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What makes a "successful" marine protected area? The unique context of Hawaii's fish replenishment areas

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ABSTRACT

In 1998, in order to combat the degradation of yellow tang populations on the west coast of Hawaii Island, fish replenishment areas (FRAs) were established prohibiting aquarium fishing along more than thirty percent of the coastline. Unlike other marine management approaches in Hawaii, which have largely been controversial, fraught with confusion over regulations, inadequately enforced, and lacking public support, these FRAs have been lauded as a marine conservation success, with wide-ranging support and evidence of rapid replenishment of the yellow tang population. In order to better understand the contextual factors contributing to the success of the West Hawaii FRAs, this research explores the following questions: (1) What factors documented in the literature on marine protected areas (MPAs) have been demonstrated to contribute to or inhibit MPA success internationally; (2) which of these factors do the FRAs of West Hawaii exhibit; and (3) are there additional factors that may have contributed to their wide acceptance and success? Common factors contributing to MPA success are determined through a synthesis of the literature. These include: level of community engagement, socioeconomic characteristics, ecological factors, MPA design, governance, and enforcement. The outcomes of West Hawaii's FRAs are examined in the context of these factors. While the common factors agreed upon in the literature were key to the success of the FRAs, additional contextual factors such as the unique nature of the aquarium fishery and its social marginalization also played a vital role.

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1. Introduction

Marine protected areas (MPAs) have been increasingly used to combat marine degradation across multiple scales and habitats with varying degrees of success [1–4]. MPAs can provide a variety of benefits, including scientific data about marine environments, educational opportunities, ecosystem services, protection of cultural and natural resources, management of fisheries, and increased economic opportunities through tourism [5]. While MPAs have been lauded for their potential to improve marine conservation efforts worldwide [6,7], they have also been criticized as a false panacea [8,9]; a one-size-fits-all approach to marine conservation that fails to address many critical marine management issues. There has also been growing political pressure to establish MPAs. In the United States, President Clinton issued the Marine Protected Areas Executive Order in 2000, which called for the strengthening and expansion of the nation's MPAs [5]. Internationally, the United Nations Convention on Biodiversity called for the protection of 10% of the world's oceans by 2012, although the timeframe for this goal was recently extended to 2020 due to political challenges and a failure to make timely progress [10]. Scientific recommendations for the spatial extent of MPAs cited in the literature are actually much greater than these political targets, ranging from approximately 20–50% of the world's oceans, with a minimum of 10% to provide some advantages in marine protection [10–12]. In spite of these goals, MPAs currently cover only about 2.3% of the world's oceans [13], and the implementation of "successful" MPAs has proved a unique global challenge.

Numerous case studies have examined the outcomes of MPAs in a variety of locations and contexts, citing a range of explanatory factors that contribute to these outcomes, both positive and negative. While these case studies have provided useful insight, frameworks for evaluation are needed to better understand which factors contribute to MPA success in order to facilitate effective MPA design in the future. This paper develops such a framework through a synthesis of existing literature regarding MPA outcomes worldwide. The framework is then applied to the fish replenishment areas (FRAs) of West Hawaii Island, a small MPA network often lauded as a successful example of proper MPA design and implementation [14,15]. This paper aims to answer the following questions: (1) According to the literature, what factors contribute to or inhibit MPA success, (2) Which of these factors do the FRAs of West Hawaii exhibit, and (3) Are there additional factors not common to the literature that may have contributed to the wide acceptance and success of these MPAs? We find that while the

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common factors found in the literature contribute to the success of West Hawaii's FRAs, additional contextual factors unique to this case are critical to its being considered a "successful" MPA. While the literature review and case study outcomes provide significant insight for MPA implementation worldwide, unique aspects of the West Hawaii case highlight the importance of local context when considering MPA design, implementation, and outcomes.

