Social equity in shore-based fisheries: identifying and understanding barriers to access

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Abstract: Understanding fishing access and social outcomes, including potential inequities, is essential for fisheries managers to develop more holistic management strategies that balance desires for all stakeholders. For shore-based fisheries, which support many lower income and subsistence anglers, fishing opportunities and outcomes are influenced by multiple socio-environmental factors. Drawing from a theoretical framing in social equity, this paper aims to examine the following questions: 1) Who is shore fishing in Key West, Florida; 2) What motivates anglers to participate in shore fishing; and 3) Is there social equity in shore fishing? More specifically, is there equal a) access to natural resources, b) amount of space allocated to individuals or groups, and c) representation of stakeholder groups in participatory conservation and decision-making? To answer these questions, we conducted 105 creel intercept surveys in Key West, Florida from June to August 2019. Our findings showed that low-income fishers and Black shore fishers were less satisfied with fishing access and regulations than higher income or white fishers and more likely to be fishing for subsistence. Low-income fishers and people of color were more likely to be fishing along natural mangrove shorelines compared to seawalls or piers. The most reported barrier to shore-based fishing was fishing access, and barriers disproportionately affect people of color and lower income fishers. Collectively, our results demonstrate that three types of inequities including access, spatial, and participation can exist in shore-based fisheries, resulting in both distributive and procedural injustices. Overcoming these inequities will require intentional and collaborative efforts among many key stakeholders including fisheries managers, coastal zone management institutions, and local municipalities.

Keywords: creel intercept surveys, fishing behaviors, shore-based fisheries, shoreline alteration, social-ecological systems, social equity

Highlights:

- Creel intercept surveys were used to examine social equity in shore-based fisheries
- Resource inequities, spatial inequities, and participation inequities were identified
- Low-income and Black fishers were less satisfied with fishing access and regulations
- Barriers to shore-based fishing disproportionately affect people of color and lower income fishers

1. Introduction

Social equity – a fair distribution of opportunities, costs, and benefits across individuals or groups of people – is a widely stated goal of fisheries management (MSFCMA, 2007; Colburn and Clay 2012; Klein et al. 2015; Loomis and Ditton 1993). Social impact studies related to commercial fisheries have a long history (Smith and Clay 2010; Marshall and Marshall 2007; Scyphers et al. 2019; Picou et al. 1992; Pollnac et al. 2001; McCay 1978). Fewer studies, however, have focused on social equity in recreational fisheries, including shore-based fishing. Previous studies on social impacts and inequities in recreational fishing have focused on economic or regulatory influences on subsistence fishing (Schumann and Macinko 2007; Poe et al. 2015) and other catch-related outcomes (Arlinghaus 2006; Beardmore et al. 2015; Anderson et al. 2007). For example, previous studies have highlighted the importance of subsistence fishing for well-being, food security and culture, specifically for marginalized communities including Black and Indigenous fishers (Brown and Toth 2001; Walsey and Brewer 2018; Poe et al. 2015). Comparatively, very few studies consider environmental connections to social equity such as access to natural shorelines for shore-based fishing. Yet, barriers such as coastal development and allocation of resources persist and grow while subsistence fishing is largely ignored in fisheries policy (Harris et al. 2007; Schumann and Macinko 2007). Shoreline condition has been directly linked to the health of fisheries, with natural habitats like marshes and mangroves typically supporting more abundant and diverse fish communities than degraded or developed shorelines (Gittman et al. 2016; Drew and Eggleston 2008; Scyphers et al. 2015). Access to natural coastal habitats could be a useful indicator of social equity for shore-based fishers; however, there is a paucity of literature on the relationship between types of shorelines and the characteristics of fishers.

In contexts beyond fisheries, environmental justice (EJ) literature has widely documented the mental and physical health benefits associated with exposure to healthy and functioning ecosystems, often termed green and blue spaces (Sturm and Cohen 2014; de Vries et al. 2016; Nutsford et al. 2016; Gascon et al. 2015). Social inequities in access to such spaces frequently exist (Wolch et al. 2014; Jenerette et al. 2011; Barbosa et al. 2007; Wendel et al. 2011). Barriers to accessing nature for low-income and people of color include absence of nearby high quality recreational areas, lack of time, family commitments, personal safety, money, language barriers, and lack of transportation (Scott & Kim 1998; Ghimire et al. 2014). EJ studies have also emphasized inequities surrounding subsistence fishing (Corburn 2002; Brown and Toth

2001), food security (McClanahan et al. 2015), and human health (Pulford et al. 2017), with people of color and low-income fishers facing more barriers to blue space access and to good water quality (Dernoga et al. 2015; Pulford et al. 2017).

Previous EJ studies have also highlighted unequal distributions of ecosystem services and disservices associated with water resources for high- and low-income neighborhoods (Harlan et al. 2006; Jenerette et al. 2011; Norman et al. 2012; Palta et al. 2016). Natural shorelines provide a variety of ecosystem services for ecological enhancement with potential co-benefits for people (Gittman et al. 2016; Scyphers et al. 2011, 2015). However, many coastal shorelines have been hardened (armored), which alters the ecosystem function and subsequent services distributed to nature and humans (Gittman and Scyphers 2017; Gittman et al. 2015; Gittman et al. 2016). Little is known about the impacts of shoreline condition on the distribution of ecosystem services across varying stakeholder groups, including those of differing economic status and racial/ethnic identities. Shoreline alteration is not only a potential driver of environmental degradation in shore-based fisheries, but it also has the potential to alter fishing opportunities, outcomes, and satisfaction. A better understanding of access and barriers to green and blue spaces for fishing, particularly in healthy and functioning ecosystems, is needed to overcome legacies of historical injustices and to enhance well-being among fishers from vulnerable populations (McClanahan and Abunge 2015; Fuller et al. 2007).

This research aims to address critical knowledge gaps regarding social equity in fishing access and outcomes in shore-based fisheries. We conducted creel intercept surveys in Key West, Florida and examined the following research questions: 1) Who is shore fishing in Key West, Florida; 2) What motivates anglers to participate in shore fishing; and 3) Is there social equity in shore fishing? More specifically, is there a) equal access to natural resources, b) equal amount of space allocated to individuals or groups, and c) equal representation of stakeholder groups in participatory conservation and decision-making?

Here we operationalize Klein and colleagues' metrics of social equity, including access to resources, space, and participation as measures of distributional and procedural justice from the EJ literature (Klein et al. 2015; Schlosberg 2009). Klein describes access equity as access to natural resources; spatial equity as the amount of space on the landscape or seascape allocated to individuals or groups; and participation equity as representation of stakeholder groups in participatory conservation and decision-making (Klein et al. 2015). Our measures of social equity that correspond to Klein et al. (2015) are described in Section 2.3. Through this research, we aim to gain a better understanding of social equity/inequity in shore-based fisheries with the purpose of providing the best possible science to inform fisheries and coastal management decisions, such as allocations, data collection techniques, and shoreline restoration.

