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Reconciling economic impacts and stakeholder perception: A management challenge in Florida Gulf Coast fisheries

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A B S T R A C T

As global fisheries management shifts towards ecosystem-based management, responsible organizations and governments must also address the socio-economic impacts of this shift. This study evaluates potential impacts of such management shift with a case study of Pulley Ridge (PR), an ecologically rich area in the Gulf of Mexico, on fishermen and economies of Florida's Gulf Coast. We developed an input-output model to estimate direct, backward-linkage, forward-linkage, and induced consumption effects of various management scenarios on the region's economy. We also solicited input on the proposed management changes from Florida saltwater fishing license holders using an online survey. Although gear restrictions may affect harvest of the region's two most lucrative fish types, snappers and groupers, the proposed changes would impact only a small fraction of the fishing industry and the regional economy. Results suggest economic impacts to affected counties and the overall Gulf Coast fishery from management changes would be limited, i.e., less than 3% reductions in income, taxes and employment. Nonetheless, almost 90% of survey respondents indicated the proposed management changes would affect their business either "Significantly" or "Very Significantly". Results suggest developing broad based support for changes affecting the commercial fishing sector may require stakeholder negotiation along with convincing evidence that the proposed changes will improve regional fishery production in the near term.

1. Introduction

Fisheries management in the United States has shifted its focus from individual sectors within marine management to ecosystem-based levels of management in an effort to adequately and comprehensively address the problems of overexploitation. The Magnuson-Stevenson Fishery Conservation and Management Act (MSA) of 1996 and its later amendments provided for Essential Fish Habitats (EFH [1]; Macpherson, M. 2001; [2]. EFH are defined as, "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" [3] p.17; [2] p. 536). Creation of EFH generally makes way for other management responses to safeguard certain species within various stages of their ontogenetic development. HAPC, or Habitat Areas of Particular Concern, is one such management tool that targets conservation, management, and research priorities. HAPC can be used as a preventative measure for preserving habitats and enhancing fish stocks even without causal evidence between potential threats and expected habitat changes [2].

Oftentimes, new protections may restrict ongoing commercial and recreational fishing activity in the area, forcing fisherman to travel elsewhere to fish and promulgating a multiplier effect within the regional economy. The fear of social repercussions within the fisheries from entry restrictions often stalls or slows management initiatives [4]. One of the ten national standards (i.e., # 8) of MSA mandates that the adverse economic impacts of fishery management actions be minimized, to the extent possible, towards specific fishing communities [5]. Conducting an economic impact analysis is critical to assessing possible outcomes associated with new management interventions to provide decision makers with the information needed to maintain the balance between protection of ecosystems and economic opportunity. Economists have extensively studied impacts of fishery management policies using a variety of regional economic models [see Refs. [5,6] for review of such studies]. In addition to the latest scientific and economic knowledge, public commentary must be incorporated for a more robust view of the management scenario to understand how these changes may affect the livelihoods of fisherman dependent on that region.

The Gulf of Mexico Fishery Management Council (GMFMC) [28] has created several HAPC over the years in order to protect critical fishery habitat. GMFMC and the Florida Keys National Marine Sanctuary (FKNMS) are currently considering expanding protections within Pulley Ridge, a coral reef system in the Gulf of Mexico and northwest of Dry Tortugas National Park and parallel to the Florida Peninsula. Scientists have acknowledged a putative ecological connection with Pulley Ridge (PR) and the Dry Tortugas (DT), for which additional marine protections may benefit the Gulf ecosystem overall [7,8,19]. However, historically fishery managers have experienced opposition in this region.

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After the announcement of creation of the FKNMS in the early 1990s, strong opposition was expressed by the Conch Coalition, a grassroots, semi-organized group that included commercial fisherman, real estate interests, treasure hunters, and other residents of Monroe County [9]. The coalition opposed federal intervention for fear of excessive regulation and the misplacement of conventional users within the area. In the end, public commentary resulted in the modification of the zone "replenishment reserve" to "ecological reserve" [9], highlighting the power of public pressure.

Fishery management literature sheds light on why commercial fishers might oppose such regulations. New regulations engender uncertainty around, and substantial time gap between, the short-term costs and the long-term benefits [4,10]. Although commercial fisheries may gain in the long run due to stock improvements, they will have to bear the costs in the short run. Although recent research shows a strong ecological connectivity between PR and DT, and Florida Keys [7,8], it is unclear when and how widely the benefit of regulations (increased stock) might materialize. Also, fishery regulations often cause intragenerational inequity in that some commercial fishers along with their crew might lose income and employment opportunities [10]. In the case of PR, the few fishers who fish in and around PR may bear the immediate loss while the benefits might transcend across the Florida Keys fishing region.

The current study seeks to evaluate the short-term economic impacts of proposed management changes in PR on the commercial fishery stakeholders in the West Coast counties of Florida. We investigated whether the suggested expansion of fishery protected habitat within PR caused any significant economic injury to commercial fishermen and to the broader economy. It is beyond the scope of this study to compare the long-term biological and economic benefits with short-term economic burden on the fisheries. Instead, the main purpose of this paper is to show whether the near-term economic losses would be *small enough* to phase out by itself in the long term. Finally, in order to assess the socio-economic dimensions of the potential effects of the alternative management scenarios, we conducted a survey amongst commercial fishermen who are dependent on the PR and DT regions in order to incorporate their opinions and insight in the analysis. Understanding the socio-economic elements within the commercial fishing industry is crucial for a comprehensive overview of the management scenario. When implementing new resource management policy, engaging stakeholders provides a wealth of knowledge that might have gone undocumented.

2. Background

2.1. Pulley Ridge and policy interventions

The Florida Keys National Marine Sanctuary (FKNMS) currently extends over 2900 nautical square miles from south of Miami and westward including the waters surrounding the Florida Keys to the DT and protects North America's most extensive living coral reef system (see Fig. 1). The FKNMS purportedly maintains strong ecological connectivity with the deepest known hermatypic coral reef system in the contiguous United States, or PR ([8,11,12,19]. PR is approximately 300 km long and 15 km wide [12,13] and most of the reef coverage (60%) exists in depths of 60–90 m of water [13,14]. The reef provides a home to coral such as *Leptoseris cucullata*, *Agaricia lamarcki* and *Agaricia fragilis* [15] with an estimated 26,936 ha of reef coverage [16], as well as a home to many commercially lucrative species, such as *Epinephelus morio* (red grouper), and *Lutjanus campechanus* (red snapper; [17,18]. Due to its remoteness and depth, PR has been relatively untouched by anthropogenic forces. However, coral reefs are sensitive habitat which predisposes the area to deterioration, especially if certain fishing gears-such as trawls or illegal anchoring-are employed in the area (Jaap and Halley, 2008). In 2005, the southern portion of PR was therefore designated a Habitat Area of Particular Concern (HAPC) by the GMFMC

