Spatial Adaptive Mechanisms of Small-Scale Artisanal Fishers in Nayarit, Mexico

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A thesis submitted in partial fulfillment of the

requirements for the degree of

Master of Marine Affairs

University of Washington

2024

Committee:

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Program Authorized to Offer Degree:

School of Marine and Environmental Affairs

University of Washington

Abstract

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Small-scale artisanal fishers (SSF) in Nayarit, Mexico, are vital for coastal community wellbeing. These fisheries have been historically challenging to monitor due to the nature of small-scale fisheries. My research focuses on using local ecological knowledge (LEK) of artisanal fishers from the region to fill gaps in knowledge about the management and well-being of these fisheries, particularly the spatial distribution of fishers within this region over several decades. Maps of the artisanal fishing grounds were produced, and an analysis showing differences in community spatial adaptation over time was also created. My work shows that artisanal fishers in this region are utilizing spatial adaptation mechanisms to cope with changes within the fishery; fishers have chosen to use fishing grounds that expand outside of their traditional ranges. This work shows the importance of LEK in managing small-scale fisheries and how fishers can use movement to adapt to changes within their environment.

1. Introduction:

Small-scale artisanal fisheries (SSF) are essential for the livelihoods of people in coastal communities globally, with most of all catches within SSF being consumed within the community (Canty & Deichmann, 2022). SSF also generate revenue for approximately 22 million small-scale fishers, producing over 274 billion dollars annually (FAO, 2012; Cheunpagdee et al., 2019). Because of this, small-scale fisheries are an essential factor in food security and economic stability globally (Kelleher & Mills, 2012; FAO, 2024).

In Mexico, small-scale artisanal fishing generally comprises multipurpose vessels under 12 m, with the most common vessel being a 7 m open-deck, fiberglass vessel with an outboard motor called a panga. (FAO 2024; Cruz-Gonzalez et al., 2018). Unlike most large-scale, industrial fisheries, small-scale fisheries are typically multi-species; this gives small-scale fishers more flexibility to fish year-round (Ojeda-Ruiz et al., 2019). Along with fishing for multiple species, small-scale artisanal fishers have been shown to undertake fishing trips of one to two days, hauling and placing gear themselves; this limits them to areas closer to shore for their catches (Cartamil et al., 2011). Typical gear for artisanal fisheries includes gill nets, handlines, and spears (McClanahan, 2004). Specifically, SSF comprise 40% of national fish production and 93% of the total fleet in Mexico (CONAPESCA, 2014; FAO, 2024). These fisheries employ hundreds of thousands of fishers within the country (CONAPESCA, 2014; FAO, 2024). These small-scale fisheries are complex systems incorporating human interactions into nature, leading to individual, collective, and governance interactions (Ojea et al., 2020). Therefore, looking at these systems as social-ecological systems (SES) at the individual and community levels is essential to understand how the system responds to environmental changes.

Despite the importance of small-scale artisanal fisheries, the nature of these fisheries makes them extremely hard to manage and monitor. In addition, several factors threaten the productivity of SSF and local coastal economies (Pecl et al., 2017; Leibbrandt et al., 2021; Allison et al., 2009). These factors include overfishing, poor management practices, and habitat destruction (Monroy et al., 2011). Recently, scholars have also documented the impacts of anthropogenic-driven climate change on coastal ecosystems, such as sea level rise (Kulp & Strauss, 2019), sea temperature increases (Cheng et al., 2019), and ocean acidification (Cattano et al., 2018).

On an individual and community level, fishers have three main avenues of responding to changes within the fishery: coping, adapting, and transforming (Chuenpagdee & Jentoft, 2015; Millan, 2019; Ojea et al., 2020). These three strategies help fishers sustain livelihoods and alleviate poverty amidst stressors (de Coninck et al., 2018; Galappaththi et al., 2021) and have been observed at the individual, collective, and governance levels of SSF. Depending on the response and strategy, fishers can either accelerate the negative impacts of climate change or generate higher levels of sustainability within the fishery (Bernos et al., 2021). Understanding these strategies within specific fisheries is vital to better managing and sustaining small-scale fisheries (Bernos et al., 2021; Barboza et al., 2024).

Coping mechanisms involve responding to disturbances through short-term actions that use already available skills, resources, and experiences (Ojea et al., 2020). Examples of coping mechanisms for small-scale fishers include borrowing money from community members or temporarily shifting to rely upon a second source of income, such as child labor (Ojea et al., 2020).

Adaptive mechanisms offer fishers a way to adjust to immediate changes in their operating environments. Adaptation strategies are defined as incremental changes within the fishery, with alterations in the existing behaviors that allow the fishery to absorb external impacts (Ilosvay et al., 2022). Examples of adaptation strategies include targeting new species, changing gear, modifying fishing ground locations, and restructuring assets (Galappaththi et al., 2021; Galappaththi et al., 2019; Joarder & Miller, 2013; Deb & Hague, 2017; Ojea et al., 2020). A critical form of adaptive strategy involves mechanisms of spatial adaptation, such as changing fishing grounds.

