Territorial-use rights for finfish fisheries: A case study in El Corredor, Baja California Sur, MX

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A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Marine Affairs

University of Washington

2022

Committee:

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Program Authorized to Offer Degree:

School of Marine and Environmental Affairs

Abstract

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Chair of the Supervisory Committee:

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Small-scale fisheries support millions of people around the world but they face a common issue of overcapacity and, subsequently, an overexploitation of resources. One solution to this is through the implementation of territorial-use rights in fisheries (TURFs) where specific areas are designated for fishing by specific individuals or groups while excluding all others. In El Corredor, Baja California Sur, small-scale fishers target a variety of reef fishes under a permit system managed by cooperatives using hook-and-line, of which the Pacific red snapper (*Lutjanus peru*) is the most important species economically and socially. After concerns arose about possible overexploitation of fishery resources, in part due to competition with industrial fishers, fishers in El Corredor became interested in establishing TURFs over their fishing grounds. Using a spatial bioeconomic model called TURFtools, we explored the possible impacts of establishing TURFs in El Corredor to provide fishers with the knowledge necessary to make informed management decisions for their fisheries. Of the five scenarios tested, we found combining

TURFs with no-take reserves—whether maintained at their current size or expanded—had the highest increase in fish abundance, fisher harvest, and fisher profit in comparison to the status quo after 20 years. TURFs may be beneficial to El Corredor fishers in addressing overcapacity issues within their fisheries given they can collaborate on how best to manage these TURFs. Though the use of TURFs to manage small-scale finfish fisheries needs to be further explored, this study is the first step in exploring their efficacy.

Territorial-use rights for finfish fisheries: A case study in El Corredor, Baja California Sur, Mexico

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We have no known conflict of interest to disclose.

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Abstract

Small-scale fisheries support millions of people around the world but they face a common issue of overcapacity and, subsequently, an overexploitation of resources. One solution to this is through the implementation of territorial-use rights in fisheries (TURFs) where specific areas are designated for fishing by specific individuals or groups while excluding all others. In El Corredor, Baja California Sur, small-scale fishers target a variety of reef fishes under a permit system managed by cooperatives using hook-and-line, of which the Pacific red snapper (*Lutjanus peru*) is the most important species economically and socially. After concerns arose about possible overexploitation of fishery resources, in part due to competition with industrial fishers, fishers in El Corredor became interested in establishing TURFs over their fishing grounds. Using a spatial bioeconomic model called TURFtools, we explored the possible impacts of establishing TURFs in El Corredor to provide fishers with the knowledge necessary to make informed management decisions for their fisheries. Of the five scenarios tested, we found combining TURFs with no-take reserves—whether maintained at their current size or expanded—had the highest increase in fish abundance, fisher harvest, and fisher profit in comparison to the status quo after 20 years. TURFs may be beneficial to El Corredor fishers in addressing overcapacity issues within their fisheries given they can collaborate on how best to manage these TURFs.

Though the use of TURFs to manage small-scale finfish fisheries needs to be further explored, this study is the first step in exploring their efficacy.

Introduction

Small-scale artisanal fisheries are important economically, socially, and culturally to local communities around the world (Dyck & Rashid Sumaila, 2010; *FAO Fisheries & Aquaculture - Small-Scale Fisheries*, 2008; Schuhbauer & Sumaila, 2016). They support an estimated 200-250 million people worldwide, providing food security and employment to local communities, and are responsible for producing most of the fish consumed in the developing world (Basurto et al., 2012; *FAO Fisheries & Aquaculture - Small-Scale Fisheries*, 2008; Jacquet & Pauly, 2008). Despite the large number of participants within small-scale fisheries, they are generally data-poor and lack formal assessment, and management actions are often not taken until a resource is overexploited (Munguia-Vega et al., 2015; Nguyen Thi Quynh et al., 2017). Federal governments often manage fisheries using a top-down approach, regulating fishing through gear specifications and open seasons, which lead to improper management especially in developing nations (Auriemma et al., 2014; Romero & Melo, 2021). Wilen (2006) argues these policies are not effective long-term as they do not address the main issue leading to overfishing. Fishers are not inclined to deplete marine resources but rather are forced to compete with one another to take advantage of limited resources with a continuously growing pool of users (Wilen et al., 2012). One potential solution to this overcapacity issue is the implementation of territorial-use rights in fisheries (TURFs).

TURFs establish boundaries for small-scale fisheries and grants exclusive fishing access to individuals or groups. This selectivity of who can fish in an area may reduce fishing effort and the overexploitation of marine resources (Nguyen Thi Quynh et al., 2017). TURFs can be effective management strategies in small-scale fisheries when management efforts are driven by local communities with government support, which can be in the form of legal, operational, or financial backing (Poon & Bonzon, 2013). Placing fishers in charge of management efforts instills in them a sense of ownership over their shared resources (Lester et al., 2016; Quintana et al., 2020). Co-management through a TURFs approach allows for real-time responses to changes in fishing trends and locally appropriate management (Poon & Bonzon, 2013). TURFs are an area-based management strategy, rather than quota-based, that relies on clearly defined fishing areas. TURF boundaries, dictated by fishers, can be aligned with those of individual communities' fishing grounds and be used to identify non-community fishers, who are excluded from fishing. These boundaries also make TURFs ideal for benthic and sedentary species (Defeo & Castilla, 2005; McCay et al., 2014; Poon & Bonzon, 2013). However, many artisanal fishers globally depend on non-benthic species for their livelihoods, prompting questions about the efficacy of TURFs for managing higher mobility species.

We focused on El Corredor in the central Gulf of California, which spans from Agua Verde in the north to Punta Coyote in the south. This region is surrounded by desert and the local economy largely relies on small-scale captures of a variety of reef fish. The nine communities within El Corredor fish commercially and for subsistence using hook-and-line under a system where permits are issued to individuals or cooperatives (Bradley et al., 2018). Fishing activity is usually concentrated over spawning aggregations of targeted reef fish, of which the Pacific red snapper *(Lutjanus peru)* represents the highest economic value based on price and catch volumes (Bradley et al., 2018). In response to concerns about possible overexploitation of fisheries resources, El Corredor fishers worked with a local non-governmental organization (NGO) called

Sociedad de Historia Natural Niparaja (Niparaja) to establish no-take reserves (NTRs) (Quintana et al., 2020); DOF 2014). These areas, closed to fishing, are temporary and must be renewed with the federal government every five years (CONAPESCA 2019). Despite the establishment of these NTRs, El Corredor fishers continued to see declines in small-scale catch while fishing effort from industrial fishing fleets outside of their communities continued to increase. In response, El Corredor fishers have expressed interest in creating TURFs to gain exclusive rights to their fishing grounds (pers. comm. Ollin Gonzalez, 7 Sep 2021; Salvador Rodriguez Van-Dyck, 2 Nov 2021) while excluding industrial fishers.