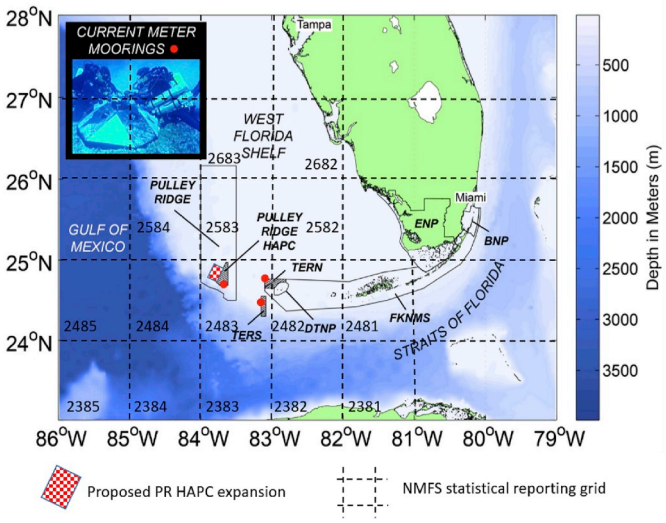

Fig. 1. Proposed GMFMC expansion of the PR HAPC enforcement area.

[12,19]. The HAPC designation granted protections to an area prone and liable to human degradation.

Furthermore, since PR is located approximately 70 km from DT, scientists hypothesize the drowned barrier reef is ecologically connected to the FKNMS. Studies [18,20,21] observe that the Loop Current, which moves water through the Gulf of Mexico, the Keys, and up the Atlantic Seaboard, may aid in moving invertebrate and fish larvae from PR to the FKNMS. Therefore, extending the marine protection to encompass the PR area would enhance both upstream and downstream ecological productivity within the area [7,21].

The GMFMC and the FKNMS have implemented/proposed a couple of new options for management of PR. First, in 2018 GMFMC expanded the enforcement area by 250 sq. miles within the PR HAPC [12]; Fig. 1) denoted by the red checkered square imposed on the current enforceable areas within PR. The expanded enforcement area includes the prohibition of bottom anchoring and the use of certain type of gears. Second, FKNMS proposed to expand its current coverage of protected areas, a plan that does not have a direct effect on the management of PR, but instead expands the sanctuary designation area. Expanding the area protected by the sanctuary designation reflects the notion that both PR and DT in Florida Keys maintain ecological connectivity and therefore closure of this area would support upstream benefits within the FKNMS.

Experts believe that additional marine protections within this area may improve fish stocks in the Florida Gulf and fishery-dependent economies. In 2015, Florida commercial saltwater fishing accounted for $479 million in direct sales and $994 million in economy-wide output impacts, without accounting for activities resulting from fishery imports [22]. The industry also provided for 6658 direct jobs in commercial fisheries and 10,257 jobs economy-wide. Within eight counties in particular- Pinellas, Charlotte, Monroe, Manatee, Lee, Hillsborough, Sarasota and Collier- PR provisions important commercial fishing grounds for certain species.

2.2. An integrated marine policy approach

Implementing a transdisciplinary approach that spans disciplines and synthesizes regional and local knowledge produces "the highest form of integrative research" [23]; p. 178). In this study, we adapted a combination of regional economic modeling tool and survey-based stakeholders' knowledge and perception. This integrated approach enabled us to tease out the regional economic impacts from the impacts perceived by stakeholders. To this end, we carried out (1) four simulations of policy changes and assess their total economic impact on two

separate groupings of counties on the Florida West Coast and (2) an online survey conducted amongst commercial fisherman dependent on the PR and DT fishing areas to incorporate their opinions and local insights into the analysis. With regard to regional economic impacts, we developed a comprehensive economic input-output (IO) model by explicitly considering multiple economic shocks originating from policy-induced supply restrictions in primary fishery industry, and in turn, backward- and forward-linked economic sectors.

An alternative to the IO model is the Computable General Equilibrium (CGE) model, which builds on the former but takes into account structural adaptations of an economy to a change in one or more economic components [24]. The CGE model would allow for substitution of inputs, outputs, and trade effects (e.g., input-import substitution) in the event of an economic shock. However, as [24] note, CGE models demand complicated sets of structural equations to represent the economy [5]. show that the majority of the fishery regional economic modeling studies have opted for the traditional Leontief IO modeling tool because of its modeling simplicity and operation. Furthermore, in the current study, we expected to see relatively small policy-driven changes in the supply-side of the economy, and in turn, relatively small economy-wide impacts. Allowing for input or important substitution effects would make those impacts even smaller. Therefore, the regional economic impact estimates derived in this study using IO model should be viewed at best as upper limits of regional economic impacts.

3. Methods

3.1. IO model for economic impact analysis

While many tools exist for regional policy impact assessment, Leontief's input-output (I-O) methodologies [30] have been commonly used to identify how potential changes within resource management may affect specific industry sectors as well as the overall regional economy [4,5,25]. The IO methodology allows us to track the impacts of changes in one or more economic sectors on the rest of the economy in terms of changes in industry outputs, regional income, employment and taxes [25]. As Ref. [5] note, traditional fishery IO models have looked at only demand-driven exogenous changes caused by management policies. However, fishery management policies like the expansion of the PR HAPC puts direct restrictions on the supply side, i.e., supply-driven changes. In such cases, a demand-driven IO model may not adequately capture the full effects.

Ref. [4,24] characterize the impacts of policy-induced output restrictions using multiple economic pathways, which involve both supply-driven changes and demand-driven changes. Under this framework, the fishery-dependent economy is assumed to consist of three distinct groups of sectors, namely, primary fishery (PF) sector, backward linked (BL) sectors, and forward linked (FL) sectors. First, a proposed fishery management change impacts the PF sector through output restrictions, which will have a direct negative impact on fishery labor and proprietary income. Second, this output restriction lowers the final demands for the output produced by the BL sectors. These demand-driven impacts on BL will result in a host of direct, indirect, and induced impacts on the entire economy, which we collectively refer to as *backward-linkage industry impacts*. Third, because of the shortage in the output of the PF sector that supplies "core input" [24] to certain FL sectors (e.g., fish sold to local processing sector), the latter downsizes their own outputs purchasing less regional inputs and household labor. This FL industry downturn will result in a host of direct, indirect, and induced impacts, which we call *forward-linkage industry impacts*. Finally, the fishery crew and capital owners in the PF sector who would lose income due to output restrictions will spend less on local goods and services causing an *induced impact* on the rest of the economy. Fig. 2 captures all the above inter-sectoral interactions. In order to capture these multiple impacts, previous studies have combined demand-driven Leontief IO model and supply-driven Ghosh's IO model [4,24].