2. Methodologies

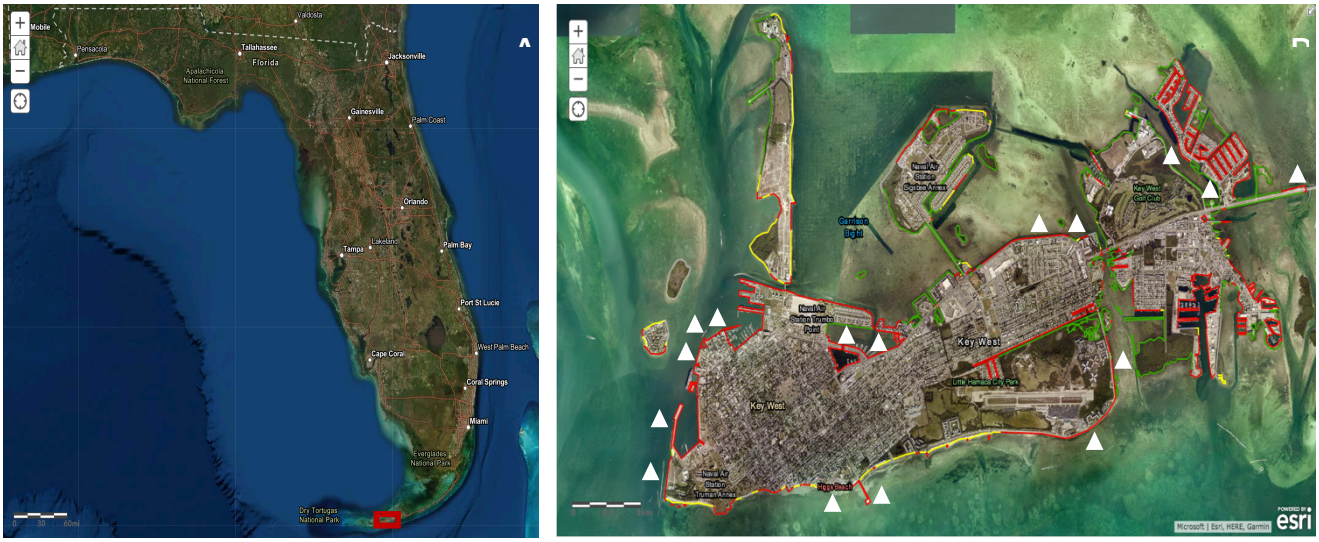
2.1 Study System

Key West, Florida is an ideal location for studying social equity in shore-based fishing because it has variable shoreline types, a diversity of target species, and a sizable recreational fishing community that is comprised of an economically and racially/ethnically diverse population including many subsistence fishers. Key West has a population density of 1,440 km^2 and a total population of 26,990. The city of Key West is comprised of the island of Key West, the northern part of Stock Island, Dredgers Key, Fleming Key, and Sunset Key. Approximately 49.2% of shorelines in the city are armored, while 38.7% are vegetated (mostly mangrove), and 8.5% are beaches (Figure 1). The diversity of fish species targeted for recreational fishing in the Florida Keys are managed across two federal fishery management councils, the Gulf of Mexico Fishery Management Council (GMFMC) and the South Atlantic Fishery Management Council (SAFMC), as well as Florida's state agency, Florida Fish & Wildlife Conservation Commission. Using public opinion polls and data and scientific advice from NOAA Fisheries, the councils prepare Fishery Management Plans (FMPs) and set appropriate fishing regulations. Currently, there are approximately 10 snapper species, 15 grouper species, 10 other reef fish species, 9 pelagic species, 16 coastal species, 7 crustaceans and mollusks, and 9 sharks that are regulated for Florida saltwater fishing. Furthermore, hundreds other species are currently unregulated, such as Jack Crevalle (*Caranx hippos*) and Lionfish (*Pterois volitans*), as well as several prohibited species that are unlawful to harvest, such as Goliath Grouper (*Epinephelus itajara*) and Sawfish (*Pristis pectinata*).

Key West has a diverse and sizable recreational fishing community that provided the opportunity to examine a plethora of research questions. For example, subsistence fishing rates among low-income and racially/ethnically diverse groups is unknown. Yet, Key West is in the 80th percentile of US cities for linguistically isolated populations, 59th percentile for minority populations, and 56th percentile for low-income populations, according to the EPA's environmental justice software (http://ejscreen.epa.gov/mapper/). Although subsistence fishing rates are unreported and localized data are more challenging to obtain, NOAA's Marine Recreational Information Program indicates that there were just over 70 million recreational fishing trips in 2019 in Florida, and about 60% of those trips were shore fishing. The majority of all recreational licenses in Florida are obtained by white fishers. Black and Hispanic fishers hold shoreline licenses disproportionately compared to other recreational licenses and charter licenses (NOAA MRIP), indicating that Black and Hispanic fishers are more likely to fish from shore than from boat.

Figure 1. A) Map of the state of Florida with the study system of Key West, Florida highlighted in red and B) Map of Key West, Florida with creel intercept survey sites identified with white triangles. Map of Key West also indicates shoreline type around the city using NOAA's Environmental Sensitivity Index, with red shorelines indicating hardened shorelines, green indicating naturally vegetated shorelines or mangroves, and yellow indicating beach.

A. B.



2.2 Creel Intercept Survey Recruitment

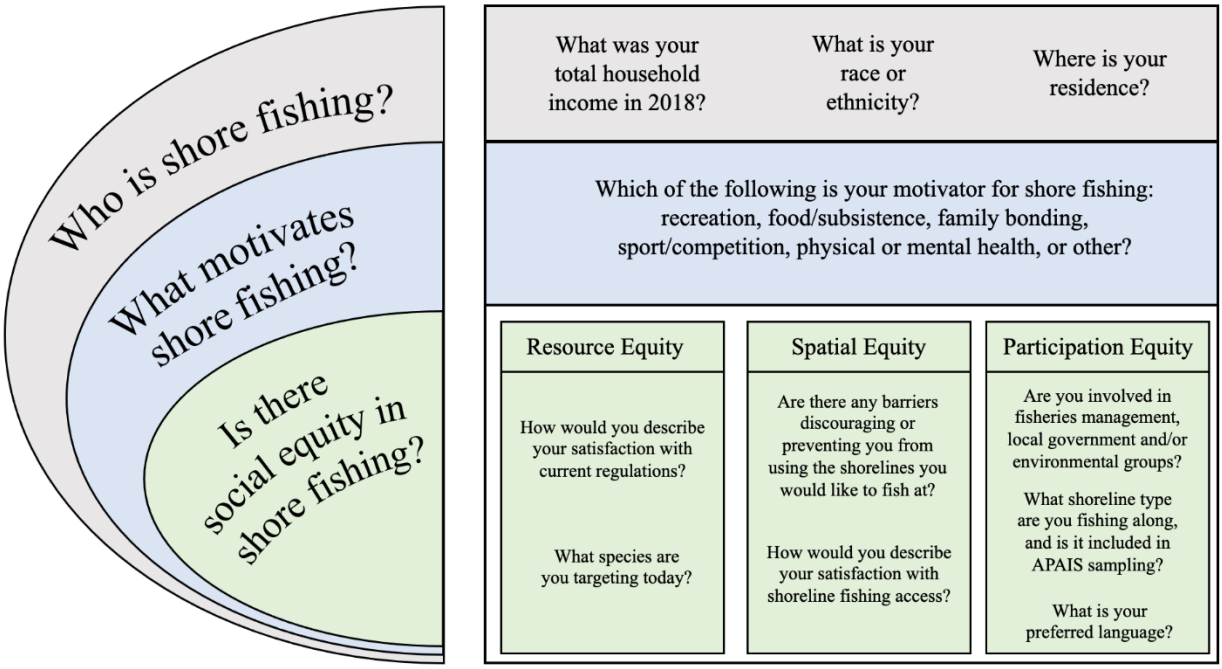
We conducted creel intercept surveys around the city of Key West, Florida from June 29 through August 9, 2019, over 22 sampling days. Prior to survey deployment, we identified 59 sites that allowed public fishing across the two main islands of Key West and Stock Island that represented every shore typology in Key West, including mangrove, seawall, riprap revetment, pier, bridge, and beach. We divided the city into three zones (Stock Island, North Key West, and South Key West) and used a random number generator at the start of each sampling event to determine the order of site visitation. Once the order was determined, two researchers drove around the island to each site, stopping to intercept fishers for survey completion. Presence/absence of fishers at 59 sites was recorded, along with date, survey start and end time at each site, weather, and marine conditions. If fishing was occurring at a site, researchers recorded the number of people fishing as well as the number of people fishing with each gear type (i.e., hook and line, cast netting, flyfishing, etc.) and the number of rods in the water. Intercept surveys were completed at six different times of day including early morning (before 9:00), late morning (9:01 to 12:00) early afternoon

