Fish and Shellfish

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In a nutshell

- Fish and shellfish contribute to a productive coastal marine ecosystem that supports commercial and recreational fisheries both inshore and on the coral reef extending along the southeast Florida coast.
- A significant portion of the southeast Florida regional economy is supported by people from throughout the U.S. and abroad who are attracted to world-class recreational fishing opportunities and the spectacular diversity of marine species they can view through diving and other activities.
- The development of a high-density urban area has reduced critical inshore nursery habitats, and fish populations in the coral reef ecosystem show the effects of unsustainable overfishing.
- Fish and shellfish populations are vulnerable to continuing impacts from overfishing, water management, shoreline modification, and coastal construction, which will be increasingly driven by responses to sea-level rise.

Definition of the Resources

The reef fauna of the SEFC are similar to those found on the coral reef of the Florida Keys and elsewhere in the Caribbean region. The great diversity of marine species contributes to the designation of Florida as the "fishing capital of the world" (FWC, 2003). The coastal marine ecosystem of the SEFC supports both commercial and recreational fisheries and related tourism activities, and these are an important component of the regional economy (Ault *et al.,* 2005a). The coastal marine ecosystem of the Florida Keys and Dry Tortugas lies within the West Indian zoogeographic area, a subregion of the Neotropical Province. This area includes the Bahamas, Greater and Lesser Antilles, the northern coast of South America, the eastern coast of Central America, and South Florida. The lack of land barriers, connectivity of water masses, and ocean currents facilitate larval transport of progeny among these areas.

This appendix focuses on a relatively few taxa chosen to represent different roles in the ecosystem. The coral reef complex includes 19 species of fish, the spiny lobster, and pink shrimp (Table 1). Ault and Franklin (2011) used these species to investigate the current status and trends for fish and shellfish on the reef tract. In addition, we review information on the status and trends of juvenile fish, Caribbean spiny lobster, and pink shrimp in Biscayne Bay. These species have

Table 1. Species of the SEFC coral reef ecosystem.

- Coral Reef Fisheries Complex:
  - -Greater amberjack
  - -Black grouper
  - -Blue angelfish
  - -French angelfish
  - -Gray angelfish
  - -Gray triggerfish
  - -Great barracuda
  - -Hogfish
  - -Mangrove (gray) snapper
  - -Mutton snapper
  - -Parrotfish
  - -Queen angelfish
  - -Red grouper
  - -Rock beauty
  - -Tomtate
  - -White grunt
  - -Yellowtail snapper
  - -Bonefish
  - -Atlantic tarpon
- Spiny lobster
- Pink shrimp
- Lionfish

been proposed as indicators for the condition of nearshore faunal communities that will be affected by hydrologic restoration of the Everglades (RECOVER, 2010). We also review information on the lionfish, an invasive marine fish currently becoming established in the region.

The species diversity and number of fish comprising the reef fish community vary between shallow inshore and deeper offshore locations. Inshore, hardbottom substrate, seagrass beds, other submerged aquatic vegetation, and the mangrove shoreline serve as nursery habitat for juveniles of many reef fish and other sport fish species (Browder *et al.,* 2005; Crigger *et al.,* 2005; Sime, 2005; Ault, 2008). These are ephemeral habitats affected by variations in freshwater inflow and erosion and redistribution of bed material by storm events and as a consequence of marine construction activities, such as beach renourishment (Banks *et al.,* 2008). Offshore, the reef habit supports a greater variety of species and higher densities of fish. Adult reef fish are caught for food and sport both inshore and on the reef. Commercial and sport fisheries also target spiny lobster and marine aquarium fish at both inshore and offshore locations, while pink shrimp, blue crab, and spotted seatrout are inshore catches. Other species of interest include tarpon and bonefish, both highly prized by the recreational fishery, and menhaden, mullet, and stone crab, targeted by the commercial fishery.

The pink shrimp supports commercial fisheries in Biscayne Bay and is a principal prey of sport fish and other predators in the southeast Florida region (Berkeley, 1984; Ault *et al.,* 1999; Johnson *et al.,* 2012). Pink shrimp spawn offshore and enter estuaries to spend their juvenile lives, growing rapidly to late juveniles and young adults and then returning to offshore spawning areas and fishing grounds. Pink shrimp is the documented prey of gray snapper, spotted seatrout, and a host of other sport fishes (Hettler, 1989; Ault, 2008). The generally high productivity of estuaries attracts predators. Predator abundance in estuaries is counterbalanced by high primary productivity that promotes fast growth and complex habitat structure that provides protection.