Consider the following simple IO model that captures relationships between various sectors of an economy [30]:

$$X_i = \sum_{j=1}^{n} x_{ij} + Y_i \quad i = 1,\ 2,\ ....,\ n \tag{1}$$

where X_i is the total output produced by sector i; $x_{i,j}$ is the total input sales from sector i to sector j (i.e., the intermediate demand for goods of sector i from sector j); Y_i is total amount of goods and services of sector i sold to the final demand categories-household, government, industries, and export- and n is the number of regional economic sectors. We define the direct consumption coefficient (a_{ij}) as the ratio x_{ij}/X_j, which is the amount of ith sector's product or service consumed in producing a unit of output of sector j. For each industry j, let Z_j denote the total wage, proprietor's income, and government taxes paid as a part of its total input payments (X_j) and the total number of employees (E_j), respectively. We can now construct value-added coefficient, $z_j = Z_j/X_j$, and employment co-efficient $e_j = E_j/X_j$, for $j = 1,2, \ldots,n$). For brevity, we refer readers to Ref. [25] for more technical details.

Next, we present expressions for four different types of economy-wide impacts defined earlier (Fig. 2), using the construct of IO model, and its demand-driven, Leontief production coefficients [30] and supply-driven, Ghosh allocative coefficients [31]. First, the *direct economic* impact (I^{DI}), which include direct losses in value-added payments due to a reduction in total output of the PF sector ΔX_p, is measured as,

$$I^{DI} = z_p \Delta X_p \tag{2}$$

where p refers to PF sector. The *backward-linkage industry impact* (I^{BL}) is measured as,

$$I^{BL} = \sum_{k=1}^{K} \sum_{i=1}^{n} b_{ik} z_i [a_{kp} \Delta X_p] \tag{3}$$

where $k = 1,2, \ldots,K$ are the BL sectors that supply inputs to PF sector p. The term in the brackets, $[a_{kp}\Delta X_p]$, captures the reduction in the final demand of the BL sector k, which is proportional to the reduction in the PF sector supply ΔX_p.

The *forward-linkage industry impact* (I^{FL}) is measured using the following formula,

$$I^{FL} = \sum_{l=1}^{L} \sum_{i=1}^{n} b_{il} z_i \left[(1 - \theta_l) \left(\frac{x_{pl}}{X_p} \Delta X_p / x_{pl} \right) X_l \right]$$

$$= \sum_{l=1}^{L} \sum_{i=1}^{n} b_{il} z_i \left[(1 - \theta_l) \frac{\Delta X_p}{X_p} X_l \right] \tag{4}$$

where $l = 1,2, \ldots,L$ are the FL sectors that purchase fish from the PF sector and x_{pl} is the amount of fish sold by PF sector p to FL sector l. The ratio $\Delta X_p/X_p$ is the percent reduction in fish sold to each of the FL sector, and when multiplied with the FL sector output X_l gives an estimate of the total maximum reduction in the final demand of sector l. It is possible that a fixed proportion (θ_l) of the fish shortage experienced by an FL sector l is mitigated by import substitution. Thus, the term in the brackets give the effective reduction in the final demand of the FL sector. The rest of the term captures the indirect and induced income impacts in the entire economy. Notice that equation (4) indirectly takes into account Ghosh's allocative coefficients (x_{pl}/X_p) in order to determine the effect of "core" input (fish) shortage experienced by the FL sectors and the attendant economy-wide direct, indirect, and induced impacts on the economy.

Finally, the *induced consumption impact* (I^{IC}) of changes in the direct income of PF sector is obtained by,

$$I^{IC} = \sum_{m=1}^{n} \sum_{i=1}^{n} b_{ij} z_i [c_m \delta z_p \Delta X_p] \tag{5}$$

where c_m is the proportion of the total household and proprietor income spent on the goods and services sold by regional sector m. Finally, the