Compared to coping and adaptive responses, transformative responses within a fishery are usually classified as the most drastic approach; fishers are most likely to choose this response after exhausting all adaptation and coping strategies, with transformation strategies correlated with exiting the fishery (Salgueiro-Otero et al., 2022). Because of their overall nature, transformative actions are the easiest to identify, with transformative strategies usually involving activities that "can alter current social-ecological system structures and aid in creating new systems or futures" (Salgueiro-Otero et al., 2022). Examples of transformative strategies include diversifying livelihoods or migration to other regions (Ilosvay et al., 2022).

This study explores how artisanal fishers in Nayarit have historically used spatial adaptation to address changes in the distribution and abundance of their targeted fish populations. Previous research suggests that small-scale fisheries typically operate within confined spatial boundaries that may fluctuate seasonally (Gonzalez-Mon et al., 2021). However, emerging evidence indicates that these boundaries may expand as fishers venture further offshore to maintain their catch rates (Young et al., 2019). Understanding this shift is crucial for assessing how local communities respond to ecological changes and what this implies for the sustainability of their livelihoods and marine ecosystems.

This region of Nayarit is classified as a climate change hotspot, being in the 90^{th} percentile and above for climate change hazard exposure (Ilosvay et al., 2022). This region has experienced an increase in intense marine heatwaves and tropical storms (Ilosvay et al., 2022). Historically, this region had an abundance of marine fauna. Large cetaceans, turtles, and large fish were frequently found in this region, but now they are scarce (Sala et al., 2004). Human use of the inshore and coastal regions has been documented in this region before the Spanish occupation, with the west coast serving as an essential food source through mollusk harvesting (Scott, 1968; Rubio-Cisneros et al., 2017). The exploitation of this region through resource extraction has been documented ever since (Rubio-Cisneros et al., 2017). Fishing and human coastal activity in this region continued to increase, with a documented rise in the overexploitation of finfish beginning in the 1950s (Cruz-Torres, 2001; Rubio-Cisneros et al., 2017). Climate change, along with overexploitation, may be factors causing the possible spatial adaptation of fishers in this region. To figure out if these factors could be causing fishers to utilize spatial adaptation, two research questions were investigated.

My research questions are twofold: 1) Have artisanal fishers in Nayarit adapted to changes in fishery resources through spatial adaptation, specifically by extending the range of their fishing activities? 2) Can we identify patterns in these movements, both offshore and alongshore, to better understand the dynamics of their spatial strategies?

To answer these questions, local collaborators interviewed six communities of Nayarit, Mexico: Boca de Asadero, Boca de Camichín, Chacala, La Cruz de Huanacaxtle, La Peñita de Jaltemba, and San Blas. Artisanal fisheries are challenging to monitor using traditional methods used for industrial commercial fisheries (Chester & Micheli, 2011). A lack of historical data within the fisheries can complicate the creation of baselines of stock health using traditional data-rich methodologies (Mclean et al., 2020; Boubekri et al., 2022). To offset the lack of formal data on small-scale fisheries in Nayarit, my local collaborators and I documented local ecological knowledge (LEK) through interviews with long-term resource users. Local ecological knowledge is region-specific knowledge that a specific group of individuals develops through direct interactions with the environment or another physical setting (Bundy & Davis, 2013). In this study, LEK allowed me to track spatial and temporal changes in fishing activity over time and possible causes of both positive and negative changes in the fishery (Sala et al., 2004; Ainsworth, 2011; Colloca et al., 2020). By addressing these questions, I aim to illuminate the adaptive strategies employed by these fishers and inform broader adaptive measures for communities facing similar challenges due to climate change.

2. Methods

2.1 Interviews

My local collaborators conducted 102 semi-structured interviews with 85 questions, each using predefined questions with open-ended questions between August and September 2021 (Supplemental Files). Interviewees for the questionnaire were identified by previous researchers and my local collaborators as working in the artisanal fishing industry either full-time or part of the year as a primary occupation at some point in their careers. Initial participants were identified through the help of a local collaborator at the National Fisheries and Aquaculture Institute of Mexico who has worked in this region for decades (Shaff et al., 2023). After the initial participants were interviewed, snowball sampling was utilized, and each interviewee recommended other fishers to interview. For this study, I focused on the following questions from the interviews surrounding their spatial adaptations: “Where did you fish for your primary target species each decade?”, “Where did you fish for your secondary target species each decade?”, “Where did you fish for your tertiary target species each decade?”.

This dataset contains interviews from 102 artisanal fishers, with varying responses per decade. Each fisher had responses in more than one decade, corresponding to the length of their career (Table I).

Survey Respondents by Decade	
Decade	**Number of Respondents**
1960	7
1970	25
1980	38
1990	58
2000	65
2010	83
2020	82

Table I. Number of Interviewees active in the fishery between 1960-2020.