(12:01 to 15:00), late afternoon (15:01 to 18:00), early evening (18:00 to 21:00), and late evening (after 21:00). We conducted creel intercept surveys with fishers at 16 of the 59 sites described above (Figure 1b). We either did not observe fishing activity at the remainder of the sites or, if we did, the anglers did not wish to participate in our survey. During each sampling event, the team recorded the number of creel surveys completed, surveys denied, and previous survey respondents from earlier sampling events.

2.3 Data Collection: The survey instrument contained closed-ended, multiple choice, and open-ended questions. We offered fishers the survey in English and Spanish. Prior to survey administration, we worked with local fishers to review and improve the translation of our survey instrument in Spanish. Surveys were administered orally; however, the written questionnaire was heavily utilized with Spanish participants when only English-speaking surveyors were present. We collected 105 surveys along the Key West shore from June 29 to August 9, 2019 ranging in response time from 06:48 to 22:45 minutes.

To assess general fishing behaviors along the shoreline, we quantified what gear type each fisher was using, how many fish they had caught up until that point in their fishing trip, what species of fish they had caught, how many minutes or hours they had been fishing as a measure of effort, and percent of their fishing that occurs from shore. The remainder of the survey instrument was designed to answer the three research questions described above. Specific survey instrument questions that correspond to each of our research questions are outlined below (Figure 2). All participants were asked the same series of questions. Participants provided additional qualitative information during survey completion, either through answering open-ended questions or elaborated responses to closed-ended questions. We use this information in Section 4 to contextualize the quantitative survey results.

Figure 2. Conceptual figure of research questions and corresponding survey instrument questions. Resource equity and spatial equity, put forth by Klein, are metrics of distributive justice, defined by Schlosberg, Rawl and Barry as the just or fair distribution of goods in society (Schlosberg 2009). Participation equity, also put forth by Klein, is a metric of procedural justice, defined by Schlosberg, Young, Fraser, Honneth, and Taylor as fair and equitable inclusion in the institutional processes of a state/political processes (Schlosberg 2009).



Who is shore fishing?

To examine our first research question, who is shore fishing in Key West, Florida, we asked survey respondents their household income, race and ethnicity, and residency. Income was quantified by asking, "What was your household income in 2018?" For all analyses, income was binned into three categories of low, medium, and high income, corresponding to $50k or less, $50,001 to $100k, and $100k or more. Race and ethnicity were binned into four categories of white, Black, Hispanic / Latino, and other. Residency was quantified in 3 categories of resident, tourist, or frequent visitor, with a frequent visitor being a non-resident who visits Key West once or more each year. We also asked respondent's age, gender, and highest level of

education. Education was quantified in 7 categories of less than high school, high school diploma or GED, some college or 2-year degree, Bachelor's degree, Master's Degree, Doctorate, Law, or MD.

What motivates shore fishing?

To examine our second research question, what motivates shore fishing, we asked fishers "what is your motivator for shore-based fishing?" Response choices were recreation, food/subsistence, family bonding, sport/competition, physical or mental health, and other. Fishers were asked to check all that apply. After data collection, responses were binned into a binary variable of subsistence and non-subsistence fishers. Non-subsistence fishers include those were reported fishing for recreation, sport, family bonding or mental/physical health. Fishers were marked as subsistence fishers if they indicated that subsistence was at least one of their motivators for shore fishing and non-subsistence if not. We used Fisher's Exact Tests to analyze bivariate relationships of fishing motivation with income and race/ethnicity to examine what motivates different groups of shore fishers.

Is shore fishing equitable?

We designed survey questions to assess how social and ecological dynamics of shoreline fisheries intersect and to determine if these dynamics are socially equitable. Specifically, we designed our survey instrument to assess Klein's metrics of equity, including access to natural resources, spatial, and participation (Figure 2). We further analyzed survey metadata, including shoreline type fishing, location fishing, and survey language, for comparison with existing state and federal survey sampling protocols for creel intercept surveys.

Is there equitable access to natural resources (resource equity)?

To measure resource equity, we measured satisfaction with current regulations, because fishing regulations determine the ability to catch and keep certain species and determine minimize fish size that can be kept. Regulations not only impact what fish can be targeted, but importantly what fish can be used to feed subsistence fishers. This question asked, "How would you describe your satisfaction with current regulations?" Response choices were a three-point Likert scale of "not at all satisfied," "somewhat satisfied," and "very satisfied." As another measure of resource equity, fishers were asked, "what species are you targeting today?" We considered this a measure of resource equity because fishers have varying access to certain target species based on current regulations and presence of species in fished habitat type. Although species caught, described above as a general fishing behavior, could be similarly considered a measure of resource equity, we did not include it here because fishers were intercepted at a wide range of time points in their fishing trips. Therefore, examining what specific species a fisher had caught was

confounded by time and effort. Overall, catch per unit effort (CPUE) was calculated and assessed across varying demographics but there were no significant correlations with angler characteristics. We used Kruskal-Wallis Tests to measure whether fishing regulation satisfaction varied with income and race/ethnicity and Fisher's Exact Tests to measure differences in target species by fishing motivation.

Is there an equitable amount of space allocated to individuals or groups (spatial equity)?

As a broad measure of spatial equity, we asked survey respondents if there were any barriers preventing or discouraging them from using the shorelines they would like to fish, and if so, what the barriers were. Respondents listed specific barriers in an open-ended answer. We also measured spatial equity by satisfaction with current shoreline fishing access by asking, "How would you describe your satisfaction with shoreline fishing access?" Choices were the three-point Likert scale response of "not at all satisfied," "somewhat satisfied," and "very satisfied." We created a binary variable of barrier reported or not reported and used Fisher's Exact Tests to assess how reported barriers vary by income and race/ethnicity. We used Kruskal Wallis Tests to measure differences in fishing access satisfaction by income and race/ethnicity.

Is there equitable representation of stakeholder groups in participatory conservation and decision-making (participation equity)?

Finally, we measured participation equity directly by asking anglers if they are involved in fisheries management, local government, or environmental groups. We also measured shoreline type fishing to assess where fishing was occurring in comparison to where NOAA Fisheries is currently intercepting anglers. NOAA'S Marine Recreational Information Program Access Point Angler Intercept Survey (APAIS) is the main source of recreational shore-based fishing effort and catch data in the state of Florida. By surveying along sites currently unsampled by APAIS, we aimed to identify potential data gaps in their existing sampling protocols and potentially provide useful recommendations for them to design more inclusive, future surveying designs. We used Fisher's Exact Test to assess shoreline type fishing by income and race/ethnicity. Current APAIS protocol only administers surveys in English, despite Florida having a large Spanish-speaking population. For example, in our study system of Key West, 23.7% of the population is Hispanic or Latino and 23% of the population speaks a language other than English at home (United States Census Bureau, 2020). We quantified the percent of our surveys completed in English and Spanish. By assessing preferred language for survey completion, we aimed to assess if language barriers exist within current data collection processes, further preventing participation.