Using a spatial bio-economic model, we aimed to forecast changes in *L. peru* abundance, fisher harvest, and fisher profit under five management designs based on the biology of *L. peru*, the ecological characteristics of the area, and the local communities' traditional fishing practices. Building off of existing NTRs, we incorporate TURFs with the goal of alleviating fishing pressure on *L. peru* while reducing overcapacity within the fishery for the benefit of El Corredor's small-scale fishers. Of the scenarios we test, we expect TURFs used in conjunction with no-take reserves to be the most beneficial to both fishers and *L. peru*. Although the final decision of establishing TURFs within El Corredor will depend on multiple factors (legal, social, cultural), this paper aims to inform these discussions by providing El Corredor communities the tools and knowledge necessary to guide their decision-making process.

Methods

We used TURFtools developed by Oyanedel et al. (2017), which quantifies the biological and economic trade-offs of different TURF designs. Using this model, we seek to predict changes in fish abundance, fisher harvest, and fisher profit over 20 annual time steps. The model is parameterized using local knowledge and information from peer-reviewed literature.

We initially characterized general habitats present within El Corredor as no map previously existed. In ArcGIS, we adapted a map in Batimetria Corredor San Cosme-Punta Coyote (provided by Salvador Rodriguez Van-Dyck) describing the El Corredor community fishing grounds to visualize fishing zone boundaries of each of the nine communities. Because there is a lot of overlap in fishing areas between communities, we merged all to create one large area as we are looking at the entire El Corredor region as a whole, rather than in parts (Figure 1). To characterize marine habitats, we conducted interviews with local experts (pers. comm. Ollin Gonzalez, 7 Sep 2021; Salvador Rodriguez Van-Dyck, 2 Nov 2021) knowledgeable about the ecology of the area. Interviews consisted of two rounds. The first gathered foundational information, such as the habitats over which fishers target finfish and the locations of mangroves in El Corredor, for creation of a draft map. The second round elicited feedback on previous drafts and verified locations of seamounts and no-take reserves before creating a final habitat map (Figure 2).

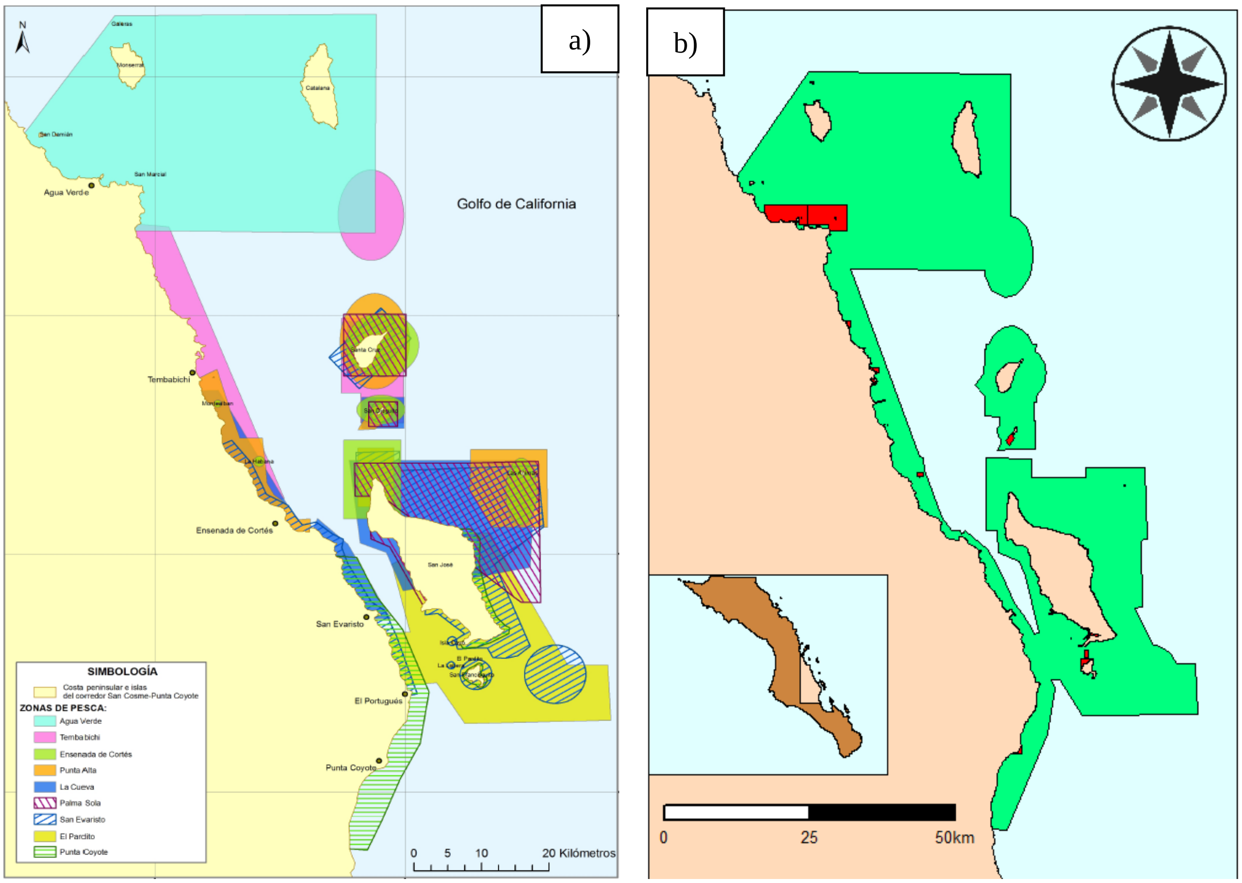

Figure 1. a) Fishing areas of each community within El Corredor. (Source: Niparaja) b) Adapted map of El Corredor community fishing grounds depicted in green with currently established no-take reserves in red.

