

Impact of Non-fishery Factors on the Performance of Commercial Fisheries: Case Study of the Florida Keys, 1950-2007

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ABSTRACT

The study considers the long-term effects of non-fishery factors, comprised of socio-demographic, macroeconomic, management, and natural-anthropogenic factors, on the performance of and participation in major Florida Keys commercial fisheries. Evaluated over a half century (1950 - 2007), the results demonstrate the non-fishery factors have exerted a strong influence on the region's commercial fisheries, such that socio-demographic and macroeconomic factors facilitated the growth and proliferation of the fishing industry across the island chain in the first half of the study period, followed by increasing cost of living, resource competition, import pressure, and adverse environmental conditions that together with management measures forced the contraction of the fisheries in the second half of the study period. The results also determine that land-side costs, such as housing and cost of living, combined with rising fishery trip costs and stagnant or declining price trends, have been the major non-fishery factors culpable for the increased vulnerability in the Florida Keys commercial fishery. If the sustainability of commercial fishing communities remains an objective for fisheries management, approaches taken to discipline performance and participation need to consider the socio-economic environment, predicting how management actions may interact with non-fishery factors.

KEY WORDS: Commercial fisheries, Florida Keys, socioeconomics

Impactos de Factores que no Están Relacionados con Pesquerías Comerciales en el Rendimiento de Pesquerías Comerciales y la Sostenibilidad de Comunidades Pesqueras en los Cayos de Florida

Este proyecto evalúa los impactos acumulativos de los cambios socio-demográficos (ex. crecimiento de la población), condiciones macroeconómicas (ex. precios de combustible, costo de vivir, conteniendo valores de hacienda, etc.), decisiones de gerencia ambientales (ex. áreas manejadas marinas, medidas de la protección de las especies, etc.), y eventos naturales (ex. huracanes, blanqueamiento de corales, etc.) en las industrias pesqueras comerciales y comunidades pesqueras en Los Cayos de la Florida. Tomando un enfoque principalmente histórico, la discusión principal del análisis es que los factores que no están relacionados con pesquerías han tenido impactos significativos en las industrias pesqueras comerciales de la región y, en muchos casos, han sido igualmente o más determinativos del participación de los pescadores comerciales y el rendimiento de la industria pesquera que medidas de manejo pesquero tradicional. Es decir, los factores que no están relacionados con pesquerías en algunos casos han actuado sinérgico con la gerencia de la industria pesquera en el abastecimiento de resultados positivos, pero en otros casos tales factores han trabajado antagónico con la gerencia de la industria pesquera y han conducido a los resultados negativos. Mientras que la gerencia de la industria pesquera en los Estados Unidos bajo Acto de Magnuson-Stevens se mueve hacia la acción de sostener pesquerías (Estándar Nacional 2) y preservar a comunidades pesqueras (Estándar Nacional 8), un enfoque ensanchado y histórico como utilizado en este proyecto es importante en predecir resultados y mejorar gerencia.

PALABRAS CLAVES: Pesquerías comerciales, comunidades pesqueras, Los Cayos de la Florida, manejo pesquero

Les Impacts des Facteurs de Non-pêche sur la Performance de Pêcheries Commerciales et la Viabilité des Communautés de Pêche dans les Keys de Floride

Ce projet évalue les impacts cumulatifs des changements socio-démographiques (ex.: croissance démographique), les conditions macro-économiques (ex. : prix du carburant, coût de la vie, valeurs du logement, etc), les décisions de gestion environnementale (ex. zones de gestion marine, mesures de protection des espèces, etc), et des événements naturels (ex. ouragans, blanchissement des coraux, etc) sur les pêcheries commerciales et les communautés de pêche dans les Keys de Floride. Adoptant une approche essentiellement historique, l'argument principal de l'analyse est que les facteurs non liés à la pêche ont eu des impacts significatifs sur les pêcheries commerciales de la région et, dans de nombreux cas, ont été autant, sinon plus déterminants quant à la participation des pêcheurs commerciaux et de la performance qu'ont les mesures de gestion traditionnelle de la pêche. Autrement dit, les facteurs non liés à la pêche ont, dans certains cas, agi en synergie avec la gestion des pêcheries en fournissant des résultats positifs, mais dans d'autres cas, de tels facteurs ont travaillé de façon antagoniste avec la gestion de la pêche et ont abouti à des résultats négatifs. Comme la gestion de la pêche en vertu de la loi Magnuson-Stevens se déplace vers le maintien des stocks de pêche (Standard national 2) et la préservation des communautés de pêcheurs (Standard national 8), une approche élargie historique comme utilisée dans le présent projet est importante à la fois dans la prédiction des résultats et l'amélioration de la gestion.

MOTS CLÉS: Pêcheries commerciales, communautés de pêche, Keys de Floride, gestion des pêcheries

INTRODUCTION

Commercial fisheries in the State of Florida have experienced a significant decline in the past two decades, as measured by the number of participants and fishing communities. Almost 10,000 Saltwater Products License

(SPL) holders, or licensed fishers, left the commercial fishing industry across the state from 1990 to 2008 (FWRI, 2010), a period during which Florida's population increased by 41%, adding 5.4 million residents to the almost 13 million residents in 1990 (US Census 2009). Within the

Florida Keys, which contains some of the state's most diverse and lucrative fisheries, commercial fishing accounted for 3,200 fishers in 1990; by 2008, over 57% had exited the industry, leaving less than 1,400 participants (FWRI 2009). The diminished presence of commercial fishing from the waterfront, which heretofore occupied waterfront space through commercial docks and facilities, accelerated rates of gentrification where such working waterfronts were re-developed for other, non-waterfront related uses. Even with measures by local and state governments to preserve working waterfronts (SPFRC 2005), commercial fishing communities in the Florida Keys have continued to fragment and decline.

While it is certain that certain fisheries have suffered as a result of over-capacity and lowered stock abundances (especially finfish fisheries (Ault *et al.* 1998 Bohnsack *et al.* 1994)), participation in several, major Florida Keys fisheries has more often declined due to a combination of fishery and non-fishery factors. In some fisheries, such as the spiny lobster industry, participation was reduced by almost half in the 1990s as part of a management effort to decrease the number of traps (and fishers) in the fishery; however, further consolidation from the 2000s onwards occurred although active trap reduction measures had been largely suspended, due in part to flattened ex-vessel values, increasing trip costs, and lower abundances (Shivlani *et al.* 2005). The shrimp trawl industry, once the dominant fishery in the Florida Keys, was decimated by a combination of ecological factors in mid-1980s and further diminished by unfavorable trade conditions, increasing fuel costs, and reduced dock space (Adams *et al.* 2008, Schitonne 2001). Similarly, the stone crab trap fishery, arguably among the healthiest fisheries in the region (Muller *et al.* 2006), experienced a steep decline in the number of licensed fishers in the 2000s after effort in the industry increased in the 1990s following the aforementioned lobster trap reduction program and the 1994 Florida Net Ban (Shivlani *et al.* 1998). Whether management can develop strategies to sustain commercial fisheries in the Florida Keys and across the region may depend on the ability of management measures to determine how (and mitigate against) non-fishery factors impact fishing communities and their sustainability.

