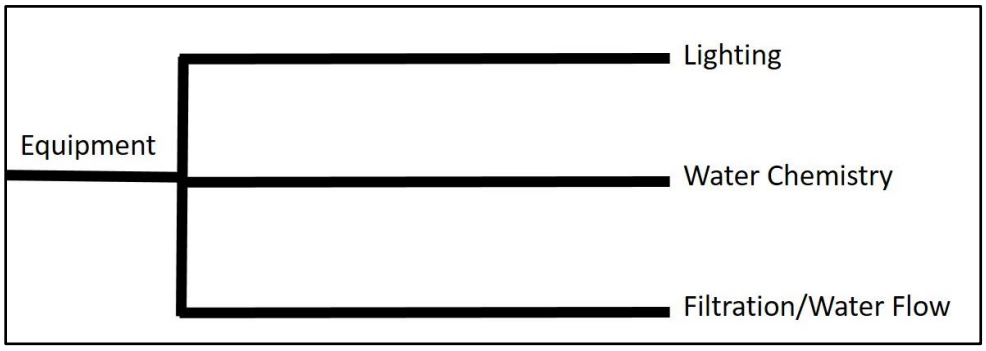

Figure 32: Equipment clade for serious reef aquarists is divided into lighting, water chemistry, and filtration/water flow specializations.

The majority of equipment specialists were observed as they highlighted their knowledge and skill at the MACNA, either as speakers or as vendors. They were simultaneously hobbyists and paid experts in their respective fields. Many were regular attendees of the annual MACNA, which connotes an importance in both topic and their expertise as go-to people in their field. It is important to note that these three groups overlap in some aspects, but each remains a distinct specialization with unique characters. These three fields, or subgroups, are reviewed in turn below.

Lighting Characterizations and Participants

As stated on www.reefhacks.com, "Few hobbies amplify the complex world of light to the degree as reef tanks…. lighting is far more than an aesthetic design." Essentially, while lighting an aquarium seemed to be for the aquarist, in the reef hobby it was primarily for the coral. Lighting was a necessary part of a reef aquarium as most coral species require light to live. A reasonable proficiency allowed an aquarist to successfully keep coral alive while those who *specialized* in lighting were essential gatekeepers for all successful reef hobbyists. Characterizations of this niche of participants was scientific expertise in the physics of light, its application to reef aquaria (i.e., coral biology), and an ability to communicate these two facets with others.

As with the in-situ ecosystem niche of reef aquarists, this group was characterized by scientific specialization with a pertinent but tangential applied specialty to the reef aquarium. To elaborate, expertise in lighting is not specific to reef aquaria but is a useful concentration. For example, in-situ ecosystem specialists were experts in wild

reef ecosystems – this specialization is not specific to aquariums. Likewise, lighting specialists had expertise in lighting, not aquariums. Further, their scientific expertise was engineering. Both in-situ and lighting niches found a spot that rewarded their unique skills and knowledge.

The scientific application for lighting specialists included the physics of light. As a scientific field, understanding physics included a great deal of jargon. For example, there were many confusing terms, such as lighting spectrum, Kelvin, watt, PAR rating, and wavelength. While scientifically oriented, go-to participants had to communicate adequately with hobbyists from various backgrounds and education levels.

One of the best-known lighting specialists in the hobby was a well-regarded speaker who attended, and spoke, at the last *seven* national conferences[21]. It is noteworthy to mention MACNA speakers have every aspect of their visit to the conference paid for, including travel, lodging, food, as well as a speaker fee. Speaking at MACNA is highly prestigious and rewarding. These rewards did not seem monetary, but rather status oriented. For example, other hobbyists held this speaker in such high regard, one posted online: "Once [he] decides to put LEDs over his reef display tank I will consider going back to LEDs. Until then, if it's not good enough for him, it's not good enough for me." These examples characterize this niche as one with important gatekeepers, trendsetters, and good communicators.

[21] Data were difficult to obtain past 2012.

In addition, this individual was also an engineer by training[22]. According to his biography, he grew up abroad without the aquarium equipment available in the United States. During this time be engineered his own ecosystem. In an interview sourced from an online Reefkeeping magazine he stated, “When I design an aquarium system, I think like an engineer would”. While not all lighting specialists are engineers by trade, the predisposition to engineer fixes and “do it yourself” was an important characteristic of this niche.

Lastly, he delineated his interest in coral keeping as one *not* contingent upon following coral trends or tracking their hobby names. This behavior opposed the coral propagation niche since propagators comprised diligent people (e.g., Hunter) who followed trends in coral keeping and maintained “hobby names”. Interestingly, the lighting specialist propagated coral but it was not his focus of participation. Instead, his corals grew because he took care to provide them with the best lighting. Further supporting his disinterest in following trends was that he had achieved a rewarding hobby career without focusing on coral propagation. While there were other such experts across the reef aquarium hobby, this particular individual epitomized characters of the lighting niche. Expertise in lighting makes for experts in maximizing coral color and growth, two important foci of serious reef aquarists.

[22] At the Ph.D. level in Industrial and Manufacturing Engineering

Water Chemistry Characterizations and Participants

Another equipment related niche is that of understanding water chemistry. Defined as the overall *quality* of the aquarium water at a given time, reef aquarists of all levels were required to test several chemical dimensions of water quality in a reef aquarium. These included four major dimensions: pH, ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3). To succeed in the marine hobby, every aquarist had to have a rudimentary understanding of these components and their interactions over time. *Specialists* had a firmer grasp of the need to test, to have the most accurate "test kits", and to track water chemistry over time. For example, at a regional conference one of the speakers mentioned he maintained his tank through "record keeping [where] pH and temperature are checked daily". He also kept a notebook of these parameters to monitor changes. This shows water quality is an important aspect of the hobby with specialists focused on chemistry found within this niche.

A key defining characteristic of this group was as a scientific orientation, specifically towards chemistry. Further, niche specialists were able to provide go-to help regarding testing the four water parameters above – as well as several more "trace elements". Lastly, similar across all equipment subgroups, these specialists were often go-to people in online webpages and at aquarium conferences.

Observations at the 2017 MACNA provided data on water chemistry specialists. The following provides an example of a major trendsetter in modern reefkeeping, specifically regarding a new "method" of water testing. His seminar talk encompassed several facets including "the exploration of chemistry and biochemistry of reef and

aquarium ecosystems, their links and differences, high precision testing of seawater… trace elements and their relevance." Trained in chemistry and production technology, he and his wife ran a water quality-testing laboratory. While he was the only one who spoke at the event, their business/laboratory were major sponsors at the conference. With one of three of the largest vendor spaces, his company spent at least $25,000 to display their water quality testing method and testing materials. Further, two informants interviewed in this study mentioned his methodology. David stated he could "professionally test water by mailing it to a lab, have the results sent back, and know what to do to fix any problems". These characters are found in other specialists and they provided a valuable service to others within the reef hobby.

