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Fish Species Environmental Vulnerabilities Consolidation

By Mitchell A. Roffer and Candice Hall.
Roffer's Ocean Fishing Forecasting Service, Inc. (ROFFS™), West Melbourne, FL
https://www.roffs.com - fish7@roffs.com

Introduction:

This is a literature review to consolidate the documents related to the apparent vulnerabilities to environmental change for the important commercial and recreational fishes in the South Atlantic, Gulf of Mexico and Caribbean regions. It is provided as background material for the "Climate Variability and Fisheries Workshop: Setting Science Priorities for the Gulf of Mexico, South Atlantic, and Caribbean Regions," St. Petersburg Beach, FL, October 26-29, 2015. It was not our purpose to conduct the actual vulnerability assessments for the 70 species we reviewed. However, in some cases where they was none we assigned an assessment.

The main species under consideration were subjectively selected from the top 21 species identified from 2013 NOAA commercial annual landings and values for the South Atlantic States and Gulf of Mexico regions (http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS) added additional species derived from the Caribbean Fisheries Management Council's Fishery Management Plans (http://www.caribbeanfmc.com/index.html) and South Atlantic Fisheries Management Council's managed species list. In addition, we added important recreational and highly migratory species.

Each species review includes: a) an initial summary of their apparent vulnerability status and information related to their tolerances to key physical parameters; b) Rapid Assessment Profiles; c) SouthEast Data, Assessment, and Review (SEDAR) documentation; and d) additional information derived from a variety of sources.

Statements of vulnerability are derived from the rapid assessment profiles, the SEDAR documentation (both detailed below), or determined by us from the available information contained in this document. We did not change the vulnerability statements ("high," "moderately," and "low") from other sources and we only used the term "vulnerable" for the Roffer and Hall consideration. The amount of information provided for the individual reviews are not equal for each species due to the varying availability and subjective importance of the data.

The rapid assessment profiles (if available) were derived by the Atlantic States Marine Fisheries Commission (ASMFC, http://www.asmfc.org/), the Mid-Atlantic Fisheries Management Council (MAFMC, http://www.mafmc.org/), the New England Fisheries Management Council (NEFMC, http://www.nefmc.org/), and the South Atlantic Fishery Management Council (SAFMC, http://www.safmc.net/). Certain species have profiles in multiple management council documents. Direct quotes are provided where appropriate. The rapid assessment profiles included government risk or management

risk and is the consideration of whether and how agile the management will be able to adjust its management to changes related with climate variability.
Not all species had rapid assessment profiles, but the rapid assessment profiles address the following key questions:

- Climate vulnerability?
- Ecosystem considerations?
- Linkages to other fisheries?
- Known climate-related concerns?
- Social and economic concerns?
- Management Risk?

In the SEDAR subsection, the stock assessment documentation for each species is included, but not all species have SEDAR stock assessments (see http://sedarweb.org/). Page numbers from within the SEDAR document are included for easy reference. Note that multiple documents are included in SEDAR pdf's.

Each species summary also includes additional information related to the species-specific environmental tolerances that are important when considering changing climate and climate vulnerabilities. Conditions considered include temperature, salinity, oxygen and pH, depth range, life-cycle environments and locations, spawning season, and substrate preference. Additional interesting information is included for inquisitive minds.

There is also a summary spreadsheet. Below is the summary by category.

Category summary (n=70)
Highly vulnerable (includes very, quite, medium-high) = 25
Vulnerable (includes medium, moderate) = 27
Low (includes low-medium) = 12
Possible = 1
Need more information = 5

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Below is a list of the species considered within this review:

American eel
American shad
Atlantic bay scallop
Atlantic blue marlin
Atlantic bluefin tuna
Atlantic deep-sea scallop
Atlantic croaker
Atlantic menhaden
Atlantic sailfish
Atlantic spadefish
Bar jack
Bigeye tuna
Black drum
Black sea bass
Blackfin tuna
Blue crab
Blue runner
Bluefish
Blueline tilefish
Brown shrimp
Butterfish
Caribbean spiny lobster
Cobia
Corals
Deepsea golden crab
Dolphin
Eastern oyster
Gag grouper
Golden tilefish
Goliath grouper
Gray triggerfish
Greater amberjack
Gulf flounder
Gulf kingcroaker (kingfish)
Gulf menhaden
Harvestfish
Hogfish
King mackerel
Northern kingcroaker (kingfish)
Other reef fish
Pinfish
Pink shrimp
Quahog clam
Queen conch
Red drum
Red porgy
Red snapper
Rock shrimp
Royal red shrimp
Scallops
Scamp grouper
Sheepshead
Skipjack tuna
Southern flounder
Southern kingcroaker (kingfish)
Spanish mackerel
Spiny dogfish
Spot
Spotted seatrout
Striped mullet
Summer flounder
Swordfish
Tilefish
Tomtate
Vermilion snapper
Wahoo
Weakfish
White grunt
White marlin
White shrimp
Yellowfin menhaden
Yellowfin tuna

American eel: *Anguilla rostrata*

Vulnerability:	Highly vulnerable (ASMFC)
Depth Range:	Need information
Temperature Range:	3 – 31 °C (Chesapeake Bay); 4 – 25 °C (FishBase 2006)
Salinity Range:	Need information
Oxygen Rage:	Greater than 4 mg/L
pH Range:	Need information

2013: $880,996.00, 31.9 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC
Management authorities? Interstate: ASMFC; State: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? "Highly vulnerable. Changing oceanic conditions affect the ability of out-migrating silver (mature) eels to reach breeding grounds in the Sargasso Sea." "Changes in ocean current and temperatures impact the return of passively-dispersed larvae to estuaries along the entire Atlantic coast. Changes in the temperature, salinity, and habitat composition of estuarine and freshwater habitats impact the growth, morbidity, and maturity rates".

Ecosystem considerations? "Both predator and prey in the myriad of ecosystems in which they are found throughout their range and life cycle. However, disturbances to these predator-prey interactions are complicated and thus difficult to predict."

Linkages to other fisheries? "Preferred baits for the striped bass recreational fishery" (after reduction in availability of river herring due of population declines). "Eels are prey for striped bass, bluefish, and catfish and decreases in eel populations could contribute to declines in these" fisheries. "Horseshoe crabs are preferred bait in the yellow eel pot fishery". Reduced landings in horseshoe crab harvest are already impacted the eel fishery (some progress in developing artificial baits, which until recently has not been very successful).

Known climate-related concerns? "There is a concern over changes in oceanographic temperatures, which could influence the dispersal of the leptocephali larvae. This is a long term concern. Additionally, climate related concerns have been expressed for the decline in European eel stocks." "The concern of a changing climate on American eels was one of the main reasons the USFWS is considering listing eels under the Endangered Species Act.

Social and economic concerns? "Temperature influences the arrival of glass eels to East Coast Rivers. Huge swings in the winter temperature result in an unstable economics in the glass eel fishery if the eels recruit much earlier or later than when the fishing season is open."

Management Risk? Unknown. "One of the most unique life histories. 1) Recruitment is at random throughout the range (Canada to Brazil). Conservation efforts made in the US may not necessarily benefit US stocks of American eels. 2) If range consolidation caused by shifting oceanographic conditions is mistaken for increasing population trends and is followed by increasing fishing pressure then the result could be detrimental to the entire range. 3) Warmer water temperatures and decreasing salinity in eel habitats may also be associated with increased prevalence of the non-native swim bladder nematode, *A. crassus*. The parasite can increase stress response that may cause secondary bacterial infections and mass mortalities. Swim bladders are irreversibly damaged by the parasite, and infections can result in early migration failure because of reduced swimming performance and inability to regulate depth during migration."

2. No SEDAR document available

3. ASMFC Chapter 7: American Eel
   http://www.asmfc.org/uploads/file/Chp7_American_Eel_Final.pdf

"Factors that are thought to influence the daily abundance of migrating elvers include nightly tidal height, river water temperature and discharge, and the difference between bay and river temperatures (McCleave and Kleckner 1985; Sorensen and Bianchini 1986; Ciccotti et al. 1995; McCleave and Wipplehauser 1987; Wipplehauser and McCleave 1987; Martin 1995; Jessop 2003). Migration occurs in waves and is initially triggered by an increase in temperature to between 12 and 14°C. After initiating migration, temperature does not appear to have a functional influence on migrating elvers (Jellyman and Ryan 1983; Martin 1995; Jessop 2003)."

4. IUCN Red List http://www.iucnredlist.org/details/191108/0 (Endangered).

"The American Eel is tolerant of a wide range of temperatures. In Chesapeake Bay, it has been captured at temperatures ranging from 3 to 31°C, with the greatest occurrence at 16–28°C (DFO 2014). Water temperature is important in the seasonal activity of eels; in winter, when temperatures are <5°C, eels bury themselves in soft substrate and are believed to enter a state of torpor (Greene et al. 2009)."

Major Threats:
"In an extensive review of status of the American eel in Canada, COSEWIC (2012) identified the threats as: 1) barriers in freshwater resulting in the accumulative loss of formerly productive habitats; 2) turbine mortality of hydroelectric dams; 3) vulnerability of life stages to fisheries; 4) bioaccumulation of contaminants; 5) exotic swimbladder nematode parasite (*Anguillicola crassus*) potentially introduced from stocking; 6) climate change and shifting oceanic conditions. A recent report indicated that barriers to migration and fisheries were likely the greatest threats across the species' range, while

other threats would have more regional influences (Chaput et al. 2014). Many of the current major stressors affecting *A. rostrata* in North America are those facing other species of anguillid eels. Large barriers severely impede upstream migration of juvenile eels if no passage is provided, extirpating large areas of habitat suitable for growth and maturation of freshwater eels. Although eels are able to ascend many smaller barriers, recent studies have documented a tenfold reduction in eel density above each potentially passable barrier (Machut et al. 2007). Machut et al. also found significantly lower American Eel condition with increasing riparian urbanization in the Hudson River in the U.S."