3. Results

3.1 General Fishing Behaviors

The creel intercept survey respondents were predominantly hook-and-line fishing with 92.4% (n = 97) of respondents using rods, 2.9% (n = 3) handlining, 2.9% (n = 3) cast netting, and 1.9% (n = 2) flyfishing. Fifty-eight percent (n = 61) reported that more than 90% of their fishing is from shore. The 105 survey respondents reported a total of 255 fish caught across 127.9 hours of fishing, resulting in an overall CPUE (catch per unit effort) of 1.99 fish per hour (Table 1). The average catch was 4.49 fish, the average hours fishing was 1.22, and the average CPUE was 3.39 fish per hour. Snappers were the most frequently caught fish, with Gray Snapper having the highest catch of all species (Table 1). The average snapper catch was 1.26 and the average CPUE was 1.43 fish per hour. Other catch included Grunts (*Haemulon sp.*), Barracuda (*Sphyraena sp.*), Pinfish (*Lagodon rhomboides*), Sharks, such as Nurse (*Ginglymostoma cirratum*) and Bonnethead (*Sphyrna tiburo*), and Bait Fish (Table 1). Twenty percent of the catch (n = 52) could only be identified down to the family or genus level and another 16.9% (n = 43) were reported as unidentified species. This was often the result of how accurately catch and release anglers were able to recall their earlier catch, prior to being intercepted. Catch reported represent a variety of federally managed, state managed, and unregulated species (Table 1). Most species caught currently have an unknown overfishing and/or overfished status according to their latest SEDAR assessments.

Table 1. Reported catch of participants in Key West creel surveys and their corresponding fisheries management jurisdiction and stock status. **Note:** Management jurisdiction reported using Florida Fish and Wildlife Conservation Commission State Regulations and Gulf of Mexico Fishery Management Council Federal Regulations

Common Name	Scientific Name	Management	Overfishing?	Overfished?	Assessment	Total Catch (#)
SNAPPERS						
Gray Snapper	*Lutjanus griseus*	Federal & State	No	Unknown	SEDAR 51	82
Lane Snapper	*Lutjanus synagris*	Federal & State	No	Unknown	SEDAR 49	17
Snapper sp.	*Lutjanus sp.*					16
Yellowtail Snapper	*Ocyurus chrysurus*	Federal & State	No	No	SEDAR 64	11
Schoolmaster	*Lutjanus apodus*	State	Unknown	Unknown		4
Mutton Snapper	*Lutjanus analis*	Federal & State	No	No	SEDAR 15A Update	1
Red Snapper	*Lutjanus campechanus*	Federal & State	Yes (SA); No (Gulf)	Yes (SA); Rebuilding (Gulf)	SEDAR 41 (SA) & 52 (Gulf)	1
GRUNTS						
Grunt sp.	*Haemulon sp.*					24
French Grunt	*Haemulon flavolineatum*	Unregulated				7
White Grunt	*Haemulon plumierii*	Unregulated			FWC, 1999	6
Bluestriped Grunt	*Haemulon sciurus*	Unregulated				3
Porkfish	*Anisotremus virginicus*	Unregulated				1
SHARKS						
Bonnethead Shark	*Sphyrna tiburo*	Federal & State	Unknown	Unknown	SEDAR 34	5
Nurse Shark	*Ginglymostoma cirratum*	Federal & State	Unknown	Unknown	SEDAR 11	4
Bull Shark	*Carcharhinus leucas*	Federal & State	Unknown	Unknown	SEDAR 11	1
Shark sp.	*Superoder: Selachimorpha*					1
OTHER						
Unknown sp.						43
Pinfish	*Lagodon rhomboides*	Unregulated				17
Barracuda	*Sphyraena sp.*	State	Unknown	Unknown		5
Jack sp.	*Caranx sp.*					3
Grouper sp.	*Family: Serranidae*					1
Tarpon	*Megalops sp.*	State	Unknown	Unknown		1
Needlefish	*Family: Belonidae*	Unregulated				1

CPUE Metrics	Average	Total
Catch (number)	4.49	255
Effort (hours)	1.22	127.9
CPUE (number of fish per hour)	3.39	1.99

3.2 Who is Shore Fishing: Angler Characteristics

Of the 105 survey respondents, 42.9% (n = 45) were Key West residents, 33.3% (n = 35) were tourists, and 23.8% (n = 25) were frequent visitors (visit Key West once each year or more) (Table 2). Furthermore, 11.4% (n = 12) were female and 88.6% (n = 93) were male, while 65.7% (n = 69) were white, 13.3% (n = 14) Hispanic / Latino, 13.3% (n = 14) Black, and 7.6% (n = 8) other non-white, which included Asian and multiracial participants (Table 2). Respondent represented a diversity of incomes, with 52.4% (n = 55) having an annual income less than $100,000 and 29.5% (n = 31) less than $50,000, in 2018. Respondents also represented a diversity of education levels, and 60.8% (n = 62) had a 2-year college degree or less. The average age of respondents was 44 years.

Table 2. Sociodemographic characteristics of participants in Key West survey sample.

Demographic	Percent
Residency	
Resident	42.9% (45)
Frequent Visitor	23.8% (25)
Tourist	33.3% (35)
Gender	
Female	11.4% (12)
Male	88.6% (93)
Race	
White	65.7% (69)
Black	13.3% (14)
Hispanic / Latino	13.3% (14)
Other	7.6% (8)
Income	
Low ($50k or less)	29.5% (31)
Medium ($50,001 to $100k)	22.9% (24)
High ($100k or more)	32.4% (34)
Prefer Not to Answer	15.2% (16)
Education	
Less than high school	3.8% (4)
High school diploma or GED	27.6% (29)
Some college or 2 year degree	27.6% (29)
Bachelor's degree	22.9% (24)
Master's degree	12.4% (13)
Law or MD	1% (1)
Doctorate	1.9% (2)
Prefer Not to Answer	2.9% (3)

3.3 Why People Fish: Motivations

The majority of fishers reported recreation as a fishing motivation (71.4%; n = 75). Comparatively, 16.2% (n = 17) of participants reported fishing for food or subsistence. The remainder of the sample reported family bonding, mental and/or physical health, and sport as motivators for shore-fishing. Low-income, Black, and Hispanic / Latino fishers were significantly more likely to be fishing for subsistence

then higher income and white fishers, with over a third of low-income, Black, and Hispanic / Latino fishers reporting that they were fishing for subsistence (Table 3; Fisher's Exact Test; p = 0.004, p = 0.011). Specifically, 35.7% (n = 5) of Black and 35.7% (n = 5) of Hispanic / Latino fishers were fishing for subsistence, compared to 10.1% (n = 7) of white fishers. Similarly, 35.5% (n = 11) of low-income fishers were fishing for subsistence, compared to 8.3% (n = 2) and 5.9% (n = 2) of medium and high-income fishers, respectively.

Table 3. Subsistence fishing by race and income.