Filtration/Water Flow Characterizations and Participants

The last equipment-based niche emerged as filtration and water flow. Filtration was defined as the means in which aquarium water quality is *maintained*, which it also heavily depends on water flow. Unlike the previous chemical-based niche, Filtration specialists were adept at mechanical and biological filtration techniques in addition to understanding water chemistry. Essentially, water quality and filtration experts are two sides of the same coin.

In addition to understanding the three aspects of adequate filtration listed above, specialists in this niche were characterized by a "do it yourself mentality", which had an engineering component. The DIY mentality was much broader in this group compared to the other equipment niches as it encompassed several scientific fields. In comparison,

water quality and lighting experts focused on one major scientific field each (chemistry and physics, respectively) with the outcome of their expertise resulting in understanding coral biology. Biology, however, is integral to filtration.

To elaborate, proper filtration of a reef system was contingent on understanding, predicting, and balancing its "bioload". The term "bioload" was used across all types of aquarium keeping, not just reef aquaria. Essentially it was a "calculation" of the input and export of nutrients in a closed system. For example, aquaria have a limit to how many organisms can be successfully maintained. Further, bioload changed over time, dependent upon life history changes in the organisms (e.g., reproduction, growth) and with the actions of the aquarist (e.g., water change frequency, equipment). Understanding and applying knowledge about bioload was a key aspect of this niche. Unfortunately, without a true test or calculation for bioload, this skill was latent. Further, due to the complexity of the "calculation", it was not possible to identify go-to participants based on knowledge alone. While bioload was important, it was not an easily recognizable character.

It seemed that those who *invented* equipment or unique filtration *methods* for the reef aquarium hobby were those who understood bioload and the three filtration aspects. For example, protein skimmers were a major piece of equipment as it performs the unique function of removing dissolved organic compounds through foam fractionation (i.e., specific water flow). No other piece of equipment has yet to perform this integral function, and any change to this filtration method were modifications (e.g., changing the impeller, shape of the unit). Modifying equipment was indicative of a filtration –oriented

aquarists, however, it was those who provided inventions and methods that were the true filtration specialists.

These individuals were further identified by informants within the study, specifically through the use of their equipment inventions/methods. For example, Dr. Jean Jaubert used a "plenum" under his aquarium substrate to aid in filtration, a method referred to as the Jaubert Method. Norbert Tunze and Erwin Sander popularized protein skimming – an essential piece of equipment for most[23] reef aquaria and one mentioned by every informant in this study[24]. Algae Turf Scrubbers (ATS) were natural filtration methods, where turf algae were grown to remove nutrients and capture particulate matter. Due to its size requirements there were few ATS in use by hobbyists. In addition, there are several other pieces of equipment (e.g., sumps, refugia) and methods (e.g., Berlin) that aquarists used to maintain the water quality of their reef ecosystem. Those who invented these are the core filtration specialists found in this niche.

Summary

Specifically, there were three overarching, but interrelated, subworlds. Ecosystems, organisms, and equipment are all subworlds, or niches, of specialization. Members of these three are visible online and showcase their expertise at national conference. Recognition encompassed attending the conference lectures and vendor hall, use of their inventions/methods, or through specific naming of the specialist. Many were

[23] It was possible to circumvent the use of a skimmer, but results are mixed.
[24] Wilber modified his skimmer to reduce the smell.

invited to repeat their expert advice and techniques at the annual MACNA, which lends credence to their expertise. Across all three subgroups, it is evident the equipment niche is an important niche, but one that is hard to break into.

Conclusion

To conclude, this investigation found saltwater aquarists find distinction because they have mastered aspects of science done as leisure. In addition, these findings add to the leisure literature by showing participants find their niche and provide important contributions to the hobby as a whole. These findings are significant because the majority of previous studies focus on understanding participants – not their relation to others. Thus, the social organization of the aquarium hobby is evident in these results.

CHAPTER V

CONCLUSIONS

Introduction

The impetus for this study was to examine the variation existing within an activity closely linked to wildlife and natural resources. The saltwater aquarium hobby in the United States is an ideal context for such an investigation. For one, the U.S. is the world's leading importer of aquatic wildlife with more than 4.9 million American households maintaining a saltwater aquarium in 2015-2016 (American Pet Products Association, 2017; Figure 2). This equates to 3.9% of the total households in the U.S. during that time period. Not only is this a large number of people interacting with aquatic wildlife, each aquarium requires a number of accoutrements in order to create a working ecosystem. Essentially, these statistics reflect a very large industry surrounding an understudied leisure activity.

Two complimentary frameworks were used to understand variation in saltwater aquarists. The framework of serious leisure was utilized for two reasons: first, to characterize the most serious participants in this consumptive wildlife leisure activity and, second, to explore the developmental process of the serious participant. The second framework is recreation specialization. This was used as a heuristic device to help categorize the variation found across serious leisure participants. Another result was the discovery of specialized niches (i.e., styles of participation) across the saltwater hobby. It was also complementary to the serious leisure framework because these specializations are also career trajectories for skilled and knowledgeable (i.e., serious)

participants. These frameworks also allowed for the exploration of science as a leisure activity. For example, some serious participants are “amateurs” in the sense they have professional counterparts.

Major Findings

Contributions of this research include six major findings. Detailed below, these are (1) the ability of the serious leisure and specialization constructs to explore a relatively serious activity, (2) the potentially related bifurcation of the activity into two distinct activity styles, (3) the focus of information gathering and a hobbyist’s mode of procuring it as a key characteristic of participation, (4) the continued motivation to create an aesthetically pleasing aquarium, (5) the intense connectivity between this leisure activity and science, and (6) the emergence of a conservation ethic in serious participants.

The first contribution of this research is the ability to use the serious leisure and specialization constructs to explore a slice of leisure that can best be described as “hard-core” (Scott & McMahan, 2017). By its very nature, salt-water aquarium keeping is a highly specialized hobby and requires extraordinary commitment. Moreover, virtually all participants had previously kept freshwater tanks. This is supported by each of the informants in the study mentioning the care of a freshwater organism (e.g., betta) before participating in the saltwater side of the aquarium hobby.