5. MIT Sea Grant, Coastal Resources: americaneel.pdf
https://massbay.mit.edu/seafood/americaneel.pdf

Habitat: "American eel habitats range from warm freshwater rivers and lakes to coastal brackish areas to the open ocean, to cold trout streams (Facey and Van Den Avyle 1987). American eels can tolerate temperatures from 4 to 25 ºC" (FishBase 2006).

Ecological Impacts: "American eel populations have declined by as much as 99% in the last 20 years due to hydropower plants, over-fishing, and other unknown causes (USFWS 2006b). Many American eels have also been infected with the *Anguillicola crassus* parasite, brought to the United States by Japanese eels. The parasite destroys the eel's swim bladder. The American eel has been considered for protection under the Endangered Species Act (USFWS 2006b)."

Economic Impacts: "Glass eels have become a delicacy in Asia, and as such there is a large demand for harvested glass eels. Some states have restrictions and bans to protect American eels (USFWS 2006b). The annual harvest of American eels, although declining, has a value on the order of $5 million" (ASMFC 2000).

Reference: FishBase 2006. Species Summary: Anguilla rostrata. FishBase. 2 May 2006. http://www.fishbase.org/Summary/SpeciesSummary.php?id=296.

American shad: *Alosa sapidissima*

Vulnerability:	Vulnerable (ASMFC). Recruitment affected by the river flow levels (precipitation) and water temperature.
Depth Range:	Need information
Temperature Range:	13 – 26 °C (eggs), ocean migrations: 13 – 18° C sea surface isotherms (Leggett, 1973; Leggett and Whitney, 1972) and 7–13°C bottom temperatures (Neves and Depres, 1979)
Salinity Range:	0 – 15 ppt
Oxygen Rage:	Need information
pH Range:	Need information

2013: $312,528.00, 355.4 tonnes: (http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC
Management authorities? Fed: NOAA; Regional: NEFMC, MAFMC; Interstate: ASMFC; State: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? "Shad recruitment is affected by the flow levels of the rivers where they spawn, as well as the water quality. Climate change induced changes in precipitation patterns may have a large impact on shad recruitment and juvenile survival, some of which may be positive, depending on the river system. Additionally, mismatches between ocean and river temperatures may have an impact on the timing and success of spawning. Recruitment may also be negatively affected by warmer river temperatures during egg deposition, incubation, hatching, and juvenile growth prior to migration."

Ecosystem considerations? "Shad feed predominantly on plankton, and are thus vulnerable to climate change induced changes in the timing and magnitude of plankton blooms in both marine and freshwater systems. In addition, they are an important prey species for both riverine and marine species"

Linkages to other fisheries? "None based on human behavior"

Known climate-related concerns? "Increased water temperatures and changes in peak flow are thought to impact spawning and recruitment. As these factors become more erratic, it is thought that recruitment failure will become more common"

Social and economic concerns? None

Management Risk? None

2. No SEDAR document available

3. American Shad and Hickory Shad – University of Maryland
http://www.dnr.state.md.us/irc/docs/00000260_09.pdf

Pg. 2:
“Is anadromous, lives at sea, and only enters freshwater in the spring to spawn. Schooling species and highly migratory.” “Migrate from sea to coastal rivers in the spring for spawning when water temperatures range from 16-19 °C. Some enter the mouth of their natal rivers when temperatures are as low as 4°C or less.”

Pg. 10:
“Suitable water temperatures for the development and survival of American shad eggs range from 13-36 °C.”

Pg. 11:
“Eggs collected in areas of the upper Chesapeake Bay with 0-1 ppt salinity. Eggs and larvae can survive exposure to salinities ranging from 7.5-15 ppt.”

4. Ocean distribution of the American shad (*Alosa sapidissima*) along the Pacific coast of North America http://fishbull.noaa.gov/1094/1094pearcy.pdf

Pg. 440 (1 of 14):
“According to tagging studies, their extensive ocean migrations, of sometimes thousands of kilometers during one season, are closely correlated with 13–18° sea surface isotherms (Leggett, 1973; Leggett and Whitney, 1972) and 7–13°C bottom temperatures (Neves and Depres, 1979).”

Pg. 449 (10 of 14):
“Neves and Depres (1979) caught Atlantic shad at SSTs of 2–23°C but concluded that bottom temperatures of 3–15°C provided a better basis for predicting movements of Atlantic shad in the ocean during all seasons of the year.”

5. Atlantic Coast Diadromous Fish Habitat: Chapter 2: American Shad
http://www.asmfc.org/uploads/file/Chp2_American_Shad_Final.pdf

Spawning water temperature

Activity	Temperature (°C)	Location	Citation
Migration	5 - 23	Throughout range	Walburg and Nichols 1967
Migration (peak)	8.6 - 19.9 (16 - 19)	North Carolina	Leggett and Whitney 1972
Peak migration	16.5 - 21.5	Southern rivers	Leggett 1976
Spawning	8 - 26	Throughout range	Walburg and Nichols 1967;

Activity	Temperature (°C)	Location	Citation
			Stier and Crance 1985
Optimum spawning	14 - 20	Throughout range	Stier and Crance 1985
Optimum spawning	14 – 24.5	Throughout range	Ross et al. 1993

Table 2-3. American shad migration and spawning temperatures for the Atlantic coast

Atlantic bay scallop: *Argopecten irradians*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Bay scallop embryos require a narrow range of temperature-salinity combinations for proper development. Changes in pH negatively impact shellfish.
Depth Range:	0.3 – 10 m, though occurrence to 18 m reported
Temperature Range:	15 – 30 °C; optimal for embryos is 21.9 °C (both laboratory conditions). Massachusetts bay scallops need a temperature over 7.2°C for growth.
Salinity Range:	20 – 30 ppt; optimal for embryos is 24.4 ppt (both laboratory conditions). Minimum = 14 ppt (Fish and Wildlife Service)
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Smithsonian Marine Station at Fort Pierce
http://www.sms.si.edu/irlspec/Argopecten_irradians_concentricus.htm

Regional Occurrence:
"Argopecten irradians concentricus occurs in seagrass beds in Atlantic coastal waters from New Jersey to Florida and in the Gulf of Mexico (Kruczynski 1972, Fay et al. 1983, Arnold et al. 1998, Irlandi et al. 1999)."

Life history and population biology:
"The average life span of *Argopecten irradians concentricus* is 12 - 18 months (Barber and Blake 1985a). The longest living individuals will live for 26 months (Fay et al. 1983). The larval mortality rate is somewhat high. It can range from 10%-50% within the first 8 days of settlement. High water temperatures in the summer months can lead to a shortened lifespan in adults (Blake 2005)."

Abundance:
"The *Argopecten irradians concentricus* fishery along the east coast of the United States has collapsed since the 1950s (Blake 2005). This species is very sensitive to natural (i.e. hurricanes, red tide events) as well as anthropogenic (i.e. overharvesting and habitat loss) processes (Summerson and Peterson 1990, Blake 2005). The decline in seagrass beds on the west coast of Florida may be a large contributing factor to the loss of bay scallop populations. Studies from several regions suggest that inadequate larval supply does not allow *A. irradians concentricus* to recover rapidly from depletion events (Arnold et al. 1998). In areas where the bay scallop does thrive, densities can be as high as 24.8 individuals per m^2 (Fay et a1. 1983)."

Reproduction:
"The bay scallop is a functional hermaphrodite, having both male and female sex organs (Barber and Blake 1985b). Spawning will not occur until seawater temperatures reach 20°C. Individuals of *Argopecten irradians concentricus* have one reproductive cycle during their lifetime. Oocyte development begins in August and spawning usually occurs by October (Barber and Blake 1985b)."

"The growth of juvenile bay scallops is rapid during the spring months and slows down as water temperatures decrease in the fall (Irlandi et al. 1999)."

Physical tolerances
"Temperature: Under laboratory conditions, the optimal temperature for the development of bay scallop embryos is 21.9°C. When seawater temperature dropped below 15°C, or increased to temperatures above 30°C, bay scallop embryos could not survive. Adult *Argopecten irradians concentricus* exhibit a small increase in its oxygen intake when seawater temperatures increase (Barber and Blake 1985b)."

"Salinity: Under laboratory conditions, the optimal salinity for the development of bay scallop embryos is 24.4 ppt. Mortality occurred when salinities dropped below 20 ppt or increased above 30 ppt (Tettlebach and Rhodes 1981). Adult *Argopecten irradians concentricus* exhibit an increase in its ammonia content in response to decreasing salinities (Barber and Blake 1985b)."

References:
Barber BJ and NJ Blake. 1985b. Substrate catabolism related to reproduction in the bay scallop *Argopecten irradians concentricus*, as determined by O/N and RQ physiological indexes. Marine Biology 87:13-18.

Tettlebach ST and EW Rhodes. 1981. Combined effects of temperature and salinity on embryos and larvae of the northern bay scallop *Argopecten irradians concentricus*. Marine Biology 63:249-256.