Larvae of the Caribbean spiny lobster are dispersed widely by ocean currents, and individuals found in the waters of the Florida Keys may have originated from nearly anywhere in the Caribbean and Gulf of Mexico. Post-larvae settle in shallow, protected waters where seagrass beds and mangrove-protected shorelines provide nursery habitat. Between the juvenile and adult stages, individuals migrate from these shallows into deeper waters of the coral reef and hardbottom habitats. They seek refugia within the three-dimensional structure of the coral reef, under sponges, or any other available cover in the hardbottom habitat. The Caribbean spiny lobster preys on snails, crabs, and clams, and it is preyed upon by many high-trophic level fish species.

Attributes People Care About

People care about sustaining the reef fish community and marine sport fisheries along the SEFC, as well as having a local source of fresh seafood. Reef fish support both a commercial and a recreational fishery and associated tourism activities such as SCUBA diving and snorkeling that account for a significant portion of the regional economy. The sustainability of the reef fish community depends on maintaining both offshore reef habitat consisting of coral and hardbottom communities and associated water column and the inshore habitats that support many reef species in their post larval and juvenile stages. Sustainability refers to the ability of a fish population to produce goods and services (i.e., landings) at sustainable levels in the short term, while maintaining sufficient reproductive capacity to continue providing these goods and services indefinitely into the future (Walters and Martell, 2004, Ault *et al.,* 2008).

Attributes We Can Measure

Ault and Franklin (2011) reviewed available fisheries-dependent data on the species of the coral reef complex. These data included information on the level of fishing effort, catch amount, and size of the fish caught, by species. The available data are not sufficient for a complete evaluation of the sustainability of the reef populations. However, the data do allow comparisons against sustainability benchmarks established by Florida state and U.S. federal fisheries agencies.

Two fishery-dependent data sources are related to the recreational fishery: the Marine Recreational Fishing Statistical Survey (MRFSS) and the National Marine Fisheries Service (NMFS) headboat fishery survey. The MRFSS collects data on recreational landings from shore-based fishing and from private vessels and charter boats. MRFSS estimates the catch, landings, and the combined total of releases and discards based on phone interviews and creel surveys. Fishing effort is the estimated number of fishing trips taken by individual anglers. The NMFS headboat survey collects fisheries and biological data from fishing vessels that carry multiple anglers who have paid "by the head." The data include landings, by species, and "angler days," a measure of fishing effort.

The Accumulated Landings System (ALS) provides data related to the commercial fishery, consisting of the quantity and value of marine species caught by fishermen and sold to established seafood dealers or brokers. Other catch and trip information are included. The ALS consists of data collected by the Florida Trip Ticket Program and the NMFS Trip Interview Program (TIP). In addition to quantity and value, the Trip Ticket program provides information on gear used and area fished, by trip. TIP is a shore-based sampling program in which port agents collect size and frequency data and age at length data from the catch as it is unloaded or while it is in storage at the fish houses. Port agents also collect data on the fishing trip, such as area fished, type and quantity of gear, fishing time, etc.

Several fishery-independent multispecies monitoring efforts collect data on fish (both juveniles and adults) and invertebrates in the reef ecosystem (Smith *et al.,* 2011) and on pink shrimp, blue crabs, other invertebrates, and small fishes in nearshore areas within Biscayne Bay (RECOVER, 2010). These are part of the monitoring and assessment plan established to characterize the response of the coastal ecosystem to changes in freshwater inflows anticipated as a result of hydrologic restoration in the Everglades. A visual survey of the fish community of the mangrove shoreline has been conducted twice each year since 1998. The data collected by this survey are analyzed to provide community statistics, such as taxonomic richness and species dominance, and abundance metrics for individual taxa, such as occurrence and density.