1.1. MPAs and success

In order to begin the discussion regarding MPA success, it is first important to define what is meant by an MPA, as well as how we define "success." The International Union for Conservation Nature (IUCN) defines an MPA as a "clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" [16], p. 9. Agardy [17] elaborates on the scale and scope of MPAs, which encompass "everything from small marine parks established to protect an endangered or threatened species, a unique habitat, or a site of historical or cultural interest to vast reserves intended to achieve a range of conservation, economic, and ;social objectives and encompassing different types of protection." Hilborn [18] also includes political goals amongst these objectives, as marine management is highly politicized. MPAs make use of a wide range of restrictions, from strict no-take areas to areas where resource use or extraction is only partially restricted.

This broad definition and spectrum of rules has led to much debate in the literature regarding what constitutes successful outcomes in MPAs [2,4,19,20]. MPAs are expected to meet both biological and socioeconomic needs, meaning that MPA success is not contingent just on the long-term endurance and secure institutional/legal status of the protected area, but must take into account ecological, social, political, and economic outcomes. While much of the available literature focuses predominantly on either ecological or social outcomes of MPAs, this study takes a holistic approach to examining MPA "success," considering both ecological and social outcomes. For the purposes of this analysis, a successful MPA incorporates most, if not all, of the following four outcomes based on common MPA goals:

1. Increases in species targeted for conservation, biodiversity, or improved ecological conditions in the MPA
2. General compliance with established MPA rules and regulations, either through legal enforcement or social pressures
3. A perception of positive outcomes from the MPA by the majority of local community members and stakeholder groups
4. No significant loss of income or livelihood potential for local stakeholders, or losses are balanced by alternative benefits from the MPA

Of course no individual MPA is likely to achieve these outcomes completely and without caveats. In addition, some MPAs may achieve certain outcomes while falling short in others. However, the degree to which these outcomes, which are common goals for the majority of MPAs, are achieved across the variety of case studies and contexts can help us determine what factors contribute to a successful outcome in MPA management.

1.2. Hawaii Island's fish replenishment areas

Hawaii's large-scale implementation of MPAs for marine conservation, coupled with socioeconomic factors that can affect marine resources (including commercial, recreational, and subsistence fishing pressures, tourism, and cultural interactions with the ocean environment) make it an ideal case study location for examining MPA implementation and outcomes. The island's economy is highly reliant on coastal tourism, with approximately 20.6% of jobs on Hawaii Island coming from the tourist sector [21]. While fishing does not make a significant contribution to the overall economy, fishing and marine resources do play an important role in Hawaiian culture [22]. In the state of Hawaii, eleven Marine Life Conservation Districts (MLCDs, a type of MPA) have been implemented in order to combat the dramatic decline of coastal resources over the past 100 years [23]. Five of these MLCDs are located on the island of Hawaii. The implementation of Hawaii Island's protected areas was due in part to an increase in commercial pressure for the collection of marine ornamentals and rare endemic species that fetch a high price in the aquarium market [24].

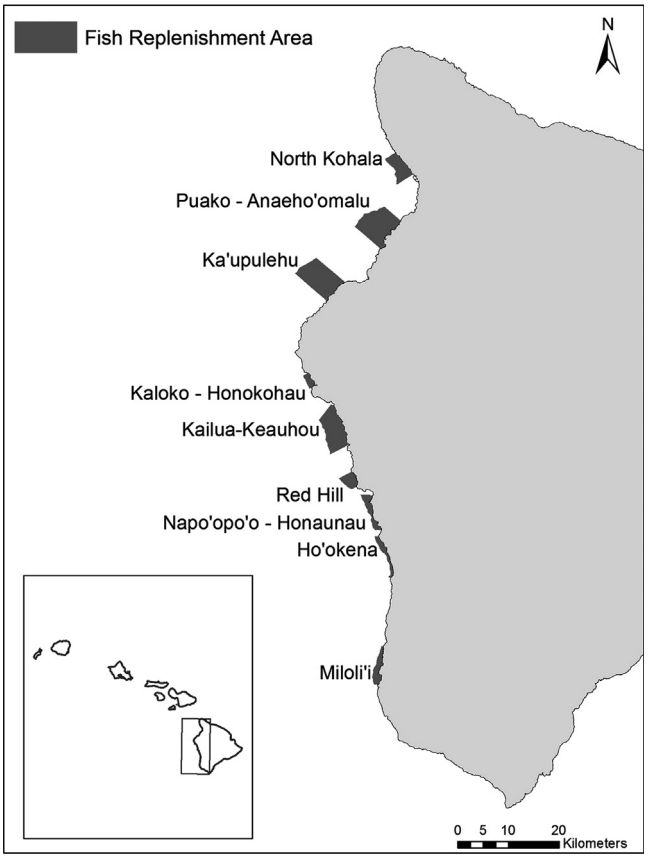

Fig. 1. West Hawaii fish replenishment areas.