4. Fish and Wildlife Service – Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic): Bay Scallop. Biological Report 82 (11.12), October 1983. 82_11-12.pdf
http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-012.pdf

Pg. 10:
"In the mid-Atlantic region, bay scallops spawn from mid-April through early September (Chanley and Andrews 1971) . Specific spawning times, however, vary considerably across the species range. In Massachusetts (Belding 1910), Connecticut (Cooper and Marshall 1963), Rhode Island (Risser 1901), and Long Island Sound (Hickey 1978), most spawning occurs during June and July, as water temperatures increase. In contrast, populations in North Carolina (Gutsell 1930; Sastry 1966) and Florida (Sastry 1963; Barber and Blake 1983) spawn between August and December, as water temperatures decrease. This apparent latitudinal difference in spawning time may

represent different physiological adaptations to environmental conditions among the three recognized subspecies of bay scallops (Sastry 1970a)."

Pg. 12:
Depth:
"Even though adult scallops retain the ability to attach by byssal threads (Castagna 1975; Peters 1978), they are seldom found attached in nature (Castagna 1975). Adult scallops prefer quiet waters, protected from high winds, storms, and tides (Belding 1910). Preferred depths range from 0.3 to 10 m (1 to 33 ft), though occurrence to 18 m (59 ft) has been reported (Belding 1910; Broom 1976). Scallops are often most abundant on tidal flats with only 0.3 to 0.6 m (1 to 2 ft) of water at low tide."

Pg. 17-20:
Temperature:
"Castagna (1975) reported that survival and development of eggs were best at water temperatures above 20°C (68°F). Optimum temperatures for development appeared to be 26° to 28°C (79° to 82°F). Belding (1910) stated that Massachusetts bay scallops need a temperature over 7.2°C (45°F) for growth, and growth rate was closely tied to temperature and food supply. Marshall (1960) found that adult bay scallops tolerated exposure to air temperatures as low as -6.6°C (20°F) for 2 hr. Below this temperature, tolerance time decreased."

"Probably the most significant information on the effects of temperature on bay scallops is that contained in a series of studies by Sastry (1963, 1966, 1968, 1970a, 197C)b), and by Sastry and Blake (1971) on relationships between temperature, food, gonad development, and spawning . Overwintering scallops in a "resting reproductive state" could not survive direct exposure to 25°C (77°F) or 30°C (86°F). They survived at 25°C if an acclimation period of 30 days at 15°C (59°F) or 20°C (68°F) and adequate food were provided." "Also, tolerance of changes in water temperature was lowest for ripe scallops, and much higher for "reproductive development" stage individuals (Sastry 1966). Sastry (1970b) and Sastry and Blake (1971) concluded that both food and temperature were important factors determining initiation and overall rate of gonadal development, readiness to spawn, and spawning time, and therefore may account for geographic differences in spawning activities observed over the species range (Sastry 1970a)."

Salinity:
"Because of the estuarine habitat, bay scallops are frequently exposed to changes in salinity, especially when salinity is reduced from freshwater runoffs (Duggan 1975). Castagna (1975) reported that the minimum salinity required for eggs to develop to the straight-hinged veliger larval stage was 22.5 ppt. In general, the minimum salinity requirement determining overall distribution patterns of settling juveniles and adults is about 14 ppt (Belding 1910; Gutsell 1930; Sastry 1961; Castagna and Chanley 1973). Bay scallops have occasionally been found at salinities as low as 10 ppt (Gutsell 1930), but whether this was the prevailing salinity at the collection site was not indicated. Vernberg et al. (1963) reported that exposure to 12-15 ppt caused gill cilia to cease

beating." "Evidence suggested that short periods of exposure to low salinities, such as from heavy runoff, probably does not affect survival of bay scallops."

Temperature-Salinity Interaction:
"Bay scallop embryos require a narrow range of temperature-salinity combinations for proper development. The optimum combination for normal development was reported at 20°C (68°F) or 25°C (77°F) (test temperatures at 5°C increments) and 25 ppt salinity. Salinities above or below 25 ppt significantly affected normal embryonic development. No embryos developed normally at 10 ppt or 15 ppt salinity, or at water temperatures of 10°C (50°F) or 35°C (95°F) (Tettelbach and Rhodes 1981)."

"Bay scallop larvae could not tolerate 10-ppt salinity or 35°C; at least some larvae survived at all other test temperatures and salinities. Maximum larval survival occurred at 20°C and 25 ppt salinity. Minimum requirements for larval growth were 25° to 30°C (77° to 86°F) and 20- to 35-ppt salinity. Larval growth was maximized at 25°C and 25 ppt salinity (Tettelbach and Rhodes 1981)."

Water Currents:
"Water currents seem to influence food availability, waste removal, growth rate, larval movements, and distribution of juvenile settlements (Broom 1976; Robert 1978). Kirby - Smith (1972) found that scallops grew best in water currents less than 1 cm/s (0.03 ft/s); maximum growth occurred at 0.21 cm/s (0.007 ft/s). Scallop growth ceased at a water velocity of 12 cm/s (0.4 ft/s)."

"Water currents probably influence the directional movements and distribution patterns of planktonic life stages of the bay scallop (Moore and Marshall 1967; Merrill and Tubiash 1970). However, once bay scallops reach the adult stage, water currents play a lesser role in influencing movement, though they may cause apparent directionality of movement in otherwise random individual scallop movements (Moore and Marshall 1967; Broom 1976)."

Turbidity:
"Stone and Palmer (1973) demonstrated that bay scallops exposed to 1000 ppm turbidity (clay particles) for several weeks showed a 19% reduction in dry weight compared to control animals." "Stone and Palmer (1973) suggested that long-term exposure to levels of turbidity greater than 500 ppm may interfere with normal growth and reproductive processes of bay scallops."

Substrate:
"The availability of appropriate substrates for settlement, attachment, and feeding activity is essential. Beds of eelgrass and other seagrasses growing on sand substrates are preferred (Belding 1910). Soft mud and silt substrates are harmful to the survival of settling juveniles, but only if juveniles do not first attach directly to seagrass for a short period of growth before dropping to the bottom (Castagna 1975). Extremely thick seagrass beds, with no open spaces, cut off water circulation entirely and are detrimental to settling juvenile scallops (Belding 1910)."

Oxygen Requirements:
“Resting requirements of oxygen for adult bay scallops averaged 70 ml/kg/hr at 20°C (68°F), a value comparable to that of other temperate bivalves possessing strong swimming powers (Van Dam 1954). Rate of oxygen uptake was independent of dissolved oxygen concentration down to a level of 1 .5 ppm. Percentage of available dissolved oxygen removed by scallops ranged from 0.5% t o 13% (Van Dam 1954).”

Atlantic blue marlin: *Makaira nigricans*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature and oxygen that will likely be changed by climate change.
Depth Range:	0 – 200 m
Temperature Range:	13 – 31 °C; prefer 25 – 30 °C (Boyce et al., 2008); 22 – 31 °C (Fish Base)
Salinity Range:	Need information
Oxygen Rage:	Lower hypoxic habitat boundary: 3.5 ml/l
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Florida Museum of Natural History, accessed October 12, 2015
http://www.flmnh.ufl.edu/fish/gallery/descript/bluemarlin/bluemarlin.html

"Habitat
Occurring offshore in blue oceanic waters, the blue marlin prefers to stay in the warm waters near the surface, above the thermocline. They follow the seasonal water temperature changes, being closely tied to these warm waters. They are found in ocean waters great distances from the continents as well as coastal regions near deep waters, such as near the Mississippi River in the Gulf of Mexico."

"Reproduction
Spawning is known to occur near Cuba between May and November. Egg hatching is dependent upon temperature, but likely occurs well within a week."

4. Fish Base http://www.fishbase.org/summary/216

"Marine; pelagic-oceanic;" "depth range 0 - 200 m (Ref. 43). Subtropical; 22°C - 31°C (Ref. 43); 50°N - 45°S, 98°W - 17°E (Ref. 43)".

Ref. 43: Nakamura, I., 1985. FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fish. Synop. 125(5):65p. Rome: FAO.

5. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic blue marlin extract from "Table 1. Overall (Min., Max.), and mean

(Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage."

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Blue marlin	*Makaira nigricans*	13	31	20.68	30.05	25.00	30.00	9.37	6

6. Prince et al. 2010. Ocean scale hypoxia-based habitat compression of Atlantic istiophorid billfish. Fisheries Oceanography 19:6, 448-462. Prince 2010 OMZ Tuna.pdf

Pg. 1:
"In the eastern tropical Pacific (ETP), the surface mixed layer is defined by a shallow thermocline above a barrier of cold hypoxic water, where dissolved oxygen levels are ≤ 3.5 mL L)1. This thermocline (~25–50 m) constitutes a lower hypoxic habitat boundary for high oxygen demand tropical pelagic billfish and tunas (i.e., habitat compression)."

Pg. 11:
"It is also clear that blue marlin may be capable of making very short-term maximum (spike) dives to strata below the 3.5 mL L)1 DO threshold (Figs 3b and 4b); long-term survival at these levels would not be sustainable (Brill, 1994)."