	Subsistence	
	Yes	No
Race		
Black	35.7% (5)	64.3% (9)
Hispanic / Latino	35.7% (5)	64.3% (9)
Other	0% (0)	100% (8)
White	10.1% (7)	89.9% (62)
Income		
Low	35.5% (11)	64.5% (20)
Medium	8.3% (2)	91.7% (22)
High	5.9% (2)	94.1% (32)

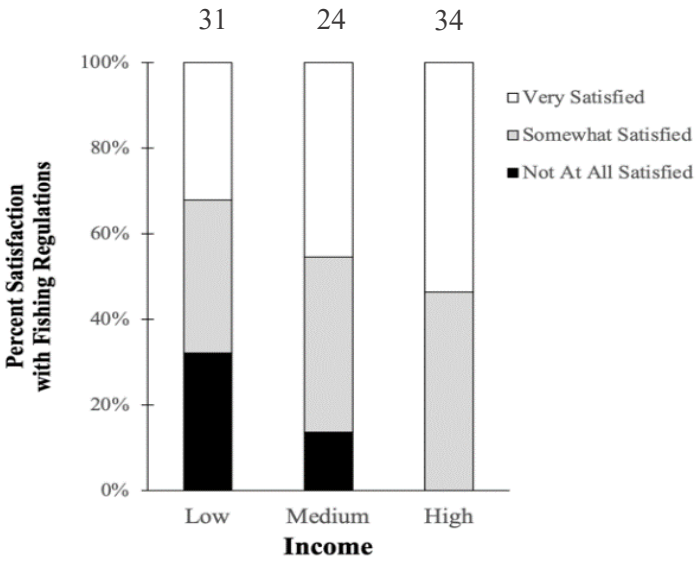
3.4 Social Equity in Shore Fishing

Resource Equity:

Low-income residents were significantly less satisfied with fishing regulations compared to higher income counterparts, indicating potential resource inequities (Figure 3A; Kruskal-Wallis; p = 0.038). Similarly, Black anglers were significantly less satisfied with fishing regulations than white anglers and those of other races or ethnicities (Figure 3B; Kruskal-Wallis; p = 0.049). Over half the respondents were targeting no particular fish species (56.2%; n = 59). Of the respondents targeting a specific species, 69.6% were targeting Snappers (*Lutjanus sp.),* including Gray (*Lutjanus griseus*), Mutton (*Lutjanus analis*) and Yellowtail (*Ocyurus chrysurus*). Target species varied significantly by motivation (Fisher's Exact Test; p = 0.001). The majority of subsistence fishers were targeting snapper species (53%; n = 9), whereas the majority of recreational fishers were targeting no particular species (61.4%; n = 54).

Figure 3. A) Satisfaction with fishing regulations by income (Kruskal-Wallis H; p = 0.038) and B) satisfaction with fishing regulations by race (Kruskal-Wallis H; p = 0.049). Sample size (n) is indicated on the top of each bar for the corresponding x-axis variable.

A.



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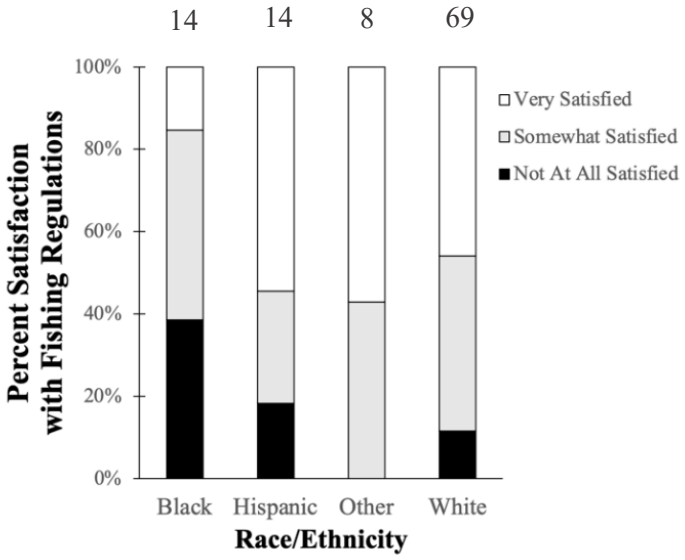


Spatial Equity:

Of all respondents, 53.3% (n = 56) listed a barrier that prevented or discouraged them from shore fishing at their preferred shoreline location. Gaining access to the shoreline was by far the most common barrier. Of the 53.3% of respondents who listed a barrier, 46.4% (n = 26) identified limited access to the

shoreline as a barrier. Behind access, parking (21.4%; n = 12), water quality (16.1%; n = 9), and physical obstacles (12.5%; n = 7) were the most identified barriers to shore fishing. Other barriers reported included feeling unwelcome, fishing regulations, time, construction, and crime. Low-income residents were more likely to identify barriers than high-income counterparts, with over 67.7% (n = 21) of low-income respondents identifying one or more barrier (Figure 4A; Fisher's Exact Test; p = 0.057). Similarly, low-income anglers were significantly more likely to list shoreline access, the most identified barrier of all respondents, as a barrier to shore fishing (Figure 4B; Fisher's Exact Test; p = 0.014). Residency was also correlated to shore fishing barriers, with residents reporting significantly more barriers than tourists (Fisher's Exact Test; p = 0.002). Further, residents were more likely to identify access as a barrier to shore fishing (Fisher's Exact Test; p = 0.000) and to be less satisfied with fishing access (Kruskal-Wallis; p = 0.026). Almost 40% of low- and middle-income anglers were not satisfied with fishing access (Figure 5A; Kruskal-Wallis; p = 0.1). Similar trends among satisfaction were observed by race/ethnicity. The most glaring difference was that 64.3% (n = 9) of Black anglers were not satisfied with fishing access (Figure 5B; Kruskal-Wallis; p = 0.006).

Figure 4. A) Percent of low- (below $50k household income), middle- ($50,001-$100k) and high-income (over $100,001) respondents who reported a barrier to shore-based fishing (Fisher's Exact Test; p = 0.057). B) Percent of respondents who reported an access barrier to shore-based fishing by income (Fisher's Exact Test; p = 0.014). Sample size (n) is indicated on the top of each bar for the corresponding x-axis variable.