In order to specifically counter the pressure on aquarium species due to marine ornamental fishing, the Hawaii State legislature passed Act 306 in 1998 which mandated the designation of at least 30% of the West Hawaii Island coast as fish replenishment areas (FRAs) off-limits to aquarium fishing. The State of Hawaii's Division of Aquatic Resources (DAR) was charged with designating these MPAs, and a council of diverse stakeholders, known as the West Hawaii Fisheries Council (WHFC), was formed to provide local input and guidance during MPA design [14]. This led to the creation of nine FRAs, which when taken in total with existing MPAs, prohibited aquarium fishing along 35.2% of West Hawaii's coastline (Fig. 1).

2. Methods

2.1. Synthesis of the MPA literature

Seventy-four publications that discuss factors contributing to successes and failures of MPAs were reviewed. The review was

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limited to manuscripts published between 2000 and 2013. This range of dates begins at a time when the surge of recently implemented MPAs were well enough established to begin to assess MPA outcomes, and continues up to the present. While there is literature available before 2000, the majority is theoretical or predictive in nature with limited empirical analysis. The literature included a mix of case studies and review papers. Factors that were found to contribute to successful MPA outcomes were documented from each paper. Six key themes emerged consistently throughout the literature: level of community engagement, socioeconomic characteristics, ecological factors, MPA design, governance, and enforcement.

2.2. West Hawaii Island case study

The FRAs implemented in West Hawaii were examined in the context of the results of the literature review on MPA success. A synthesis of existing literature regarding the history of the FRA program and factors contributing to or inhibiting the success of this regional MPA initiative informed this case study analysis. In addition, interviews were conducted with 33 key informants in order to expand the analysis through insight from local managers and stakeholders regarding MPA outcomes. Interviews took place on the islands of Oahu and Hawaii during the summer of 2012. Interviews were semi-structured and lasted anywhere between thirty minutes and two hours. The interview subjects included local fishermen (12), researchers (3), representatives from non-profit groups (8), and government officials/managers (10). The interviews were conducted as part of a larger project examining marine management in Hawaii, and therefore not all questions focused on FRAs. It is of note, however, that all interviewees expressed dissatisfaction with the level and effectiveness of conservation in the islands, yet all those who specifically mentioned the FRAs described them as a success story.

3. Results

3.1. Factors contributing to MPA success/failure

As previously stated, six key themes were consistently identified in the literature as contributing to successful MPA outcomes. The first, *level of community engagement*, can be defined by three main aspects: (1) who is involved in the MPA process; (2) how are they involved in the MPA process; and (3) the goal of community involvement in the MPA process. Many articles discussed the need for stakeholder involvement, particularly meaningful, participatory decision-making [1,4,19,25–29]. Exactly what defines "meaningful" involvement and participation can be very subjective, however, ranging from involving local communities in education and outreach activities to actual community participation in MPA designation and decision-making processes. Many papers also point out the need for this engagement to include stakeholder exposure to the scientific knowledge regarding the establishment of MPAs, including the justification behind the MPA's size and scope, and expected benefits from the MPA [4,25,26,30–32]. There were two main goals identified in the literature for community involvement: addressing stakeholder needs [33–35] and reducing stakeholder conflict [1,36,37].

The next key theme identified was *socio-economic characteristics.* These can be defined as social, cultural, political, and economic aspects of individuals, groups, communities, and organizations [38] living near or interacting with marine resources within the MPA. Cinner et al. [39], in their broad overview of forty-two MPAs, found that MPAs in regions where local stakeholders were better off economically had a greatly increased likelihood of success. This may relate to the level of local dependence on marine resources for subsistence and livelihoods, with greater resource dependence leading to increased likelihood that local people would not comply with restrictions on marine resource extraction [4,35,40]. Other studies cite the importance of accounting for socioeconomic characteristics such as cultural values [4,28,30], place attachment [19], how benefits are distributed among stakeholders [4,37] and the availability of alternative income sources [41].