Pg. 16:
"Climate change, global warming, oceanic acidification, and oxygen minimum zones: The impacts of the ETP [Eastern Tropical Pacific] and ETA [Eastern Tropical Atlantic] OMZs [oxygen minimum zone] on the management of tropical pelagic fishes should not be understated. This is particularly relevant considering the escalated pace of global warming and concurrent rise in ocean temperatures that would increase the size, hypoxic severity, and shoaling of these OMZs in the future (Rosa and Seibel, 2008; Stramma et al., 2008, 2009). The synergistic effects of global warming and ocean acidification, relative to expansion of the OMZs, on high oxygen-demand tropical pelagic fishes and their preferred prey will predictably further reduce suitable habitat (Rosa and Seibel, 2008; Stramma et al., 2008), while increasing vulnerability to higher levels of exploitation by surface fishing gears (Prince and Goodyear, 2006). It remains to be seen whether the likely expansion of OMZs with global warming increases exploitation rates or rather dilutes the stocks sufficiently so that exploitation is little affected or declines. Therefore, the population status of tropical pelagic fishes in these areas should be monitored vigilantly to insure these stocks are not further diminished. In this regard, incorporating compression impacts into the stock assessment process seems essential, given the extensive geographical coverage of these oceanographic features in the tropical Atlantic and the escalated rate of global warming that will likely exacerbate future compression impacts."

Atlantic bluefin tuna: *Thunnus thynnus*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature, chlorophyll and oxygen that are likely changed by climate change.
Depth Range:	0 – 985 m, able to dive to depths in excess of 1000 m
Temperature Range:	2.8 – 31 °C; prefer 14.9 – 22.9 °C (Boyce et al., 2008); Juveniles found in waters warmer than 12°C; GOM spawning: 24.9 – 29.5 °C
Salinity Range:	Larvae collected within narrow = 36 ppt
Oxygen Rage:	Lower limit: between 2 to 2.7 ml/l (Sharp, 1978).
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Climate change vulnerability of bluefin tuna – multiple references:

a. Muhling, B.A., Y. Liu, S.-K. Lee, J.T. Lamkin, M.A. Roffer, F.E Muller-Karger, and J.F. Walter III. 2015. Potential impact of climate change on the Intra-Americas Sea: Part-2. Implications for Atlantic bluefin tuna and skipjack tuna adult and larval habitats. J. Mar. Syst. 148: 1-13.: muhling_etal_2015_jms-1.pdf
http://www.sciencedirect.com/science/article/pii/S0924796315000226

Abstract excerpt: "Increasing water temperatures due to climate change will likely have significant impacts on distributions and life histories of Atlantic tunas." "Results showed marked temperature-induced habitat losses for both adult and larval bluefin tuna on their northern Gulf of Mexico spawning grounds." "This work suggests that influences of climate change on highly migratory Atlantic tuna species are likely to be substantial, but strongly species-specific. While impacts on fish populations remain uncertain, these changes in habitat suitability will likely alter the spatial and temporal availability of species to fishing fleets, and challenge equilibrium assumptions of environmental stability, upon which fisheries management benchmarks are based."

b. Muhling, B.A., P. Reglero, L. Ciannelli, D. Alvarez-Berastegui, F. Alemany, J.T. Lamkin, and M. A. Roffer. 2013. A comparison between environmental characteristics of larval bluefin tuna (*Thunnus thynnus*) habitat in the Gulf of Mexico and western Mediterranean Sea. Marine Prog. Ser. 486:257-276: Muhling2013_environ_bluefinlarval.pdf
http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/41659/CiannelliLorenzoCEOASComparisonBetweenEnvironmental.pdf?sequence=1

Abstract excerpt: "Despite being well adapted for feeding in cold water on their North Atlantic feeding grounds, Atlantic bluefin tuna undertake long migrations to reach warm, low productivity spawning grounds in the Gulf of Mexico and Mediterranean Sea.

Environmental conditions within spawning areas have been presumed to benefit larval survival, through appropriate feeding conditions, and enhanced larval retention and growth rates." "Results showed that larvae on both spawning grounds were most likely to be found in warm (23 to 28°C), low chlorophyll areas with moderate current velocities and favorable regional retention conditions. In the Gulf of Mexico, larvae were located in offshore waters outside of the Loop Current and warm eddies, while in the western Mediterranean, larval occurrences were associated with the confluence of inflowing Atlantic waters and saltier resident surface waters. Although our results suggested common themes within preferred spawning grounds on both sides of the Atlantic Ocean, the ecological processes governing larval survival and eventual recruitment are yet to be fully understood."

c. Muhling, B.A., M.A. Roffer, J.T. Lamkin, G.W. Ingram, Jr., M.A. Upton, G. Gawlikowski, F.E. Muller-Karger, S. Habtes, and W.J. Richards. 2012. Overlap between Atlantic bluefin tuna spawning grounds and observed Deepwater Horizon surface oil in the northern Gulf of Mexico. Marine Pollution Bull. 64(4):697-687.
http://www.sciencedirect.com/science/article/pii/S0025326X12000574

Abstract excerpt: "The 2010 Deepwater Horizon oil spill impacted the northern Gulf of Mexico (GOM) during the spring spawning season of Atlantic bluefin tuna (BFT). Overlap between BFT spawning habitat and surface oil in the northern GOM was examined using satellite-derived estimates of oil coverage, and spawning habitat models. Results suggested that although eggs and larvae were likely impacted by oil-contaminated waters in the eastern GOM, high abundances of larvae were located elsewhere, especially in the western GOM. Overall, less than 10% of BFT spawning habitat was predicted to have been covered by surface oil, and less than 12% of larval BFT were predicted to have been located within contaminated waters in the northern GOM, on a weekly basis. Our results provide preliminary but important initial estimates of the effects of the spill on larval BFT mortality, as concern continues over the appropriate management responses to impacts of the spill."

d. Muhling, B.A., J.T. Lamkin, J.M. Quattro, R.H. Smith, M.A. Roberts, M.A. Roffer, and K. Ramirez. 2011. Collection of Larval Bluefin Tuna (Thunnus thynnus) Outside Documented Western Atlantic Spawning Grounds. Bull. Mar. Sci. Bull. Mar. Sci. 87(3):687-694.).:
Muhling2011_BluefinLarval_outsideSpawningGround.pdf
http://www.ingentaconnect.com/content/umrsmas/bullmar/2011/00000087/00000003/art00024

Abstract excerpt: "In early April 2009, low numbers of very small larval bluefin tuna were collected within and south of the Yucatán Channel, and along the western boundary of the Loop Current, northeast of Campeche Bank. In situ current velocity measurements showed that these larvae were collected in moderate to strong northward flow regimes, suggesting that they were spawned outside of the Gulf of Mexico."

4. NOAA Fisheries Atlantic Highly Migratory Species
http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch6.pdf

Pg. 15 – 18:
"Distribution: In the western north Atlantic, bluefin tuna range from 45° N to 0° (Collette and Nauen, 1983). However, they have recently been found up to 55° N in the west Atlantic (Vinnichenko, 1996). Bluefin tuna move seasonally from spring (May and June) spawning grounds in the Gulf of Mexico through the Straits of Florida to feeding grounds off the northeast U.S. coast (Mather et al., 1995). It is believed that there is a single stock which ranges from Labrador and Newfoundland south into the Gulf of Mexico and the Caribbean, and also off Venezuela and Brazil. The Labrador Current may separate this western stock from that found in the east Atlantic (ICCAT, 1997; Mather et al., 1995; Tiews, 1963)."

"From November to January bluefin tuna are concentrated into two separate groups, one in the northwest and the other in the north central Atlantic. In February the central Atlantic aggregation breaks up, with some fish moving southeast to the Azores and some moving southwest (Suda, 1994). Southerly movements from the feeding grounds off the northern United States and wintering areas are not well understood."

"Bluefin tuna distributions are probably constrained by the 12° C isotherm, although individuals can dive to 6° to 8° C waters to feed (Tiews, 1963). Year-to-year variations in movements have been noted (Mather et al., 1995). While bluefin tuna are epipelagic and usually oceanic, they do come close to shore seasonally (Collette and Nauen, 1983). They often occur over the continental shelf and in embayments, especially during the summer months when they feed actively on herring, mackerel and squids in the north Atlantic (Houde, pers. com.). Larger individuals move into higher latitudes than do smaller fish. Bluefin tuna are often found in mixed schools with skipjack tuna, these schools consisting of similarly sized individuals (Tiews, 1963)."

"Life history: Western north Atlantic bluefin tuna spawn from mid-April to mid-June in the Gulf of Mexico and in the Florida Straits (McGowan and Richards, 1989). Although individuals may spawn more than once a year, it is assumed that there is a single annual spawning period. Larvae have been confirmed from the Gulf of Mexico and off the Carolinas (Richards, 1991). Most of the larvae found were located around the 1,000 fathom curve in the northern Gulf of Mexico, with some sporadic collections off Texas. In the Florida Straits they are primarily collected along the western edge of the Florida Current, suggesting active transport from the Gulf of Mexico. This would also explain their occasional collection off the southeast United States. Atlantic bluefin tuna have not been observed spawning (Richards, 1991)."

"It is not believed that much spawning occurs outside the Gulf of Mexico (Richards, 1991; McGowan and Richards, 1989). Also, it appears that larvae are generally retained in the Gulf until they grow into juveniles; in June, young-of-the-year begin movements in schools to juvenile habitats (McGowan and Richards, 1989) thought to be located over the continental shelf around 34° N and 41° W in the summer and further offshore in the winter. Also, they have been identified from the Dry Tortugas area in June and July (ICCAT, 1997; Richards, 1991). Juveniles migrate to nursery areas located between Cape Hatteras, NC and Cape Cod, MA (Mather, Mason and Jones, 1995)."