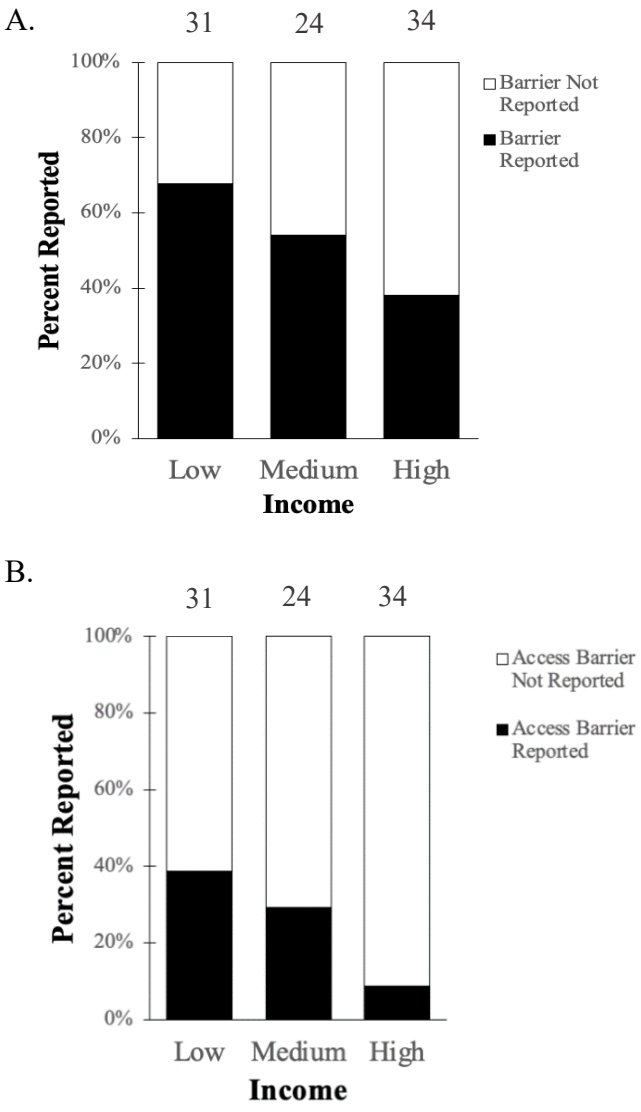
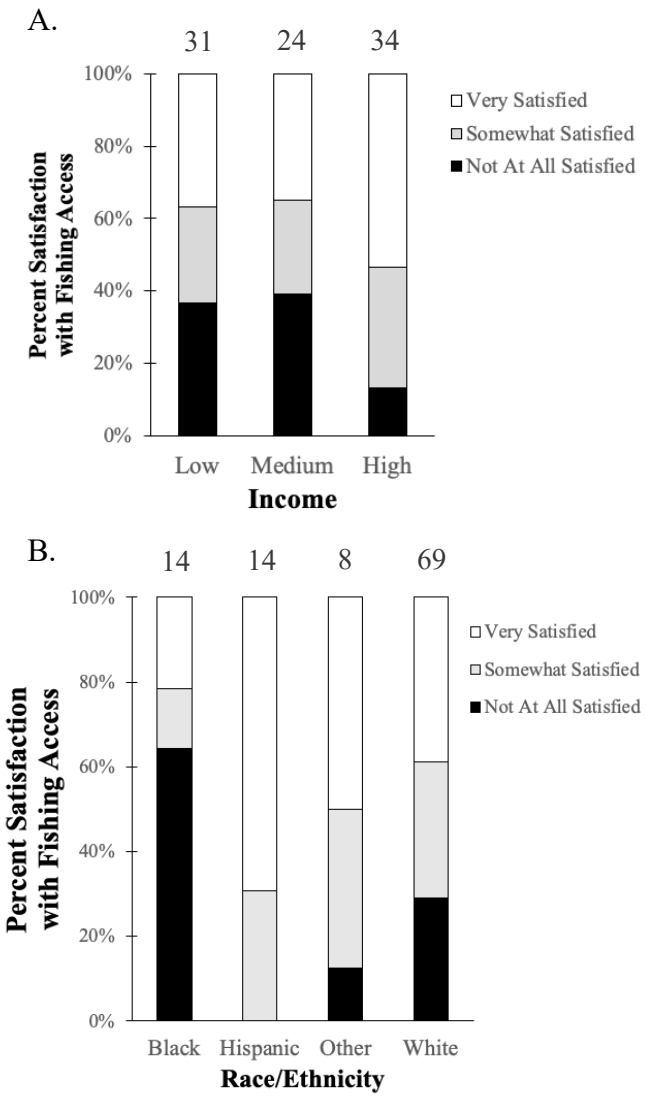


Figure 5. A) Satisfaction with fishing access by income (Kruskal-Wallis H; p = 0.10) and B) satisfaction with fishing access by race/ethnicity (Kruskal-Wallis H; p = 0.006). Sample size (n) is indicated on the top of each bar for the corresponding x-axis variable.

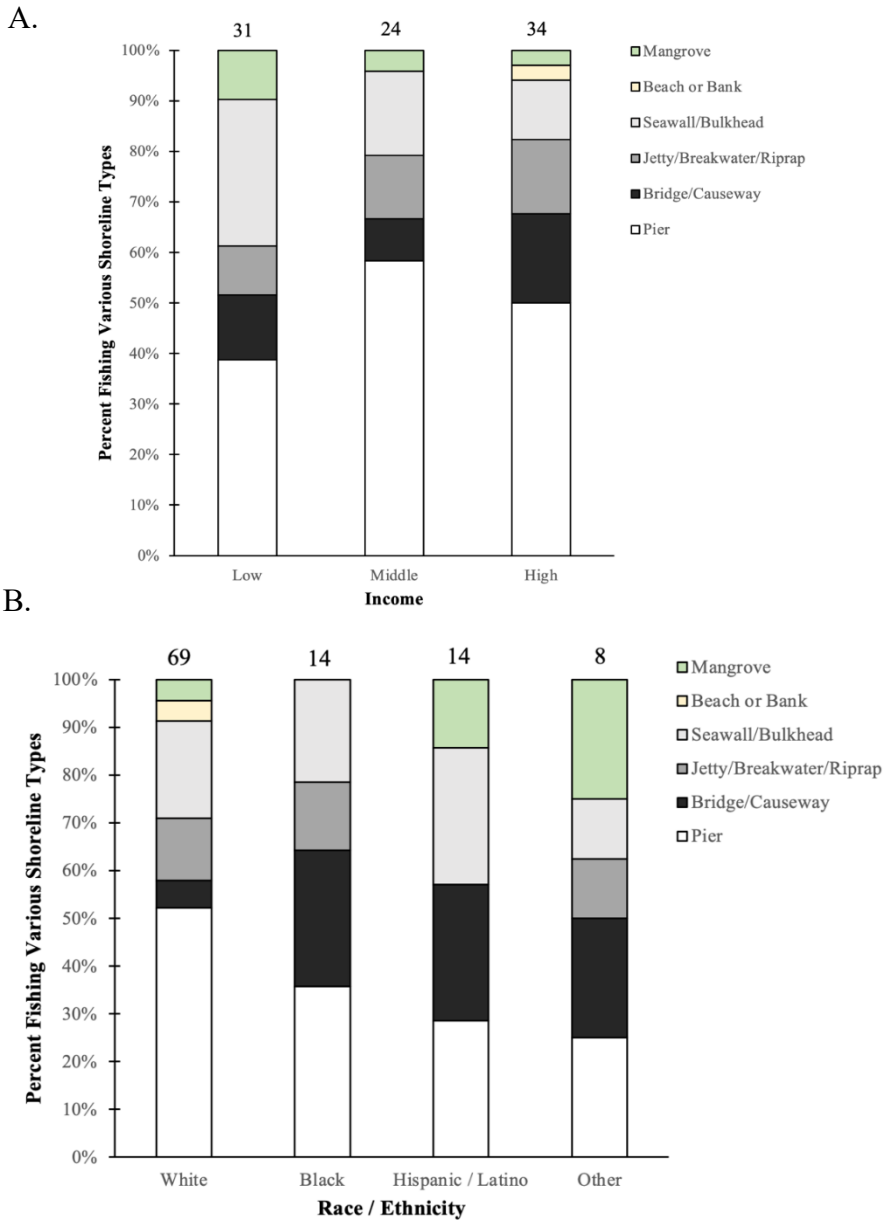


Participation Equity:

When analyzing participation equity metrics, we found that few shore fishers, regardless of income or race, were participating in any organization that influences fishing policies or regulations, with only 4.8% (n = 5) involved in fisheries management, 2.9% (n = 3) in environmental groups, and 1.9% (n = 1) in local government. The most prevalent shore types for fishing were piers and bridges, while the least fished

were mangroves and beaches. However, 14.3% (n = 2) of Black fishers, 25% (n = 2) of other non-white fishers, and 9.7% (n = 3) of low-income fishers were fishing in mangroves, compared to less than 5% of white and high-income fishers. While only 6.7% of our sample were fishing along mangroves (n = 7; Figure 6), mangroves had the highest proportion of low-income and people of color fishers. Specifically, 60% of the respondents fishing along mangroves were low-income and 57.1% were people of color (Figure 6). Comparatively, none of NOAA's Marine Recreational Information Program Access Point Angler Intercept Survey (APAIS), which is the main source of shore-based fishing data for the state, occur along mangroves. Furthermore, Florida's recently implemented State Reef Fish Survey currently does not consider shore fishing at all in their data collection. Surveys were completed in both English and Spanish, with 91.4% (n = 96) completed in English and 8.57% (n = 9) of surveys completed in Spanish. Currently NOAA's surveys are only offered in English.