Ecological factors include the underlying ecology of the MPA, as well as human impacts on the marine environment. Prior ecological knowledge of the area (baselines, threats, impacts, etc.) and a solid scientific foundation were cited by many as a necessity for MPA success [26,28,35,42]. Along these lines, Roberts et al. [43] lay out ecological criteria for the establishment of marine reserves which include: biogeographic representation, habitat representation and heterogeneity, human threats, natural catastrophes, ecosystem linkages, and ecosystem services. Given MPAs' spatial boundaries, there was discussion in the literature regarding species of limited mobility seeing the most benefits [4,9,42], that MPAs were potentially more useful as a fisheries management tool when spillover effects were likely to occur with the target species [4], and that networks of MPAs can strengthen fish replenishment [44]. Accounting for larval dispersal is also considered important [43,45], especially in relation to reserve connectivity [46–49] but the detailed information required to incorporate connectivity explicitly into MPA design is often lacking [43]. There is a lack of consensus in the literature regarding the ecological effects of MPA size [4,26,28,30,35,42,50], and recommendations for the percentage of habitat that should be set aside ranges from 10 to 50% [10–12].

There is significant discussion in the literature regarding structural factors in *MPA design* in planning and implementation. In addition to the ecological criteria described above, important factors in the literature on MPA design include such elements as long-term monitoring of MPA outcomes [26,42], sustainable funding sources [30], and incorporation of local/traditional ecological knowledge [42,51]. Incorporating adaptive management is commonly cited as a critical component of MPA design [1,28,32] that should be incorporated into all aspects of MPA management. MPA goals and objectives are also an important component of MPA design, and it is recommended that these be place appropriate [1,52], clearly defined [1,25,27,34,53,54], compatible with one another [9], and account for inherent uncertainty [34]. Mechanisms must also be in place that have the ability to mitigate the potential negative socioeconomic effects of an MPA [25,55].

The next key theme was *governance,* which refers to both "the formal and informal laws and traditions of a society," [56] and can also be described as "steering human behavior through combinations of people, state, and market incentives to achieve strategic objectives" [57]. Governance can be broadly divided into two areas: (1) management policies and (2) governance context and institutions. Management policies include a variety of incentives, which Jones et al. [57] categorize as economic, interpretive, knowledge, legal, and participative Management policies must promote trust building [4,32,39], have a means of conflict resolution [37] and information dissemination [1,25,36], and have some mechanism of accountability [4,30,37,58]). Co-management, or devolution of shared authority to local resources users and stakeholder groups in collaboration with government, is seen by many scholars as critical to producing more effective fisheries governance [56,59,60], as is adaptive management [1,28,32]. Management policies, in turn, are tightly linked to governance context and institutions. Critical factors include having a political environment that facilitates MPA establishment at multiple scales [61] (local, regional, and global) with supportive management institutions responsible for the MPA establishment, perpetuation, monitoring, and enforcement. These institutions may include governments, NGOs,

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community groups, local and international organizations, and/or academic institution [61–64]. Strong leadership within MPA governing institutions (at a variety of institutional levels) has been found to be critical to MPA success [19,59,65]. Heck et al. [33] also call for high levels of cooperation among various levels of government. Cross-scale linkages between institutions at multiple scales are called for to strengthen and legitimize governance [61,63].

The final key theme was *enforcement*. There was considerable consensus in the literature that strong enforcement, with clear penalties [30,66] and sanctions that fit the offense [4,39] are required in order to preserve MPA integrity. While enforcement of MPA rules and regulations is an element of MPA governance, it has been included as a separate category because many enforcement challenges, such as the unique spatial problems facing enforcement in a marine context, pose problems even when strong governance structures are in place. There is some discussion in the literature surrounding these issues, such as the difficulty of demarcating marine borders and monitoring marine resources [67–69]. A shortage of financial resources and the limited capacity of local agencies to patrol MPA boundaries to ensure compliance with rules and regulations are frequently cited constraints in MPA enforcement [70–72]. Adaptive management is also mentioned as a critical element of effective enforcement, and involving local communities and community-based institutions can sometimes improve compliance with MPA rules and regulations in smaller communities that have strong systems for local marine tenure and limited external threats [73].