The Florida Keys (as bounded by Monroe County, Florida) was selected as a case study to evaluate the effects of non-fishery factors on the islands' commercial fisheries. The county accounts for 90% of the state's spiny lobster landings and contains a significant portion of the stone crab fishery, as well as other species of notes, such as shrimp, reef fish, coastal migratory finfish, and offshore finfish, among others (Steve Brown Pers. comm.). Also, the Florida Keys have experienced the effects of a variety of non-fishery factors that have shaped the islands' fisheries since the end of World War II. In this study, four non-fishery factors, comprised of socio-demographic, macroeconomic, management, and natural-anthropogenic factors,

were evaluated in the Florida Keys for the period between 1950 and 2007, to evaluate how the factors interacted with fishery conditions and with other factors to shape the archipelago's fisheries and affect fishing communities.

METHODOLOGY

The methodology consisted of two main tasks: The first task was the evaluation of each of the four non-fishery factors on the performance of commercial fisheries in the Florida Keys using a variety of primary and secondary data sources; and, the second task was the development of a historical characterization of commercial fisheries in the Florida Keys, as obtained from databases and secondary literature. The study selected four, main non-fishery factors and evaluated how each factor had contributed to changes in the Florida Keys fisheries from 1950 to 2007. Information was gathered from a variety of primary sources, such as commercial fisher and other stakeholder interviews, and data collected from secondary sources, including statistical and longitudinal databases on fisheries and non-fishery factors; altogether, 30 respondents, representing a variety of stakeholder interests ranging from fisheries to management, were interviewed for the study. The study also utilized historical narratives completed for several hundred other stakeholders in studies conducted by the principal investigator in the Florida Keys from 1995 to 2007. Secondary literature, consisting of previous studies, reports, volumes, and other unpublished literature, served to provide extensive information on fisheries and fishing communities and non-fishery factors in the Florida Keys.

Socio-demographic factors consisted of factors related to the population growth in the Florida Keys from the post World War II era onwards, including changes in the major occupations that employed the labor force, increasing diversity as population growth was accommodated mainly by immigration, and shifts in demand for coastal and marine resources, including fish and fisheries, as tourism and stakeholder group competition grew. The US Census data, as provided by population and housing reports from six censuses from 1950 to 2000, served as the primary source of socio-demographic characteristics and trends in Monroe County. Census data were supplemented by information contained in various statistical abstracts and archival newspaper articles. Tourism and stakeholder population and use trends were obtained from various studies conducted with these groups from the 1990s onwards in the Florida Keys, as well as older, selected reports on stakeholder characterization studies.

Macroeconomic factors, closely related to socio-demographic factors, included factors such as housing and cost of living expenses in the Florida Keys, as well as commercial fishery costs as determined by fishing trip and operations costs and the effects of imported species on the ex-vessel value of Florida Keys' landed seafood. Housing and cost of living data were obtained from the US Census and other statistical abstracts, and trade information on

fisheries imports were obtained from the National Marine Fisheries Service Statistics and Economics Division website. Previous studies on fishery trip and operations costs provided information on changes in the cost of commercial fishing in the Florida Keys.

Fishery and environmental management factors were comprised of state and federal fishery management measures, including size and seasonal restrictions, qualification requirements, limited access and effort, and closed areas, and environmental management actions resulting in the establishment of protected species and no-fishing zones, among others. State and federal fishery management regulations were utilized to identify the evolution of the fishery management regulatory framework under the Florida Fish and Wildlife Conservation Commission (FWC) and its predecessor, the Florida Marine Fisheries Commission, and the two federal fishery management councils. Information on environmental management factors was obtained from management plans, reports, and other literature related to the performance and effects of state and federal protected areas in the Florida Keys, such as John Pennekamp Coral Reef State Park (JPCRSP) and the Florida Keys National Marine Sanctuary (FKNMS), among others.

Anthropogenic-natural factors consisted of either wholly natural or which are in part or completely driven by anthropogenic activities, such as hurricanes, natural recruitment and abundance patterns, and diseases in target or related species, as well as physical impacts and land-based and marine pollution. The National Hurricane Center and NOAA Coastal Services Center websites served as the main sources of data on hurricane tracks and impacts, whereas a multitude of secondary literature provided information on ecological trends in Florida Bay and the Florida Reef Tract, coastal and marine species, and anthropogenic impacts.

The historical characterization of major fisheries in the Florida Keys was completed for spiny lobster, stone crab, shrimp, reef fish, and coastal migratory finfish fisheries based around the 1950 - 2007 FWC fishery database, which contained information on landings and value (1950 - 1960), landings, value, and partial trips (1961 - 1985), and landings, value, and trips and trip areas (1986 - 2007). Other fishery data, from the Marine Fisheries Service (NMFS) Office of Science and Technology Annual Commercial Landings Statistics website, along with a variety of historical reports, published and gray literature, newspaper archives, and interview information, were all used to build up the historical characterization.

Finally, non-fishery factor information and the historical characterization of each major fishery were analyzed to determine how individual fisheries performed over the study time period, i.e., 1950 - 2007, and which factors influenced trends in fishery participation and performance patterns. The study developed narratives for each major fisheries that evaluated the importance of the

various non-fishery factors as positive factors that may have influenced, even promoted, the growth of fisheries and as negative factors that may have dampened, or even caused, the demise of fisheries.

RESULTS

The results first describe each set of the four non-fishery factors in chronological order to present the factors' effects in the context of the region and over the time period of the study, followed by historical characterizations for the major fisheries that incorporate the aforementioned factors in identifying how the factors interacted with fishery conditions to influence performance and affect participation.

Socio-demographic Factors

Within socio-demographic factors, population growth and increased tourism in general and inter-group competition had profound impacts on the shaping of the post World War II commercial fisheries in the Florida Keys. In terms of population growth, Monroe County (as well as the rest of the State of Florida) experienced explosive growth from the 1950s to the 1980s (US Census 2009). The Florida Keys population, which had been largely concentrated in the Key West area in the southwestern edge of the archipelago, had actually declined in the period prior to World War II. Key West's population decreased to less than 15,000 residents in the 1930s as a result of the Great Depression (Ogle 2003). The commercial fishing industry, which had developed to supply king mackerel and spiny lobster to northern markets from the 1910s onward (in part due to the advent of the Overseas Railroad in 1912 that created a land connection from the Florida peninsula to Key West), was decimated with the economic downturn (Little 2000). For instance, spiny lobster landings, which had surpassed 1.3 million pounds in 1932, dropped to 270,000 pounds the following year and did not match earlier production until the end of the decade. However, as the Overseas Highway was completed in 1938, an aqueduct built by the support of the US Navy for its Lower Florida Keys naval installations, and prosperity increasing in the 1950s, the Florida Keys gained popularity as both a tourism destination and a domicile (Ogle 2003, Swift 1997). Unlike in the pre-war years when Key West dominated population growth and tourism, development from the 1950s onwards concentrated on the heretofore sparsely populated Upper and Middle Keys (and, to a certain extent, parts of the Lower Keys located outside of Key West).