2.2 Data Structuring and Figure Creation

All 102 interviews were systematically processed to create a dataset from the above questions. To identify the fishing grounds of local fishers, my local collaborators chose not to use maps during the interviews, for fishers in this region typically do not conceptualize their traditional fishing areas visually through maps. This was made clear during the interview process, as no fishers mentioned their fishing grounds through coordinates. Instead, in the interviews, fishers explained that they use geological references such as a distinctive rock or bay to identify their fishing grounds. Consequently, maps were found not to be helpful in the interviewing process. Instead, my local collaborators asked fishers for the common names of their fishing sites. I then constructed maps ex-post in the laboratory based on their responses. Given potential name variations to the same site, I eliminated potential duplicates during a workshop with my local collaborators. Once a list of unique fishing grounds was created, I produced maps using three main methods: a) site identification using known geographical features, such as islands or bays, b) expert identification through conversations with my local collaborators, c) information from recreational fishing companies provided on their websites. This last method was beneficial for the location of seamounts, which were identified using maps published in fishing charter websites and sport fishing archives (such as puertovallartafishing.net). This led to the creation of a map that includes 212 fishing grounds (Fig. 1)

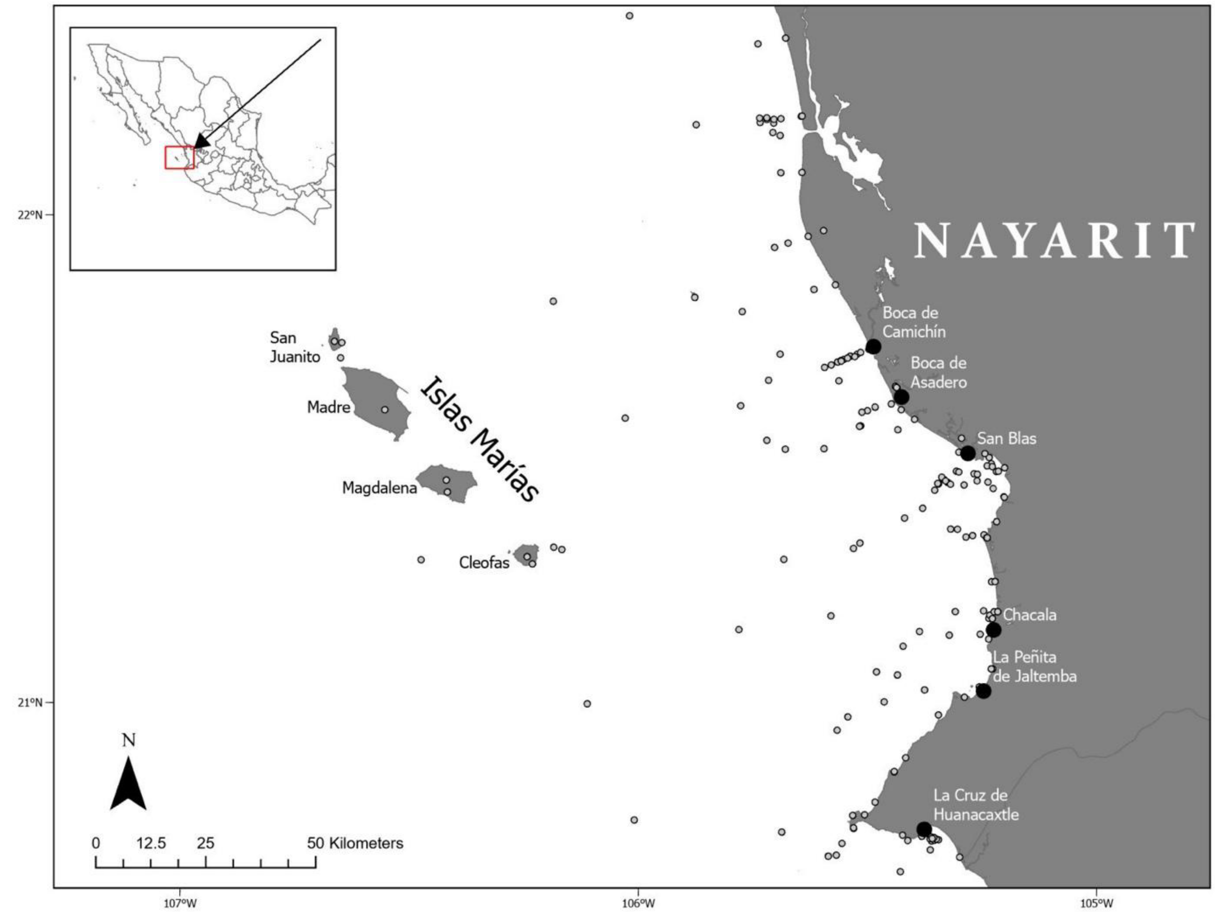

Figure 1. Map showing artisanal fishing grounds.