3.2. Evaluation of FRAs

The passing of Act 306 to designate FRAs in West Hawaii happened in response to a growing conflict over the aquarium fishery. Local dive operators and aquarium collectors had previously attempted to stem conflict with a "gentlemen's agreement" in 1987, by which aquarium fishers agreed to steer clear of certain diving spots without any formal regulations [74]. This agreement failed, and a local NGO called the "Lost Fish Coalition" (LFC) subsequently called for legislation to ban aquarium collecting completely [75]. It was in this contentious climate that the Hawaii State Legislature passed Act 306, establishing the West Hawai'i Regional Fishery Management Area with the goals of ensuring fisheries sustainability, enhancing nearshore marine resources, and minimizing use conflicts in the area [76]. The WHFC established nine fish replenishment areas (FRAs) within the Regional Fishery Management Area where aquarium fishing was prohibited, which became effective in December 1999 [77]. In the following section, the establishment and outcomes of these FRAs are explored in light of the factors, outlined above, that have been documented as important to MPA success.

3.2.1. Level of community engagement

Substantive community involvement was one of the specific provisions of Act 306, and local stakeholders were highly involved in its implementation. The original WHFC included a diverse group of stakeholders (NGOs, dive operators, state officials, local conservation groups, etc.) including members from the aquarium collecting industry (three fishermen and one shop owner) [75]. Stakeholders were given the opportunity to outline which areas they thought should be targeted for conservation. During a public meeting in 1999, the proposed FRA plan received overwhelming public support (93% of 876 testimonies) from a diverse range of community representatives [14]. Interview respondents described the formation of the WHFC as one of the great successes of the FRA process, with the voluntary body still operating to date.

Views of the aquarium industry regarding FRA placement were described as being surprisingly in line with other members of the WHFC [75], although some aquarium fishers balked at participating in the process [14]. Despite several meetings in which aquarium fishers could express preference about where the FRAs should be located, interviewees stated that aquarium fishers have expressed dissatisfaction with the final outcome. Today, the WHFC has three aquarium fishermen representing the industry (out of a total of approximately forty on Hawaii), but many aquarium fishermen refuse to engage in the management process.

3.2.2. Socio-economic characteristics

Not all stakeholders involved in the establishment of the FRAs received an equal distribution of benefits from their establishment; dive operators benefited from the restriction of fishing and net increase in charismatic aquarium species found in their dive sites, while aquarium fishers were displaced from many of their normal fishing areas and were not provided with any alternative income sources. While spill-over of adult tang from the FRAs into adjacent areas has been documented [15], this is unlikely to adequately compensate for the net loss of species outside of protected areas, as more fishermen are crowded into smaller areas, increasing local pressures on the target species [78].

There were an estimated 40 active aquarium fishermen in 2009, and fleet size has not been significantly affected by FRA implementation [15,79]. Aquarium fishers represent a very small stakeholder group in the state of Hawaii and are not considered to be impoverished or disadvantaged [80]. While the cost of fishing has increased as aquarium fishermen are forced to travel farther and to less ideal locations to fish, most aquarium fishermen state that they are economically better off than they were before the FRAs were established [80]. Stevenson and Tissot [80] found that while aquarium fishers did not perceive the FRAs to have improved fish abundance, they have not suffered significant negative economic effects from the reserve designation. This is largely due to the increased market price for aquarium species targeted in Hawaii (unrelated to FRA implementation), which has more than offset any losses they might have otherwise experienced.