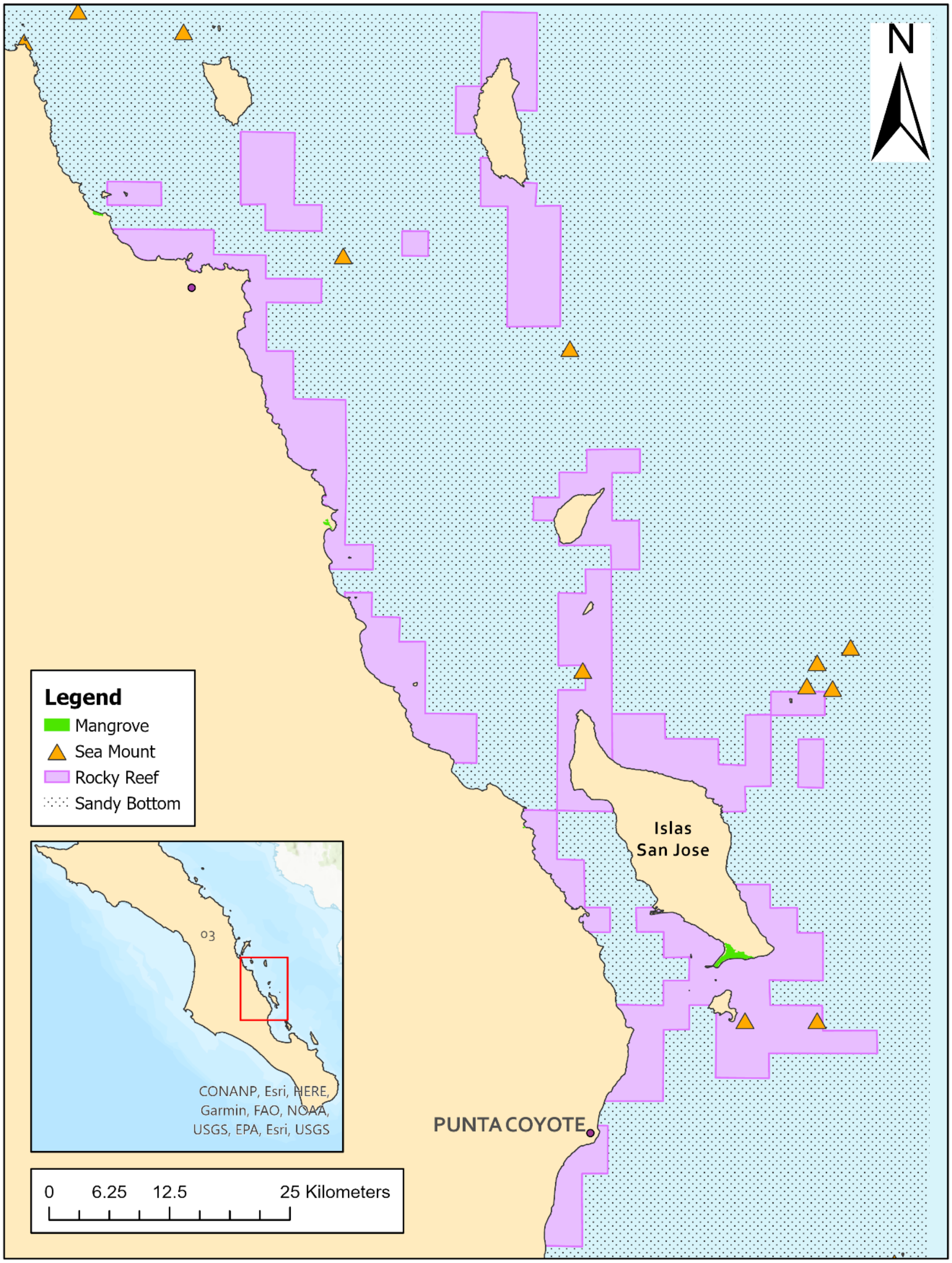

Figure 2. Habitat characterization map. Purple polygons characterize rocky reef; orange triangles characterize seamounts; and green polygons characterize mangrove forests.

TURFtools uses habitat characterization within a patch, which is characterized by a 10 cell by 10 cell grid, to determine habitat-based carrying capacity. The scale of a patch and its cells are based on the size of the study region and how fine of a resolution is desired. To avoid overgeneralizing habitats in El Corredor, we designated each individual cell to be 2.5 km by 2.5 km, creating a patch of 25 km by 25 km. We overlay patches on a map of El Corredor with no overlap between patches then characterized the habitats within each cell based on our habitat map. The dominant marine habitats in this area are rocky reefs, seamounts, mangrove forests, and sandy bottoms. We also accounted for land as part of the Baja California peninsula. We used a hierarchical sorting method to determine the predominant habitat contained within a cell in order of importance to *L. peru* (Figure 3). If the cell contained a seamount as described by Klimley (2017), the entire cell was classified as “Seamount.” Because we are unsure of the span of each seamount, we were conservative in our classification and assumed it dominated the entire cell. We applied the same decision process to mangrove forests and rocky reefs. All cells without a determined habitat were classified as sandy bottom.

To simulate population dynamics, the model assumes logistic growth in *L. peru* and calculates the stock abundance within a patch for each time step, removing fish through simulated legal and illegal harvest and replenishment through fish settlement. Cells are connected through larval dispersal and adult movement while individual patches are each treated as closed systems. This dynamic equation is not age-structured and does not differentiate between larval, juvenile, and adult life stages. Movement of adults within a patch is limited by *L. peru* home range but also determined by a Gaussian probability distribution. To simulate changes in fisher harvest and profit within a patch, TURFtools uses the price of fish per kg and the cost to catch 1 kg of fish while only considering legal harvest as illegal harvest was assumed to be done by fishers outside the community. It determines the total profits of a design across the entire patch by calculating the discounted profit then the net present value.