"Habitat associations: It is believed that there are probably certain features of the bluefin tuna larval habitat in the Gulf of Mexico which determine growth and survival rates, and that these features show variability from year to year, perhaps accounting for a significant portion of the fluctuation in yearly recruitment success (McGowan and Richards, 1989). The habitat requirements for larval success are not known, but larvae are collected within narrow ranges of temperature and salinity - approximately 26° C and 36 ppt. Along the coast of the southeastern United States onshore meanders of the Gulf Stream can produce upwelling of nutrient rich water along the shelf edge. In addition, compression of the isotherms on the edge of the Gulf Stream can form a stable region which, together with the upwelled nutrients, provides an area favorable to maximum growth and retention of food for the larvae (McGowan and Richards, 1989). Size classes used for habitat analysis for bluefin tuna are based on the sizes at which they shift from a schooling behavior to a more solitary existence. Bluefin have traditionally been grouped by "small schooling," "large schooling," "giant," etc. Future analyses should more fully evaluate habitat differences between the traditional size classes if the data are available."

"Essential Fish Habitat for Atlantic Bluefin Tuna:

- Spawning, eggs and larvae: In pelagic and near coastal surface waters from the North Carolina/South Carolina border at 33.5° N, south to Cape Canaveral, FL from 15 miles from shore to the 200 m isobath; all waters from offshore Cape Canaveral at 28.25° N south around peninsular Florida to the U.S./Mexico border from 15 miles from shore to the EEZ boundary.
- Juveniles/Subadults (<145 cm TL): All inshore and pelagic surface waters warmer than 12° C of the Gulf of Maine and Cape Cod Bay, MA from Cape Ann, MA (~42.75° N) east to 69.75° W (including waters of the Great South Channel west of 69.75° W), continuing south to and including Nantucket Shoals at 70.5° W to off Cape Hatteras, NC (approximately 35.5° N), in pelagic surface waters warmer than 12° C, between the 25 and 200 m isobaths; also in the Florida Straits, from 27° N south around peninsular Florida to 81° W in surface waters from the 200 m isobath to the EEZ boundary.
- Adults (>145 cm TL): In pelagic waters of the Gulf of Maine from the 50 m isobath to the EEZ boundary, including the Great South Channel, then south of Georges Bank to 39° N from the 50 m isobath to the EEZ boundary; also, south of 39° N, from the 50 m isobath to the 2,000 m isobath to offshore Cape Lookout, NC at 34.5° N. In pelagic waters from offshore Daytona Beach, FL (29.5° N) south to Key West (82° W) from the 100 m isobath to the EEZ boundary; in the Gulf of Mexico from offshore Terrebonne Parish, LA (90° W) to offshore Galveston, TX (95° W) from the 200 m isobath to the EEZ boundary."

References for above statements:

1. Collette, B. B and C. E. Nauen. 1983. FAO species catalogue Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. FAO Fish. Synop., (125) Vol. 2: 137 p.

2. Tiews, K. 1963. Synopsis of biological data on the bluefin tuna Thunnus thynnus (Linnaeus) 1758 (Atlantic and Mediterranean). Pages 422- 481 in: H. Rosa Jr. ed. Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species. FAO Fisheries Reports No. 6 (2)

5. Florida Museum of Natural History, accessed October 12, 2015 http://www.flmnh.ufl.edu/fish/gallery/descript/bluefintuna/bluefintuna.html

"Habitat
This tuna is epipelagic and oceanic, coming near shore seasonally. It can tolerate a considerable range of temperatures and has been observed both above and below the thermocline, down to depths of greater than 3000 feet (985 m)."

"Bluefin tuna exhibit strong schooling behavior while they are young. While schooling is believed to be sight oriented, schools have been observed at night. Therefore, other senses (particularly the lateral line) appear to be involved in this behavior. Schools of bluefin seasonally migrate northward during the summer months along the coast of Japan and the Pacific coast of North America. Tagged adult fish have made trans-Pacific migrations: some eastward, and some westward. Other tagging studies have shown that a bluefin can cross the Atlantic in less than 60 days. They can swim at speeds up to 45 mph (72.5 kph)."

"Reproduction
Bluefin tuna are oviparous. In the Atlantic, spawning has been detected in only two areas: the Mediterranean and Gulf of Mexico. In the Pacific, spawning occurs off the Philippines. This is a limited spawning area compared to other tropical tunas. Little is known about the spawning of bluefin, as it has not been observed. Spawning in the Gulf of Mexico occurs from April to June and Mediterranean spawning occurs from June to August. Differences in timing could be due to any of a number of factors, such as differing environmental cues or genetic variation. In the Gulf of Mexico, spawning occurs at temperatures of 76.8 to 85.1 °F (24.9 to 29.5 °C) while in the Mediterranean it occurs at 66 to 70 °F (19-21 °C)."

6. Fish Base http://www.fishbase.org/summary/147

"Marine; brackish; pelagic-oceanic;" "depth range 0 - 985 m (Ref. 55291), usually 0 - 100 m. Subtropical; 3°C - 30°C (Ref. 88796); 72°N - 58°S, 99°W - 42°E".

References for above statements:

Reference 51243: Florida Museum of Natural History, 2005. Biological profiles: bluefin tuna. Retrieved on 26 August 2005, from

www.flmnh.ufl.edu/fish/Gallery/Descript/BluefinTuna/BluefinTuna.html. Ichthyology at the Florida Museum of Natural History: Education-Biological Profiles. FLMNH, University of Florida.

Reference 55291: Block, B.A., H. Dewar, S.B. Blackwell, T.D. Williams, E.D. Prince, C.J. Farwell, A. Boustany, S.L.H. Teo, A. Seitz, A. Walli and D. Fudge, 2001. Migratory movements, depth preferences, and thermal biology of Atlantic bluefin tuna. Science 293: 1310-1314.

7. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the northern bluefin tuna extract from "Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage."

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Northern bluefin	*Thunnus thynnus*	2.8	31	7.63	26.17	14.90	22.93	18.54	25

9. FAO http://www.fao.org/fishery/topic/16082/en

Tuna and their environment
"Important environmental parameters for tuna are the sea surface temperature, the quantity of dissolved oxygen in the water and the salinity. Lower thermal boundaries vary between 10°C for temperate tunas and 18°C for tropical tunas (see above; Brill, 1994). The minimum oxygen requirement is estimated between 2 to 2.7 ml/l for principal market tuna species except for bigeye tuna which can tolerate oxygen concentrations as low as 0.6 ml/l (Sharp, 1978; Lowe, 2000))."

"Atlantic bluefin tuna are able to dive to depths in excess of 1000 m, encountering an exceptionally wide range of temperatures (Block et al., 2005)."

References:
1. Sharp, G.D., 1978. Behavioural and physiological properties of tunas and their effects on vulnerability to fishing gears. pp 397-450 In G.D. Sharp and A.E. Dizon (eds), The physiological ecology of tunas, Academic Press, New York: 485 p.

2. Lowe, T.E., R.W. Brill, and K.L. Cousins, 2000. Blood oxygen-binding characteristics of bigeye tuna (*Thunnus obesus*), a high-energy-demand teleost that is tolerant of low ambient oxygen. Marine Biology, 136: 1087-1098.

3. Block, B. A., S. L. H. Teo, A. Walli, A. Boustany, M. J. Stokesbury, C. J. Farwell, K. C. Weng et al., 2005. Electronic tagging and population structure of Atlantic bluefin tuna. Nature 434: 1121-1127.

4. See Molly Lutcavage lab. reprints: http://www.tunalab.org/publications.htm.

5. See Barbara Block reprints: https://woods.stanford.edu/publications/directory/author/barbara%20block

Atlantic croaker: *Micropogonias undulates*

Vulnerability:	Possible vulnerability (ASMFC). Recruitment is variable, but evidence suggests favorably impacted by warmer water temperatures. Vulnerable (Roffer and Hall, 2015 this document – Winter distribution and catch variability is related to the North Atlantic Oscillation (NAO). Anoxia affects distribution.)
Depth Range:	0 – 200 m
Temperature Range:	0 – 32 °C
Salinity Range:	0.5 – 18 ppt
Oxygen Rage:	Need information
pH Range:	Need information

2013: $3,512,339.00, 1,781.8 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes - ASMFC
Management authorities? Inter-state: ASMFC; States: NY, NJ, DE, MD, VA, NC, SC, GA, FL

Climate vulnerability? Possible. Recruitment is variable, but evidence suggests favorably impacted by warmer water temperatures. Climate change would shift their range northward, causing a range shift rather than a range expansion.

Ecosystem considerations? Estuaries as nursery grounds - sensitive to changes in habitats, as well as to changes in their prey field (primarily invertebrates and small fish). Juvenile croaker are an important prey item for other commercial important species.

Linkages to other fisheries? Yes. Croaker is forage for other fish.

Known climate-related concerns? Changes in annual rainfall and freshwater flows to estuarine habitats, as well as coastal development and loss of habitat in coastal areas

Social and economic concerns? Near shore recreational fishery baitfish.

Management Risk? No

2. SEDAR Stock Assessment – AtlanticCroakerSAR.pdf:

Pg. 197:
“During the cooler months (i.e., spring), Atlantic croaker are in the warmer waters of the southern part of the survey’s range. As water temperatures warm, this species moves north and inshore.”

Pg198:
“Lankford and Targett (2001) conducted a series of tests on age-0 Atlantic croaker to determine their environmental tolerances and make comparisons along a latitudinal gradient along the east coast of the US. The initial work established the rates of survival at different temperatures. It ranged from 0% at 1°C to 99.3% at 7°C. The survival rate dramatically increased between 3°C (1.3%) and 5°C (86.8%). They also found that size had an impact on survival with smaller individuals being able to survive longer than larger individuals. Also, at higher salinities, survival increased. The next series of experiments compared these findings from age-0 Atlantic croakers collected in different Atlantic Coast estuaries (Lankford and Targett 2001). The sites were Delaware Bay, DE, Cape Fear River, NC, and Indian River Lagoon, FL. Growth capacity, feeding rate, growth efficiency, and cold tolerance were similar across geographic locations. This provided supporting evidence of a single genetic stock of Atlantic croakers along the US east coast. (Reference: Lankford, T.E., Jr., and T.E. Targett. 2001. Low-temperature tolerance of age-0 Atlantic croakers: recruitment implications for U.S. Mid-Atlantic estuaries. Trans. Amer. Fish. Soc. 130:236-249.)”