To process the data from a tabular format to a visual map, statistical analysis tools were used in ArcGIS Pro to create a flow map showing fishing ground locations per decade. To create the flow map, XY coordinates of each specific point were calculated using "Calculate Geometry Attributes". After each point had associated XY coordinates, the XY-to-line tool created lines between interview locations and fishing grounds.

To analyze the data further besides displaying the fishing grounds spatially, Sankey diagrams were created. Sankey diagrams help create meaningful visuals displaying the flow of information through various pathways (Riehmann et al., 2005). For the Sankey diagrams, R studio statistical software, using the “ggsankey,” “tidyverse,” and “NetworkD3” packages, was used to graph each fisher response into two Sankey diagrams: one showing the max fishing distance from shore per individual fisher and another showing fisher movement per community per decade (Fig. 1).

3. Results

From 1960 to 2020, artisanal fishers exhibited various movement patterns from shore (Fig. 2). One unexpected trend shown in my results is that fishers reported fishing as far as 110 km to the furthest Islas Marías island, San Juanito, as early as the 1970s (Fig. 2). From my results, it appears that fishers utilizing further distances switched to using Islas Marías as fishing grounds from the 1960s to 1970s. This can be seen directly in my results with all fishers switching from 20-30 km (bottom purple flow in the 1960s) to 90-100 km (light orange box in the 1970s column) between these two decades (Fig. 2). Interestingly, the fishers who switched to fishing in these faraway locations at Islas Marías were also indicated to fish the farthest in the 1960s. This proportion of fishers stayed steady throughout the decades, from 1970 to 2020; the only deviation from this pattern can be seen starting in the 1990s, with flows of fishers shifting from fishing at Islas Marías to other locations closer to shore (Fig. 2). This can be seen directly in the figure through flows of fishers in the 90-100 km category (light orange) going to the 0-5 km (dark grey/black box), 5-10 km (light grey box), and 10-20 km (dark purple box). Up until the present day (2020s), light orange flows and light yellow flows can be seen leading to the same, closer-to-shore distances (dark grey/black, light grey, and dark purple), indicating that fishers continued to move closer to shore in the following decades after the 1990s (Fig. 2).

Another pattern shown in my results is a steady proportion of fishers reporting a very small maximum distance from the coast; this is evident in my results by the large percentage of fishers in the 0-5 km (dark grey/black color) category that stays constant through all decades (Fig. 2). My results demonstrate little direct exchange between the close to shore and far from shore groups (dark grey/black for the close to shore group and orange/yellow for the furthest away groups), showing that fishers show little preference for switching their fishing grounds by extreme distances (Fig. 2).

The most striking result in Figure 2 is the emergence of fishers utilizing sites between 30 and 70 km. Beginning in the 1990s, fishers reported using fishing grounds in these middle distances, and with each decade, the number of fishers reporting utilizing these sites increased. Overall, my results from Figure 2 suggest that fishers are stable in their distance from shore, with some notable changes occurring in the distances between Islas Marías and the shore.