Many local residents in Hawaii hold negative views of the aquarium fishery. Unlike local fishing for food species in Hawaii, which is considered a vital social and cultural process [22] the aquarium fishery is not a considered a cultural right that needs to be protected. This is likely due to the fact that aquarium fish are not fished for the purpose of consumption, and the aquarium fish catch does not provide wider benefits to the local community in terms of food or cultural consumption. Traditional Hawaiian notions of natural resource stewardship including asking permission to fish, taking only what you need, sharing your catch, and respecting the sacredness of the process run counter to the commercial practice of aquarium fishing [81]. Aquarium fish are immediately shipped off-island, not benefiting the local population, with economic benefits only realized by a very small (and often non-indigenous) sub-set of the local population. In addition, coral reefs and yellow tang, the most commonly collected species, are considered to be a local treasure that embodies West Hawaii.

3.2.3. Ecological factors

While there was much speculation prior to FRA establishment that the decline in yellow tang was due to the aquarium fishery, there was no definitive study documenting this trend until 2003, well after the FRAs had been put into place [79]. The mandated target of designating just over thirty percent of West Hawaii's coastline as protected areas was a political compromise, and was determined by the legislature only after the push for complete closures and a fifty percent closure had failed [14]. However, the

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final percentage designated fits within the middle of the range of scientific recommendations for percent MPA coverage (generally 10–50%) [10,11], and is significantly greater than the 10% agreed upon by the UN Convention on Biodiversity.

There was little biological information available regarding the species targeted by aquarium fishermen at the time of reserve designation, making it challenging for the WHFC to designate reserves based strictly on ecological criteria such as biogeographic representation, habitat representation and heterogeneity, or ecosystem linkages. The network was thus spread out relatively evenly across the coastline, with FRAs placed next to existing MPAs whenever possible [70]. However, consistent biological monitoring has been in place since the implementation of the FRAs, and yellow tang populations have increased inside reserves [15].

While the limited mobility of the yellow tang can be seen as having a positive effect, allowing for rapid recovery of the species, its limited mobility has also limited the extent of spillover effects. However, studies do document some positive impacts from the FRAs on non-reserve areas. Christie and Tissot [82] found that yellow tang larvae can travel great distances, ranging from 15 to 185 km, and Williams [15] documents evidence of some spillover occurring from the FRAs. This coupled with species longevity (the oldest known collected yellow tang was 41 years old) and frequent spawning (females spawn once a month) allow for a rapid increase in tang populations on reefs both inside and outside of reserves [83]. While the final FRA boundaries represent a compromise between scientific information and stakeholder preferences, data from Christie et al.'s [82] study of larval dispersal in West Hawaii suggest that the spacing of the reserves may allow for larval dispersal effects along much of the coastline.

3.2.4. MPA design

The FRAs fare well under most criteria for strong MPA design. As stated above, they follow ecological guidelines for percentage of area designated for conservation, and there here has been consistent long-term ecological monitoring of the FRAs since their inception, with thirteen years of comprehensive data on aquarium species and habitat in the FRAs, a rarity among MPAs. The FRAs' goals and boundaries have been clearly defined, and there is little confusion among stakeholders regarding what is and is not allowed in the FRAs. This differs from other MPAs in West Hawaii, which, according to interview respondents, are often misunderstood. While no mechanisms are currently in place to mitigate potential negative socioeconomic effects of the FRAs, the economic impacts to aquarium fishers have fortunately been offset by increasing market prices for aquarium species, and other areas remain open to aquarium fishing.

One component of MPA design where the FRAs face challenges, however, is in implementing adaptive management. More than a decade ago, the WHFC proposed a set of rule changes that were delayed for several years as they went through a lengthy bureaucratic process. DAR finally recommended the acceptance of the entire rule package in December 2012. While FRA management has exhibited the ability to make changes in the face of demonstrated need, the slow pace of the agency's bureaucracy poses a serious hurdle for responding quickly or adaptively to new needs as they arise.

3.2.5. Governance

Hawaii's governance context is especially unique. While it is a U.S. State, Hawaii is far removed from the U.S. mainland. In addition, the island of Hawaii is distant from the center of state governance, which primarily takes place in Honolulu on the island of Oahu. Many interviewed described the political process in Hawaii as "Honolulu-centric." The literature on MPA and common-pool resource governance calls for cross-scale linkages and cooperation among various levels of government and local stakeholders. The WHFC itself embodies these types of cross-scale linkages, as it is made up of diverse stakeholders from various sectors of government and civil society, including local residents, fishermen, NGOs, and agency representatives. The FRAs' successful implementation and outcomes may be due, in part, to the fact that significant authority was devolved to the local office of a state agency (DAR) and the WHFC. This allowed local actors to take the lead in FRA design and designation, with legislative support at the state level, but without heavy-handed state interference. Some interviewed expressed this devolution of authority as being "left alone" so that they could do what they wanted without being caught up in state bureaucracy. The WHFC also had strong leadership, which has been found to be critical to successful fisheries co-management [59].