I did not ask if informants *intended* to move on to saltwater from the onset of their participation in the freshwater hobby. However, it seemed as if the move from

freshwater to saltwater was organic, where participants developed an interest in further challenging themselves or to find another mode of participation in the aquarium hobby. Thus, choosing to study the saltwater style, I was essentially choosing the most complex, and serious, aquarium activity available to someone interested in keeping aquatic organisms.

Virtually all the saltwater aquarists in this study aimed to create a scientifically functional and long-term miniature reef aquarium as the product of participation. It is this aspect of participation that echoes what Scott and McMahan (2017) referred to as "hard-core" leisure. In their conceptualization, they defined hard-core leisure as "a form of serious leisure that involves extraordinary commitment that is directed toward an "authentic" style of social world activity" (p. 570). Few saltwater aquarists are "less than serious" and a casual style of participation is virtually non-existent. My study supports and extends their conceptualization of hard-core leisure into a new field of inquiry that of which connects leisure, science, and the potential for the interaction to produce passionate, professional aquatic scientists. This study suggests that saltwater aquarium keeping, specifically the creation and maintenance of miniature reefs, is by its very nature a hard-core, scientific leisure pursuit.

The second contribution of this study stemmed from the first. Specifically, the participatory variation I found within the saltwater aquarium hobby was grossly divided between two categories – a small number compared to other activities using the same framework(s). I attribute this to the fact that saltwater aquarium keeping is a relatively

serious activity and one that does not show a strong continuum of involvement. During the analyses, several variations of activity participation were present, but they were not capable of being placed along a continuum of involvement. These varieties were referred to as niches, which described subsets of specialization, or trajectories. These trajectories were "equal" in involvement so they could not be placed along a continuum. It made sense to delineate two categories of saltwater aquarists – sources and sinks.

Previous use of the serious leisure and specialization frameworks delineated three or more groups that could be placed along a continuum of specialization. For example, there were casual, novice, intermediate, and advanced variations of birdwatching involvement (McFarlane & Boxall, 1996). Similarly, Kuentzel and colleagues analyses of boaters (2006) elicited low, low stable, mixed, high stable, and high involvement groups, again capable of being placed along an specialization continuum. Even more specialized subsets were capable of being delineated along a continuum of involvement, specifically a study on Carolina shag dancers resulted in five involvement categories (Brown, 2007). Results of my study indicate saltwater aquarium keeping is not conducive to casual participation as a casual orientation leads to the death of the organisms and the end of participation. This extends the previous research on serious leisure by describing variation in a hard-core pursuit, which resulted in a limited number of involvement types. Thus, future studies may find that a small number of participatory categories indicate the activity may be hard-core.

The hard-core aspect, as described above, is connected to science skill and knowledge. Saltwater aquarists must procure scientific information because the lives of

the organisms depend on them. In turn, maintaining live organisms over the duration of their lives progressively causes the aquarist to broaden their knowledge and skill in *multiple* scientific fields. The care afforded to aquatic organisms over time creates a bond between the caregiver and the organism, which can give way to significant connectivity to ocean and reef conservation issues. These are reviewed in turn below.

The third contribution of this research was a delineation of participatory styles among saltwater aquarists (i.e., sources and sinks), based on the procurement of knowledge. The accumulation of knowledge mirrors what has been found in previous research studies in the leisure sciences. For example, McFarlane and Boxall (1996) found knowledge variation between experienced and least specialized birdwatchers. Experienced and least specialized are participatory styles in birdwatching, according to the authors. Similarly, variation was found across source and sink styles in saltwater aquarium keeping. Bryan, in his original conception of the specialization framework, found trout fisherman were an advanced form of angler and these "technique setting specialists" were also more knowledgeable in the activity than other participatory styles (1977, 1979). Other activities reflect a similar trend of variation in knowledge including, boaters (Donnelly et al., 1986; Kuentzel & Heberlein, 2008), spearfishing (Diogo, Pereira, & Schmiing, 2017), and assorted wilderness activities (McFarlane et al., 1998; McMahan, 2015; McNeill, Clifton, & Harvey, 2018; Waight & Bath, 2014)

The point of the saltwater hobby is to maintain live fish and, ideally, corals in a captive environment. To succeed in such an endeavor, the aquarist made not only make

financial investments, but research investments as well. Marine fish, and coral more so, have extremely high care requirements. Meeting these requirements demands precision, attention to detail, and a willingness to overcome mistakes (i.e., challenges). These requirements may be unique to this hobby. To my knowledge, no other studies have shown such high information-based requirements for even entry-level participation in a leisure hobby. Further, information gathering is recurrent. Even after initial participation has begun, the aquarists must continue gathering information to progress towards the ultimate goal of maintaining a miniature reef.

Knowledge procurement was a major source of division among saltwater aquarists. As stated, involvement was delineated between two groups, *Sources* and *Sinks*. Sinks were those who drained information instead of finding it or providing it to others; there was no intermediate group. *Sources* were individuals who procured information and provided it to others. Characterized by a high level of motivation and knowledge, these were skilled and described as go-to aquarists. Many sources acquired answers to their questions by reading, researching, and only posing questions to others when necessary. The *sinks*, however, were more passive and described by some sources as "lazy". They preferred to gather information from other people (the sources), be told what to do, or have their "hand held" which drained a great deal of time and energy from sources. These differences also provided points of conflict within the hobby. Sources recognized that although saltwater aquarium keeping is regarded is a leisure activity, it nevertheless requires systematic research, diligence, and hard work—all characteristics of professional science.

It is worth noting that sinks tend be new saltwater aquarists, but not always. Online forums reflected information procurement as a major point of conflict between these two groups, where new hobbyists would be grouped in with sinks. Sources were often frustrated with the repetitive questions posted online, resulting in the sometimes cruel treatment of new marine aquarium keepers. New aquarists may be assumed to be a sink (e.g., lazy) when they are simply inexperienced. Strongly worded, negative reprimands were common, referred to as being "flamed".

Many sources in this study were highly patient individuals (e.g., Scott and Richard) and willing to answer the same question and in a kind manner. Further, sources showed a commitment to educating other aquarists in order to decrease the negative effects of the hobby. To reduce these effects, they attempted to educate participants on proper care of reef organisms in order to reduce preventable wildlife death. This, in turn, helped support less experienced hobbyists, an act that seemed to limit the number dropping out of the activity.

This finding contributed to the study of serious leisure because one dimension of participation was much more important to the development of the individual (e.g., knowledge and skill), than were other dimensions (e.g., an attractive identity). Future studies may be done to understand the impact each of the dimensions of serious leisure have in a specific activity, how they vary among activities, and if quicker progress can be made in one dimensions over another. If knowledge and skill were 'sped up' across individuals in the aquarium hobby, I argue the hobby would pose a lower ecological impact on aquatic wildlife and the locations in which they are caught.