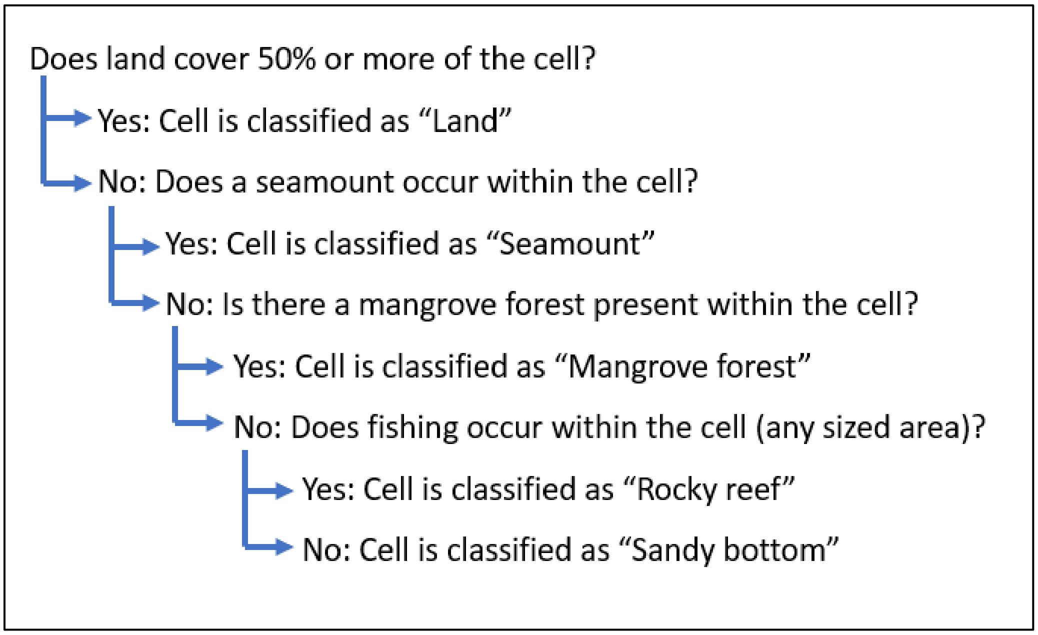

Figure 3. Decision tree for classifying habitats

We designed TURF reserves—TURF patches connected with no-take reserves—to simulate changes in fisher profit, fisher harvest and fish abundance based on five scenarios:

1. Establish a TURF where communities currently fish. Maintain NTRs as in the status quo.
2. Establish a TURF where communities fish. Remove NTRs.
3. No TURF is established. Extend NTRs to be at least 4.11 km long.
4. Establish a TURF where communities fish. Extend NTRs to be at least 4.11 km long.
5. No TURF or NTRs in place.

	Status Quo	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
TURFs	–	✓	✓	–	✓	–
No-Take Reserves	✓	✓	–	✓ ≥ 4.11 km	✓ ≥ 4.11 km	–

Table 1. Presence of TURFs and no-take reserves under status quo and scenarios. Check marks indicate presence, dashes indicate absence.

The status quo was characterized by management methods currently in place, which only consist of 12 NTRs. In scenario 1, we placed TURFs over areas currently fished by the communities and kept all NTRs. In scenario 2, we placed TURFs over community fishing grounds as in scenario 1 but removed NTRs so that TURFs were the only management strategy in place. Under scenario 3, we did not include any TURFs and instead expanded existing NTRs to be 2 cells by 2 cells, totaling 5 km x 5 km, per the recommendation of Munguia-Vega et al. (2018) for minimum NTR size based on *L. peru* home range. If a marine reserve did not exist in the patch or the existing reserve was already at or larger than 5 km x 5 km, no cells were changed. In scenario 4, we combined the designs of scenario 1 with scenario 3 where TURFs were placed over community fishing grounds and included expanded NTRs. With scenario 5, we removed any NTRs within the patch and did not add TURFs so the entire patch was subject to open-access fishing. With the input we provided, the model simulated population size, legal and illegal harvest, fish abundance, fish harvest, and profits after 20 years then calculated percent change from the status quo.

Parameter values used within TURFtools included population growth rate, linear home range, the current stock status, price per kg, and the cost to fish per kg of fish (i.e. fuel and gear)

(Table 1). To predict population dynamics of *L. peru* within our model, we compiled biological information from peer-reviewed articles. In cases where we were unable to find growth parameters or information about our target species specifically, we drew from related species within family Lutjanidae (e.g., *L. argentiventris* and *L. campechanus*). *L. peru* begins life as pelagic larvae that settle in sheltered areas (Zapata & Herrón, 2002) then, as juveniles, moves to shallow, soft bottom habitats such as in mangrove forests (Aburto-Oropeza et al., 2009; Hernández-Álvarez et al., 2020; Saucedo-Lozano et al., 1998). As juveniles approach sexual maturity, they may shift to shallow rocky reefs and begin to exhibit high site fidelity when in their adult habitats similar to *L. argentiventris* (Green et al., 2015; Reguera-Rouzaud et al., 2020; Tinhan et al., 2014); however, during the spawning season from summer to early autumn they can travel up to 15 km to form spawning aggregations at seamounts. As an aggregate spawner, *L. peru* may also travel similar distances to seamounts in summer to early autumn to reproduce (Dumas et al., 2004; Erisman et al., 2010; Saucedo-Lozano et al., 1998); Reyna-Trujillo, 1993). To predict changes in fisher profit in TURFtools, we drew from articles studying the *L. peru* fishery in the Gulf of California and that of other Lutjanidae fish. This information included the price per kg of fish and the cost to fish per kg of *L. peru*, which included the cost of fuel and gear.

To determine how sensitive TURFtools was to changes in *L. peru* home range, illegal fishing rates, and discount rates, we conducted a sensitivity analysis. We selected one patch that had an existing NTR and was of a size that we could expand to 4.11 km under scenarios 3 and 4. We tested different values for each parameter under scenarios 1 through 4 to assess how they affected percent changes in fish abundance, fisher harvest, and fisher profit. To test home range values, we set up our model with the values initially used to assess the outcomes of our scenarios then changed only the home range value with each run of our model. We repeated this with our range of illegal fishing rates and discount rates.