In 1950, the Florida Keys population was at just under 30,000 residents, of which almost 90% lived in Key West. Key West's overall population increased to its peak in 1960, but its overall share of the Florida Keys population decreased in each census count after 1950 (US Census 2009). Settlements such as Marathon and Rock Harbor, which were fishing and farming settlements, increased in

population and size from 1950s onwards. The increasing population growth fueled the demand for development, which was in part facilitated by the environmentally destructive practice of clear cutting mangroves, dredging nearshore bottom, and creating finger canals along spoil islands; the practice led to the development of various communities, especially in the Upper and Middle Keys, until it was discontinued in the 1970s (Garrett 1997). The commercial fishing industry grew along with the population growth, and the formal commercial fisher population (as measured by the US Census) accounted for an average of 5% of the islands' labor force from 1950 to 1980 (US Census 2009). Overall landings also increased considerably during that thirty-year period, with total landings increasing from less than nine million pounds in 1950 to almost 24 million pounds in 1980 (Steve Brown Pers. comm.).

The percentages of overall population growth and labor force employed in commercial fisheries both declined from the 1980s onward. Stricter environmental regulations, including the 1975 designation of Monroe County as an Area of Critical State Concern, led in part to the passage of a county growth management plan that included a rate of growth ordinance (ROGO) (MCGD 2009). Under ROGO, the county limited building permits to 255 permits per year with the goal to reduce immigration to 600 residents per year. While the rest of the state experienced double-digit growth rates in the 1990s and 2000s, the Florida Keys grew only by 2% from 1990 to 2000 and then actually decreased in population throughout the 2000s (US Census 2009) (Figure 1).

As population stabilized and declined in the Florida Keys from 1990s onwards, the tourism economy increased, dominating the region's economy and providing competition for coastal and marine resources, such as fisheries and habitat. Almost 2.4 million visitors spent 14.4 million days in the Florida Keys in 1990, accounting for 70% of the area's total employment (Kearney/Centaur 1990). By the mid-1990s, tourism grew to 2.5 million visitors who spent 16.3 million visitor days and of which two thirds engaged in a water-based activity (Leeworthy and Wiley 1996). By the start of the 2000s, the Florida Keys had adopted tourism as the county's primary economic driver, attracting almost three million visitors per year who increasingly demanded access to waterfronts and coastal and marine resources. Recreational anglers in Miami-Dade and Monroe Counties in 1993 accounted for a majority of resident fishing trips in 1991-92, with an expected increase of 26.5% by 2010 (Milon and Thunberg 2010). For-hire, or charter fishing, operations in the Florida Keys grew in response to the demand for recreational fishing trips, such that by the mid-1980s, there were 210 charter fishing vessels and 241 in 1997 (Ditton *et al.* 2001). Within the spiny lobster fishery, recreational fishing effort increased as SCUBA diving became more popular, and by the 1990s, the recreational sector accounted for 30% of total landings in one of the region's most important commercial fisheries (Sharp *et al.* 2005). Apart for extractive uses such as fishing and lobster diving, other recreational uses that increasing competed with commercial fishing were those related to recreational diving and snorkeling. Use in the country's first underwater park, John Pennekamp Coral

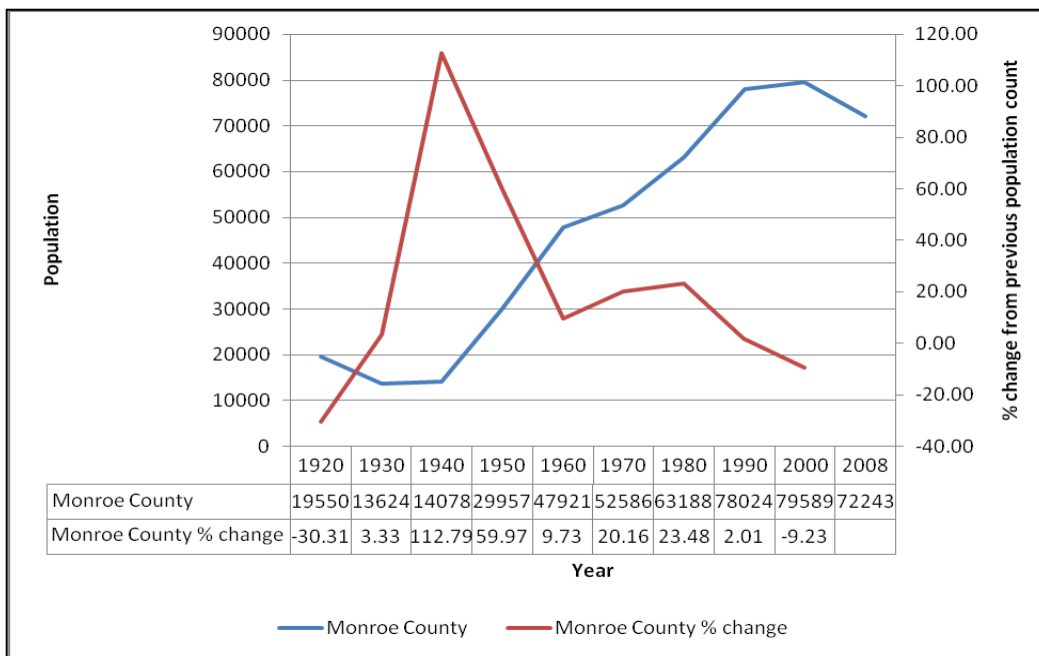


Figure 1. Monroe County population growth: 1950-2008 (Source: US Census 2009)

Reef State Park, increased from 200,000 visitors in the 1960s to 645,000 by the mid-1980s (Mattson and DeFoor 1985). Dive use in the Lower Keys' Looe Key National Marine Sanctuary increased by 400% from 1985 to 1990. By the 1990s, non-extractive uses had increased in popularity such that one in three visitors reported taking a dive or snorkel trip in 1995 - 1996 (Leeworthy and Wiley 1996), and diver and snorkeler expectations of successful trips were based on their expectations to view fish diversity and large number of fish, thereby competing with extractive activities in the valuation of such resources (Shivlani *et al.* 2003).

Macroeconomic Factors

The Florida Keys have presented always presented a logistical challenge to their residents, in terms of the limited availability of resources such as fresh water and the costs associated with transportation of supplies, and these challenges have often resulted in the higher than State of Florida average cost of living expenses. Over the period considered for the study, the cost of living (or land-side) costs increased at a rate much higher than did returns for commercial fisheries. Two main reasons accounted for these changes: First, as development slowed and tourism increased in the Florida Keys, land prices rose relative to other parts of Florida; and second, economic globalization facilitated the availability of imported species from the mid-1970s onward to compete with locally landed seafood while global demand increased oil and other commodity prices (especially in the 2000s), leading to higher gear and trip costs. Confronted with higher expenses and often diminished or stagnant returns for seafood, the Florida Keys fisheries declined in terms of participants and landings over the past decade.