Another contribution of this study is that while information gathering is a major facet of participation, a crucial motivating factor among all saltwater aquarists was a desire to create a beautiful reef ecosystem. However, what constitutes an aesthetically pleasing tank evolved over time. Indeed, this study revealed that saltwater aquarists progressed through stages of involvement, from fish-only tanks, to those with live rocks, and finally a miniature reef.

While information gathering is a key component of the hobby, some participants were not as rigorous. Sinks did not procure their own information, read books, or conducted their own research before making purchases. Instead, they focused on quickly obtaining results, which is a beautiful ecosystem. The desire to keeping a beautiful "moving picture" was true of all newcomers to saltwater aquarium keeping. Providing a safe, functional ecosystem for wildlife is a skill and trait that develops with time. Yet, aesthetics is a major draw of the hobby and fuels even the most ardent saltwater aquarist. Experienced participants were keen on selecting specific organisms and corals in their "aquascape", and maintaining them for visually stunning displays. However, unlike newcomers, experienced aquarists were more focused on creating a beautiful, ecologically and scientifically sound aquarium ecosystem.

Not only had the creation of a reef *ecosystem* motivated the aesthetic drive, serious saltwater aquarists were extremely sensitive to differences in color and pattern of *organisms*. These aesthetic attributes are the most vivid in saltwater species, which are largely considered the most colorful of all aquatic life. Aesthetically pleasing aquaria are associated with color diversity, which is maximized by displaying as many different

species as possible (i.e., biodiversity). Interestingly, reef keepers take this to an extreme by collecting various *color morphs* of coral via fragments.

This aesthetically driven collection practice may result into a career trajectory that specializes in collecting, and subsequently propagating, varieties of coral fragments (i.e., involvement in the coral niche). These finding extend the leisure literature to connect aesthetics as a motivating factor in progression, potentially pinpointing attractiveness as a driving factor in some leisure activities. Birdwatching may come close to this mentality among serious "listers", but a key difference is that birders do not remove or propagate organisms. Aquarists who collect frags literally propagate their collection and share it, thus increasing the collections of others. In fact, it seems that status can be earned in this way.

A contribution of this finding towards the literature on serious leisure is that the activity itself is attractive, perhaps more attractive than being a participant in the activity. Stebbins states serious leisure offers an "attractive identity" to participants, but at the same time, he has referred to participation in serious leisure as one done by those on the "margin". This means participation in a serious activity, or at a serious level, categorizes the participant as one that is marginal to other participation (e.g., casual or professional). I argue attraction to aquarium keeping is in the result of the act rather than the act itself. At least for some portion of participants across some portion of their time in the activity. For example, in my discussions with aquarists, several mentioned that their friends and significant others did not like their activity as an aquarist as it was time consuming and expensive, but they did appreciate the aesthetic value of the aquarium. Arguably, some

aquarists must find the identity as an aquarist to be an attractive one, but my results indicate this is closely tied to the product of involvement.

The fifth contribution of this investigation is the connectivity between leisure and science. Stebbins originally posited this connection in the Serious Leisure Perspective (Figure 3) using amateur archeology (Stebbins, 1992). While both archeology and aquarium keeping are scientifically oriented leisure activities, aquarium keeping has a more profound connection. A number of activities within the aquarium hobby rely on informal science participation across two facets: the gathering of scientific information and, in turn, applying that knowledge in scientific behaviors (i.e., skills).

Previously, I reviewed the intrinsic connection between aquarium care and information gathering. That information is largely scientific in nature. For example, coral color is a major focus for reef aquarists, but caring for colorful corals relies on understanding various characteristics of the species in question, including its physiology and biology as well as proper lighting, water flow, and nutrition. Each of these characteristics requires information from a separate scientific field (e.g., ecology, biology, chemistry). The aquarist must have baseline knowledge in each just to maintain aquatic life. To promote the best coloration and growth, optimization of these characteristics provides the best results. The desire to maintain healthy colorful coral focuses the aquarist on gathering and applying scientific concepts. These concepts are progressively learned overtime.

Further, the saltwater aquarium hobby is complex, and mistakes are a common occurrence. Many of the informants admitted to “tank crashes” where every living organism in the aquarium died at once. These trials and tribulations in the hobby allow an aquarist to use the scientific method to form, and reform, scientifically grounded plans of action. For example, an aquarist may observe their fish not eating. Instead of researching the problem, they may jump to conclusion and apply a fix. Without research, these actions may be a waste of time, money, and potentially the life of the organisms. The major turning point for aquarists was the realization that they must put effort into research before making purchases and changes to their system, especially if they want to reduce the amount of time and money they spend caring for their aquarium. This effort trains aquarists to think like a scientist. Essentially, the use of the scientific method becomes a natural problem solving routine for saltwater aquarists.

In Table 9, the scientific method, the process of inquiry used by scientists to discover and solve problems, is listed in steps from observation to conclusion. In the next column, I list number these steps as a scientist would make them in order to compare them to the last column – the order in which non-experienced aquarists make them. The research step, the second step, is out of line with scientific processing and action. For aquarists, this misalignment has downstream effects listed above – tank crashes, loss of organisms, and so on.

Table 9: The scientific method, or process, is a series of ordered steps. Scientists follow one order, while many aquarists follow another.

	Order of the Scientific Process	
Scientific Process	Scientists	Aquarists
Observation	1	1
Research	**2**	**7**
Hypothesis	3	2
Experiment	4	3
Collect Data	5	4
Analysis	6	5
Conclusion	7	6

With more experienced aquarists, however, I found the research step mirrors the process of a scientist rather than that of an aquarist. In support of this finding is a retroactive look at one aquarist who earned accolades for their aquarium on an internet forum.