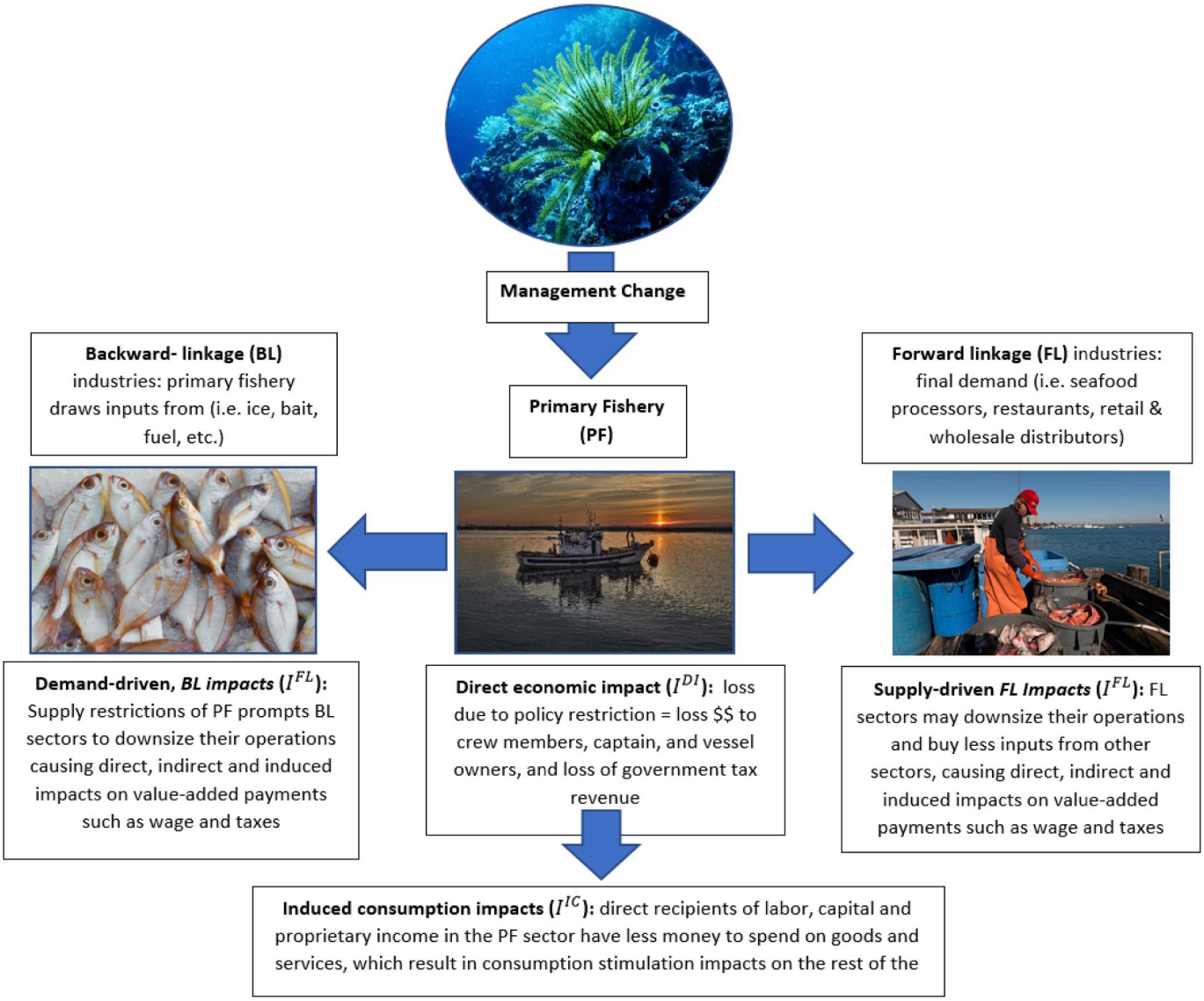

Fig. 2. Visualizing how policy change affects commercial fishing and linked sectors.

total economic impact I^{TE} of a given fishery management policy can be obtained by adding equation (2) through (5), i.e.,

$$I^{TE} = I^{DI} + I^{BL} + I^{FL} + I^{IC} \quad (6)$$

The model in (2) to (6) can be easily modified to find the employment effects of the given policy change by replacing value-added coefficients z_i with employment coefficient e_i.

3.2. Utilization of commercial fishery in PR and the Florida Gulf Coast

To estimate the current levels of commercial fish production in the proposed PR HAPC, PR, and the Florida Gulf Coast, we obtained catch, landings, and their associated value data from NOAA's Unified Data Processing Logbook (UDP) and Accumulated Landings System (ALS) database. Professionals within the Fisheries Monitoring Branch (FMB) of the Southeast Fisheries Science Center (SEFSC) in Miami, Florida queried the data from specific regions within and surrounding PR, and aggregated the data to protect confidentiality as per the NMFS's requirements.[1] From these two datasets, we acquired information on (1) total fisher reported catches by gear, species, and NMFS statistical reporting area of the Florida Gulf Coast (2) total landings by county port and species, (3) average operating cost by NMFS area by aggregated counties and gear, (4) price per pound by species group and county and (5) total number of trips per area by gear and by county. The data used within the survey represents approximately 95% of the catch within the inquired region from the years 2012–2014. We computed annual average values of quantity and value of catches and landings and extrapolated to 100%. This was the most recent, three-year data that was available at the time of this study. We opted data over a three-year period instead of just one year in order to control for any unusual year-to-year variations.

Economic trip data is obtained from a sample of fishermen selected yearly to report costs per trip as well as any economic data that is supplied voluntarily. Around 40% of all trips contain economic and cost information. The catch and cost data used within the data represents a sample proportion of approximately 25%–32% of the cost data from vessels fishing within the queried regions surrounding PR. The above survey data provided only the variable costs of fishing. We obtained the data on percent of fixed cost from Lam et al. [29] for various gear types and then derived the net profit margin for various fishing gear types. All other data pertaining to production input coefficients (i.e., costs

[1] Respective data was omitted when the number of vessels or dealers was less than three. When needed, similar variables were aggregated or combined to include more data.

coefficients) and value addition payments (i.e., household wages, proprietor income, and government taxes) for various BL (ice, fuel, retail, etc.) and FL (i.e., seafood sector) sectors are available from the 2015 IMPLAN model database for the respective study counties.

3.3. Impact analysis: data and management simulation

We used the IMPLAN Pro software and 2013 Florida state data to aggregate a large number individual economic sectors into a smaller and more manageable number of industry groups. We retained IMPLAN'S original primary commercial fishery sector, BL sectors (e.g., ice making, fuel, and retail) and FL sectors (e.g., seafood processing, restaurants, and retails) in our IO model, and combined the rest of the economic sectors into relevant groups. IMPLAN software allows for aggregating multiple county IO models into larger regional models. We grouped the IO data of about 25 Florida Gulf Coast counties into six geographically contiguous regional models to align the IO data with the NMFS fishery utilization data discussed earlier.

Using the IMPLAN IO data for the six study regions, we created total requirement coefficients (b_{ij}), income coefficients (z_j) and employment coefficients (e_l) for each region. UDP logbook data provided the average costs of fishing by input type, fishing gear, and species. The market values of gear-wise and species-wise landings were available from the ALS database. Combining the two, we estimated direct consumption coefficients (a_{ij}) of the primary fishing sector. These coefficients were necessary to compute the BL impact (equation (3)). To compute the FL impact (equation (4)), we used the IMPLAN data on fishery output sales or allocations to various FL sectors ($x_{pl}/X_p;\ l = 1,2,\ ...,n$). We assumed that the same percent allocations would apply to management-induced changes (i.e., shortage or increases) in output sales to FL sectors. We observed from the IO model that most of the FL sectors ($l = 1,2,\ ...,n$) of the study regions imported a large portion of their total input requirements from out of their regions. The extent of the FL industry impact depends on whether the FL sectors substitute any regional input shortages with imports (θ_l). Furthermore, based on the IMPLAN-generated regional purchasing coefficients, we noticed that the seafood processing industry was heavily dependent on fish produced within the region (i.e., a low θ_l value), while other FL sectors (e.g., retail and essential goods sectors) were found to rely on large amounts of imported inputs and were more likely to mitigate regional shortages with imports (high θ_l values). Therefore, we considered forward linkage industry impact for only seafood sector and ignored other sectors that purchased less than one percent of the total regional fishery output.

Finally, we found from the IMPLAN IO model for our study regions that households spent anywhere between 55 and 66% of their income on regionally produced goods and services. We set the value of parameter accordingly (i.e., = 0.55 to 0.66). Household consumption demands for regional economic sectors found in the IMPLAN model were used to compute the regional consumption coefficients (c_m). Using the assumed and computed values of and c_m, respectively, we converted the management-induced reductions in fishery sector direct income into estimates of household demand changes for regional goods and services. The estimates of relevant demand changes were inserted in equation (5) to compute the induced consumption impact.

We estimated the regional economic impacts under different management and economic scenarios. While the proposed PR HAPC regulations does not ban commercial fishing, certain vessels and/or species may be restricted. Therefore, we estimated the baseline regional economic contributions of the commercial fishing industry in federal waters of the Florida Gulf Coast NMFS areas, the entire PR region, and the PR HAPC region. Then, we estimated the economic impacts of two management restrictions: (a) banning commercial fishery entirely in the PR region, and (b) banning only specific gear (longlines) and species (groupers) in PR HAPC.