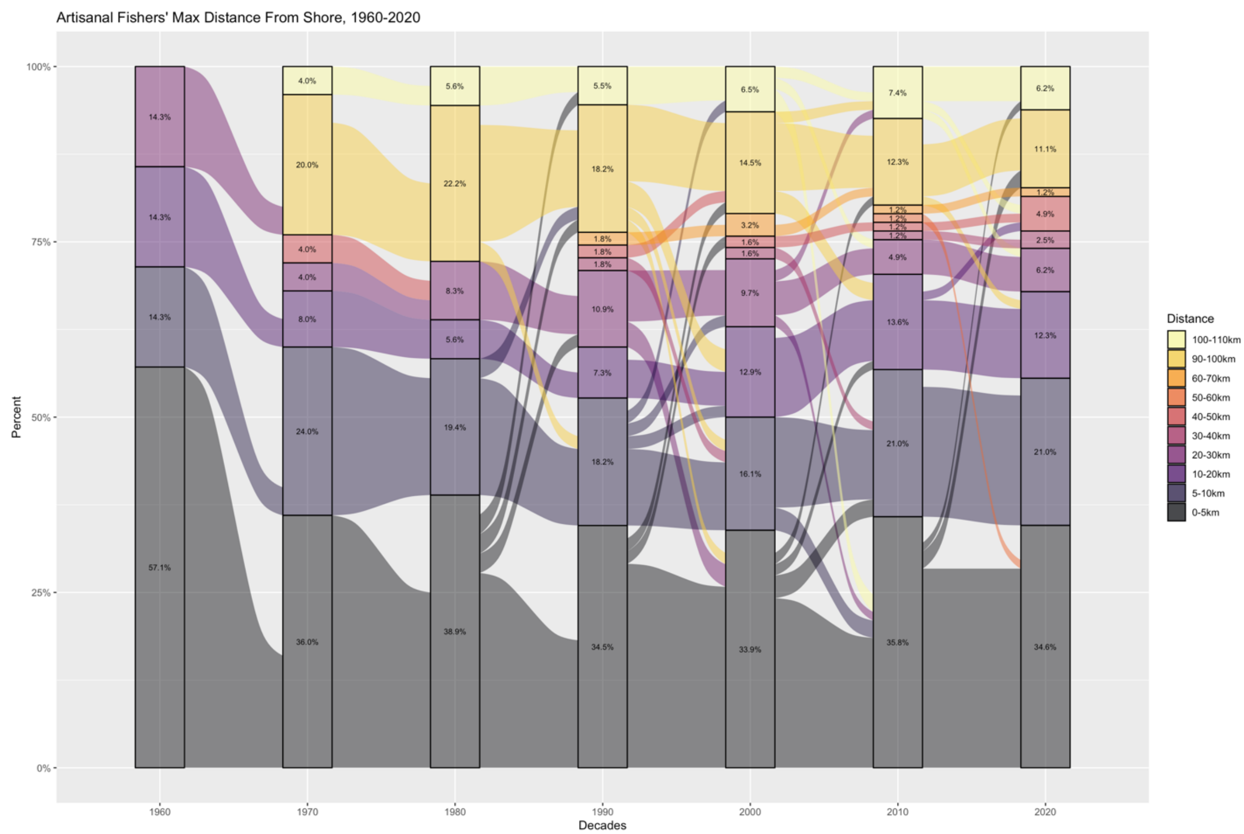

Figure 2. Artisanal fisher max distance from shore from 1960-2020. Each decade is represented by a column, with percentages displayed within each colored box, showing the proportion of fishers in each distance category. Lines between columns show the movement of individuals.

Figure 3 shows fisher movement along and from the coast by community. Within and between each decade, each community has notable differences in the movement of fishers. The first notable result that can be seen in the figure is the sudden appearance of fishers traveling to Islas Marías from La Cruz de Huanacaxtle (orange). La Cruz de Huanacaxtle had the most significant number of fishers fishing at Islas Marías throughout all the decades, and fishers from this community can be seen constantly fishing near the islands from the 1970s onward (Fig. 3). Although fishers from other communities responded that they began fishing at Islas Marías, no other community had as strong of a presence at the islands compared to La Cruz de Huanacaxtle, as seen in the flow map.

Another notable result in the flow map is the emergence of San Blas fishermen in areas between Islas Marías and the coast. Fishers from San Blas can be seen fishing these new grounds en masse starting in the 1990s, and the number of San Blas fishers (brown lines) in these areas stayed strong from that decade onward (Fig. 3). This supports what was seen in Figure 2, with the emergence of 30-70 km fishing grounds in the 1990s, with a slowly increasing proportion of fishers responding that they began traveling to fishing grounds at these distances.

The flow map also shows the expansion of fishers from Boca de Asadero and Boca de Camichín into new fishing grounds north of the two communities. This can be seen in the figure through the emergence of a large number of blue and yellow lines in the northern part of the map, increasing with each passing decade (Fig. 3). This result in the figure also indicates that in the 1980s, 1990s, and 2000s, fishers from Boca de Asadero (blue lines) can be seen venturing further north than fishers from Boca de Camichín (yellow lines), even though Boca de Camichín is further north than Boca de Asadero (Fig. 3). While fishers from these two communities began expanding their fishing grounds north, a slow decline of fishers from both communities responding that they fished at Islas Marías can be seen in the same decades (Fig. 3).

One last glaringly apparent result from Figure 3 is the prevalence of fishers from Chacala fishing only near the shore. From the map, few, if any, fishers from this community responded that they fished any of the furthest distances on the map. Fishers in this community prefer to stay closer to the coast than any other community.