Parameter	Value	Source
Stock Status	Possible overfishing occurring	Bradley et al., 2018; Diaz-Uribe et al., 2004
Primary habitats	Rocky reef	Aburto-Oropeza et al., 2009; Rocha-Olivares, 1998; Tinhan et al., 2014; Topping & Szedlmayer, 2011
	Seamounts (during spawning season)	Jorgensen et al., 2016; Tinhan et al., 2014
	Mangroves (observed in *L. argentiventris*)	Aburto-Oropeza et al., 2008
Home Range	2,866 m (based on *L. campechanus*)	(Green et al., 2015; Watterson et al., 1998)
Intrinsic Growth Rate (r)	0.5	(Cisneros-Mata, 2016; Diaz-Uribe et al., 2004) Cisneros-Mata et al. 2000; DOF 2010; Reddy et al. 2013
Price per kg (MX pesos)	50 pesos	(Bradley et al., 2018)
Cost to fish 1 kg of fish	5.69 pesos	(Cisneros-Mata, 2016)

Table 2**.** Parameters used in TURFtools for *L. peru*. Stock status, primary habitats, home range, and intrinsic growth rate used to simulate population dynamics. Price per kg and cost to fish used to calculate net present value.

Results

Across the five scenarios, scenarios 1, 2, and 4 showed positive percent changes in abundance, harvest, and profit relative to the status quo (Figure 4). These three scenarios had similar values of percent change but the largest increase in abundance was observed under scenario 4. When both TURFs and the larger NTRs are in place as in scenario 4, *L. peru* abundance is expected to increase by 8247.1% after 20 years. NTRs may already provide *L. peru* with some habitats free from fishing but the expansion of these reserves and introducing TURFs, especially over large areas, may greatly reduce fishing pressure and allow *L. peru* populations to grow. We saw the largest increase in fisher harvest and profit under scenario 2 (3817.3% and 2701.0%, respectively) where TURFs were put in place but NTRs were removed. This may be due to NTRs prohibiting harvest within its boundaries so with their removal more area is accessible for fishing, which increase harvests and profits.

Two scenarios not generally beneficial are scenarios 3 and 5. In scenario 3, no TURFs are implemented but NTRs are expanded. Our results suggest an increase in fish abundance (396.4%) but a decrease in fisher harvest and profit (-19.8% and -39.4%, respectively). Although reserves are larger and can protect more *L. peru* habitat, their home range and movement to sea mounts may be too large to effectively encompass with a reserve. Under scenario 5, where all areas within a patch are open to fishing, fish abundance declined compared to the status quo (-334.6%) but the open-access nature of the fishing grounds resulted in slight increases in harvest and profit (38.2% and 56.0%, respectively). With no limitations on fishing efforts, this may lead to an overharvest of *L. peru*, driving down the population. At the same time, this increased effort to fish increases harvest and, in turn, profits.

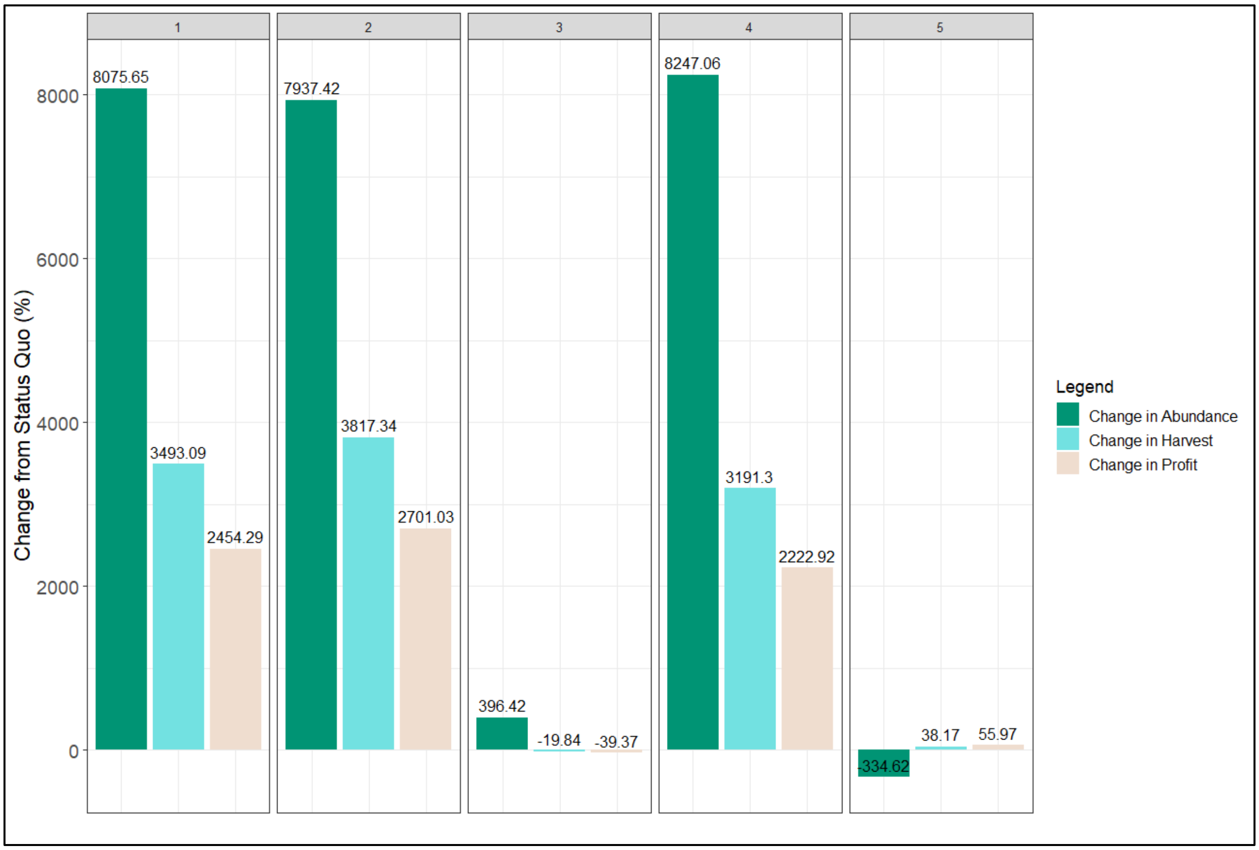

Figure 4. Total percent change in fish abundance, fisher harvest, and fisher profit across all scenarios and all patches in comparison to the status quo

Sensitivity Analysis

A sensitivity analysis showed fish abundance, fisher harvest, and fisher profit are sensitive to changes in *L. peru* home range, illegal fishing rates, and discount rates. The baseline home range value was 3000 m for *L. peru* and we tested ten values from 500 m to 5000 m at evenly spaced intervals. When home ranges were smaller than 3000 m, we saw higher percent changes in harvest and profits (Figure 4). However, when home ranges were larger than 3000 m, we saw declines in fisher harvest and profits. When we tested sensitivity of the model to different illegal fishing rates, we saw fish abundance and fisher harvest were affected more than profits (Figure 5). With a baseline value of 0.2, an illegal fishing rate of 0.1 resulted in lower fish abundance and fisher harvest. When illegal fishing rate was higher though, abundance and harvest increased. When testing the sensitivity of the model to discount rate, we found only profits were affected. At lower discount rates, profits were higher, but they decreased at higher discount rates.