Pg. 218:
“Habitat Description: Atlantic croakers are eurythermal with the early life stages more cold tolerant than adults. Juvenile croakers have been caught at water temperatures ranging from 0° to 32°C (ASMFC 1987). Atlantic croaker are also euryhaline being taken at salinities from 0 ppt to 70 ppt. More juveniles are associated with salinities in the oligohaline and mesohaline range (0.5 to 18 ppt) and the 0 to 70 ppt are the extremes (ASMFC 1987). As Atlantic croaker grow, they are much more likely to be found at high salinities (ASMFC 1987). [Reference: Atlantic States Marine Fisheries Commission (ASMFC). 1987. Fishery Management Plan for Atlantic Croaker. Fisheries Management Report No. 10, Oct 1987.]”

3. SEDAR Stock Assessment – AtlanticCroaker2010BenchmarkStockAssessment.pdf:

Pg. 3:
“Stock Identification and Distribution
Atlantic croaker (*Micropogonias undulatus*) is a demersal sciaenid present in estuarine and nearshore waters from the Gulf of Maine to Argentina. Along the U.S. Atlantic coast, the species is common from New Jersey through Florida, and most abundant between the Chesapeake Bay and Indian River Lagoon, Florida. Atlantic croaker exhibit migratory behavior. Genetic studies indicate a single stock of Atlantic croaker on the Atlantic coast.”

Pg. 42:
“Atlantic croakers are opportunistic bottom-feeders on benthic epifauna and infauna and consume a variety of invertebrates, including polychaetes, mollusks, ostracods, copepods, amphipods, mysids, decapods, and occasionally fish (see ASMFC 1987 for a review). In Delaware Bay marsh creeks, Nemerson and Able (2004) found that juvenile diet transitioned along a salinity gradient but with high consumption of annelids occurring at all sites. In lower salinity, crustaceans figured prominently in the diet (15–34%), whereas mysids dominated at higher salinity sites (46%).”

“The distribution and migration of larval and juvenile Atlantic croaker have been observed to follow the general trend of ontogenetic migration by estuarine fish described by Dando (1984) in which the post-larvae are normally found in the highly productive zone just down-estuary from the freshwater interface, and juveniles descend to the middle and lower reaches of an estuary as they grow.”

Pg. 44:
“Nursery areas differ considerably among locations, possibly in response to tidal range. Atlantic croakers are able to tolerate a wide range of salinity, water temperature, and water depth; however, significant hypoxia-induced habitat shifts have been noted by Eby et al. (2005) and Craig and Crowder (2005). Juveniles are associated with areas of stable salinity, but adults prefer areas of high salinity and become less tolerant of cold temperatures.”

“Hare and Able (2007) studied winter temperature variability and its effect on Atlantic croaker population dynamics. They showed a correlation between Atlantic croaker adult abundance and winter temperatures with high abundance corresponding with warm winter water temperatures (Hare and Able, 2007). A coupled climate-population model based on temperature-driven, overwinter mortality of juveniles in estuarine habitats was developed (Hare et al., in press). The model indicated that both exploitation and climate change significantly affected Atlantic croaker abundance and distribution. They recommended that climate effects be incorporated into the stock assessment models and used for scientific advice to achieve sustainable exploitation.”

“Substrate plays a large role in determining juvenile Atlantic croaker distribution. Atlantic croakers were described by Petrik et al. (1999) as habitat generalists. Field surveys of post settlement Atlantic croaker in estuarine nursery areas found no significant differences in abundances among submerged aquatic vegetation, marsh edge, and sandy bottom (Petrik et al. 1999). Refer to the ASMFC Fishery Management Plan for Atlantic Croaker (ASMFC 1987) and ASMFC Amendment 1 to the Interstate Fishery Management Plan for Atlantic Croaker (ASMFC 2005a) for more detailed information regarding Atlantic croaker habitat.”

4. IUCN Red List: http://www.iucnredlist.org/details/193268/0 (Least concern)

"Occurs over mud and sandy mud bottoms in coastal waters to about 200 m depth. Nursery and feeding grounds are located in estuaries. It is dependent on estuaries during early juvenile stages. It feeds on bottom-dwelling organisms, mainly worms, crustaceans and fishes (Chao and Musick 1977)."

Additional References:

1. Prior studies - winter temperature and variability in catch is related to the North Atlantic Oscillation (NAO); demonstrating link between Atlantic croaker dynamics, thermal limited overwinter survival, and the larger climate system of the North Atlantic. Hare & Able, 2006. http://onlinelibrary.wiley.com/enhanced/doi/10.1111/j.1365-2419.2006.00407.x/

Atlantic deep-sea scallop: *Placopecten magellanicus*

Vulnerability:	Medium to high vulnerability (NEFMC)
Depth Range:	18 – 110 m
Temperature Range:	Adults below 21°C; juvenile < 15°C; larvae <18°C and eggs below 17°C. Spawning adults <16°C
Salinity Range:	Adults: above 16.5 ppt; larvae: between 16.9 ppt – 30 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – NEFMC
Management authorities? Fed: NEFMC; State: All states from Maine to NC have the authority to manage this species within state waters. Maine and Massachusetts have the most active fisheries as well as the most developed management systems

Climate vulnerability? "Medium to high vulnerability" ("not a lot of direct research on this subject"). "Because the Atlantic sea scallop resource is a shellfish it is more sensitive to temperature change and ocean acidification than other species that are more mobile. The distribution for this species is relatively widespread from Canada to North Carolina, so it may be somewhat resilient in some areas. Populations in the south and inshore may be more impacted at first."

Ecosystem considerations? "Starfish are a major predator for scallops. But if climate change causes a truncation in the range in the south and inshore, other warmer water shellfish species will likely replace them like calico scallops. Climate change could influence the prey of scallops with potentially greater impacts to the fishery and nation since scallops is a very high revenue fishery. Researchers believe that large algal blooms have been a primary factor in very high recruitment events in the Mid-Atlantic, but more research is needed in this subject. In terms of habitat alternations from climate change, scallops may not be as vulnerable as other species because they seem to settle in areas based primarily on the physical substrate, and not the epifauna, which would likely be more vulnerable to climate change than the physical substrate."

Linkages to other fisheries? "Many scallop vessels have other permits in other fisheries, but for the most part they are predominantly dependent on scallops. The fisheries with the highest degree of overlap are skate, monkfish, and summer flounder. All scallop permits are limited entry so there could not be new entrants in this fishery. However, some of the smaller permit categories are not as active (LAGC NGOM and LAGC incidental) so effort could increase in those fisheries. This seems to be the case in 2013 – total scallop landings and the number of active vessels have increased dramatically in NGOM, the same year a shrimp moratorium was put in place."

Known climate-related concerns? "In 2013 the Council specifically included this subject as a research priority for the Scallop Research Set-Aside Program. The industry advisory panel and full Council first recommended this addition. The concerns are short-term, intermediate, and long-term**."**

Social and economic concerns? "The social and economic considerations for this fishery are likely similar to other fisheries; climate change could have negative impacts on the species and fishery by reducing landings and revenue."

Management Risk? "There is a lot at risk with this fishery since it is such a high revenue fishery – $500-$600 million dollars annually. This has major consequences since this species plays such a large part in supporting fishing community businesses in ports along the east coast. Because there is an annual catch limit for this fishery the governance system could adapt by reducing the limit based on climate change impacts.

2. No SEDAR document available

3. NOAA Fisheries, Greater Atlantic Region: Essential Fish Habitat Description: Atlantic sea scallops (*Placopecten magellanicus*). scallops.pdf
http://www.greateratlantic.fisheries.noaa.gov/hcd/scallops.pdf

Pg. 1:
"Eggs: Bottom habitats in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border". "Eggs are heavier than seawater and remain on the seafloor until they develop into the first free-swimming larval stage. Generally, sea scallop eggs are thought to occur where water temperatures are below 17° C. Spawning occurs from May through October, with peaks in May and June in the middle Atlantic area and in September and October on Georges Bank and in the Gulf of Maine."

"Larvae: Pelagic waters and bottom habitats with a substrate of gravelly sand, shell fragments, and pebbles, or on various red algae, hydroids, amphipod tubes and bryozoans in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border". "Generally, the following conditions exist where sea scallop larvae are found: sea surface temperatures below 18° C and salinities between 16.9‰ and 30‰."

"Juveniles: Bottom habitats with a substrate of cobble, shells and silt in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border that support the highest densities of sea scallops". "Generally, the following conditions exist where most sea scallop juveniles are found: water temperatures below 15° C, and water depths from 18 - 110 meters."

"Adults: Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border that support the highest densities of sea scallops". "Generally, the following conditions exist where most sea scallop adults are found: water temperatures below 21° C, water depths from 18 - 110 meters, and salinities above 16.5‰."

"Spawning Adults: Bottom habitats with a substrate of cobble, shells, coarse/gravelly sand, and sand in the Gulf of Maine, Georges Bank, southern New England and the middle Atlantic south to the Virginia-North Carolina border that support the highest densities of sea scallops". "Generally, the following conditions exist where spawning sea scallop adults are found: water temperatures below 16° C, depths from 18 - 110 meters, and salinities above 16.5‰. Spawning occurs from May through October, with peaks in May and June in the middle Atlantic area and in September and October on Georges Bank and in the Gulf of Maine."