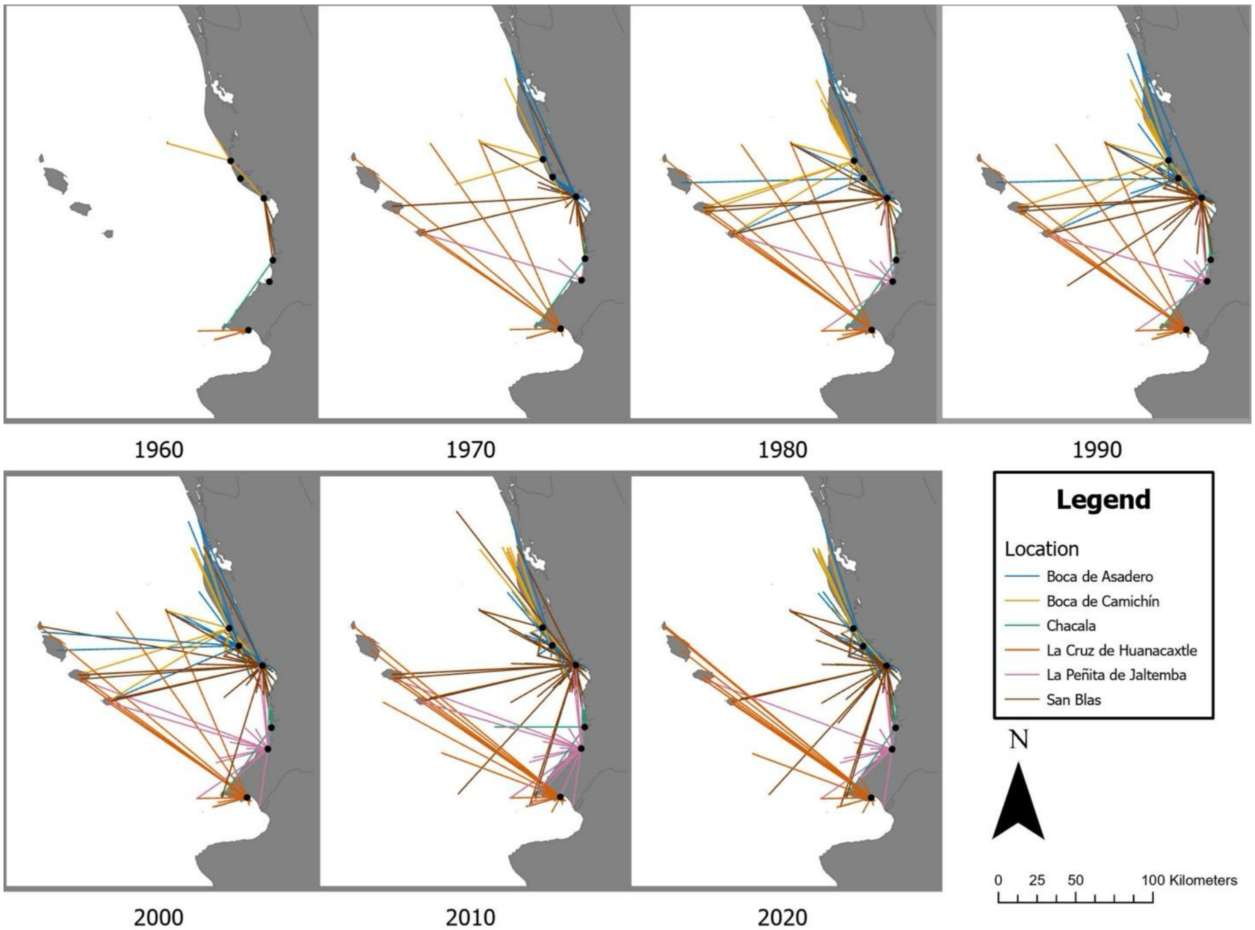

Figure 3. Flow map showing the distance from the shore of fishing grounds for artisanal fishers from 1960 to 2020. Each line represents a different fisher response, with each color representing a different community: blue (Boca de Asadero), yellow (Boca de Camichín), green (Chacala), orange (La Cruz de Huanacaxtle), pink (La Peñita de Jaltemba), brown (San Blas).

4. Discussion

My results support the idea that artisanal fishers in Nayarit have used spatial adaptation mechanisms and have had to diversify their fishing grounds over time. The movement of artisanal fishers to different fishing grounds could be due to various factors, including changes in targeted species abundance due to climate change and stock depletion (Gonzales-Mon et al., 2021).

Initially, I hypothesized that fishers would only begin using the furthest away fishing grounds in recent decades. Figures 2 and 3 show that artisanal fishers in La Cruz de Huanacaxtle occupy fishing distances up to 110 km offshore to the furthest Islas Marías island, San Juanito, as early as the 1970s. This long-distance fishing practice of this community can obscure a general trend showing movement further from the coast for the rest of the communities. If fishers who travel to Islas Marias continually throughout all decades are treated as a constant, then an increment in the use of areas 30-70 km from shore through time of fishers from other communities can be observed, especially in Figure 3. Therefore, I conclude that using distance from shore as a metric for adaptation without factoring in traditional fishing patterns could lead to an underestimate of changing patterns near the coast, as some fishers have not changed their fishing grounds in decades, but their traditional fishing grounds are farther away than other communities.

According to the original interviews, fishers from La Cruz de Huanacaxtle mainly target *Thunnus Albacares* (Yellowfin Tuna) and *Lutjanus Peru* (Pacific Red Snapper). 20 out of 23 interviewed fishers from this community had red snapper or tuna as their primary target species. The Yellowfin Tuna near Islas Marías is renowned for its large size and, thus, high value (Jurado-Molina et al., 2022). Pacific Red Snapper is also a high-value species and can be found near the islands (Tholan et al., 2020). Therefore, it is plausible that the high prevalence of tuna and high value of red snapper mentioned as a target species in this community could explain why fishers in La Cruz de Huanacaxtle shifted to having Islas Marías as a fishing ground from the 1970s onward. If fishers from La Cruz de Huanacaxtle are treated as outliers to the data, then my results match the overall prediction and consensus in the literature that fishers are moving further from shore to either follow their current target species or to target new species to catch (Bell et al., 2018; Deb & Haque, 2017; Galappaththi et al., 2021). This can be seen in the movement of fishers from other communities to regions further from shore in Figures 2 and 3. The movement of fishers away from the shore is especially clear in San Blas (brown) and La Peñita de Jaltemba (pink) fishers in Figure 3, beginning in 1980 and increasing into the 2020s (Fig. 3).