Median home prices in Monroe County were similar to those for the State of Florida for the period between 1950 and 1980. After the state established the Area of Critical State Concern designation and the county commenced on growth management, the housing units available declined, and the median home price in 1990 in the Florida Keys reached almost 200% of the median state home price (\$147,800 in Monroe County versus \$77,000 of the State of Florida) (US Census 2009). By 2000, median home prices increased to \$241,200 (\$287,795 in 2007 dollars), and the median price almost triple by 2007, reaching almost \$672,000. The median price in Key West was even higher in 2007, at almost \$750,000 (US Census 2009). The higher housing costs were reflected in the overall cost of living in the Florida Keys, which was the highest in the State of Florida in the mid to late 2000s (BEBR 2009). As a result, many multi-generation residents, known as Conchs, moved out of the county (Ball 2005), and the percentage of residents who earned their living by work in Monroe County decreased to less than 50% by the mid-2000s, representing a profound shift on the population's relationship with the archipelago's coastal and marine

resources, including commercial fishing. Commercial fishing facilities also suffered as waterfront uses shifted to accommodate recreational and residential uses. Fish houses, loci where commercial fishers unloaded and sold harvest, docked vessels, and stored gear, were under increasing pressure from diminished landings and fishers exiting the industry such that the fish houses sold out to other, often gentrification interests during the 1990s and 2000s. For example, there were 11 fish houses in 1995 - 1996 in Stock Island/Key West (Milon *et al.* 1997), and that total declined to only two fish houses in 2008 (Shivlani *et al.* 2008). While both Monroe County and the State of Florida implemented measures to counteract the diminution of so-called "working waterfronts" (SFPRC 2005), the effort only addressed a part of the larger set of macroeconomic factors that had destabilized the Florida Keys commercial fishing industry.

Fixed and variable fishery costs, as measured by annual operating (ex. gear, dockage, etc.) and trip costs, remained stable in the 1980s and 1990s but rose sharply in the 2000s in conjunction with land-side costs. A longitudinal survey of operating and trip costs from studies conducted with the fishery in 1996 (Milon *et al.* 1997) and 2005 (Shivlani *et al.* 2008), area-specific studies that evaluated the pre- and post-closure fishery effects of the Dry Tortugas Ecological Reserve (Thomas J. Murray & Associates 2005, NOAA 2000), and commercial fishery panel monitoring data (Thomas J. Murray & Associates 2007), demonstrated that trip costs had increased significantly over the decade and that fuel costs were largely responsible for the higher trip costs. Stone crab and spiny lobster trip costs increased from 1996 to 2005 by 77% and 69%, respectively (Shivlani *et al.* 2008). For those fishers who targeted the offshore grounds of the Dry Tortugas, shrimp trawl costs increased by an average of 48% from 1999 to 2005 (Thomas J. Murray & Associates 2005). Long-term monitoring results from fishery panels in the Florida Keys determined that total net earnings declined in almost all panels, and that much of the decline was a result of lower landings and higher operating costs, especially in offshore fisheries that required more fuel (Thomas J. Murray & Associates 2007). While fuel was the primary factor in increasing trip costs across most fisheries, such that fishers actually reduced other trip costs to compensate for the higher cost of fuel, dockage and other operating expenses also increased the overall costs of fishing operations. Average dockage rates increased by \$800 per year from 1996 to 2005, and trap fishers reported gear maintenance costs of an average of \$22,000 in 2005 compared to \$10,000 in 1996 (Shivlani *et al.* 2008). These costs were exacerbated by the higher costs of licenses and related expenses, including trap certificate and tag fees, among others.

While costs in fishery operations increased, inflation adjusted, ex-vessel values in most of the major fisheries in the Florida Keys remained either stagnant or decreased

(Steve Brown Pers. comm.). Species such as spiny lobster and yellowtail snapper returned stagnant prices after peaking in the 1970s, with spiny lobster ex-vessel values averaging \$5.50 for the past two decades and yellowtail snapper ex-vessel values remaining at or below \$3.00 from the 1970s onward. The pink shrimp fishery, a keystone fishery for the region that accounted for a majority of all landings from the 1950s to the 1980s, experienced a price decline from the mid-1980s onward. In 1986, fishers obtained an average of \$5.26/pound, which decreased to \$3.17/pound in the 1990s and \$1.92/pound in the 2000s, and fell to \$1.78/pound in 2007. Only the stone crab fishery withstood this long-term price stagnation or decline, but while prices for stone crab claws increased, the prices were also highly sensitive to shifts in purchasing power resulting from recessions (Figure 2). An important reason why local prices displayed largely depressed price trends is because a majority of the county's seafood is exported out of the region and, according to species, may compete with similar species (ex. spiny lobster) in the world market. Thus, as fishery markets globalized from the 1980s onwards, national and international markets increasingly set prices for most fisheries over local and regional ones. Conversely, demand in the Florida Keys by the tourism sector was met by imported seafood.

Imports in the major Florida Keys fisheries likely had a significant impact in the ex-vessel values. Shrimp imports, for instance, increased in the US from 200 million pounds in 1975 to 1.2 billion pounds in 2005 (NMFS 2009). Price over that period effectively halved, from \$6.63/pound in 1975 to \$3.32/pound in 2005. Spiny and rock lobster imports also dominated the US market in recent decades, with local production comprising less than 8% of the 87.5 million pounds in the 1990s and an even

lower 5.6% of the 87 million pounds imported from 2001-2007. As with shrimp prices, spiny and rock lobster prices dropped from \$4.89/pound in the mid to late 1980s to around \$4.30/pound in the 1990s and 2000s. Price trends for fin fish such as snapper (reef fish) and dolphin (offshore or pelagics) showed stable ex-vessel values from the 1990s to 2000s, at under \$2/pound for snapper species and just over \$2/pound for dolphin, and imports dominated both species' markets, comprising 80% or more of the total US market. The only major species in the Florida Keys that did not confront direct competition from imports was stone crab, which is branded as a unique Florida species. It was also the only fishery that showed an upward trend in ex-vessel values over the past two decades and which did not encounter price fluctuations as prolifically as some of the other fisheries.

A final macroeconomic factor that may have had a significant impact in the escalation of effort in several Florida Keys fisheries but for which quantitative data are sparse is the drug smuggling industry that flourished in the region in the 1970s (Zimmerman 2006). Fishing vessels served either as 'feeder' boats that would rendezvous with vessels carrying drugs and transport the drugs back to the Florida Keys or would transport drugs directly from mainly Latin American ports back to the US mainland (Brown 1993). As fishers gained income from drug smuggling, several invested/launched the funds into their fishing operations by purchasing or upgrading vessels and increasing gear totals (K. Lessard Pers. comm.). While the drug trade in the Florida Keys declined by the early 1980s, the legacy of the informal economy in increasing fishing power and overcapitalization had significant effects on effort (and management) in the 1990s onwards.