3.2.6. Enforcement

Hawaii Island generally lacks any real enforcement in the marine context, primarily due to the fact that DAR lacks funding and patrolling resources. This has served as a limitation for managing marine resources in Hawaii [70]. This sentiment was expressed by nearly all who were interviewed, including fishermen. There was also discontent over penalties; in the rare instances when violators were caught, they were thrown into the criminal justice system, where the nature of their crime was minor compared to others, and thus they were rarely punished.

The FRAs provide an unusual exception to this problem of enforcement, as compliance with FRA rules and regulations happens primarily through social pressure. Aquarium fishers are required to register with DLNR and prominently display signs and flags indicating that they are aquarium collectors. They are not allowed to have aquarium collecting gear onboard their vessels (except during transit) in any area where aquarium fishing is prohibited. These regulations mean that aquarium collectors are highly visible to the public. Given the fact that aquarium fishing is generally an unpopular profession in Hawaii, and that aquarium fishermen could potentially lose their license if caught illegally fishing, the risk of being caught and reported outweighs the potential gain of catching fish within the FRA, contributing to very high levels of compliance with FRA boundaries. In the case of the aquarium industry, community-based enforcement (backed by state regulations) has been adequate to ensure compliance with FRA regulations.

4. Discussion

Overall, the FRAs of West Hawaii Island exhibit most of the criteria found in the literature regarding conditions important to MPA success. However, they do fall short in some areas. By revisiting the original four criteria of MPA success discussed above (ecological improvement, compliance, perceived positive outcomes, and lack of livelihood loss), a better understanding emerges regarding what factors contribute to each aspect of success.

The undisputed increases in aquarium fish abundance documented in the FRAs are likely the result of effective MPA design and West Hawaii's unique ecological context. This small set of MPAs was designed with clear goals, regulations, and boundaries. The amount of habitat set aside for closure falls within the middle of the range proposed as necessary by the scientific community. Although there was limited ecological information available to incorporate into initial reserve designation, regular scientific monitoring since the establishment of the FRAs has documented their

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progress and demonstrated an increase in species targeted for conservation. Aquarium fish also exhibit limited mobility and high reproductive rates, which has allowed these species to rebound quickly within MPA boundaries. While ecological progress within the MPAs has been impressive to date, adaptive management of the FRAs has proved challenging, and rule changes have been slow to enact. It remains to be seen whether the FRAs will be flexible enough to respond to potential challenges and perturbations in the future, which may arise due to exogenous or endogenous factors, and could disrupt the ecological stability of the protected areas.

Overall compliance with FRA rules has been high. As discussed, this is a result of community enforcement, which is facilitated by the high visibility of aquarium fishers and the marginalized nature of the fishery itself. Community enforcement works in this context because the local community does not favor aquarium fishing [84]. During interviews, enforcement of marine regulations in general was described as exceedingly weak in Hawaii due to a variety of financial, institutional and cultural constraints. The Division of Conservation and Resources Enforcement (DOCARE) is charged with enforcing both marine and terrestrial regulations, but the agency is understaffed to accomplish such goals across a diverse landscape. Interviewees stated that it often takes DOCARE hours to respond to reported violations, and by the time they are on scene the offenders are long gone, and their identity is unknown. Given the small number of people participating in the aquarium fishery, it is hard for them to fish anonymously. The prominent labeling required for aquarium fishing boats, the limited area in which they are allowed to fish, and their social marginalization mean that aquarium fishers cannot easily hide from or escape enforcement.