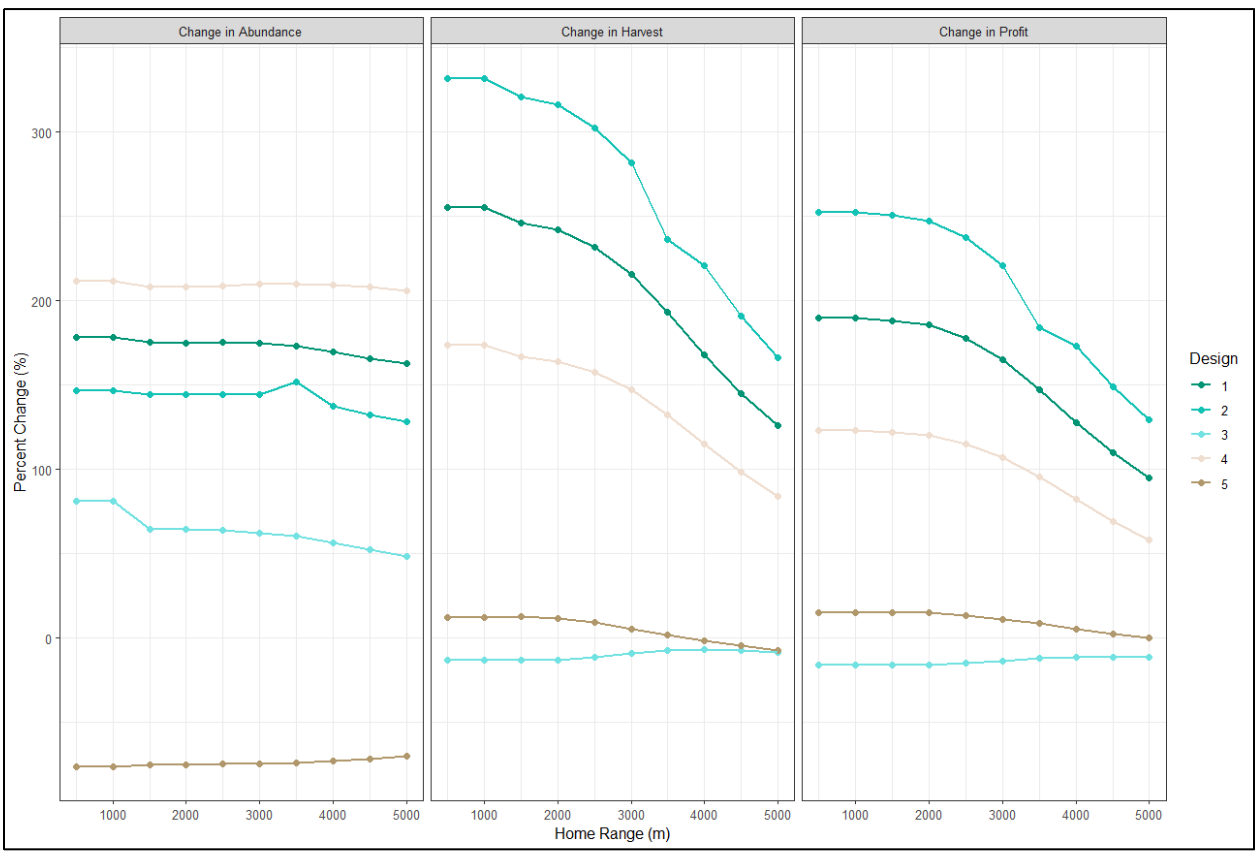

Figure 5. Sensitivity analysis of home range on change in fish abundance, fisher harvest, and fisher profit. The baseline parameter value used in our simulations was 3000 m.