A complementary program samples small fish and invertebrates (reef fish prey) in the seagrass beds adjacent to the shoreline. The twice-year visual survey and alongshore epifauna sampling, along with bottom vegetation and continuously recorded salinity monitoring, are part of the Integrated Biscayne Bay Ecological Assessment and Monitoring (IBBEAM) project. From 2005-2011, another monitoring and assessment project, the Seagrass Fish and Invertebrate Network (FIAN), sampled fish, crabs, and shrimp living in seagrass beds at seven Biscayne Bay locations (North Miami, Port of Miami, north of Black Point, south of Black Point, Card Sound, Barnes Sound, and Manatee Bay) to characterize changes in the seagrass-associated community over time. In FIAN, data collected twice annually included abundance (individuals per square meter) by species, physical characteristics of the seagrass bed, and conditions in the water column at the time of sampling (salinity, temperature, turbidity, and water depth).

A general indication of the condition of fish populations and fisheries can be inferred from trends in fishery-related data, such as population density, catch, effort, catch per unit of effort, etc. U.S. fisheries assessment scientists compare current fishery data to standard benchmarks such as Maximum Sustainable Yield (MSY) and Spawning Potential Ratio (SPR) that they have computed from historic data to assess the condition of the stock. They also refer to other, more exacting indicators of sustainability. Ault and Franklin (2011) used a length-structured population model to estimate mortality rates and other population-dynamic parameters based on the mean size of animals obtained from the TIP data. This length-based assessment methodology has also been applied to the Florida Keys and Puerto Rico reef fish populations (Ault *et al.,* 1998, 2005a, 2005b, 2008).

Drivers of Change

Fish and shellfish in the SEFC marine ecosystem are threatened by (1) fishing, (2) alterations to inshore habitats (e.g., loss of mangroves, seagrasses, and intertidal zones to shoreline development, channel dredging, ship groundings, beach renourishment, etc.), (3) non-native species, and (4) disease (Figure 1). Human use of the SEFC marine environment is increasing in intensity as a direct consequence of the proximity of coastal marine ecosystems to the highly urbanized coastal areas that extend from Miami to West Palm Beach. For example, the number of vessel registrations in the SEFC region has increased steadily over the past 45 years from fewer than 40,000 in the mid-1960s to over 150,000 vessels in 2010 (Smith *et al.,* 2011). This growth reflects increasing recreational use of the coast, as commercial vessel registrations remained stable over this period while the number of recreational vessels tripled (Ault and Franklin, 2011).

Fishing

Intensive exploitation and overfishing are perhaps the major threats to the reef fisheries of southeast Florida (Ault *et al.,* 2005a, 2009). Generally, fishing can reduce ecosystem integrity in at least three ways. First, removing targeted species and killing non-target species (as bycatch) may result in cascading ecological effects (Frank *et al.,* 2005). Second, because fishing is size-selective, concerns exist about ecosystem disruption by removal of ecologically-important species such as top-level predators (e.g., groupers, snappers, sharks, jacks) and prey (e.g., shrimp, baitfish) of certain