Aquarium hobby forums have informal, monthly competitions called “Tank of the Month”. Aquarists who earn this accolade are advanced in the hobby and other participants look to them for inspiration. I explored the previous experiences of Tank of the Month winners and found many to have persevered through challenges, many of which relied on the accumulation and application of scientific knowledge. For example, the aquarist “teenyreef” earned a Tank of the Month in June of 2018 on www.nano-reef.com. When I explored his previous posts in the forum, I found that in 2014 he failed at understanding the impact a brass-plumbing fitting would have on live saltwater organisms. To be clear, brass leaches metallic ions into the system and these are deadly to invertebrate animals. Because of his lack of research before purchasing and installing

the fitting, he summarily killed several of the invertebrates and almost crashed the entire system. Here is his account in his own words:

> After a few more weeks things started to stabilize, so I ordered some new corals, including a few SPS[25]. Everything went well at first but then the zoas[26] started closing up and some of my SPS were turning brown, so I decided to improve my filtration. I'd read a lot about using AC-70[27] filters as a refugium[28], so I got one along with an InTank[29] media basket. I also decided I needed to improve the flow in the tank for the SPS. So I drilled a larger return in the bulkhead and put in a HydroFlo[30] rotating water deflector. This helped a lot!
>
> There was just one problem...the 5/8" tubing kept getting kinked, so I got a 90 degree fitting at the hardware store, which solved that problem. I sat back to watch everything settle in over the next couple days. The very next day, most of the zoas were closed and the SPS were no longer extended. I did a partial water change and reduced the flow in case that was the problem. After two days, the acros[31] were receding and mushrooms[32] were closed up. Finally, I realized that the 90 degree fitting I had installed was made of brass and was leaching copper into the tank. Total noob[33] mistake! I have no idea what I was thinking that day at the hardware store...

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[25] SPS is an acronym for small-polyp stony coral
[26] The term zoas is shorthand for Zoanthid, a genus of coral also called Button Polyps
[27] Brand name
[28] A refugium is a separate, but connected, space where organisms are kept away from those in the main display system. This is done for several reasons; in this case, the aquarist was growing bacteria, micro-invertebrates, and algae to help filter and maintain the water chemistry.
[29] Brand name
[30] Brand name
[31] Shorthand for Acropora, a genus of SPS coral
[32] A type of coral
[33] Community term for new person in the hobby

> I pulled everything out of the tank, threw out the old sand, did a 100% water change, and put in some new sand. I ended up losing two of my three Sexy Shrimp, all of the SPS, and most of the Acans[34]. Although the starfish looked dead when I pulled him out, he moved a little bit after I put him in new water, and eventually made a full recovery. I didn't take many pictures during this time, it was too depressing. This one is right after things stabilized and I got in a few new frags[35] to repopulate - definitely the worst this tank had looked since going through the initial cycle[36].

In this narrative account, the aquarist makes clear observations (e.g., "the zoas started closing up and some of my SPS were turning brown") and develops hypotheses (e.g., "I decided to improve my filtration"). In some instances, he commits himself to research before making a change (e.g., "I'd read a lot about…") and follows the scientific process in the correct order. Doing so ended in a positive experience, where he states, "This helped a lot!"

Other times, the research was not thorough and a simple mistake cost him the lives of some of the organisms. For example, he observed the plumbing was not working correctly (i.e., and observation) and jumped beyond the research step in the process and applied a fix (i.e., "I got a 90 degree fitting at the hardware store"). Unfortunately, without thorough research, the experiment failed and "After two days, the acros were

[34] A type of coral
[35] Community term for a live coral fragment
[36] Biological cycle which occurs in aquaria less than a month old

receding and mushrooms were closed up". For clarity, this account is outlined in Table 10 along with the steps in the scientific process.

This narrative is compelling for several reasons. First, it exemplifies how the scientific process works to solve problems in the aquarium hobby. The aquarist need only use it in the correct order. Unfortunately, aquarists omit the acquisition of skill and knowledge (i.e. the research step) in lieu of quick results. Many long-term aquarists advise newcomers to "take it slow" and state, "an ounce of prevention is worth a pound of cure". This advice supports the notion that more experienced aquarists learn to think things through before altering the aquarium.

Another compelling outcome of this narrative is a Tank of the Month recipient spent a good deal of time (i.e., from 2014 to 2018) working through mistakes and applying fixes. Perseverance played a role in progressing to an acclaimed status in the aquarium community. Arguably, making mistakes and finding solutions is the definition of experience in the aquarium hobby, and as shown in Tables 9 and 10, this process is very much scientific in nature.

Table 10: Specific example of the scientific process illustrated in Table 9.

Sequence for Science	Step in the Scientific Method	Example Using TOTM Quote	Sequence for Aquarists
1	Observation	Needed stable plumbing fixtures for the reef	**1**
2	Research	Brass fittings contain copper and copper kills coral	**7**
3	Hypothesis	Brass is more stable and will be better than PVC	**2**
4	Experiment	Purchased and used the brass fitting	**3**
5	Collect Data	Fitting worked but reef is suffering	**4**
6	Analysis	Three days later live coral have health issues	**5**
7	Conclusion	Brass contains copper, which harms corals	**6**

Scientific experience in the aquarium hobby ends up peaking the interest of participants in various scientific fields. For example, solving plumbing problems may be interesting to one aquarist, while solving biological problems may be to another. Since the associated skill and knowledge acquisition in the hobby are Scientific in nature, scientific niches become defined. Consistent with scientific disciplines, there are various branches or what I described in Chapter 4 as specialized niches (Figure 33). For example, the ecosystem niches are essentially ecology-based. The organism niches encompass the life sciences, including other more specific scientific fields (e.g., ichthyology). Lastly, the equipment niche is physical science, including chemistry (i.e., water quality), physics (i.e., lighting), and engineering (i.e., filtration).