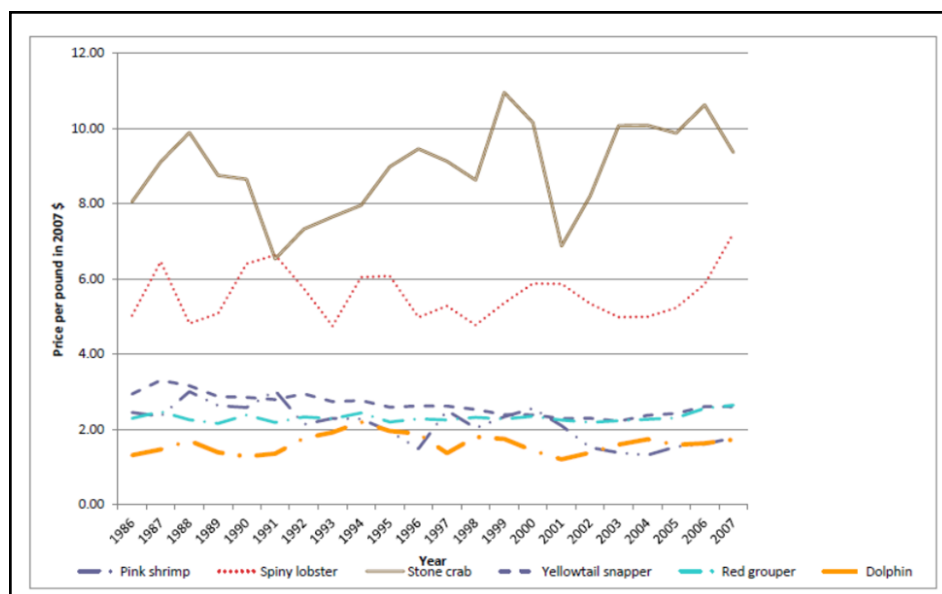


Figure 2. Ex-vessel value of major Florida Keys fisheries: 1986-2007 (Source: Steve Brown, FWC, personal communication)

Management Factors

Management factors, as related to management decisions in fisheries and ecosystem management, had profound effects on performance of and participation in Florida Keys commercial fisheries. Fishery management at both the state and federal levels increasingly employed market-based solutions to reduce effort and thereby increase efficiency (and decrease overfishing, for certain stocks) in various fisheries from the 1990s onward.

The State of Florida had taken an active role in certain fisheries, such as spiny lobster, throughout the 20th century, but the major regulatory change that formalized the state's role in fishery management was the passage of the Marine Fisheries Commission (MFC) in 1983. Under the MFC, which later was reorganized into the Florida Fish and Wildlife Conservation Commission (FWC), disparate local and state fishery laws were delegated to the commission that would use a deliberative process to manage fisheries. Apart from a requirement that all commercial fishing operations hold a license, the MFC established financial restrictions titled the "Restricted Species" provision that required fishers to demonstrate a financial stake (i.e., revenues from landings) to qualify for certain fisheries (FWC 2009). From 1988 to 2005, the commission designated a total of 16 species under the "Restricted Species" category, including all major Florida Keys species, creating the first of several barriers to entry. Next, the MFC implemented limited entry endorsements for several species. Starting in 1991, fishers were required to purchase endorsements for species, which were later subject to moratoria and, in some cases like the spiny lobster and stone crab trap fisheries, set up as market-based effort reduction programs. Under the MFC/FWC framework, participation in Florida Keys fisheries and in the stone crab and spiny lobster fisheries declined

(FWRI 2009). Overall participation dropped from a peak of 3,186 license holders in 1990 to 1,365 in 2009, representing a decline of over 57%. Those fishers holding "Restricted Species" permits decreased by 40% from 1995 (1,951 permits) and 2009 (1,172 permits), and participation in stone crab and spiny lobster fisheries declined by 74% and 63%, respectively (Figure 3).

Overall, the MFC/FWC system had three main impacts on the Florida Keys fisheries:

- i) The commission led to a contraction in the region's fishing industry, mainly by creating financial restrictions to entry;
- ii) The commission profoundly affected the previously existing access system by making entry into the most lucrative fisheries increasingly cost prohibitive, and
- iii) By compartmentalizing a traditional, multi-species fishery system by increasing costs in individual fisheries, the commission exposed the participants to greater risk with single species failures.

The federal management era in the US commenced with the passage of the Fishery Conservation and Management Act (now the Magnuson-Stevens Act, or MSA) in 1976. Under the MSA, two fishery management councils (and the US National Marine Fisheries Service (NMFS) Highly Migratory Species Division) manage fisheries in the federal waters off the Gulf of Mexico and South Atlantic waters off the Florida Keys (Public Law 94-265). From the late 1970s onwards, the two councils implemented a series of fishery management plans (FMP) for major species, as well as amendments to the plans, to manage the various fisheries (Gulf Council 2009, SAFMC 2009a). Several of the plans increasingly adopted limited entry systems over the past decade, such that participation was

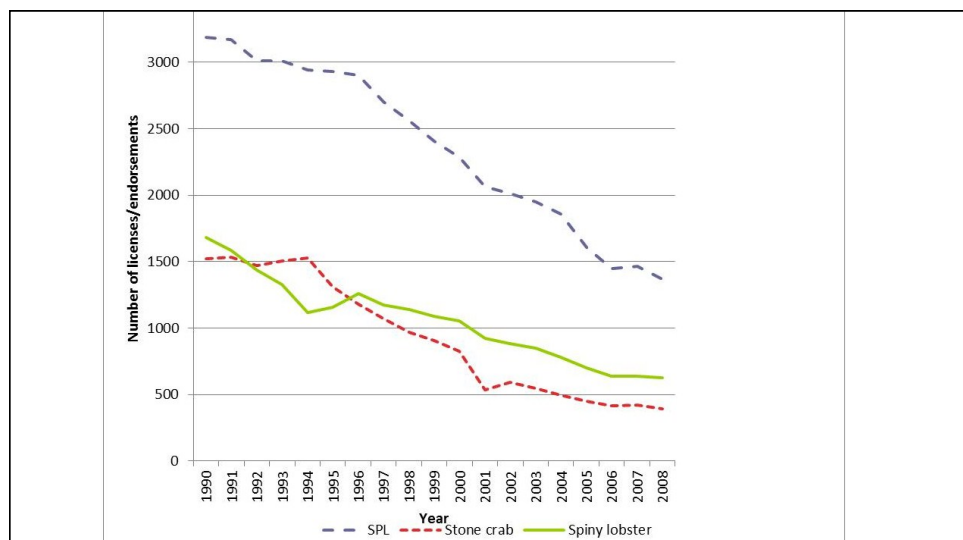


Figure 3. Florida Keys (Monroe County) commercial fishing licenses and endorsements: 1990-2009 (Source: FWRI,2009)

limited to fishers who were already in their respective fisheries and where entry was only allowed if a participant sold his/her permit. In the case of the South Atlantic Fishery Management Council's (SAFMC) reef fish FMP, the council decided in 1998 that incoming fishers would be required to purchase two reef fish permits to enter the fishery; this so-called "two for one" program was implemented to reduce effort in the fishery (SAFMC 2009b). Other efforts that were also adopted by both councils included restricted areas, such as shrimp nursery grounds, essential fish habitat, and other marine protected areas, which excluded fishers from harvesting certain species in these areas. As with the state approach, federal fishery management in the Florida Keys increasingly adopted measures to limit participation and a market approach to transfer permits, thereby facilitating the most efficient operators to remain their respective fisheries. However, both the state and federal approaches did not account for the effects of non-fishery factors, particularly those related to fishery operations and land-side costs, and the measures taken to increase efficiencies and reduce participation often exacerbated impacts on fisheries already under significant economic pressure.