Small-scale fisheries in Mexico have been shown to have higher fishing activity as the decades have progressed, leading to over-depleting resources (Cinti et al., 2014). Higher effort of fishers to compensate for the lack of species and heightened competition is one factor leading to the depletion of stock, which could be one possible explanation for fishers stating that they were forced to move fishing grounds (FAO, 2024; Gough et al., 2020).

More specifically, the shift of artisanal fishers in San Blas to fishing locations farther from shore could be correlated with the rise of shrimp aquaculture in the region and land-use changes causing pollution in the marine estuaries surrounding the town. Anthropogenic land-use change, specifically through shrimp aquaculture, has been documented to account for approximately 1900 hectares of land being altered for use for shrimp production between the years 1992 and 2001 (Berlanga-Robles & Ruiz-Luna, 2006). The amount of land used for shrimp aquaculture in this region has increased, with an estimated total of 14,428 hectares in 2020 (Noguera-Muñoz et al., 2021). Shrimp aquaculture, in general, has been linked with the release of pollutants into nearby waterways (Páez-Osuna et al., 1998). In this region, it appears that fishers are aware that shrimp aquaculture has led to heightened pollution of estuaries, given that three fishers specifically cited that they changed target species due to shrimp farm runoff into estuaries.

However, as Figure 2 shows, the proportion of fishers using Islas Marías appears to decrease slightly in the 1990s and 2000s, with many fishers opting to move to different fishing grounds closer to shore. Fisher responses and the history of the Islas Marías islands may explain this observation. From 1905 to 2019, a Mexican federal prison occupied one of the islands, Islas Marías Madre (Tholan et al., 2018). The constant prison monitoring during these decades led to the area acting as a marine reserve before officially becoming a biosphere reserve in 2003 and a UNESCO heritage site in 2007 (CONANP-SEMARNAT, 2010; Shaff et al., 2023).

The prison and the subsequent monitoring of Islas Marías Madre have been cited to scare some fishers away from going to this location, as well as the closest neighboring islands, with some saying that they switched from fishing near the archipelago altogether due to fear of being caught (Appendix). However, due to the federal penitentiary being located only on Madre, fishers have been able to take advantage of the further islands for fishing, such as San Juanito. During the interviews, the monitoring of the islands was not cited as a concern by the fishers until the 1990s. In my results, there were large flows of fishers who moved from fishing near Cleofas to other locations closer to the mainland (Fig. 2). The proportion of fishers shown to have fished near Cleofas and Madre decreased in the 2000s, relative to the 1990s and 2010s (Fig. 3). This flow of fishers could be explained by the formal designation of the archipelago as a biosphere reserve, which created more formal monitoring of the islands besides prison authorities around Madre (Shaff et al., 2023). Fishers could have also been discouraged from using this area as a fishing ground due to new, more formal tourism plans through the construction of the Islas Marías Tourist Center and partnerships between the Mexican government and tourism companies (Mega et al., 2019).

My results also showed that many fishers prefer to stay near the shore. Two main factors could explain the strong presence of fishers staying near the coast: a) technological limitations and b) the high productivity of coastal ecosystems.

Small-scale artisanal fishers have a wide array of gear at their disposal, but the sophistication of the technology they use to catch their gear is often simpler than that of large-scale industrial fisheries (Schuhbauer et al., 2019). SSF usually employ gear that can be carried by hand to fishing locations, such as gillnets, hook and line, traps, and longlines (Finkbeiner, 2015). Gear, combined with boat accessibility, limits these fishers to specific regions if they cannot access different gear (Schuhbauer et al., 2019; Finkbeiner, 2015). This could explain why most fishers have chosen not to move further from shore; they do not have the correct gear that would allow them to go further. It appears that fishers in this region either do not want to or cannot switch fishing gear.

Also, in this region, many coastal estuaries and wetlands are formed by the presence of many major rivers leading to the Pacific Ocean from inland regions (Berlanga-Robles & Ruiz-Luna, 2006). Marine estuaries and coastal wetlands support high habitat diversity and biodiversity within the ecosystem (EPA, 2024; Liu & Cameron, 2001). Because marine estuaries are one of the most biologically productive ecosystems on Earth (EPA, 2024), a strong presence of artisanal fishers in this region is expected. Specifically, the large coastal wetland in this region is Marismas Nacionales; located in the southern region of Sinaloa and northern region of Nayarit, Marismas Nacionales is one of the most extensive wetlands in North America that borders the Pacific Ocean (Flores-Verdugo et al., 1997; Rubio-Cisneros et al., 2017). This region has diverse ecosystems, including beaches, coastal dunes, lagoons, and mangrove forests

(Lithgow et al., 2019). This highly biodiverse and productive region could also explain why many fishers have not moved away from the coast.