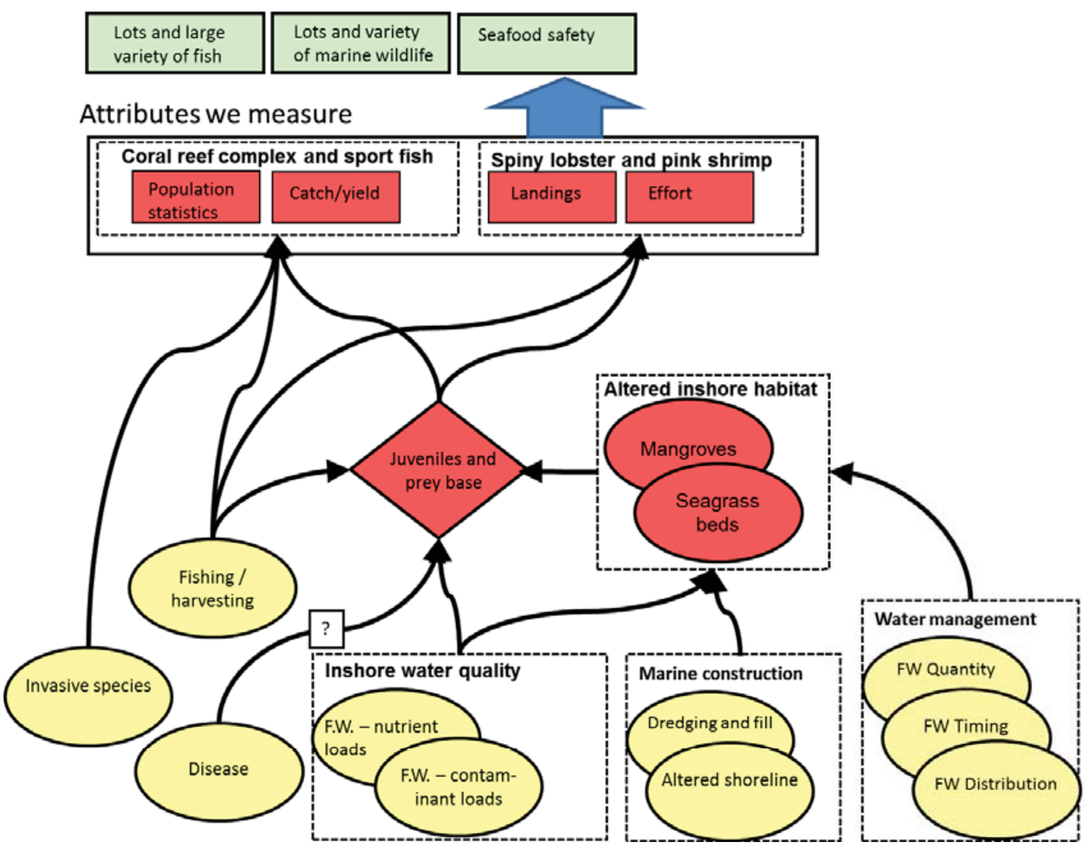

Figure 1. The fish and shellfish conceptual ecological submodel for the southeast Florida coast.

sizes. Third, gear and fishery impacts with critical habitats can reduce the quality and productivity of the environment that supports these valuable fisheries.

Alteration to Inshore Habitat

Urban development has altered habitat along the entire SEFC from St. Lucie Inlet to Biscayne Bay. The natural shoreline consisting of intertidal mangrove wetlands has been replaced with fill and seawalls. Residential islands have replaced bay water at many locations within the northern bay. Except for the Oleta River and Virginia Key areas, north Biscayne Bay has been almost entirely bulkheaded. Construction of the Intracoastal Waterway dredged a navigation channel inside of the barrier islands through the full length of the coast, altering water circulation patterns. Natural inlets through the barrier islands have been deepened and stabilized and new inlets constructed, with the result of introducing marine waters and altering the nature of estuarine and freshwater waterways. Construction and operation of a system of freshwater canals throughout South Florida has drastically altered the timing and amount of freshwater inflow to estuarine and coastal waters. The net result is that the entire coastline presently exists as an engineered structure that is closely managed to maintain the functioning of coastal municipalities and upstream agricultural lands.

The effect of development on the St. Lucie Estuary has been to alter the timing, distribution, quantity, and quality of freshwater inflow (Sime, 2005). Construction of the regional network of drainage canals greatly expanded the estuary's watershed. In particular, the C-44 canal artificially routes freshwater from Lake Okeechobee into the estuary and, as a consequence, the estuary receives large inflows of freshwater and nutrients from the lake when there is a need to draw down the water level in the lake. Regulatory freshwater releases from Lake Okeechobee and stormwater releases within the watershed alter estuarine salinity, impose increased loads of nutrients and contaminants, and increase turbidity and color in the water column.

Development has dramatically altered the ecology of the Lake Worth Lagoon (Crigger *et al.,* 2005). Historically, Lake Worth was a freshwater lake, receiving inflow from wetlands along its western edge and isolated from coastal waters behind a barrier island that extended along about three quarters of the coastline of Palm Beach County. In 1877, a stable inlet was constructed, providing a permanent connection between the lake and the ocean. Subsequently, a canal was dredged to connect the northern end of the lake to Jupiter Inlet. A second permanent inlet was opened in 1917, and, in 1925, the West Palm Beach Canal was completed, connecting the lake as an outlet to the regional system of water management canals. Approximately 65 percent of the natural shoreline has been replaced with bulkheads and seawalls. The quality of the inshore habitat remaining in the lagoon is affected by the quantity, quality, and timing of freshwater inflows from the water management canal system and ongoing marine construction activities.