4. Additional reference: Fish and Wildlife Service – Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic): Sea Scallop. Biological Report 82 (11.67), August 1986. 82_11-067.pdf http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-067.pdf

Atlantic menhaden: *Brevoortia tyrannus*

Vulnerability: Vulnerable (ASMFC)
Depth Range: Spawning in <10 – 20 m
Temperature Range: 3 – 33 °C; spawning: 13 to 24°C; adults prefer 18°C
Salinity Range: Spawning: 29 – 36 ppt offshore
Oxygen Rage: Mean lethal dissolved oxygen: 0.4 mg/l
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes - ASMFC
Management authorities: Inter-state: ASMFC; States: ME, NH, MA, RI, CT, NY, NJ, DE, MD, DC, PRFC, VA, NC, SC GA, FL

Climate vulnerability? Display range shifts and changes in timing and spatial pattern of seasonal migration in response to climate change. Exhibit highly variable pelagic recruitment events, influenced by environmental conditions, could result in a change in productivity of the stock. Menhaden exhibit time-varying growth; if this growth pattern includes an environmental component, menhaden growth could be influenced by climate change.

Ecosystem considerations? Climate-induced changes to estuarine habitat affect growth, maturity could affect the productivity of the stock. Menhaden are an important forage fish for many Atlantic coast predators, causing ripples effect among multiple predator stocks and throughout the ecosystem. However, complicated and difficult to predict.

Linkages to other fisheries? Fishermen will switch effort into other fisheries. If other bait fisheries are influenced by climate change fishing pressure on menhaden could increase or decrease.

Social and economic concerns? "Significant direct impact harvesters, dealers and processors, and secondarily consumers."

Management Risk? High "Inflexible governance to rapid shifts in environmental conditions due to climate change".

2. SEDAR Stock Assessment – Atlantic Menhaden 2003 Stock Assessment Report.pdf:

Pg. 11:"Atlantic menhaden recruit to the fishery at age-1 and only begin to spawn two years later. Therefore, menhaden are subjected to fishing pressure prior to formulation of any abundance index or management actions to protect incoming fish prior to spawning."

“Levels of current recruitment are in the lower quartiles of historical times series for these indices. Potential causes of declines in abundance of 1-year old menhaden may include reduced spawning stock biomass, unfavorable oceanographic or juvenile nursery conditions, and predation on larval and juvenile menhaden.”

Pg. 12:
“No comprehensive analysis of the ecological role of menhaden was included in the stock assessment report. Evidence in the literature and new data presented to the Panel strongly support the important role of Atlantic menhaden in: (1) ecosystem phytoplankton and nutrient dynamics, and (2) as a forage base for piscivores (e.g., bluefish, weakfish, and striped bass). These aspects will be further addressed by the Commission workshop on multispecies interactions being planned for 1999.
Until management has specified an allocation goal for menhaden as a forage fish or filter feeder, it will not be possible to develop a reference point to conserve menhaden ecological function.”

Pg33:
“The growing season begins in spring and ends in fall as water temperatures rise above and fall below 15 °C” (Kroger et al. 1974).

Pg. 35:
“Atlantic menhaden produce pelagic eggs about 1.5 mm in diameter, which hatch within 2.5-2.9 days at an average temperature of 15.5 °C (Hettler 1981). Embryonic development is completed in <36 hr at 20-25° C, but takes about 200 hr at 10 °C (Ferraro 1980). Egg mortalities observed in the laboratory were > 90% at 10 °C and 48-92% at 15, 20 and 25 °C” (Ferraro 1980).

“Atlantic menhaden produce pelagic eggs about 1.5 mm in diameter, which hatch within 2.5-2.9 days at an average temperature of 15.5 °C (Hettler 1981). Low temperatures (<3°C for >2 days) killed most larvae held in laboratory experiments (Lewis 1965, 1966), although mortality depended on acclimation temperature and the rate of thermal change. Best survival occurred at temperatures >4°C and salinities of 10-20‰.”

“Other studies (Weinstein 1979; Weinstein et al. 1980; Rogers et al. 1984) also show young menhaden are more abundant in shallow, low salinity (< 5‰) estuarine zones.”

Pg. 36:
“The morphological changes that occur at metamorphosis are associated with a change in feeding behavior. Larvae feed on individual zooplankton, whereas juveniles rely more heavily on filter feeding (June and Carlson 1971; Durbin and Durbin 1975). Water temperatures >33°C caused death in young-of-the-year and age-1 Atlantic menhaden (Lewis and Hettler 1968), although the time until death depended, in part, on acclimation factors. Sudden exposure to lethal temperatures, for example, caused greater mortality. Juvenile Atlantic menhaden can adjust rapidly to abrupt changes (increase or decrease) in salinity from 3.5 to 35‰ and vice-versa (Engel et al. 1987).

Juveniles raised in low salinity water (5-10‰) were more active, ate more, had higher metabolic rates, and grew faster than juveniles raised in high salinity water (28-34‰) (Hettler 1976)."

Pg39:
"An additional source of mortality are fish "kills", which occur when schools of menhaden enter enclosed inshore bodies of water in such large numbers that they consume all available oxygen and suffocate. The mean lethal dissolved oxygen concentration for menhaden has been reported to be 0.4 mg/l (Burton et al. 1980). Bluefish are known to follow (or even chase) schools of menhaden inshore, feeding on them, and may contribute to their mortality by preventing them from leaving an area before the oxygen supply is depleted. High water temperatures, which increase the metabolic rate of the fish, accelerate oxygen depletion."

Pg. 45:
"The directed menhaden purse seine fishery for reduction is seasonal. The presence of menhaden schools is dependent on the temperature of coastal waters. The fall fishery begins about November as migratory fish appear off Virginia and North Carolina. In early fall, this southward migration is initiated by cooling ocean temperatures. By late November-early December, most of the fish are found between Cape Hatteras and Cape Fear, North Carolina. Menhaden vessels based in Beaufort, North Carolina and Reedville, Virginia harvest these fish during the fall fishery. Fishing may continue into January (and sometimes February), but is highly weather-dependent. Menhaden generally leave the nearshore coastal fishing grounds in January, dispersing in ocean waters off the south Atlantic states (ASMFC 2001)."

More References:
Hettler, W.F. 1976. Influence of temperature and salinity on routine metabolic rate and growth of young Atlantic menhaden. J. Fish Biol. 8: 55-65.
Lewis, R.M. 1965. The effect of minimum temperature on the survival of larval Atlantic menhaden, *Brevoortia tyrannus*. Trans Am. Fish. Soc. 94: 409-412.
Pauly, D. 1979. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. CIEM 39(2): 175-192.
Engel, D.W., W.F. Hettler, L. Coston-Clements, and D.E. Hoss. 1987. The effect of abrupt salinity changes on the osmoregulatory abilities of the Atlantic menhaden *Brevoortia tyrannus*. Comp. Biochem. Physiol. 86A: 723-727.

3. SEDAR Stock Assessment – 2012MenhadenStockAssmtUpdate_July2012.pdf:

Pg. 4:
"Therefore overfishing is occurring, but the stock is not overfished. However, the TC warns that there is a technical mismatch between the current overfishing and overfished reference points. The TC recommends that, given the Board has adopted an F15% overfishing definition, a matching overfished definition of SSB15% should be adopted as well."

4. SEDAR Stock Assessment – SEDAR20-ASMFC_Menhaden_SAR.pdf

Pg. 5:
“Environmental factors that affect recruitment are generally viewed as density independent. These factors include physical processes, for example transport mechanisms, water temperature, DO, freshwater inflow and nutrient loadings. Biological factors, such as amount of food and competition for food, or predation by higher trophic levels which control survival and growth of young-of-the-year menhaden prior to recruitment to the fishery, can be either density independent or density dependent.”

Pg. 32:
“The growing season begins in spring and ends in fall as water temperatures rise above and decline below 15° C (Kroger et al. 1974).”

Pg. 44:
“Habitat: Atlantic menhaden occupy a wide variety of habitats during their life history. Adult Atlantic menhaden spawn primarily offshore in continental shelf waters. Larvae are carried by inshore currents to estuaries where they congregate in large concentrations near the upstream limits of the tidal zone and undergo metamorphosis into juveniles (June and Chamberlin 1959). As juvenile menhaden grow and develop, they form dense schools and range throughout the lower salinity portions of the estuary, eventually migrating to the ocean in late fall-winter.”

“The geographic range of Atlantic menhaden contains three large subregions. The northernmost region is the Gulf of Maine, a semi-enclosed sea bordered on the east, north, and west by the coasts of Nova Scotia, New Brunswick, and the New England states and bordered to the south by the open ocean of Georges Bank. The mid-Atlantic region extends from Cape Cod, MA to Cape Hatteras, NC. The south Atlantic region extends from Cape Hatteras south to Biscayne Bay and the Florida Keys.”

“Many factors in the estuarine environment affect the behavior and health of Atlantic menhaden. The combined influence of weather, tides, and river flow can expose estuarine fish to rapid changes in temperature and salinity. It has been reported that salinity affects menhaden temperature tolerance, activity and metabolic levels, and growth (Lewis 1966; Hettler 1976). Factors such as waves, currents, turbidity, and dissolved oxygen levels can impact the suitability of the habitat, as well as the distribution of fish and their feeding behavior (Reintjes and Pacheco 1966). However, the most important factors affecting natural mortality in Atlantic menhaden are considered to be predators, parasites, and fluctuating environmental conditions (Reish et al., 1985).”