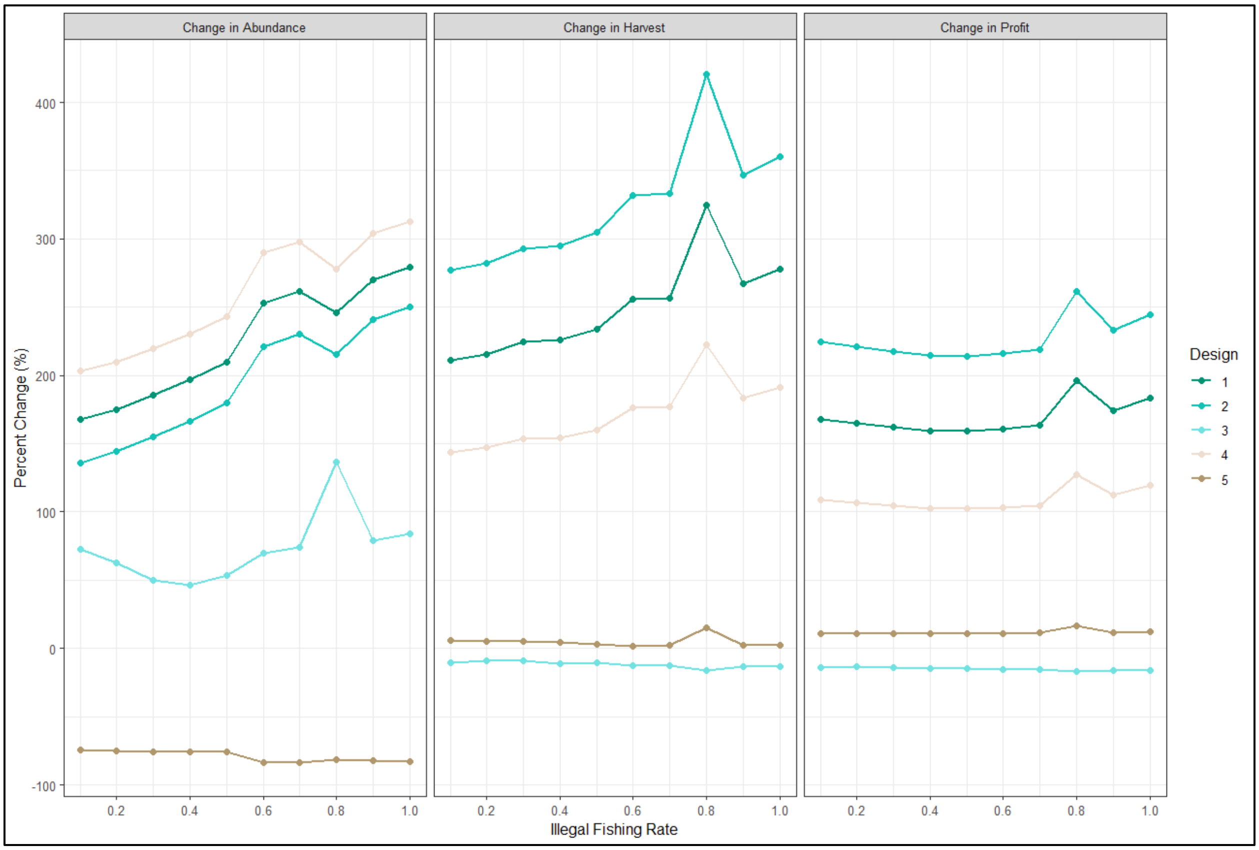

Figure 6. Sensitivity analysis of illegal fishing rates on change in fish abundance, fisher harvest, and fisher profit. The baseline parameter value used in our simulations was 0.2.

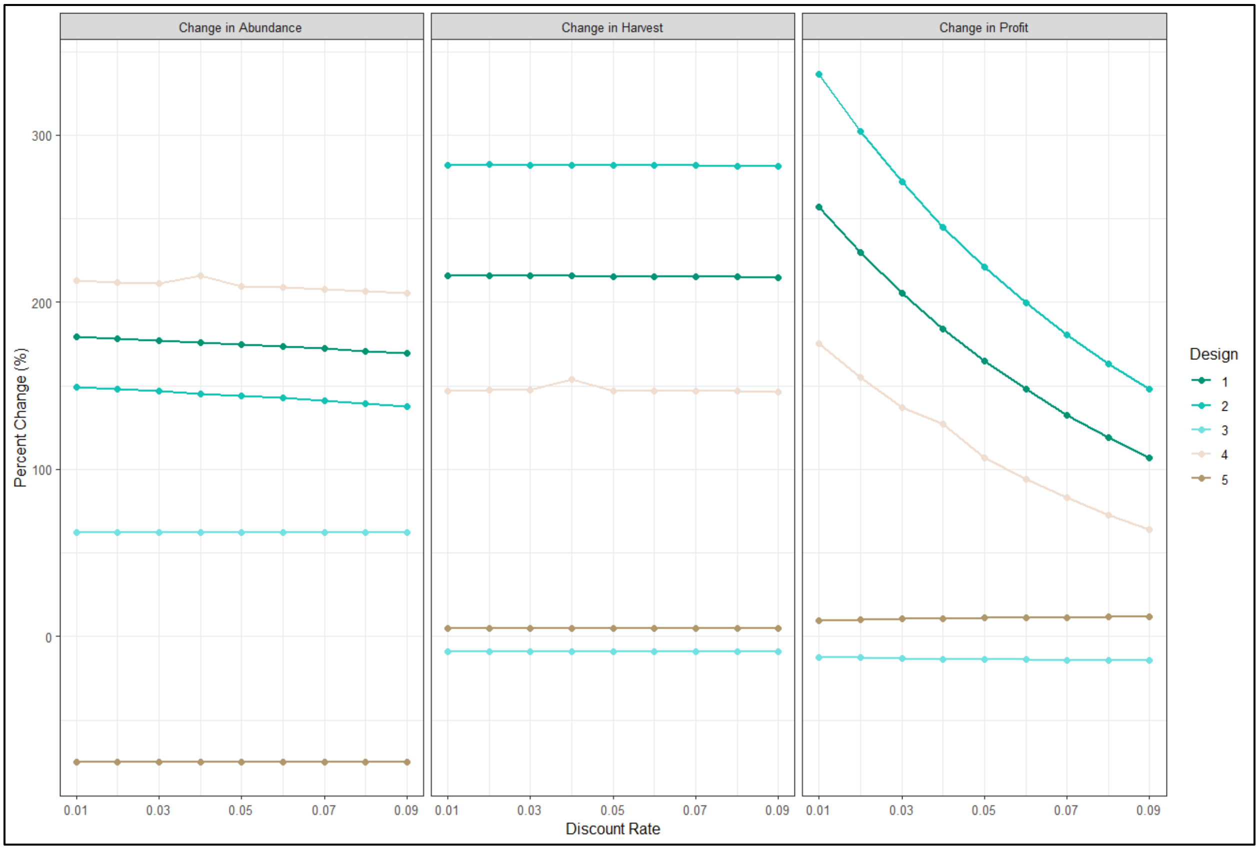

Figure 7. Sensitivity analysis of discount rates on change in fish abundance, fisher harvest, and fisher profit. The baseline discount rate value used in our simulations was 0.05.

Discussion

Of our five scenarios, we recommend implementing TURFs over El Corredor community fishing grounds in conjunction with NTRs. Under scenario 1 where NTR sizes are maintained, fish abundance, fisher harvest, and fisher profit all exhibit large positive percent changes compared to the status quo. TURFs will exclude non-community fishers, reducing fishing pressure on *L. peru*, and allow the population to grow. At the same time, El Corredor fishers' harvests and profits are higher when there is less competition over the harvest of *L. peru*. Under scenario 4 where NTRs are larger, there is a slightly higher percent change in fish abundance compared to the status quo than in scenario 1. With more areas in place where fishing is prohibited, fishing mortality decreases and allows for the fish population to grow. However, expanding reserves reduces available fishing grounds, reducing fisher harvest. It may also require fishers to exert more effort to catch the same amount of fish, negatively impacting profits.