Biscayne Bay has been altered both as a result of major changes to the hydrology of its watershed, dredge, and fill to create new islands or increase the elevation of existing islands, construction of seawalls, dredging of navigation channels, and opening new inlets (Browder *et al.,* 2005). Most of the structural changes occurred in the bay from Rickenbacker Causeway north, but hydrologic changes affected the entire bay. Construction of the major canals through the Everglades and dredging natural tributaries has lowered water tables and reduced water storage in the watershed and decreased groundwater flow into the bay. Combined with urban development, this has increased the velocity of stormwater runoff and inputs of nutrients and contaminants to the bay. The dredging of inlets at Haulover and Government Cut increased the connection between the northern part of the bay and the ocean. As a result of these alterations, Biscayne Bay has changed from an estuarine to a more marine system. Nevertheless, parts of the northern bay and most of the southern bay are still productive, ecologically interesting, and beautiful areas. Water quality in the bay has been improved over the last 30 years as result of eliminating direct discharge of sewage into the bay and other pollution control measures; however, inputs of nutrients, trace metals, organic chemicals, and suspended sediments remain a concern.

Non-Native Species

The non-native lionfish is a threat in Biscayne Bay and the coastal marine ecosystem. This highly invasive species is altering the structure of native reef fish communities by out-competing native reef organisms and reducing forage fish biomass (Morris and Whitfield, 2009). Their venomous protective spines, aggressive feeding habits, unique reproduction, and lack of predators all contribute to their competitive advantage. Impacts from lionfish could include direct competition with groupers for reef fish and crustacean pret (Ruiz-Carus *et al.,* 2006; Albins and Hixon, 2008; Morris and Atkins, 2009). Because of its rapid increase and venomous spines, lionfish could potentially disrupt the ecological balance of ecosystems and pose a danger to divers and fishermen (Ruttenberg *et al.,* 2012).

Disease

Disease exerts a significant influence on faunal populations in the Caribbean region. The viral epidemic that struck the long-spined sea urchin in 1983-1984 may be the best known example. This epidemic decimated urchin populations throughout the Caribbean, and the sudden loss of a major herbivore in the food web contributed to a shift in dominance on many reefs from coral to macroalgae. More recently, a viral disease, PaV1, has become widespread in the spiny lobster population. This disease increases mortality primarily in juvenile lobsters, and the consequences of this epidemic are not yet known (Butler *et al.,* 2008).

Mechanisms of Change—Pressures

Fishing

Precise data on trends in coral reef fishing effort, combining both commercial and recreational activities, do not exist, but trends are suggested in state-wide fishing statistics and numbers of registered boats. In 2001, for example, an estimated 6.7 million recreational fishers took 28.9 million marine fishing trips in Florida and caught 171.6 million fish, of which 89.5 million (52 percent) were released or discarded (U.S. Department of Commerce, 2002). From 1964-2010, the number of registered recreational boats in southern Florida grew by more than 500 percent, while the number of commercial vessels grew at a much lower rate, about 150 percent. Many of these vessels are used for fishing and for non-extractive activities, such as sailing, sightseeing, transportation, snorkeling, and SCUBA diving.

Increased fishing fleet size has been accompanied by a number of technological advances that have approximately quadrupled average fishing power, i.e., the proportion of stock removed per unit of fishing effort (Gulland 1983; Mace, 1997; Quinn and Deriso, 1999). These advances include improvements in fishing tackle, hydroacoustics (depth sounders, fish finders), navigation (charts and global positioning systems), communications, and inexpensive, efficient, and more reliable vessel and propulsion unit designs (Bohnsack and Ault, 1996; Ault *et al.,* 1997, 1998, 2005a). These fishing trends raise concerns for fishery sustainability and persistence of the coral reef ecosystem.

Results of the analysis by Ault and Franklin (2011) of fisheries-dependent data for the species of the coral reef complex indicate declining landings balanced by decreased fishing effort. For eight of 19 species for which data are available, there was no significant decline in harvest or effort in the recreational fishery covered by the MRFSS survey data for the period 1990-2009. For 11 reef fish species, the headboat survey data showed a decline in landings by 85 percent between 1990 and 2006, but this coincided with a 50 percent decrease in fishing effort by headboats (angler-days). Landings in the commercial fishery, for six of the reef fish species plus the aggregate category of "grunts," declined by 73 percent between 1990-2006. It is unclear if this decline reflects a decrease in effort in the commercial fishery because no estimates of annual fishing effort could be made. For angelfish, which is exploited for the marine aquaria market, both the landings and number of trips declined in a way that suggests an unchanged trend in landings per trip.