Figure 6. A) Percent shoreline type fished by low- (below $50k household income), middle- ($50,001-$100k) and high-income (over $100,001) (Fisher's Exact Test; p = 0.680) and B) percent shoreline type fished by white, Black, Hispanic / Latino and other race/ethnicity survey respondents (Fisher's Exact Test; p = 0.060). Sample size (n) is indicated on the top of each bar for the corresponding x-axis variable.



4. Discussion

4.1 Inequities in shore-based fisheries

Studies have highlighted the importance of catch rates of target species as drivers of fishery dynamics (Beardmore et al. 2015; Anderson et al. 2007; Hunt et al. 2019). Our study revealed more nuanced socioeconomic and environmental influences on fishing behaviors and outcomes in Key West's shore fishery. Most importantly, we examined three metrics of social equity and found significant inequities across all three, including resource, spatial, and participation equity. Angler catch per unit effort (CPUE) was found to be similar across shoreline types and angler demographics. Nevertheless, people of color and low-income anglers reported significantly more barriers to accessing the shore fishery in Key West. Furthermore, these same demographic groups reported subsistence as their motivation for fishing significantly more than white and high-income anglers. Low-income fishers and fishers of color were also more likely to be intercepted at fishing sites not currently included in agency surveying protocol, and the sample as a whole report little to no participation in fisheries management or local government. Together, these metrics of equity highlight distributive and procedural injustices in shore fishing that have not previously been described. Our study highlights the importance of understanding how individuals across income and racial/ethnic groups are able to participate in a shore-based fishery.

4.2 Resource inequities for subsistence fishers

A key finding of our study was that low-income fishers and people of color were significantly less satisfied with current fishing regulations. This result indicates a potential resource inequity in shore fishing, with various socioeconomic groups perceiving their access to certain fish species differently. While fishers with non-subsistence motivations often reported having no specific target species, Snappers were the most commonly targeted fish amongst those fishing for subsistence and the most commonly caught species across all respondents. Gray Snapper, in particular, was the most targeted and caught fish species. Attitudes toward fishery management organizations were generally quite negative. Notably, even in this context of shared values and concerns, income-related disparities in access were apparent. For instance, one lower-income angler stated: "how are you supposed to feed a family of eight when you can only catch five fish?" referencing the current bag limit of five for Gray Snapper. On the same topic, a subsistence angler and homeless Key West resident who was handlining (a fishing technique with only a line and hook for gear) with a glass bottle at the time of the interview said he fishes every day for food but hadn't caught anything of legal size in the last several days. A higher-income shore angler commented, "it's not worth taking the boat out and paying for fuel with such strict regulations – not worth the price for only five Gray Snapper."

Distributive justice, defined as the just and fair distribution of goods, has long been a central component of environmental justice theory (Schlosberg 2009) and has more recently been incorporated into fisheries literature (Gustavsson et al. 2014; Lam and Pitcher 2012). Yet, most distributive justice literature within fisheries science has focused on quota allocations in management across commercial and

recreational sectors, and much less work has been done connecting injustices with fisher satisfaction. Advances in human dimensions of fisheries literature have highlighted the complex interactions between fishing outcomes (i.e. fishers' experience, services received from fishing), fisher satisfaction, fisher motivation, and well-being (Hunt and Sutton 2013; Pollnac et al. 2006). More specifically, previous research has described the roles of fisher motivation (i.e. catch, consumption, trophy) (Arlinghaus 2006; Beardmore et al. 2015), environmental quality (Holland and Ditton 1992), and participation in decision-making (Crandall et al. 2019) in determining fisher satisfaction. Here, our results highlight the importance of equity in determining satisfaction and thus call for further research to understand these mechanisms in greater detail to inform management.

4.3 Spatial inequities through fishing access

Along with fishing regulations, potential distributive injustices were discovered through spatial inequities in fishing access. Spatial inequity, defined as the amount of space on the landscape or seascape allocated to individuals or groups (Klein et al. 2015), emerged as a particularly important metric in shore fishing as low-income and people of color were significantly less satisfied with fishing access than higher income and white fishers, and reported access as a barrier significantly more often. Many of the lower-income fishers interviewed along public roadways and seawalls noted private land ownership, entrance fees, and free parking as influencing their fishing site choice. In contrast, tourists and higher income residents were often intercepted along the shorelines of Fort Zachary Taylor State Park, which requires an admission fee, or at fishing sites near the public marina which typically requires paid parking. One local whose family has been here for five generations said "access to shorelines is horrible now. Growing up you could fish everywhere around the island but now it's all privatized and owned by resorts and the tourism industry and you can't access the shore for fishing." Previous fisheries literature has indicated that fishers who used a cast net were more likely to be fishing for food and to be dissatisfied with the number of access points to shoreline recreational fishing (Goedeke et al. 2016). Black and white subsistence fishers have been shown to have differing access to fishing based on differing cultural patterns, such as harvesting strategies and social relations (Brown and Toth, 2001). Similarly, previous environmental justice literature has highlighted the existing constraints for low-income communities and people of color in proximity to green space and participation in outdoor leisure activities (Stamps and Stamps 1985; Tarrant and Cordell 1999; Shores et al. 2007; Taylor et al. 2007). Specifically, distance to green spaces is often cited as a prominent barrier to recreational activities for low-income fishers and people of color (Wolch et al. 2014; Ekkel and de Vries 2017). The standard for a walkable distance in the U.S. is 0.25 miles, making accessibility particularly challenging for those without transportation access and enhancing the necessity of understanding such barriers (Sturm and Cohen 2014).

Inequalities exist in quality, diversity, and size of green spaces across neighborhoods of different socioeconomic status (Barbosa et al. 2007; Wendel et al. 2011). In Key West, access limits fishing along natural shorelines, with most public fishing sites occurring along hardened shoreline types. Only 38.7% of the coastline in Key West remains naturally vegetated, with 49.2% currently hardened into artificial shorelines such as seawalls or riprap revetments (NOAA Office of Response and Restoration). Yet, natural shorelines such as mangroves are known to provide a plethora of ecosystem services (Barbier 2016; Odum et al. 1982; Ewel et al. 1998) and to provide increased habitat complexity fostering nursery habitat for fishes and substrate for sessile invertebrates, often increasing coastal biodiversity (Drew and Eggleston 2008; Lorenz 1999; Gratwicke and Speight 2005). Gray Snapper specifically relies on mangrove forests during their ontogeny with increasing body size for predator refugia (Faunce and Serafy 2007). Enhancing our understanding of barriers to fishing access, particularly sites with high fish productivity, is essential to achieve spatial equity moving forward. This study and future studies alike are instrumental in informing policy to protect natural landscapes and remove existing barriers to accessing such areas.