3.4. Primary survey of commercial fishermen

To assess the opinions and perceptions of commercial fisherman who fish within Pulley Ridge and the surrounding regions, we created an approximately 50-question survey using the Qualtrics survey software for online distribution in 2015. We obtained the e-mail addresses for individuals who held saltwater product licenses through public records. For this survey, we contacted individuals who held these licenses within the eight counties of the study area (Monroe, Manatee, Lee, Collier, Charlotte, Sarasota, Pinellas, and Hillsborough). In total, nearly 1600 individuals were e-mailed the survey through the Qualtrics platform in two separate distributions. Respondents whose answers were recorded in the first distribution were omitted from the e-mail list in the second distribution to avoid repetition. The responses from the two survey distributions were combined and are featured in this survey representing 78 individuals. Due to the low survey response rate, the survey responses should not be extrapolated beyond the participants in the study and should be treated as descriptive and anecdotal information.

4. Results

4.1. Regional impact analysis

Table 1 presents average annual landings from 2012 to 2014 for seven different landing regions of Florida, and the portions of these landings harvested from the NMFS reporting areas in the Florida Gulf Coast (FLGC) and the PR region. The PIHIMA county region had the highest landings of $18.558 M, followed by SREWOB of $11.853 M and MONCOL of $8.740 M. Most PIHIMA landings were extracted from the FLGC's NMFS reporting areas (i.e., federal fishing water) at a level of $13.408 M. Almost all the MONCOL and SREWOB landings came from the NMFS reporting

Table 1
Annual estimated average commercial fishery production in Florida Gulf Coast region (2012–14).

Landing Region Receiving Fish from the Florida Gulf Coast	Total Landing	Total Catch from Gulf Coast NMFS Reporting Areas	Catch from PR Region[a]	Catch from NMFS 2483 Area[b]	Percent Catch from PR[a]
	In Million US $				
Monroe and Collier (MONCOL)	8.740	8.172	0.588	1.898	6.72
Pinellas, Hillsborough, and Manatee (PIHIMA)	18.558	13.408	1.358	0.527	7.32
Lee, Charlotee, & Sarasota (LECHSA)	1.474	1.282	0.185	–	12.58
Santa Rosa, Escambia, Walton, Okaloosa and Bay (SREWOB)	11.853	0.023	0.005	–	0.04
Dixie, Taylor, Citrus, Levy, Pasco, Hernando, Franklin, Gulf, Jefferson and Wakula (DTCPHW)	5.681	0.313	0.024	–	0.42
Breward, Volusia, St Lucie, and Indian River (BVSLIR)	4.856	0.005	–	–	–
Miami Dade, Broward, Palm Beach and Martin (MDBPBM)	3.903	0.570	–	–	–
Total	55.064	23.774	2.160	2.425	3.92

[a] Represents catch for the entire Pulley Ridge (PR). PR is assumed to cover 25% of area 2483, 70% of 2583, and 22% of 2683.
[b] PR HAPC and DT National Park are located in within this reporting area.

Table 2
Species- and gear-wise annual estimated average commercial fishery productions in the Pulley Ridge and DT areas (2012–2014).

Fishing Gear	In Million US $						
	Amberjack	Groupers	Mackerels	Snappers	Tilefish	Other	Total
Entire PR (consisting of 25% of 2483, 70% of 2583, and 22% of 2683)							
Gillnet	–	–	0.049	–	–	–	0.049
Hook & line and trolling	0.007	0.318	0.055	0.383	0.008	0.005	0.777
Vertical w/longlines & buoy	0.001	1.223	–	0.084	.017	0.009	1.333
Other	–	0.001	–	0.000	–	0.000	0.001
Total	0.007	1.542	0.104	0.467	0.025	0.014	2.160
NMFS Reporting Area 2483[a]							
Monroe and Collier (MONCOL):							
Gillnet	–	–	0.195	–	–	–	0.195
Hook & line and trolling	0.027	0.069	0.222	1.324	0.030	0.015	1.687
Vertical w/longlines & buoy	–	0.009	–	0.002	–	–	0.011
Other	–	0.004	–	0.001	–	0.001	0.005
Sub-total	0.027	0.081	0.417	1.327	0.030	0.016	1.898
Pinellas, Hillsborough, and Manatee (PIHIMA):							
Hook & line and trolling	–	0.027		0.017	0.002	0.001	0.047
Vertical w/longlines & buoy	0.001	0.369		0.102	0.006	0.003	0.480
Sub-total	0.001	0.395	–	0.119	0.007	0.005	0.527
Total for 2483 area	0.028	0.476	0.417	1.445	0.037	0.021	2.425

[a] NMFS area 2483 within which the current and proposed PR HAPC are located.

area at $8.172 M and $1.282 M, respectively, indicating that boats originating from these counties fished mostly in federal waters. PIHIMA fishermen were the most productive, with an average annual catch value of $1.358 M from the PR region, which covers 25% of NMFS area 2483, 70% of area 2583, and 22% of area 2683. The MONCOL counties had the second highest catch in the PR region. Although LECHSA fishers average only $0.185 million in annual catch from PR, the region supplies 12.58% of their total catch, the highest of the six landing regions. Finally, the total annual catch from the PR region for all the Florida counties combined was $2.160 M representing just under four percent (3.92%) of the total landings of the Florida coastal counties of $55.064 M.

Table 2 presents the annual commercial harvests of species and gears. The first estimate includes the entire PR belt consisting of parts of NMFS area 2483, 2583, and 2683. The second fishing area covers the entire NMFS area 2483 within which the current and proposed PR HAPC and the DT National Park are located. The annual value of total fish production in the entire PR region totals $2.160 M, with most annual value emanating from groupers ($1.542 M) and snappers ($0.467 M). Vertical longlines were the most lucrative gear type catching a market value of fish of $1.333 M annually-most of which were groupers ($1.223 M). Hook and line produced the second highest value of fish catch in the PR region at $0.777 M, which comprised almost equal amounts of groupers ($0.318 M) and snappers ($0.383 M). Fishermen from both MONCOL and PIHIMA fished in the NMFS area 2483 at an annual total catch value of $2.425 M. MONCOL fishermen caught about $1.898 M annually-a significant portion of which was attributed to snappers ($1.327 M) and hook and line gear ($1.687 M).

Table 3 displays the annual estimates of regional economic contributions from simulations 1–4 of commercial fish catch that originate from four different fishing areas in the Florida Gulf Coast. Because changes in catch-landing flow patterns from the proposed management are expected to be limited to the MONCOL and PIHIMA landing regions, we only report their respective economic impact numbers. Simulation 1 reflects the economic contributions of the total catch coming from all federal and state waters adjacent the above two county landing regions. Simulation 2 represents contributions from catch only from NMFS federal waters, while Simulation 3 includes vertical and longline catch only in NMFS 2483 and Simulation 4 includes catch from hook and line in NMFS 2483. The estimates in this table are under the baseline assumption that the regional seafood processing sector depends on local catches for 80% of their operation and the remaining on imports.