Altered Freshwater Inflow

Freshwater inflow affects conditions in the downstream estuary. The rate of inflow establishes salinity gradients, temperature gradients, and gradients in turbidity and nutrients. High rates of freshwater inflow associated with regulatory releases from the regional water management system degrade the nursery function of inshore habitats (Crigger *et al.,* 2005; Sime, 2005; Ault *et al.,* 2003). The sudden introduction of a large volume of freshwater into a lagoonal estuary can block access by marine ichthyoplankton to the estuarine habitat. Exposure to low salinity water can induce eggs and larvae to settle prematurely or in inappropriate habitats. In the extreme, exposure to salinity outside of an organism's range of tolerance can lead to death. Freshwater inflows introduce land-based pollutants into the estuary. Large regulatory releases into the St. Lucie Estuary have been linked to a range of fish health problems and abnormalities (Sime, 2005). Large freshwater flows can also carry sediments that are then deposited in the estuary, degrading benthic habitats near the point of inflow (Crigger *et al.* 2005). Santos *et al.* (2011) demonstrated landscape fragmentation in areas of canal outflows.

The relationship between pink shrimp and salinity suggest that water management affects inshore pink shrimp abundance. Laboratory trials with growth and survival of small juvenile pink shrimp from western Florida Bay were significantly related to salinity (Browder *et al.,* 2002). Indices of pink shrimp abundance based on Tortugas fisheries data were significantly related to indices of freshwater flow from the Everglades (Browder, 1985; Sheridan, 1996). Meta-analyses of prominent fauna in Florida Bay found pink shrimp were more closely correlated with salinity and seagrass than other species examined (Johnson *et al.,* 2002a, 2002b, 2005). Based on the historical record from western Florida Bay, mean fall (September/October) densities of juvenile pink shrimp were significantly negatively correlated with salinity within the range 28-45. The salinity of seawater is considered to be 35. Salinities greater than 35 indicate that the combination of freshwater inflow and local rainfall are not sufficient to replace water loss from evaporation, even with seawater mixing.

Coastal Construction

In the future, sea-level rise will indirectly drive continued alteration of inshore habitats along the SEFC. For the most part, the urban areas along the coast are completely built-out. The remaining natural shoreline is protected in parks and preserves, and regulations are in place to protect inshore habitats from further destruction. However, as rising sea levels degrade and overtop existing structures, resulting in flooding of developed areas, the response will be to repair and upgrade the affected structures, leading to an increase in construction and consequent impacts to inshore habitats.

Non-Native Species

Red lionfish, formerly residents of the western Pacific, Red Sea, and eastern Indian Ocean, were first reported in the 1980s along South Florida and are now well established along the Florida Keys, the southeast U.S., and Caribbean (Ruiz-Carus *et al.,* 2006; Morris *et al.,* 2009, Ruttenberg *et al.,* 2012).

Status and Trends

Fish of the Coral Reef Complex

The results of Ault and Franklin (2011) provide a mixed picture of the condition of reef fish and lobster populations. Landings data declined for several of the target species, such as groupers, snappers, and hogfish, but these trends were accompanied by decreases in fishery effort, in particular, a decrease in participation in the headboat and lobster commercial fishery. Comparison of the population statistics, derived from analysis of the size of fish caught, with U.S. federal sustainability benchmarks indicated that all the reef fish, except the greater amberjack, experienced overfishing. Black grouper, mutton snapper, gray snapper, and gray triggerfish were in the poorest condition in this regard. These results provide only a characterization of the condition of reef fish and lobster populations, and they are constrained by their reliance on data only from fished populations.

Analysis of the fisheries-independent survey of the fish community along the mangrove shoreline in Biscayne Bay indicate that the abundance of gray snapper and yellowfin mojarra have been relatively stable over the period 1998-2008.