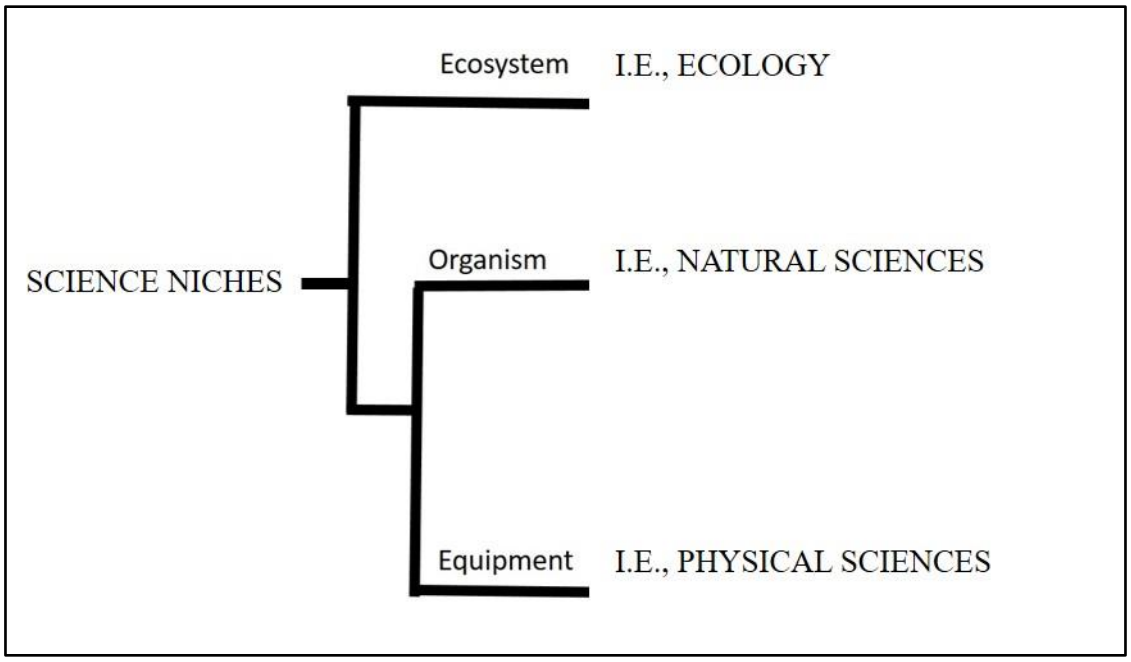

Figure 33: Saltwater aquarium niches are also science niches, or career trajectories.

As a scientific hobby, utilizing understudied wildlife for display purposes, aquarists are capable of discovering new scientific facts. For example, most marine fish species have either an unknown life history or one that is challenging to replicate in captivity. Enterprising aquarists, specifically those in the fish- and coral-specific niches, challenged themselves to use their own funds to explore marine fish reproduction. Fish specialists document their success, and failures, on the website for the Marine Breeding Initiative (www.mbisite.org). Similarly, other serious aquarists have focused their skills on coral propagation. These aquarists do not focus on breeding corals, which implies sexual reproduction. Instead, they propagate coral fragments, a mode of asexual

reproduction. However, there are many species of coral that cannot easily asexually reproduce, so sexual reproduction is a future scientific discovery specialized aquarists are capable of making.

The major finding regarding the connectivity of science and leisure are concluded here. Specifically, this investigation shows the process of keeping a successful aquarium exposes the aquarium keeper to a vast array of scientific information, principles, processes, and methods. As noted, keeping of an aquarium is primarily motivated by aesthetics, but the side effect of aquarium keeping is an accumulation of science-oriented skill and knowledge. A major contribution of this study is the interconnected nature of aesthetics, science, and leisure.

The science as leisure construct is based upon the need for the activity participant to accumulate scientific skill and knowledge. Accumulation, as used here, is the slow progression of adding scientific knowledge through experience, a process tempered by a need to keep the organisms alive. In addition, accumulation is mediated by an interest in aesthetics, with stages marked by increased scientific thinking and awareness (i.e., FO to FOWLR to reef). Henceforth, science as leisure participants increasingly think like a scientist.

It is noteworthy that science done as leisure is understated. The individual does not necessarily recognize s/he is accumulating skills or knowledge. Further, the participant seems to enjoy the activity, even if it involves learning. My study indicated keeping a beautiful reef masks recognition of learning science. While science communication requires an activity to elicit a personal response (Burns, O ’Connor, & Stocklmayer,

2003), this study shows it can be done subtly though awareness, enjoyment, interest, opinion forming experiences, and understanding.

A major contribution of this finding towards the serious leisure literature is than an activity such as aquarium keeping, when perseverance, skill, and knowledge coalesce, the individual not only mirrors a professional aquarist, but also a professional scientist. This is an important outcome because there are numerous studies asking how to improve scientific inquiry in groups such as women (Blickenstaff, 2005; McKinley et al., 2017; Silvertown, 2009). Considering the aquarium hobby is populated by men and integrates a scientific element, improving the participation of women may also improve the number of women who feel comfortable entering science as a career.

The last contribution of this investigation was finding the formation of a conservation ethic in serious aquarists. Landlocked individuals do not have an easily accessible marine resource, but participants in the saltwater aquarium hobby focused their interests and even promoted an identity reliant on marine ecosystems. Some aquarists stated their motivation for keeping a saltwater tank was to have a "slice of the ocean". Interestingly, some informants found the aquarium hobby to be so influential, they began planning trips to tropical reefs to experience an authentic reef system. At the time of her interview, Jai was planning a dive trip to the Cayman Islands. This shows the consumption of the aquarium trade can help promote an attachment to ex-situ locations, which I refer to as ex-situ place attachment. Place attachment is an attachment to a location (Bricker & Kerstetter, 2000) while ex-situ place attachment is the formation of

such an attachment *without* having visited that place in person. They only experience it ex-situ, or in this case, through an aquarium (e.g., tropical reef).

The main conservation concern in the saltwater aquarium hobby stems from the moral and ethical issues of selling live organisms, especially those from the wild. Additionally, the omission of research before purchasing organisms is a major detractor for the aquarium trade. Although retail environments may prosper from repeat purchases stemming from the death of organisms, the freedom to purchase almost anything from a wild reef is an exciting aspect but a major cause for conservation concern. Unfortunately, results of this study indicate a disregard for some of the detrimental effects hobbyists have on wild natural resources. This mindset is reflected in Chapter 4 where *sources* are medium to high on conservation knowledge, but low to medium on the application of that knowledge. Sinks, in contrast, have worse conservation-oriented behaviors.

However, if the marine trade were halted, there will be an extremely limited biodiversity available to home hobbyists. Results of this study have shown this biodiversity worked as a strong driver for long-term participants who stated they were motivated to continue participation due to “the diversity of marine life”. Without such biodiversity, “it would make the hobby boring”, potentially reducing participation levels. I believe aquarists would eventually get used to the limited number of species available to them if wild caught specimens became unavailable; it is the change and the fear of change in which hobbyists seem focused. (Figure 34).

Figure 34: The pet industry has started the Aquatic Defense Fund, whose rhetoric has raised thousands of dollars in donations (Per. Comm.).

There is some hope. Results showed there is a shift from overconsumption of specimens during the initial phases of aquarium keeping, towards acquiring very specific species or specimens. These specimens may be sought after because they are captively raised and or colorful. The serious aquarist changes from purchasing corals as replacements for failures towards the purchase of coral for purposes of collecting or propagating. Studies on birdwatching showed the formation of a conservation ethic

where participants care deeply for the natural resources their hobby utilizes (Andrews, 1990; Hvenegaard, 2002c; McFarlane & Boxall, 1996).