Non-fishery management measures are those approaches adopted that affected Florida Keys fisheries but which were not related to fishery management directly and were often designed to address area management, i.e., marine protected areas (MPAs). The Florida Keys have had a long history of MPAs, with protected areas such as the Key West National Wildlife Refuge having been designated in 1908 (FWS 2009), followed by a series of other refuges in the Lower and Upper Keys. Among the first MPAs to restrict harvest in the region was the 1960 John Pennkamp Coral Reef State Park, established primarily to restrict coral extraction, and the park's boundaries were extended into federal waters in 1975 with the implementation of the Key Largo National Marine Sanctuary (Mattson and DeFoor 1985). National parks in the Florida Keys also restricted harvest within their boundaries, starting with Everglades National Park which prohibited all commercial fishing in 1986 (Browder 2007); Dry Tortugas National Park in 1992 also restricted all commercial fishing (NPS 2009a), and in the 2000s, Biscayne National Park, which already prohibited spiny lobster harvest in a designated sanctuary, commenced a fishery management plan process that sought to implement further restrictions on fishing within the park (NPS, 2009b). Most recently and perhaps most importantly, the Florida Keys National Marine Sanctuary (FKNMS) implemented a series of no-take zones in 1997 and 2001 that encompassed over 5% of the FKNMS (NOAA 2000, NOAA 1996). Included within these zones were two large ecological reserves (Dry Tortugas Ecological Reserve, Sambos Ecological Reserve), which were set aside as areas of ecosystem function and which included a variety of important habitats.

The net effect of MPA management in the Florida Keys had mostly deleterious effects on fishery operations, resulting either via the loss of access to fishing grounds (Thomas J. Murray & Associates 2005, Milon *et al.* 1997), or through increased trip costs resulting from fishing alternate areas (Shivlani *et al.* 2008, Thomas J. Murray & Associates 2007). Certain fisheries were disproportionately affected, as exhibited by the effects to mainly the shrimp, spiny lobster, and reef fish fisheries following the Dry Tortugas Ecological closure in 2001 (Thomas J. Murray & Associates 2005).

However, in considering management effects on commercial fisheries, it is important to consider the combined effects of fishery and non-fishery management impacts, specifically on how the two management approaches have been perceived by commercial fishers, many of whom have concluded that these are part of a larger conspiracy to eliminate commercial fishing from the Florida Keys (Shivlani *et al.* 2008, Suman *et al.* 1999). Because both forms of management, whether directly related to fisheries or other resources, have had some impact on fisheries, fishers have not differentiated between the intent of the management actions. Many fishers interviewed as part of this and other studies (Shivlani *et al.* 2008, Thomas J. Murray & Associates 2007, Thomas J. Murray & Associates 2005, Shivlani *et al.* 2005) have stated that they believe that they are part of the last generation of commercial fishers in the Florida Keys and, most importantly, they would not encourage their children to enter the profession as it holds no future.

Natural-anthropogenic Factors

Natural-anthropogenic factors that have affected Florida Keys commercial fisheries refer to tropical cyclones (hurricanes) that have resulted in gear, port, and infrastructure damage and habitat changes and thus affected participation and performance, and changes in the region's coastal and marine ecosystems, such as coral reefs, sea grasses, and mangroves, among others, that provide habitat for commercial species. Whether attributable to anthropogenic activities or natural events, the major fisheries in the Florida Keys and the commercial fishing industry in general have been greatly affected by climatic and ecological events and changes over the study period.

Tropical cyclones have profoundly shaped the history of the Florida Keys. The most powerful storm to make landfall in the US over recorded history was the Labor Day Hurricane of 1935, which destroyed the Overseas Railroad (Zeiller 2006). In more recent decades, the threat of hurricanes has led to the county adopting restrictive growth measures, to facilitate and expedite hurricane evacuation. In the past few years, intense hurricane seasons resulting in more frequent and stronger storms have been followed by higher costs of living via spikes in home insurance rates, which in turn have affected patterns of development and socioeconomic status of the resident population in the

Florida Keys (Ball 2005). Within commercial fisheries, tropical cyclones pose three forms of damage/disruption: First, storms damage fixed gear such as traps, which are deployed during part of the Atlantic hurricane season (June 1 to November 30); second, storms cause shore-damage, to vessels, gear, and product storage sites; and third, storms affect markets by disrupting supply, which may result from damage to transportation routes and/or fishing gear.

Two storm years demonstrate the unpredictable effects of tropical cyclones in the Florida Keys. Hurricane Donna, a powerful tropical cyclone, made landfall over the Middle Keys on September 10, 1960. Marathon, the main population center in the region, experienced considerable damage, losing up to 75% of its structures (Solloway 1960). However, the effects on the commercial fishing industry were minimal, mainly due to the fact that most of the industry was still located in the Key West part of the Lower Keys. While landings did decrease from 27 million pounds in 1960 to 22 million pounds in 1961, the higher landings in 1960 were in fact largely a result of the storm itself, which flushed juvenile and small shrimp into the fishing grounds due to rainfall (Joyce and Eldred 1966). In 2005, by contrast, four tropical cyclones passed over parts of the Florida Keys, with the last major hurricane of the season, Hurricane Wilma, passing closest over the Lower and Middle Keys. The commercial fishing industry estimated that it lost a total of 300,000 spiny lobster and stone crab traps, amounting to \$12 million in damages, and \$30 million in lost revenues (Wadlow 2005). Spiny lobster

landings in the Florida Keys dropped from 4.5 million pounds in 2004 to 3.0 million pounds in 2005, and stone crab landings decreased by 0.2 million pounds over the two seasons (from 1.1 million pounds to 0.9 million pounds). In the case of Hurricane Donna (and Hurricane Betsy in 1965), the Florida Keys commercial fishing industry was saved because of where the storm made landfall; however, by the 2000s, the industry and fishing areas had proliferated across the region (Figure 4) such that storms like Hurricane Wilma (and Hurricanes Dennis, Katrina, and Rita) had bigger targets and could cause greater damage.

Human activities have profoundly changed the Florida Keys, including the canalization and water diversion projects in mainland Florida, the filling in of passes between Florida Bay and the Atlantic Ocean to construct the Overseas Railroad bridges, the dredge and fill activities in support of development project in the Upper and Middle Keys, the effects of population growth and sewage disposal systems on water quality, and the proliferation of recreational uses that have resulted in physical damage and resource overuse (Gallagher 1997). Anthropogenic impacts that altered or destroyed important habitats that serve as nursery or home grounds for important species may have had significant effects on commercial fisheries. Mangroves, which were clear cut for three decades for development projects in the Florida Keys (Gallagher 1997), are known to serve as important nursery habitats for many species and are a link from the shoreline to sea grasses to coral reefs and comprise part of the larger coral reef