4.4 Participation inequities through data collection

Along with distributive injustices, our results indicate that procedural injustices, defined as fair and equitable inclusion in the institutional processes of state/political processes, may be occurring in fisheries management. A key finding of our study was that, while the majority of anglers were seen fishing along piers and bridges, mangroves were more frequently fished by lower-income anglers and people of color. As stated previously, NOAA's Marine Recreational Information Program Access Point Angler Intercept Survey (APAIS) is currently the main source of on-site recreational fishing data collection. While the majority of our surveys occurred at existing APAIS sites, 36.2% of our intercepted fishers were at sites not currently sampled by APAIS. In Key West specifically, active APAIS sites consist predominantly of marinas (18 sites), boat ramps (4 sites), bridges (3 sites), and piers (1 site) (NOAA Fisheries). Although our results suggest that bridges and piers are the most frequently fished shore types, the disproportionate presence of low-income and people of color at mangrove fishing sites indicates a potential lack of inclusion in our current data collection process. More recently, the state of Florida has implemented its own State Reef Fish Survey (SRFS), but importantly, this survey does not currently include shore sampling (Florida Fish and Wildlife Conservation Commission). Together, our findings of spatial and participation equity reveal a complex relationship between shore fishing access and social equity. We found a lack of public access for shore fishing along mangroves, generating a low sample of mangrove fishers and suggesting spatial inequities beyond general fishing access to mangrove access specifically. As higher proportion of those who were fishing along mangroves were low-income and people of color, our results highlight the

importance of 1) increasing public fishing access along mangroves and 2) increasing data collection along such sights for participation.

Not only are mangroves limited in federal recreational fisheries data collection designs, but current APAIS survey instruments are only distributed in English. This is of particular importance for Key West which has a diverse population with a large Hispanic / Latino community. Notably, according to the Environmental Protection Agency's Environmental Justice software, EJScreen, Key West is in the 80th percentile for linguistically isolated cities in the country (Environmental Protection Agency). Furthermore, recent census data estimates that 23.7% of Key West's population is Hispanic / Latino and 23% of the population speaks a language other than English at home (United States Census Bureau, 2020). Approximately 10% of our total surveys were conducted in Spanish. As all residents do not fish, the proportion of Spanish-speaking participants in our sample aligns with census data and thus may indicate the proportion of fishers currently excluded from data collection by a language barrier. A sampling design involving oversampling of natural shore types and creation of survey instruments in multiple languages may help to include these underrepresented community members in the data collection process and highlight equity issues. This may further promote fair and inclusive decision-making processes as underrepresented voices become more heard and resolve potential existing procedural injustices (Daigle et al. 1996).

Increased shore-based fisheries data collection is needed to better understand existing participation inequities. From January 2018 to February 2020, 61.1% of estimated recreational fishing trips in the state of Florida were from shore (National Marine Fisheries Service), yet shore data are often a source of uncertainty and data gaps. For example, Gray Snapper had an estimated 34.2% of landings from shore during its most recent stock assessment (SEDAR, 2018). Yet only 2.8% of trips where Gray Snapper samples were measured and weighed were from shore (SEDAR, 2018). While our study did not specifically focus on biological components of catch such as length and age, SEDAR (Southeast Data, Assessment, and Review) 51 data suggest a general lack of angler sampling along the shore despite a large portion of landings coming from there. Future surveying will rely more heavily on state-led surveys such as the State Reef Fish Survey. Research such as this study can help better inform the survey design during this period of transition and evolution. Furthermore, less than 5% of our sample reported involvement in any form of fisheries management, indicating a general lack of participation in decision-making. Increasing our understanding of shore fishing dynamics would therefore both decrease uncertainty in stock assessments and increase participation equity for more just decision-making.

4.5 Limitations of the study

Our study was limited by temporal and spatial constraints produced by our study system. While Key West, Florida provides important socioeconomic and ecological dynamics to examine these research questions, it is also far removed from the mainland of Florida and other key fishing communities in the South Atlantic and Gulf of Mexico. This creates logistical challenges for an expanded spatial design while conducting intercept surveys. Further, while including all potential fishing sites in the study system was key for assessing spatial and participation equity, it proved to be time intensive and often resulted in extensive effort for little return in sample. Ultimately these constraints resulted in a relatively small sample. Our study in particular was limited by its small Black, Hispanic, and other non-white sample. This is a common limitation in studies such as this, often due to the exact barriers and inequities that serve as key findings in this paper. A general lack of trust, historical underrepresentation, and lack of inclusivity can decrease willingness to participate for low-income and people of color. However, previous studies have shown that meaningful action by agencies leads to increased satisfaction with management and increased participation in decision-making (Crandall et al. 2019). Therefore, more equitable future regulations, data collection processes, and communication between agencies and stakeholders has the potential to mitigate these limitations and result in positive feedbacks to research.

4.6. Conclusions

Several key findings of our study have direct relevance for coastal and fisheries management. First, our findings show that low-income and Black shore fishers were less satisfied with fishing regulations than higher income or white fishers, and they were more likely to be fishing for subsistence. While there is much debate surrounding the equitable distribution of quota allocations between recreational and commercial fishing sectors, subsistence fishers are often absent from the conversation and remain coupled with recreational allocations. Considering subsistence fishers when determining equitable allocation is key to promoting resource equity. Second, our results indicate that low-income and people of color were more likely to be fishing along natural mangrove shorelines compared to seawalls or piers and more likely to identify fishing access as a barrier to shore fishing. Prioritizing mangrove restoration near lower income communities and improving transportation to mangrove fishing sites may help alleviate these potential spatial inequities. Furthermore, in our study system, natural mangrove shorelines are currently absent from both APAIS sampling protocols and Florida's State Reef Fish Survey, and APAIS surveys are currently only offered in English. An altered sampling design that includes a combination of hardened and natural shorelines and multi-language survey distribution may increase participation equity amongst shore fishers.

Together, these results reveal the importance of understanding local social-ecological dynamics and stakeholder priorities when implementing coastal and fisheries management. Previous studies have shown that when equity is optimized in an ecosystem-based fisheries management framework, the tradeoffs

between economy and ecology are more likely to be balanced (Voss et al. 2014). Other studies have highlighted the importance of participation, power, and equity for fisheries co-management, which has been shown to promote social and ecological benefits (Quimby and Levine 2018). Understanding these dynamics is more important than ever as existing trends indicate an increase in food insecurity and fisheries conflicts, in part due to increased reliance on fisheries in coastal communities (McClanahan et al. 2015). As sea level rise continues to intensify, coastal communities will increasingly be faced with choices between hardened and nature-based strategies. Our study suggests that as coastal and fisheries management adapts to these changes, using a coupled social-ecological approach that explicitly considers equity and justice is essential because management decisions often influence fishers' actions (Hunt and Sutton 2013; Solomon et al. 2020). Studies such as ours help to fill research gaps surrounding equity in fisheries management, but more research is needed on larger spatial scales. Specifically, an enhanced understanding of these inequities on a regional level across a larger population and across more fishing sites is key. This research will inform decision-makers in data collection, stock assessment, and management processes to enable inclusivity.

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6. Credit Author Statement:

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