Conservation of natural resources is a specific outcome, meaning not all leisure activities will have a conservation orientation. However, activities that involve animals are ripe for studying the conservation attitudes and behaviors of participants. Birdwatching and fishing, for example, have this outcome (Bryan, 1977; McFarlane & Boxall, 1996). Activities that involve the outdoors may also have a conservation dimension involved, hobbies such as camping (McFarlane, 2004), boating (Cottrell, Graefe, & Confer, 2004; Kuentzel & Heberlein, 2008), snorkeling (Branchini et al., 2015). Lastly, this finding indicates development of a conservation orientation changes over time. The speed in which this change occurs may be studied, and altered, in order to move a participant from activing without a conservation orientation to one that participates in a more ecologically sound manner. Speeding up aquarists towards a conservation ethic holds a powerful potential for change.

Limitations

This study aimed to understand serious participants in a leisure or recreation activity; however, the saltwater aquarium hobby was comprised of already rather serious aquarium keepers. As mentioned above, there are three major styles of participation in the aquarium hobby freshwater, saltwater, and brackish), and many saltwater participants come from a background of freshwater aquarium keeping. In fact, all of them informants in this study had kept a freshwater fish before embarking on the saltwater hobby.

Freshwater fish, however, can be extremely straightforward and offer little challenge to the keeper (e.g., betta fish). Further, the saltwater hobby is a "whole other beast", meaning even well versed freshwater aquarists may find saltwater challenging.

Another potential limitation of this study is the use of focus groups. I conducted some group interviews to obtain a larger number of informants at the MACNA. This was done because the informants were there specifically for the activities in which MACNA hosted, and some of the activities required participants to be physically present (e.g., raffles). Specific limitations to using focus groups was the potential for dishonesty or for agreement with other hobbyists when they did not actually agree. However, I found the focus groups allowed some informants to open up and discuss the topics, which ended up being much more informative than the one-on-one interviews I conducted.

Another potential limit was the retrospective-nature of the accounts each informant gave. When studying the development of a hobbyist, this is difficult to circumvent unless each informant is studies as they participate, in a longitudinally designed investigation. Likewise, a longitudinal study is mentioned as a suggestion for future research. Regardless of these potential limitations, I was able to reach a point of theoretical saturation and feel the limits of using retrospective account, potentially dishonest informants, was reduced significantly with member checks and clarifying questions during the interview.

A final limitation was the potential for my own biases to intercede. I committed to neutrality and posed questions from a neutral position. The exploratory nature of my study altered my initial expectations so the results presented here were not only firmly

grounded in the data, they emerged and were discovered as well. Further, to limit my biases, I specifically chose an aquarium hobby I had less experience in, thus forcing me to explore and discover rather than report. Regardless, it is important to acknowledge my involvement may have unintentionally altered my interpretation of the data and thus the conclusions of this study.

Managerial Recommendations

This study offers some managerial recommendations, four of which I will review here. First, I recommend better management of the over consumptive nature of new hobbyists. To reach this goal, I suggest a closer tie between the social world providing accurate information and support and the retail environments providing the organisms and accoutrements. Second, to maintain the level of biodiversity available to home hobbyists, I recommend pushing aquacultured specimens over wild-caught, especially to new aquarists. Third, I recommend the aquarium industry promote the scientific value of aquarium keeping. Lastly, I recommend priority funding be made for in-situ conservation efforts, specifically providing improvements in the livelihoods of fisher folk (i.e., gear, payments), and promoting another iteration of certification for wildlife collected for the trade. These are further detailed below.

This study resulted in a strong requirement for hobbyists to obtain information before and during their participation as a saltwater aquarist. This was evident in the formation of specialized trajectories and the requirement that go-to people in the hobby be centers of information. Further, key informants regarded social world participation as

a key component to their success. It would benefit the management of the hobby to increase the centrality of the social world, especially across environments frequented by new hobbyists. New hobbyists and sinks are cause for concern since their poor choices reflect upon the entire hobby. Connecting new aquarists to those who understand the implications of purchasing behaviors will be a key to reducing the loss of wildlife thorough improper captive care. Environments in which new aquarists are common include online forums, search engines, as well as retail environments (e.g., pet and local fish stores). Connecting the retail and social environments will benefit the hobby.

Second, many of the informants stated they appreciated the diversity of aquatic life, implying they enjoyed having that diversity available for purchase. However, most that diversity is wild caught and many die prematurely in the hobby. To reduce the interest in wild caught species, making aquaculture achievements a celebratory event may go a long way to funneling people towards sustainable specimens. For one, this study uncovered the keen interest in following trends (namely coral), but the same excitement could be created for fish. I recommend promoting successful aquaculture via celebrations across the social world. For example, the 2016 MACNA highlighted the successful aquaculture of "Dory" by allowing those who succeeded give seminars. During participant observation, that seminar received an uncommon standing ovation. I suggest taking this excitement further and making aquaculture achievements a theme in each annual conference. Other outreach, especially to less hard-core hobbyists, should also be improved (e.g., local clubs).

Third, results of this study show the intense connection between aquarium keeping as a leisure activity and learning about, and using, science. In fact, some schoolchildren are learning science through aquarium keeping (Champaign Urbana Schools Foundation, 2015; Lafond, 2014). The informal nature of learning science through the hobby is a key component of my proposed construct, "science as leisure". Communicating science concepts and processes through leisure takes science *to* people. Science museums, for example, rely on people to go to science. I suggest a more proactive approach, taking advantage of an activity 3.9% of the U.S. population is already participating in the saltwater hobby, a much higher number including freshwater aquarists.

Further, this research has shown multitudes of career trajectories are available to saltwater aquarists. Previous studies have shown hobbies act as early careers, with a potential to lead to professionalism (Stebbins, 1979, 1980, 1992). In addition, providing science learning through leisure will funnel interest into poorly funded science fields (e.g., life history studies; Dalton, 2003; Kemp, 2015). Lastly, improving science literacy, even if through leisure, may improve critical thinking skills and reconnect people with nature (Louv, 2005).

Lastly, I recommend funding be provided to in-situ conservation efforts. Many export locations for saltwater organisms suffer from poor collection methods (e.g., cyanide) and underpaid fisher folk. To circumvent a tragedy of the commons situation (Ostrom, 1990), it would be forward-thinking to allocate funds to the improvement of in-situ collection practices and improvements in social issues for fisher folk. The pet

industry is currently collecting donations for the "Aquatic Defense Fund" (Pet Industry Joint Advisory Council, 2016), but this tactic is retaliatory. It would be best to provide management to remove the need for such initiatives through the improvement of responsible, and sustainable, collection and retail practices.

Suggestions for Future Research

This investigation led to the need for future research. The first two recommendations include conducting a longitudinal analysis specifically aimed at understanding new saltwater hobbyists and the construction of a survey instrument to test the dimensions of serious leisure and specialization. Third, I would like to continue improving the science-as-leisure conceptualization as it has merit due to the science and conservation outcomes listed above. Fourth, I suggest future research be done to more closely examine the conservation orientations of the aquarium *industry*, which will build upon the findings presented here, which are specific to aquarium hobbyists. Lastly, I would like to pursue an investigation of professional scientists, specifically regarding their career development and if there are leisure hobbies that promoted that pathway.