Caribbean Spiny Lobster

Current heavy exploitation of the Caribbean spiny lobster by both the commercial and recreational fisheries removes a large proportion of the adult animals each year. Throughout its range in the Caribbean and Brazil, annual catch peaked between 1987 and 1997 and is currently in decline. The cause of this decline is largely attributed to overfishing, but environmental factors also play a role (Ernhardt *et al.,* 2011). Ault and Franklin (2011) found that data from the commercial fishery for the SEFC region is consistent with a constant level of landings per trip. There was a decreasing trend in commercial landings between 1990 and 2009, but this might be the result of a decrease in fishing effort.

Pink Shrimp

Results of the fisheries-independent monitoring of pink shrimp in south Biscayne Bay, i.e., Black Point to Turkey Point, are available only for 2002-2007. Over this period, observed shrimp densities in Biscayne Bay either equalled or exceeded their historical baseline (RECOVER, 2010). The 20-year record of catch per trip in the Biscayne Bay bait shrimp fishery suggests a long-term decline in shrimp abundance in Biscayne Bay (Johnson *et al.,* 2012).

Lionfish

Reports of lionfish in South Florida began in January 2009, and between January 2009 and July 2010 there were approximately 500 reported lionfish sightings in the Florida Keys (250 of those were confirmed and removed from sanctuary waters) (Morris and Whitfield, 2009). Since then, both sightings and removal efforts have been continuously increasing. Juvenile lionfish (approximately 30 mm in total length) were observed in spring 2010 at several locations in Florida Bay (Ruttenberg *et al.,* 2012), suggesting a pervasive invasion is occurring across all the habitats of the SEFC marine ecosystem. Blue crab fishermen find lionfish in their traps in Biscayne Bay. The increasing abundance and wider distribution of lionfish in the South Atlantic Bight, Bermuda, Florida, and the Bahamas indicates that lionfish have successfully established breeding populations in the tropical central western Atlantic. They are possibly the first marine fish species to do so.

Topics of Scientific Uncertainty

Insufficient and poor quality data and lack of an appropriate modeling framework have prevented sophisticated evaluations of the sustainability of reef fisheries for the purpose of setting regulations on fishing effort. Generally lacking are the data needed to conduct modern stock assessments, including demographic rates, life history parameters, and historical time-series of age-size structured catches by species, and the associated fishing effort by gear in the recreational or commercial sector (Quinn and Deriso, 1999; Haddon, 2001; Quinn, 2003; Ault *et al.,* 2005a).

A more accurate assessment of the status of reef fish populations could be provided by implementing a fisheries-independent monitoring program with a robust sampling design. The most logical plan extends the efforts of the ongoing NMFS Southeast Fisheries Science Center and University of Miami's Rosenstiel School of Marine and Atmospheric Science reef fish visual diver census program in the Florida Keys (Smith *et al.,* 2011) to include Miami-Dade, Broward, Palm Beach, and Martin counties. This approach would not only provide unbiased estimates of population status in the region of interest but also establish a framework for comparisons of reef fish throughout the Florida Reef Tract. In conjunction with studies to collect detailed life history parameters for coral reef associated fishery species, this approach could provide a robust analysis framework to evaluate the biological status of fishery species. This critical step was initiated under the state and federal supported SEFCRI (Southeast Coral Reef Initiative) program in 2012.

Spatial closures, or "no-take" marine reserves, have not yet been implemented in the MARES SEFC region. No-take marine reserves, e.g., in the Florida Keys National Marine Sanctuary, are significant management tools that have been shown to increase fish number and biomass (Halpern and Warner, 2002; Ault *et al.,* 2005a, 2012) but often represent a threat to fishermen who are concerned about the loss of fishing grounds. Priority areas for spatial closures should be identified through population connectivity studies, as well as habitat characterizations of particular locations. An effective network of no-take zones may require closure of areas outside of the MARES SEFC region to support fisheries management goals.

Information is needed to establish targets for the management of freshwater inflows from the regional water management system. Targets are needed for characteristics of freshwater inflow, i.e., volume, timing, and water quality, that are protective of the nursery function of coastal water bodies. Setting these targets requires knowledge of the functional relationship between freshwater inflow and estuarine environmental parameters that are critical to the nursery function, such as salinity, temperature, and toxin concentrations in waters, and sediments. Alternatively, it may be possible to correlate variations in freshwater inflow directly with variations in metrics of fish health or population, such as catch per unit effort in the case of the pink shrimp fishery in Biscayne Bay (Browder *et al.,* 2005; Johnson *et al.,* 2012).

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