Under Simulation 1, total income contributions (direct, BL, FL and induced income effects) were valued at $88.840 M annually to the regional economy of the two county regions. These contributions included direct crew and captain income of $11.408 M and proprietor income of $4.474 M. Therefore, while the direct fishery income was only roughly around $16 M, this sector made a significant and indirect contribution to the rest of the economy. Simulation 1 also generated a tax revenue of $10.831 M and provided 1966 jobs. As per Simulation 2, the overall income, tax revenue and the number of jobs generated totaled $71.469 M, $8.835 M, and 1,591, respectively.

The economic impact numbers for vertical and longlines under Simulation 3 are noteworthy. The total direct contributions from the PF sector were $0.205 M and $0.080 M in crew/captain income and proprietor income, respectively-which constituted about 1.8% of the direct income contributions of the entire fishery sector. The overall income contribution including BL industry, FL industry, and induced consumption impacts totaled $1.724 M or 1.91% of the total income contribution of $88.84 M of the entire commercial fish catch from Simulation 1. Of the total income impact of $1.724 M, a significant portion, $1.688 M, went to the PIHIMA counties. The overall total tax revenue and employment impacts of the vertical and longlines in NMFS 2483 area were $0.216 M and 39 jobs, respectively. Under Simulation 4, hook and line catch from the NMFS 2483, which predominantly consisted of snappers and ended up in MONCOL counties, made slightly higher regional income, tax and employment contributions than the vertical and longline catches. The total income impact of this gear class was $5.811 M, with more than 97% benefiting MONCOL county region.

Table 4 displays the results of a sensitivity analysis on the import substitution factor θ_l (ranging from 0 to 1). We analyzed the relative roles of the PF sector and forward linked sector, particularly the seafood processing industry. When $\theta_l = 0$, meaning that seafood processing sector is fully dependent on locally produced fish, the overall contributions of the fishing industry were the highest. When $\theta_l = 1$, or the seafood processing industry can easily substitute any local fish shortage with imports, the total contribution of the fishing industry was the lowest. The total regional income contribution from vertical longlines ranged from $1.724 M with full dependency on local fish to $0.564 M with no dependency on local fish or with no FL industry effect.

4.2. Survey results

Table 5 displays the descriptive characteristics of participating fishermen and fishing operations including average trip duration, crew size,

Table 3
Regional annual economic contributions of commercial fish catch of different fishing areas in the Florida Gulf Coast.[a]

	Simulation 1 Catch from GC NMFS and State Waters			Simulation 2 Landing from GC NMFS			Simulation 3 NMFS 2483 Vertical & Longline Catch			Simulation 4 NMFS 2483 Hook and Line Catch		
	MONCOL	PIHIMA	Total	MONCOL	PIHIMA	Total	MONCOL	PIHIMA	Total	MONCOL	PIHIMA	Total
	(In Million US $)											
Primary commercial fish landing	8.740	18.558	27.298	8.172	13.408	21.580	0.011	0.480	0.491	1.687	0.047	1.734
Crew and captain income in PF sector	3.652	7.755	11.408	3.415	5.603	9.018	0.005	0.201	0.205	0.705	0.020	0.725
Proprietor income in PF sector	1.432	3.041	4.474	1.339	2.197	3.537	0.002	0.079	0.080	0.276	0.008	0.284
BL-, FL- and induced consumption-related employee income	21.326	44.596	65.921	19.951	32.972	52.923	0.027	1.248	1.275	4.144	0.122	4.267
BL-, FL- and induced consumption-related proprietor income	2.556	4.481	7.037	2.400	3.591	5.992	0.003	0.160	0.164	0.520	0.016	0.535
Total income	28.967	59.874	88.840	27.105	44.364	71.469	0.037	1.688	1.724	5.646	0.166	5.811
PF and economy-wide tax revenue	3.711	7.120	10.831	3.474	5.361	8.835	0.005	0.211	0.216	0.726	0.021	0.747
Number of fishing sector and economy-wide jobs	659	1307	1966	616	974	1591	1	38	39	129	4	133

[a] Assumes 100 of the seafood processing industry depends on the regionally produced fish catch, i.e., $(1-\vartheta_l) = 1.0$.

Table 4
The impact of forward linked industry on the overall contributions of fishery sector.

Dependency of seafood processing sector on locally produced fish	Total Income Contribution	
	Vertical and Longlines	Hook and Line
	(In $ Million)	
0.0	1.724	5.811
0.2	1.492	4.991
0.5	1.144	3.762
0.8	0.796	2.532
1.0	0.564	1.712

Table 5
Sample characteristics of commercial fishermen in PR and Florida Gulf Coast, 2014 and 2015.

Variable	*n*	Mean	Std. Dev	Min	Max
Years as fisherman	77	20.3	15.2	0	59
Age	78	51.5	15.0	21	82
Combined weekly catch of all species (lbs.)	64	1725.5	3447.1	0	20,000
Trips per year (PR)	24	12.4	23.6	0	120
Trips per year (DTs)	35	13.1	26.8	1	156
Trip duration (PR) (day)	21	6.0	4.1	2	14
Trip duration (DTs) (day)	33	5.4	2.1	1	30
Trip duration (both) (day)	12	4.8	3.7	2	14
Engine Horsepower	74	416.8	299.2	50	2190
Crew size	73	2.5	1.1	1	5

horsepower etc. Seventy-eight respondents participated in our survey. About 32.1% of respondents indicated that they fished in PR, while 46.2% indicated that they fished in the areas surrounding the DTs. A smaller percentage of 24.4 indicated that they fished in both areas.

Reactions to both the HAPC expansion and the FKNMS expansion were negative. An overwhelming majority of the respondents said the proposed PR HAPC regulations would either very significantly (31.6%) or somewhat significantly (57.9%) affect their operations (Table 6). About 53.5% of respondents indicated that they would not support an expansion of the PR HAPC, because 66.7% of this group contend that the extension of the HAPC would hinder their current fishing operations. 23.3% of those who opposed expansion did so even if the proposed management action did not hurt their business. Of the 16 respondents who indicated support for the HAPC extension, only 37.5% of those respondents indicated they would support a larger expansion of around 500 sq. miles. Response to the FKNMS expansion was similar to that of the HAPC expansion in that 63.2% of respondents did not support the expansion, with 56.4% of respondents indicating that an expansion would not protect coral reef health in PR.