This investigation relied on retrospective analyses of informants. Future studies would provide a more robust understanding of the results if done in a longitudinal manner. This will capture minute details allowing for a more accurate portrayal of the lived experience.

In addition, constructing a survey instrument based on theory, testable through statistical methods, will lend a great deal of insight into the results presented here. Using

mixed methods will provide robustness and further accuracy to the results and subsequent managerial recommendations, which are very important due to the retail industry of the aquarium hobby and trade.

Further, I suggest an additional study to focus on the retail industry of the aquarium hobby. The present investigation found that new aquarists and sinks are prone to dropping out of the hobby and making lethal mistakes, sometimes repetitively killing wildlife in their care. Before laws and regulations limit the hobby, and the related commercial industries, the trade should provide proactive solutions. I believe these solutions can be promoted through better understanding the retail industry. I hope that implications from this series of studies will be preventative rather than reactive. This type of study could aid in preventing industry collapse due to lack of introspection, self-regulation, and environmental policy-related issues.

Lastly, I would like to continue my research into science done as leisure by studying professional scientists. Specifically, I would like to understand their development and turning points towards becoming professional. A special focus will be to see if there are leisure activities that promote a science orientation among young people, when their career choices are not yet set. One of the interesting results of this study was the inclusion of scientists as hobbyists, which made me wonder if the non-scientists in the hobby would have chosen their path if they had to do it over again.

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APPENDIX A

PROTOCOL AND GUIDING QUESTIONS FOR INTERVIEWS

WELCOME

Thanks for agreeing to be part of this focus group today. I appreciate your willingness to participate.

INTRODUCTION

My name is Liz Marchio and I am a Ph.D. graduate student at Texas A&M University. Thank you for agreeing to participate in this focus group. The information gathered here will be recorded via video for transcription purposes (i.e. who said what and when) but kept confidential and used only for my Ph.D. research. The governing body of both hosting clubs have approved this research, and the Internal Review Board that verifies all scientific research at the university level has also approved this study.

The focus groups and interviews I conduct over the conference here in New Orleans is the main portion of my research. For those unfamiliar with my research topic, it stems from my personal history as an aquarist. I found, through my own experience, that I learned so much about fish and ecosystems that I became very aware of aquatic science and conservation. In fact, that connection to aquatic life inspired me to pursue graduate school studying fish. I know the aquarium keeping hobby is very powerful and I'd like to document all such facets of that strength and the consequential weaknesses.

PURPOSE OF STUDY

Specifically, I aim to document if any participants in the saltwater aquarium hobby (1) move from novice to advanced-level aquarists, (2) if so, under what conditions does that progress happen and not happen, (3) how do you, the hobbyists, describe these stages, (4) do these stages correlate to styles of participation (e.g. biotopes), (5) what characterizes the stages and styles of participation, and (6) are there science and conservation-oriented traits that you feel have been learned along the way; are there science and conservation labels or characters we can plot along a continuum of aquarium keeping involvement?

FOCUS GROUPS

The purpose behind conducting a focus group is to gather a large amount of valid data from diverse people with experience in the topic of interest. Sometimes a focus group is about toothpaste. In this case, it's about the aquarium hobby, specifically the saltwater aquarium hobby. You were chosen to be in the focus group because you offer a unique, personal perspective. I am here to learn from you and I aim to facilitate discussion. Because we are limited on time, I will be terse regarding long-winded answers or rambling towards off-subject topics. This group will have a lot of novel ideas, ones absolutely useful; however, for scientific research focus must be made on these above general topics.

GROUND RULES

1. I want you to do the talking.
2. I would like everyone to participate.
3. I may call on you if I haven't heard from you in a while or I would like your perspective.
4. There are no right or wrong answers!
5. Every person's experiences and opinions are important.
6. Speak up whether you agree or disagree.
7. I want to hear a wide range of opinions.
8. What is said in this space stays in this space.
9. I want folks to feel comfortable sharing when sensitive issues come up.
10. I don't identify anyone by name in my final report. You will be coded and remain confidential.
11. I must remain as neutral as possible.
12. I may cut you off if time is short – be aware and it's nothing personal.
13. You may leave the study at any time for any reason.

STUDY DOCUMENTS

1. PARTICIPANT INFORMATION AND RECRUITMENT SHEET: the first document [colored paper] is an information sheet with all previously mentioned information (via the recruitment procedure at the poster or during the conference). It includes the study information as well as my university contact

information. This sheet is being made available for you, and as a recruitment technique for other aquarists. Please pass this on, as a flyer, to any participants you think would add to the discussions we have here today.

2. DEMOGRAPHIC INFO SHEET: Second, I would like to record who is here, demographically. This information will be used to assess any trends I may find across focus groups (e.g. maybe female dominated groups get different results from those with more male aquarists). It will contain no identifiable information unless you volunteer that information.

   If you would like to be made aware of future presentations on this data, or agree to be contacted for a potential follow-up interview, please give me your printed name and e-mail address. You will be added to a MailChimp e-mail listserv (with a link to opt out anytime) that will update participants who opt in. this is completely voluntary.

GUIDING QUESTIONS

Engagement Questions:

1. Can the saltwater aquarium hobby be described by different types, or styles, of aquarium keeping? What are these types and how do you characterize them?
2. Can we place these types or styles along a continuum of involvement? [use whiteboard to draw a continuum, explain it, and place each type along the continuum]

3. If someone took part in the hobby by keeping an advanced type of aquarium, can you assume they went through the other types of aquarium keeping?

Exploration Questions:

1. Define Science in different, accurate, ways. Ask the group if science, in any manner, can describe the aquarium hobby.
2. Can these science-orientations be characterizations of any style of involvement? Any stage?
3. Define Conservation in different, accurate, ways. Ask the group if conservation, in any manner, can describe the aquarium hobby.
4. Can these conservation-orientations be characterizations of any style of involvement? Any stage?
5. Do you have any stories of science or conservation at a certain time in your aquarium keeping hobby?

Exit questions:

1. If you were to place yourself on the continuum of involvement, where would you go?
2. Think of two saltwater aquarists, one that is to the left and one that is to the right of you on the continuum. Does their abilities and characterizations match to what we have described here today?
3. Would you be willing to ask any other aquarists, to the left and right of you on the continuum, for them to participate in this study?