Despite the highly productive coastal ecosystem, the movement of some fishers away from this region could be explained by the increased overexploitation of the coastal ecosystems in this region, combined with the adverse effects of climate change. This mix of anthropogenic-caused climate change and direct human interaction with the ecosystem has led to the degradation of the local coastal ecosystem. Increased fishing efforts in this region beginning in the 1980s have directly been linked to decreased landings of primary target species of many artisanal fishers in this region, such as red snapper (Rubio-Cisneros et al., 2017).

Overall, some fishers exhibited diversification of fishing locations and mobility between sites, with others staying at the same locations throughout their careers. My result showing fishers diversifying and moving fishing grounds is reinforced by fisher responses to why they changed fishing sites, with most fishers who added or changed sites through the decades saying that they started to alternate between fishing locations (Appendix). This supports past literature stating that fishers may move outside of their traditional fishing grounds in response to stressors; changing to be highly migratory spatially and expanding their fishing grounds can help fishers with declining target species abundance (Cudney-Bueno & Basurto, 2009; Ilosvay et al., 2022). Unfortunately, fishers changing to be highly migratory and having more fishing grounds can also lead to an exacerbation of overfishing effects and can lead to maladaptation in the long term (Ilosvay et al., 2022; Abel et al., 2016). My results indicate that fishers have not entirely abandoned any fishing locations but have added to the number of sites they visit.

In their current state, artisanal fisheries in Nayarit, Mexico, have displayed resilience to the effects of climate change and other outside forces. Fishers having the capability to react and respond to changes in the fishery show that spatial adaptation strategies are currently feasible for many fishers. However, due to the nature of small-scale fisheries and the available resources to fishers, the extent to which spatial adaptation will be helpful to artisanal fishers in Nayarit, Mexico, in the future is unknown. Given that the middle distances between Islas Marías and the mainland still need to be utilized compared to fishing grounds close to shore, this may be due to a lack of target species in these areas or that fishers do not need to use these grounds as much. The spatial adaptive response of fishers has helped to maintain the status quo. Still, unfortunately, due to the nature of these fisheries, this adaptation is likely to lead to overexploitation and an unsustainable catch rate of species (Ojea et al., 2022).

Without local ecological knowledge from the fishers, previously unknown information about the fishery catch rates and fishing grounds to support this observation would be impossible to surmise. Traditional monitoring of small-scale fisheries in this region is scarce, so this knowledge is the best way to discover trends within the fishery that have occurred since the 1960s (Shaff et al., 2023). This is especially important because my results show that fishers have used spatial adaptation since the 1960s. Given that this fishery is located in a climate change hotspot, this information is vital for new management strategies in the face of climate change (Ilosvay et al., 2022). However, this study did have two limiting factors. This study's most prominent limiting factor is the limited sample size of fishers within the 1960s and 1970s. The small number of responses for the earliest decades was expected due to the time between the 1960s, 1970s, and now. Another limiting factor for this study is also recall bias. Because many participants were asked about fishing activities in their careers as early as the 1960s, some details may have been forgotten or not accurately remembered (Shephard et al., 2021). Despite these two factors, LEK of the fishers in this region gathered in this study and beyond will be vital to maintain and monitor fishery health in the future (Shaff et al., 2023).

The outputs of this study that used LEK to create maps of artisanal fishing grounds are beneficial for future coastal zone management decisions on the western coast of Nayarit (Grati et al., 2022). Because fishers in this region depend on locally known and named geographic features to navigate to their fishing grounds, it can be difficult for those outside the fishery to know where fishing grounds are located. Maps showing traditional fishing grounds and maps documenting changes in said fishing grounds over time can assist external stakeholders in creating a baseline of health for small-scale fisheries (Jankowski, 2009). Establishing a baseline of past and current fishing grounds can help prevent further overexploitation of the fishery, promoting higher levels of sustainability for both the fishery and coastal ecosystem (Grati et al., 2022). These maps also help convey important information about the fishery to public authorities, which helps create more information-driven decisions to help regulate fisheries practices in this region (Jankowski, 2009).

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APPENDIX

Study Site Location

Reasons Cited For Fishers Relocating Their Fishing Grounds, 1960-2020	
Reason	**Number of Fishers**
Became old enough to fish further from coast	1
Began alternating between more than one location	4
Began fishing less due to age	3
Changed target species	2
Climate change	1
Competition with other fishers	4
Couldn't get gear anymore	1
Dams constructed near fishing site	1
Fishing location was no longer profitable	4
Found more productive site	2
Had to fish further from coast	1
Islas Marias surveillance	3
Target species became scarce	3
Total	30

Responses of Fishers explaining why they relocated their fishing grounds.