TURFs are most effective when their management is driven by the local fishers. We conducted this analysis with the assumption the nine communities fishing in El Corredor can work together to manage this TURF area. Because many community-designated fishing areas overlap within El Corredor, fishing communities must collaborate to ensure TURFs can provide maximum benefits. One solution to this is leaving the community fishing ground boundaries as is. Another is through creating pooling systems such as that of the sakuraebi fishery in Japan (Aceves-Bueno et al., 2020; Uchida, 2017; Uchida & Baba, 2008). Under this system, El Corredor fishers will continue to develop fishing regulations through their cooperatives but all revenues from harvests are pooled. After deducting costs such as handling and storage fees, the revenue is distributed to vessel owners and crew based on some agreed upon ratio. Although this may lead to issues of free-loading, a pooling system reduces the race-to-fish between fishers.

A limitation of our model is that it assumes logistic population growth within a closed system. In a real-world situation, environmental conditions can affect survival rates of individuals and population growth. When determining population size at each time step, our model accounts for legal and illegal harvest but not for natural mortality or mortality as a result of predation. The assumption of population growth occurring within a closed system does not translate outside of the model environment. When fish leave a patch, it is assumed the same number of fish enter it, creating a net zero increase of fish. However, replenishment within an area is inconsistent and depends largely on availability of resources. We also did not build age-structure or habitat association as a result of age into the model, which is important for a species such as *L. peru* that exhibits ontogenetic shifts in habitat and is targeted at multiple life stages. Being able to put different weights on various habitats as they correspond to fish life stage may change fish abundance and harvest as some areas may be more important than others at different points in time. Mangrove forests are believed to be key nursery habitat for juvenile *L. peru*. As spawning adults, seamounts are where large numbers of fish aggregate to reproduce. Because there is a market for juvenile and adult red snappers, we accounted for both habitats in our model but generalized their importance. We included mangrove forests but classified them as areas with low densities of *L. peru* to account for juveniles who are late to leave these areas for rocky reefs. In adults, we classified seamounts as a secondary high-use habitat to put more weight behind the importance of this habitat. Although *L. peru* spend most of their time in rocky reef habitats, seamounts are crucial to their life cycle. This exclusion of age-structure consideration may also impact the effectiveness of NTRs. Without consideration of habitats critical to different life stages, the protections granted by NTRs cannot be fully utilized.

Unexpectedly, NTR presence had little impact on fish abundance while TURFs seemed to affect abundance the most. With a home range of 3 km, most existing NTRs do not fully encompass *L. peru* movement. Even when NTRs were expanded in our analysis, there were no substantial differences in fish abundance between a scenario and the status quo. Additionally, El Corredor fishers target multiple finfish species. When designing NTRs, fishers may not have placed them in areas that would maximize protections specifically for *L. peru*. One such area would be seamounts where fishers primarily target the fish during their spawning season when they aggregate but no existing NTRs protect seamounts. However, even when NTRs were expanded in our analysis to include a seamount then used in conjunction with a TURF, fish abundance does not increase very much. They may not effectively protect *L. peru* where they are most vulnerable, but these NTRs can provide refuges for other targeted finfish species, especially if they are expanded. Although larger NTRs can benefit fish populations, they can have negative impacts on fishers. If more areas are closed to fishing, fishers are limited to fishing in smaller areas and may begin to exert more fishing effort, increasing the cost to fish, and cutting into profit margins. With El Corredor fishers who visit the same fishing areas within their communities' designated fishing grounds, this could potentially put more fishing pressure on specific areas known to have fish and potentially lead to overexploitation.

In addition to testing the sensitivity of our parameters, the sensitivity analysis also provided some insight on how TURFs and TURF-reserves may affect abundance of other fish species, fisher harvest, and profits. TURF-reserves may be more beneficial to fishers for fish with smaller home ranges than *L. peru* but not for fish with larger home ranges such as tunas or sharks. We assumed a low illegal fishing rate by non-community members in our model but that may not actually be the case in El Corredor. Even if illegal fishing rates are higher than we assumed, implementing TURFs will exclude groups thought to be illegally fishing. This exclusion reduces fishing pressure on fish stocks and allow fish populations to increase, which in turn increases the amount of fish for fishers to catch. Another assumption we made in our model was for the discount rate and how fishers prioritized long-term gain (low discount rates) over short-term gain (high discount rates). If El Corredor fishers implement TURFs and fish conservatively, they will see higher profits in the future.

Conclusion

Establishing TURFs in small-scale fisheries may be an effective way to ensure plentiful resources for fishers while addressing issues of overcapacity. Within El Corredor, TURFs will exclude industrial and non-community fishers while preserving the right to fish for small-scale fishers. Another option is to implement TURFs and expand existing NTRs. Larger NTRs can be increase the *L. peru* stock and that of other targeted finfish species by providing areas of refuge free from fishing pressure. However, this may come at the expense of fishers by reducing fishing area sizes, impacting harvest and profits.

If El Corredor fishers were to implement TURFs, they would need to collaborate on their management. They will need to collectively agree on the boundaries of each community's fishing grounds and how to enforce those boundaries. They may choose to maintain existing community fishing grounds or merge all areas together and form a pooling system like that of the Japanese sakuraebi fishery. Enforcement will be another topic of discussion for who will be leading enforcement efforts, how will it be funded, and, in fishing areas used by multiple communities, how to differentiate who can fish there.

This work is just an initial step in evaluating the efficacy of TURFs for El Corredor's small-scale finfish fisheries but can be expanded to other regions as well. Future work can include using TURFtools to assess how fish abundance, fisher harvest, and profit change with different finfish species or when looking at more than one species in each model run. Small-scale fishers target multiple fish species and this diversity should be represented in future studies. Regardless, our results will provide El Corredor fishers with information on the potential benefits of establishing TURFs and the knowledge necessary to make informed management decisions.

Acknowledgements

Thank you to our partners at Sociedad de Historia Natural Niparajá, in particular Ollin Gonzalez and Salvador Rodriguez Van-Dyck, for their information on El Corredor fisheries and our habitat maps. Thank you to my thesis committee consisting of Erendira Aceves-Bueno and Anne Beaudreau for your support throughout this project.

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