When respondents were asked which proposal would be most effective in improving coral reef health in PR, 58.5% of respondents indicated that they "said 'no' to either proposal earlier," but the next majority (18.9%) suggested that they thought a combination of both proposals would be most effective (Table 7). When asked if they thought any of the above hypothetical scenarios would increase fish stocks along the West Coast of FL, the results were largely inconclusive; 36.4% of respondents said "no," but the majority (38.2%) said they were "unsure." Likewise, when respondents were shown a prompt[2] that

[2] Prompt shown to respondents: "According to the 2011 Condition Report for Florida Keys National Marine Sanctuary, "research has shown that certain fish species (e.g., black grouper, red grouper, and mutton snapper) have responded positively to the combination of stronger fishery regulations and establishment of larger ecological reserves within FKNMS. As such, scientists and [other] stakeholders believe that potential new management changes in Pulley Ridge will lead to more reef fish in the future along the West Coast of Florida."

Table 6
Perception of commercial fishermen regarding management actions in PR HAPC and FKNMS.

Question	Responses	Percent (%)	*n*
How significant does the current HAPC designation affect your business?	Very Significant	31.6%	19
	Somewhat Significant	57.9%	
	Neither Significant nor Insignificant	10.5%	
Do you support an extension of the PR HAPC?	Yes	27.6%	58
	No	53.5%	
	Unsure	19.0%	
If no, would the proposed extension hinder your current fishing operations?	Yes	66.7%	30
	No	23.3%	
	No, would support a smaller extension	3.3%	
	Unsure	6.7%	
If no, how significant would the proposed HAPC extension hinder your current fishing operations?	Very significant	70.0%	20
	Somewhat significant	30.0%	
If yes, would you consider a larger extension of the HAPC area, say 500 sq miles?	Yes	37.5%	16
	No	31.3%	
	Unsure	31.3%	
Do you support additional protections afforded by the FKNMS in Pulley Ridge?	Yes	15.8%	57
	No	63.2%	
	Unsure	21.1%	
If yes, what percentage of reef track should be protected under the FKNMS expansion?	Less than 10%	11.1%	9
	25.0%	11.1%	
	75.0%	33.3%	
	Entire Area	44.4%	
Do you think additional protections (FKNMS) will improve coral reef health in PR?	Yes	21.8%	55
	No	56.4%	
	Unsure	21.8%	

scientifically justified a short-term decline in fish stocks for long term benefits, 32% of respondents suggested they were “unsure” on whether they would be willing to accept a short-term decline in fish stocks for increased stocks in the future. 36% indicated that they would not be willing to accept this short-term decline, while 32% maintained that they would be willing to accept this decline. Despite the uncertainty in some of the follow-up questions, 51% of respondents indicated that the creation of “no-take” zones or the extension of marine protection areas in their fishing grounds have not benefitted their operations, while 27.5% of respondents were unsure.

5. Discussion

5.1. Regional economic impacts of PR fishery and proposed regulations

The results of the regional economic impact analysis convey that the commercial fishing in the study regions of the Gulf Coast not only generate significant income within the fishery sector, but also holds strong economic linkage with the rest of the economy. While the direct income (crew, captain and proprietor) generated within the primary fishing industry is little over $15 M, its total income contribution (direct, backward, forward and induced consumption effects) to the overall economy is more than five times the direct contribution (i.e., over $80 M). We find that much of this indirect impact is attributed to the strong linkage the fishery sector has with the forward-linked industry, particularly the seafood processing sector. Although the local seafood processing industry absorbs only about 40% of the primary fish produced in the region, its value addition and the final economic contribution are substantial. Discussions about the economic impacts of fishery management often focus on the PF sector. Our results suggest more sizable impacts of fishery regulations are observed within backward- and forward-linked sectors.

The proposed management plans largely concern the NMFS statistical reporting area 2483. The catch value from this statistical area constitutes a little less than ten percent of the total landed by fishers from in the MONCOL and PIHIMA landing regions (Table 4). In terms of total regional economic contributions, the MONCOL sub-region appropriates three times more income, tax, and employment benefits from the 2483 fishing region than the PHHIMA sub-region.

The results of our analysis suggest that both proposed management changes that impose restrictions of certain commercial fishing gear -such as longlines in the expanded PR HAPC- will also restrict the regional economy in the short run. Consider an unlikely scenario-if the proposed expansion of PR HAPC restricts the entire fleet of vertical and longlines in 2483 area, the grouper fishing could suffer a slight blow back to a maximum extent of $0.491 M in fish catch. This translates to $0.285 M in direct income loss in the primary fishing industry and $1.724 M in the overall income, which are less than 3% of the overall fishery economy in the affected counties (i.e., $15.882 million and $88.840 million, respectively; see simulation 3 results). If any future regulations in 2483 area influence hook and lines gear, snapper fishing in the Dry Tortuga area may suffer a partial setback. In this case, the maximum potential loss in primary fish catch would be $1.734 M, PF income could lose $2.459 M, and overall regional income $5.811 M. However, note that the proposed management regulation will unlikely affect hook and line gear types and in turn, snapper catch.

Table 7
Fishermen's preference towards alternative fishery management actions in PR region.

Question	Responses	Percent (%)	*n*
Which strategy do you think will be most effective in improving the coral reef health in Pulley Ridge	The expansion of the HAPC (a)	17.0%	53
	The expansion of the FKNMS (b)	5.7%	
	A combination of both (a) and (b)	18.9%	
	No, I said “NO” to either proposal earlier	58.5%	
Do you believe any of the above hypothetical marine management actions will increase fish stocks along the West Coast of Florida	Yes	25.5%	55
	No	36.4%	
	Unsure	38.2%	
Which would have a bigger impact on your fishing operations in Pulley Ridge	Reductions in TAC per species	59.0%	39
	Reductions in total trips within that area	41.0%	
Are you willing to accept a short-term decline in total catch for increased fish stocks in the future?	Yes	32.0%	50
	No	36.0%	
	Unsure	32.0%	
Has the creation of “no-take” zones or the extension of marine protection areas in your fishing grounds benefited your fishing operations?	Yes	21.6%	51
	No	51.0%	
	Unsure	27.5%	

Based on the fish catch-landing flow pattern presented in Tables 1 and 2, proposed PR HAPC expansion may cause some degree of unevenness in the negative impacts on commercial operators and the regional economies. PR HAPC region predominantly supports grouper fishing and most of groupers caught from this region land in PIHIMA counties. Therefore, the proposed HAPC expansion will have higher economic impacts on operators from these counties and their fishery-dependent economy than of MONCOL.