The FRAs were generally perceived as having positive ecological and social outcomes, both within the literature, as well as amongst those interviewed. The long-term monitoring program helped to clearly demonstrate positive ecological outcomes to local stakeholders. Positive social outcomes have been seen through a reduction in intergroup conflict between dive operators and aquarium fishers who no longer compete for the same spaces. While aquarium fishermen have expressed some dissatisfaction with the FRA process and outcomes [78], they remain a very small and highly marginalized minority amongst Hawaii fishermen. Their social and political power is therefore very limited, increasing their willingness to comply with regulations, an outcome of the unique socioeconomic characteristics of the region.

Stakeholder conflict, however, has not completely disappeared [80], and the aquarium fishers are still the target of negative publicity from animal rights groups who inflate extraction and mortality rates as well as ecosystem effects of the fishery. That being said, face-to-face conflict has been reduced. Once again this can be attributed to strong MPA design. There is no confusion regarding where aquarium fishing is allowed, so interactions with dive operators have been minimal. This decreased social conflict is related to enforcement and compliance. As discussed, FRA compliance is gained through community enforcement. The aquarium fishers have a great deal to lose from violating FRA rules, and their marginalization makes them a prime target for community enforcement.

In spite of the dissatisfaction with many of the FRA rules and regulations among aquarium fishermen, they did not suffer any loss in their livelihoods as a result of the establishment of the FRAs. While much of the literature calls for alternative income opportunities for those displaced or negatively affected by MPA establishment, this was not necessary in the case of Hawaii's FRAs. From an economic standpoint, the aquarium fishers are doing just as well, if not better, than they were before FRA establishment [78]. This may not be the result of MPA planning as much as it is an outcome of economic good fortune; the price of aquarium fish went up dramatically on the international market after the FRAs were established. Had this not been the case, aquarium fishermen would likely have experienced more significant impacts from displacement, and the FRAs might have been seen as having a less than positive social outcome.

It is important to note that FRAs were established with a very narrow and targeted goal: to reduce the impacts of aquarium fishing in West Hawaii's waters. While the FRAs have been successful in accomplishing this goal, there are still other environmental concerns negatively affecting the reefs, such as changes in algae vital to reef health, as well as declines in overall fish abundance and total coral cover [85]. Other MPAs in Hawaii, which generally have broader conservation goals, have not met with the same degree of success as the FRAs, and non-aquarium reef fish species have not fared so well in the island's protected areas. Some MPA sites in West Hawaii have seen drastic declines in non-aquarium reef fish abundance over the past twenty-five years, as well as considerable deterioration in coral reef habitat [85].

5. Conclusions

By the definition given above, the FRAs can be, and in fact are, considered a successful case of MPA implementation. This is due in part to their synchronization with factors contributing to success discussed in the literature. However, this is only part of the story. The nature of the aquarium fishery in West Hawaii provides a very unique context for MPA establishment that contributes to its ability to "succeed." First of all, the FRAs target only one type of fish, rather than attempting to prohibit all take or creating a broad swath of rules and regulations. Yellow tang reproduce quickly and do not travel great distances, allowing for the rapid recovery of this most heavily targeted species in West Hawaii. In addition, aquarium fishers are a small and marginalized group who are generally not held in high esteem by other stakeholders, including other fishermen. The aquarium fishery is not a considered a cultural right that needs to be protected, nor is it a great revenue builder or source of livelihood for a large population, simplifying issues in enforcement and compliance with FRA regulations.

The social and cultural marginalization of the aquarium fishery, a factor not generally discussed in the literature, plays a critical role in the success of West Hawaii's FRAs. The establishment of FRAs has been a political success in a state where any fishing regulation is fraught with contention. Hawaii is one of the few states that still does not require a marine recreational fishing license, and establishing MPAs that prohibit additional types of fishing, as also mandated under Act 306, has so far been unsuccessful [74]. Clear scientific guidelines, thoughtful planning and design, and extensive involvement of local stakeholders in collaboration with the government have all been important to the outcomes of Hawaii's FRAs. However, the unique nature of the fishery and cultural context have also played critical roles in facilitating the success of these marine conservation programs in an otherwise challenging region for the establishment of MPAs, illustrating the value of incorporating unique aspects of local context into MPA design and implementation.

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