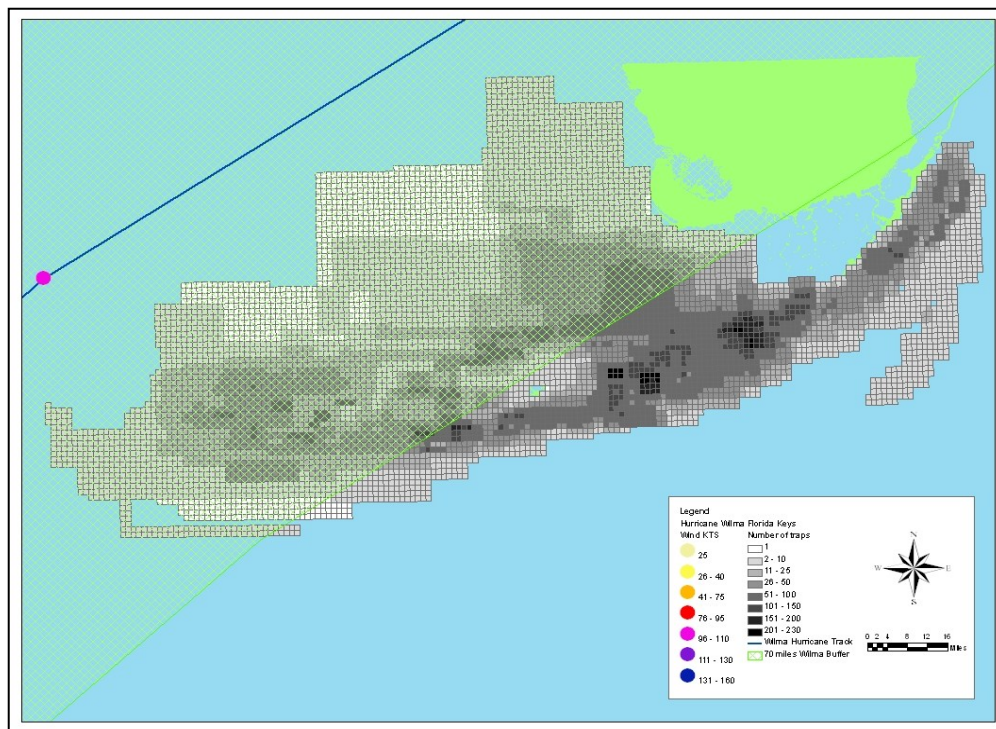


Figure 4. Hurricane Wilma (October 2005) path over Florida Keys trap fishing grounds (Source: Thomas J. Murray & Associates, 2008)

ecosystem (FAO 2007). Apart from the extensive scarring that has resulted largely from boating impacts, sea grasses in the Florida Keys underwent a massive die-off in the mid-1980s in Florida Bay, which some research (Browder and Robblee 2009, Ehrhardt and Legault 1999) suggests may have negatively affected shrimp production. Coral reefs, which support a variety of commercial fisheries, have experienced a long-term decline in the Florida Keys, as well as damage from vessel impacts (Lutz 2006), coral diseases (Reef Relief 2009), and deteriorating water quality (Pandolfi *et al.* 2006), all of which have left the ecosystem less resilient. Reef building corals of the genus *Acropora* have been especially impacted and are at a fraction of their earlier abundances, which resulted in the NMFS listing two species as threatened under the US Endangered Species Act (NOAA 2006).

Historical Characterization of Florida Keys Fisheries

Landings in the Florida Keys fisheries followed a rising trend from 1950 to the mid-1970s, followed by a declining trend to the present. As discussed in the aforementioned factors, the opposite trends were closely related to non-fishery factors that strongly influenced participation in and performance of the fisheries, and that an explanation that favors overfishing as the primary driver is simplistic and, for most species, incomplete (Steve Brown, FWRI, Pers. comm.).

The Florida Keys commercial fishing industry expanded in the first full decade following World War II. The shrimp fishery, which would remain the archipelago's most prolific fishery until the 1980s, came into prominence following the "pink gold" strike (the discovery of the fishing grounds) in 1949 (Idyll 1950). More than 300 shrimp trawlers tied up in Key West Bight in 1950, enlarging the fishing industry that heretofore had focused on mackerel and lobster; over time, smaller shrimp fleets would develop in other, adjacent ports, including as many as 100 shrimp trawlers in Marathon in the Middle Keys (DeMaria 1996). Landings from 1950 - 1959 averaged 17.7 million pounds, from a low of just over 8 million pounds in 1950 to almost 26 million pounds in 1958. Landings in the 1960s increased on average, totaling almost 24 million pounds per year. In both decades, shrimp landings dominated overall landings. The only other species group that accounted for more than 10% of total landings were coastal pelagics, such as king and Spanish mackerel, which were harvested mainly in the western Florida Keys and from Key West and Lower Keys ports, and spiny lobster, which was landed in higher numbers from the 1960s onwards.

As fishing ports developed in the Middle and Upper Keys in the 1950s and 1960s and the population grew in these parts of the Florida Keys, landings for species other than shrimp and coastal pelagics, namely the crustacean trap and reef fish fisheries, increased. Overall landings remained stable, with the county producing an average of

25.9 million pounds of seafood each year in the 1970s. Shrimp landings, which had averaged 13.4 million pounds in the 1960s, dropped slightly to 11.6 million pounds in the 1970s; the fishery, dominated by pink shrimp, accounted for a majority of total landings but dropped to less than 50% of Florida Keys seafood production. While landings remained stable on average throughout the 1980s, at over 23 million pounds per year, shrimp production – especially from 1986 onwards, following the failure of the fishery for primarily ecological reasons – began a long-term slide. In fact, shrimp landings only averaged 6.3 million pounds for the five-year period from 1985 - 1989 and a million pounds less from 1986 - 1989. Other fisheries, especially stone crab, reef fish, and offshore/pelagics, had developed in the 1980s, and the Florida Keys commercial fishing industry had diversified from shrimp and coastal pelagics, i.e. the fishery had matured across the length of the island chain, such that Middle and Upper Keys were producing reef fish and offshore/pelagics, as well as increasing overall production of spiny lobster and stone crab.

As shrimp production dropped off further in the 1990s, due mostly to the fleet having exited Key West and the Florida Keys following the gentrification of Key West Bight (Schittone 2001), total landings dropped to an average of 19.3 million pounds for the decade. Buoyed by spiny lobster and reef fish landings, however, the fishing industry intensified effort in the stone crab fishery (especially following the passage of a trap reduction program in the spiny lobster fishery in 1991 (Shivlani and Milon 2000) and the Florida Net Ban (Shivlani *et al.* 1998)). While landings were lower by 4 million pounds on average compared to the 1980s, the fishery still employed over 3,000 license holders at the start of the 1990s.

By the end of the decade, however, following the implementation of the spiny lobster trap effort reduction program, the Florida Net Ban, and increasing regulations from state and federal management agencies (including more species on the "Restricted Species" list, moratoria on state and federal fishing licenses, and the South Atlantic Fishery Management Council's 'two for one' reef fish permit retirement program, among others), the fishery commenced on a long-term decline as measured by the number of participants. From over 3,000 license holders in 1990, the participant total decreased by 30% by the end of the decade (FWRI 2009). Other, non-fishery regulations, such as the FKNMS no-take zones and the impending Dry Tortugas Ecological Reserve closure, added to the sense of insecurity that the market-based program had engendered, and fishers were more willing to exit the fishery, especially in cases where they could sell trap certificates to other participants (Shivlani *et al.* 2005; Suman *et al.* 1999).