We view the above management-induced adverse impacts as upper bound estimates and short term in nature. Two types of structural changes in the medium and long terms are expected to negate the near-term impacts. First, the protection of fish stock in PR HAPC is expected to enhance the fish abundance and productivity particularly in and around the DT area [20]. Both DT snapper and grouper stocks may benefit from upstream protection. This will eventually have positive economic impacts on fishers fishing in the Dry Tortuga region and regional economies of MONCOL landing region. Second, behavioral adjustments in fisheries are very common in response to regulations [26]). Grouper fishermen operating in the 2483 area are primarily from the PIHIMA counties, which are in the central portion of the Florida Gulf Coast. In the event of increased restrictions in PR HAPC, fishers might concentrate more in NMFS reporting areas 2583 and 2683, which are directly to the north of 2483 area and have traditionally proved to be rich grounds for groper fishing. If fishermen redistribute their fishing effort to the north of the PR HAPC expanded area, the near term adverse impacts of proposed regulations may eventually fade away.

Finally, the regional economic impact estimates are under the assumption that the forward-linked seafood processing sector in the study counties depend on locally landed fish for 100% of its operation and that it would not substitute any shortage in the local fish supply with imports. If this assumption is relaxed, policy-induced fish supply restrictions may not have the full economy-wide impact. Results in Table 7 are evident that the overall regional economic impacts of various management actions may start to decline as the seafood processing industry itself starts to adjust to the primary fish shortage. Some of the adjustment could be through importing raw material or through to secure its share of fish catch from the harvesters.

5.2. Commercial Fishers' perception and the proposed management

We present the results of our survey with the caveat that our findings may be biased towards individuals with strong views on the policies due to our low response rate. Our results suggest that there is an apparent disparity between stakeholder perception and short-term economic impacts. The economic impact analysis indicates the upper bound impact of the proposed regulation is less than three percent of the overall contributions of the commercial fishery sector. Most respondents voted “no” to either the HAPC expansion or the expansion of the FKNMS, despite either proposal would not significantly harm their operations. This disparity can be explained by a few reasons, including the lack of information on the potential impacts of regulations on their operations or through their reliance on their past experiences with the government agencies and enforcement of current restrictions and policies. However, we observed a substantive amount of uncertainty in whether respondents were convinced of the effectualness of these potential management scenarios. When asked if they believed that any of the hypothetical management actions would increase fish stocks, most respondents (38.2%) indicated that they were “unsure,” followed closely by 36.4% of respondents who definitively stated “no.” Perhaps respondents opted to not support the plans because they were uncertain of the potential effectiveness of these actions. In other words, they may not be willing to tradeoff an uncertain, long-term economic benefit with a certain short-term economic loss, irrespective how small it is.

Respondents were shown a prompt that provided scientific justification for the establishment of reserves and stronger fishery regulations, and then asked if they would accept a short-term decline in fish for long-term benefits. About 32% of the respondents indicated that they would accept the short-term decline and the same percent of respondents indicated they were “unsure.” However, 36% of respondents were obstinate even after being informed of a scientific argument and stated that they would not accept a short-term decline, which is similar to the 36.4% of respondents who also stated they believed none of the proposed management alternatives would result in augmented fish stocks. This percentage of respondents appear to be not supporting even a scientifically upheld management change.

The difference between the results of the regional impact analysis and the commercial fishermen perception survey can be explained by potential biases arising from distrust of government interventions in the past, lack of communication, and an unwillingness to bear short-term economic losses in lieu of long-term economic gains. A closer examination of the feedback that respondents articulated within the commentary section of the survey reveals a few explanations for the distrust of any further management intervention. Respondents who opted to leave commentary expressed overall discontent with the FKNMS and their ability to improve life in the Florida Keys. Some respondents,[3,4] cited the FKNMS' failure to address downstream water quality issues as their largest deficiency in protecting water resources. They posited that improvements to water quality were a likely panacea, which would promulgate widespread benefits including fish population recovery. One respondent remarked:

> *“The FKNMS really has not done much for the Florida Keys. Other than the establishment of the Tortugas Reserves (especially Riley's Hump) nothing has improved. The reef has less coral cover than it did 25 years ago. Water quality has declined. They have failed to address the jet -ski issue, etc. I am a proponent of ecological reserves and many other conservation measures, but not “feel good” measures, like coral restoration. The reef is on life support at this point, and FKNMS has been a disappointment to many of us. They have failed at their charge of protecting the resource and quality of life for us in the Keys.”*

6. Conclusion

We examined potential regional economic impacts of fishery management proposals in the PR region of the Florida Gulf Coast. The examination was based on a regional input-output analysis and an online primary survey of commercial fishermen. The input-output analysis, conducted assuming a policy-induced supply constraint, revealed the impacts of the proposed regulations on income, taxes, and employment in the PF harvesting sector and larger economy. Our case study revealed that the commercial fishery sector in the study region did have significant linkage effects on the economy. However, the proposed expansions of HAPC in the PR region and jurisdiction of FKNMS would have minimal economic impacts on the regional income, tax revenue, and employment ($< 3\%$) in the short run, particularly resulting primarily from restricted grouper fishing. Our study does not compare short-term costs with long-term benefits of proposed regulations. Nonetheless, based on the recent ecological research done in the region [7,21], there is enough evidence that short-term income and employment losses might very well be offset by economic gains following improved fish stocks downstream in the Dry Tortuga area and effort reallocation into areas north of Pulley Ridge.

For the success of the future fishery programs in the region, fishery management agencies should incorporate the opinions of stakeholders

[3] “Reducing harmful run off into the Gulf and Atlantic will have a more positive impact on fish populations than any area closers ever could.”

[4] “Close Pulley Ridge but don't delude yourselves that you're saving the reef by doing so. Until NOAA and the powers that be decide to really work and spend and use their political might to improve water quality then that would be all the sanctuary and NOAA would be good for.”

into management design. However, the agencies dealing with fishery resources located in PR HAPC and FKNMS currently face steep challenges, including stake-holders' perception about their immediate economic losses in the PR fishery, uncertainty about the long-term economic gain from the program, and trust in the government regarding increasing regulations. The short-term economic losses that fishery sector and the regional economy will suffer appear to be minimal, although distributed slightly uneven regionally. Furthermore, these losses could diminish in the medium and long term due to ecological stock improvements and behavioral adjustment within the fishery sector. Yet, based on the primary survey, commercial fishermen appear to be jaded by past fishery management experiences in the region, and have little incentive to invest in the future as they continue to age. Reconciling the gap between the stakeholders' perception of losses and regional economic losses puts additional responsibility on the part of management agencies, scientists, and community organizations. The two agencies should coordinate education campaigns for fishermen and backward- and forward-linked businesses in the region that highlight past management success stories. The survey results suggest that a portion of fisherman are uncertain about the effectiveness of protected area changes. Targeted education of past success stories and negotiation may garner broad-based support for the proposed management programs.

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