The landings in the period from 2000 - 2007 represented almost a reversal of the rise of the Florida Keys fisheries in the 1950s. Harvest averaged 10.5 million pounds, but it declined each year of the decade, from 16 million pounds

in 2000 to 9.1 million pounds in 2007. The shrimp fishery declined into a handful of trawlers that supplied only a single fish house, with landings averaging less than 2.1 million pounds; landings in 2007 were only 720,000 pounds. The shrimp fishery, which averaged almost 10 million pounds from 1950 to 1986 and was the mainstay of the Florida Keys commercial fishing industry in the post World War II era, had been effectively eliminated from the Florida Keys due to a combination of high fuel costs, unavailable waterfront, and low ex-vessel values. Spiny lobster harvest, which had increased in the years immediately following the trap reduction program, experienced a drastic decline as well. Landings dropped from 6.6 million pounds on average in the 1990s to 4.1 million pounds from 2000 to 2007. Landings were particularly low from the 2005 - 2006 season through the 2008 - 2009 season, when only an average of 3.7 million pounds of spiny lobster were harvested. Similar declines occurred in almost all other major fisheries, due in part to resource conditions (as in spiny lobster), but also as a result of reduced participation. In terms of licenses, the Florida Keys fishery contracted even further from its late 1990s level, and by 2007, there were less than 1,500 license holders, representing a reduction of over half of the fishery since 1990. Participation in the spiny lobster and stone crab fisheries, both of which had adopted trap effort reduction programs, decreased such that six in ten participants or more left either fishery. While part of this reduction in participation was planned, the speed at which the decline occurred in the 2000s was due to combined effects of fishery management and other, non-fishery factors. That is, as the cost of living and fishing trip costs increased, and especially when oil prices exceeded \$100/barrel and peaked at almost \$150/barrel in 2008, revenues increasingly dwindled. With imports constraining the ability of fishers to pass on the costs via increased ex-vessel values, participants had to accept lower prices. Finally, with shifts in the abundance of major species such as spiny lobster (due to perhaps a virus (Wadlow 2009)), many fishers could not rely on increasing catch-per-unit-effort to mitigate for stagnant prices and higher trip and living costs.

DISCUSSION

Non-fishery factors contributed to the rise and decline of commercial fisheries in the Florida Keys, especially as management approaches from the mid-1980s forward deliberately sought to reduce participation in the region's major fisheries. If the sustainability of viable fishing communities and a commercial fishery sector remain objectives, then management needs to consider how non-fishery factors may interact with fishery management decisions in impacting the commercial fishing industry. Fishery management decisions must not stop at the shoreline, and fisheries need to be considered as a system that includes the land-side conditions and trends (St. Martin 2006, Olson 2005).

While the Florida Keys, the four non-fishery factors – socio-demographic, macroeconomic, fishery and non-fishery management, and natural-anthropogenic factors – exerted a significant influence on the performance of the islands' major fisheries. Effects resulting from the factors were not uniform across the study period, in that effects during the earlier part of the study period may have been salutary but may have had negative effects towards the end of the study period or over the long-term. It is clear, however, that non-fishery factors often did influence performance and participation within fisheries independent of the overall fishery stock conditions; that is, factors other than fishery stocks often determined the sustainability of fishing communities. Socio-demographic factors were among the factors that both promoted and dampened the performance of commercial fisheries in the Florida Keys, first by creating the development infrastructure in the post World War II population growth era necessary to establish fishing ports and then by creating demand for increasing scarce resources such as land and waterfront via increased tourism, as well as via the rise of inter-group competition for fishery resources. Among macroeconomic factors, which also exerted a strong influence on the development and profitability of commercial fisheries, escalation of fishery operation costs, rise in cost of living expenses, and stagnant or declining trends in fishery products each contributed to the recent decline of the region's fisheries. Fuel cost increases from the mid to late 2000s increased the overall cost of fishing such that fishing operations either stopped fishing (ex. the Key West shrimp fishing fleet during the fuel cost spike following Hurricane Katrina in 2005 (Thomas J. Murray & Associates 2005)) or cut down on other variable costs. Other fishery operation costs related to regulatory requirements, licenses, and insurance, among others, all increased the overall cost of fishing (Adams *et al.* 2008). The cost of living in Florida Keys, which was traditionally high relative to the rest of the state, rose significantly with property values, ranking the county as the most expensive in which to reside in Florida from 2005 to 2007. Stagnant or declining trends for most fishery products, as measured by ex-vessel values, were abetted by greater import availability of species that had suitable substitutes and in 2008 with a sharp, severe economic downturn.

Fishery and non-fishery management factors were among those that affected commercial fishery performance and participation often due to deliberate measures, such as the effort reduction strategies; however, management often failed to adopt a comprehensive approach in predicting how actions may be interact with other non-fishery factors in creating unintended impacts. For example, trap reduction strategies adopted for the two main crustacean fisheries in the 1990s and 2000s did not fully consider the effects on entry, exposure/vulnerability to adopting a single species fishery system in what was traditionally a multi-species system, or on macroeconomic conditions (ex. cost

of living expenses, imports' effects on ex-vessel values) on fishery operation costs, among others. Moreover, the direction taken by both state and federal fishery management toward limited (and monetized) access and professionalization increasingly fragmented fishing communities. Access that was monetized such that participants would have to pay a fee to enter a fishery and/or to purchase the right to fish a unit of gear could not predict changes in resource conditions and availability and often did not address allocation across fishery sectors; apart from severing an apprentice system that heretofore controlled entry, the system led to the "graying of the fleet", where by 2008, older (60 years or older) fishers represented 28% of the fleet (Shivlani *et al.* 2008). Faced with these conditions, fishers either exited the fishery or were not replaced by entrants, resulting in a diminution of the industry. Pull factors such as increased income or financial stability made certain commercial fishers become charter fishing captains, while push factors related to increasing regulatory barriers and costs promoted migration from the fishery sector altogether.

Finally, natural-anthropogenic factors exerted their most profound impacts on the region's commercial fisheries as the Florida Keys' population and the population's effects on the coastal and marine environment increased. For example, while earlier tropical cyclones had minimal impacts on commercial fisheries that had not yet fully developed, later storms had widespread impacts on the industry. Anthropogenic impacts that result in habitat damage, such as vessel-based impact, or overall resource decline may be as responsible as other non-fishery factors in shaping the archipelago's fisheries.

Eventually, solutions to mitigating the effects of non-fishery factors require that fishery management strategies consider the broader socioeconomic context. Within the Florida Keys case study, two approaches could be adopted that could address the declining participation. The first would be to merge the region's dominant economy, tourism, with commercial fisheries. Because the Florida Keys' commercial fishery sector developed mainly as an export economy, tourism has often competed with commercial fisheries for waterfront access and resources. The second would be to develop a mechanism ("space") that allows for the re-development of affected fisheries. If fisheries that are displaced because of non-fishery factors can be allowed to re-occupy the space that the industry lost to other uses, fisheries can remain viable. It is not suggested the management has the responsibility to sustain fishing communities, but if maintaining participation is an otherwise healthy (in terms of fishery stocks) fishery that has been impacted by non-fishery factors is an objective, then mitigation plans must consider incentives to promote participation. Finally, and most importantly, just as the factors that affect commercial fisheries are manifold and diverse, solutions cannot employ singular options, ex. such as addressing solely cost of living disincentives. Success-

ful approaches will be those that encompass a comprehensive approach, redressing the effects of the full suite of non-fishery factors.

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