Pg. 45:
“Spawning: Temperature, depth, and salinity at presumed spawning locations varies widely depending on latitude and distance from shore (Berrien and Sibunka 1999, Bourne and Govoni 1988, Checkley et al. 1999, Kendall and Reintjes 1975). Reported water temperatures are typically in the range of 13 to 24°C. Depths of approximately

<10-20 m are most common. Salinity has been reported to be 29-36 ppt at offshore mid-Atlantic sites and 35.8-36.6 ppt at south-Atlantic sites. Inshore estuarine eggs have been found in waters with salinities of 18-28 ppt in Long Island Sound (Wheatland and Lewis 1956) and 10-22 ppt in Chesapeake Bay (Dovel 1971)."

"Recorded depth of pelagic larval habitat varies widely from 5 m (Hettler and Hare 1998) to 200m (Govoni 1993). In the mid-Atlantic, most larvae have been reported at temperatures of 15-20°C and salinities of 20-37 ppt (Kendall and Reintjes 1975). Larger, later-stage larvae being found at lower salinities (Hettler and Hare 1998)."

Pg. 45:
"Juvenile habitat: Fall immigrants (e.g. larvae in the Chesapeake Bay and south-Atlantic region) begin transformation soon upon arrival in an estuary, but typically do not complete transformation until the following spring due to cool fall and winter water temperature (Ahrenholz et al. 2000). Larvae metamorphose to the juvenile stage in low salinity (<10 ppt) estuarine waters, whereas larger juveniles are found at higher salinities (Hettler and Barker 1993)."

"In the mid- and south-Atlantic nursery areas, bottom composition is "unconsolidated", consisting of sand mud, and organic material which may be important to juvenile consumption in some areas (Lewis and Peters 1984, Peters and Schaaf 1991). Northern nursery areas are typically found in rocky coves with cobble, rock, and sand bottoms. Temperatures and depth of juveniles vary depending on location and timing of transport to lower salinity areas of the estuary (Forward et al. 1999). Juvenile menhaden remain in their estuarine nursery areas throughout the summer. In fall, most juveniles emigrate southward in schools, however some overwinter in the Chesapeake Bay and south-Atlantic region estuaries."

Pg. 46:
"Adult Habitat: The major source of information about adult habitat use is information collected from the purseseine fishery and associated tagging studies (Nicholson 1978). Immature adult menhaden are found in largest numbers in inshore and estuarine areas from Chesapeake Bay southward. Adults make extensive north-south migrations in the near-shore ocean. Older, larger adult menhaden are typically found in colder, rockier northerly habitats during summer. Overwintering occurs somewhere off the coast of North Carolina. Adults appear to prefer temperatures of about 18°C, a potential cause of inshore-offshore migrations."

"Habitat Areas of Particular Concern: Almost all of the estuarine and nearshore waters along the Atlantic coast from Florida to Nova Scotia serves as important habitat for egg, juvenile, and some spawning adult Atlantic menhaden. Pollution and habitat degradation threaten the coastal menhaden population, particularly during the estuarine residency of larvae and juveniles. Concern has been expressed that the outbreaks of ulcerative mycosis in the 1980s may have been symptomatic of deteriorating water quality in estuarine waters along the east coast (Ahrenholz et al. 1987a). Increasing coastal development and industrialization are expected to further reduce water quality unless steps are taken to ameliorate their effect on the environment (Cross et al. 1985). Estuarine and coastal habitats have been significantly reduced and continue to be adversely stressed by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, and other human related activities (ASMFC 1999a). Other potential threats to the coastal menhaden population are posed by the offshore dumping of sewage. Warlen et al. (1977) showed that DDT was taken up by menhaden as a result of their feeding on plankton and detritus."

"Estuaries of the mid-Atlantic and south Atlantic states provide most of the nursery areas utilized by Atlantic menhaden at the present time. Areas such as the Chesapeake Bay and the Albemarle-Pamlico system are especially susceptible to pollution because they are generally shallow, have a high total volume relative to freshwater inflow, low tidal exchange, and a long retention time. Most tributaries of these systems originate in the Coastal Plain and have relatively little freshwater flow to remove pollutants. Shorelines of most estuarine areas are becoming increasingly developed despite existing habitat protection programs. Thus, the specific habitats of greatest long-term importance to the menhaden stock and fishery are increasingly at risk."

5. SEDAR_S40_AtlMenhadenSAR_CombinedFINAL_1.15.2015

Pg. 507:
"Development of ecosystem indicators could therefore be used as an interim, or even complementary, step in the development of ecosystem reference points."
"Deliverables for management include (but would not necessarily be limited to):
• Environmental indicators such as
  - spatial and temporal measures of chlorophyll-a
  - sea surface temperature
  - indices of the Atlantic Multidecadal Oscillation (AMO) and the North Atlantic Oscillation (NAO)

• Indices of forage abundance for a suite of forage species identified by scientists and managers as important for monitoring ASMFC management interests and goals
• Prey: predator ratios
  - prey:predator biomass ratios for species such as Atlantic menhaden relative to bluefish, striped bass, and weakfish
  - ratios based on fishery independent measures of prey and predator abundance
  - ratios of multiple prey items and predators
  - ratios incorporating a feeding model to account for such things as prey and predator temporal and spatial overlap."

6. Population biology and life history of the North American menhadens, *Brevoortia* spp. Mar. Fish. Rev. 53(4): 3-19. mfr5342.pdf

Pg. 4:
"Menhaden are estuarine dependent, marine migratory species. Spawning generally occurs during the cooler months in the marine environment, and larvae undergo early growth and development at sea. About 1-2 months later, those larvae that have been

transported shoreward enter estuarine bays, sounds, and streams, and metamorphose into juveniles. Menhaden juveniles (young-of-the-year) normally reside in estuarine areas until the following fall or early winter when many migrate into marine waters. Adults generally occur in nearshore oceanic waters and frequently reside in large estuarine systems."

Atlantic sailfish: *Istiophorus albicans*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature and oxygen that are likely changed by climate change
Depth Range:	0 – 200 m (generally above the thermocline)
Temperature Range:	10 – 29 °C; prefer 25.95 – 27.85 °C (Boyce et al., 2008); 21 – 28 °C (FLMNH)
Salinity Range:	Need information
Oxygen Rage:	Lower hypoxic habitat boundary for billfish: 3.5 ml/l
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Florida Museum of Natural History (FLMNH), accessed October 12, 2015
https://www.flmnh.ufl.edu/fish/Gallery/Descript/Sailfish/Sailfish.html

"Habitat
The Atlantic sailfish swims in the surface epipelagic and oceanic waters. It generally remains above the thermocline, in water temperatures between 70° and 83°F (21° to 28° C). There is evidence that it also swims into deeper water. It is less oceanic than other billfishes, making frequent forays into nearshore water."

"Reproduction
In the western North Atlantic Ocean, spawning may begin as early as April, but occurs primarily during the summer months. Females swim slowly through shallow water, with their dorsal fin above the water surface. One or more males will accompany her and spawn near the surface. Spawning may also occur in deep waters along the coast of North America and over the continental shelf off the West African coast. Spawning has been observed year-round in the eastern Atlantic, with a peak in the summer months."

4. Fish Base http://www.fishbase.org/summary/78

"Marine; pelagic-oceanic;" " depth range 0 - 200 m (Ref. 43). Subtropical; 21°C - 28°C (Ref. 43); 50°N - 43°S, 99°W - 37°E (Ref. 43)

Ref. 43: Nakamura, I., 1985. FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fish. Synop. 125(5):65p. Rome: FAO.

5. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic sailfish extract from “Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage.”

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Atlantic sailfish	*Istiophorus albicans*	10	29	19.20	27.90	25.95	27.85	8.70	12

6. Prince et al. 2010. Ocean scale hypoxia-based habitat compression of Atlantic istiophorid billfish. Fisheries Oceanography 19:6, 448-462. Prince 2010 OMZ Tuna.pdf

Pg. 1:
“In the eastern tropical Pacific (ETP), the surface mixed layer is defined by a shallow thermocline above a barrier of cold hypoxic water, where dissolved oxygen levels are ≤ 3.5 mL L)1. This thermocline (~25–50 m) constitutes a lower hypoxic habitat boundary for high oxygen demand tropical pelagic billfish and tunas (i.e., habitat compression).”

Atlantic spadefish: *Chaetodipterus faber*

Vulnerability:	Very vulnerable (SAFMC). Year class strength has been positively correlated with ocean temperature and increased ocean temperatures affect survival and distribution of larvae along shelf and into estuaries
Depth Range:	Need information
Temperature Range:	Maximum abundance of larvae when temperatures were greater than or equal to 28°C
Salinity Range:	Maximum abundance of larvae when salinity ranged from 26.7 – 31.3 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Very vulnerable. Estuarine dependent species with life stages utilizing a wide range of estuarine, nearshore, and offshore pelagic habitats.

Ecosystem considerations? Changes or loss of estuarine habitat could limit availability of juvenile habitat for settlement and early development. Year class strength has been positively correlated with ocean temperature and increased ocean temperatures affect survival and distribution of larvae along shelf and into estuaries.

Linkages to other fisheries? No answer in SAFMC

Known climate-related concerns? No answer in SAFMC

Social and economic concerns? No answer in SAFMC

Management Risk? Little Management risk

2. No SEDAR document available

3. South Carolina Dept. Natural Resources: Atlantic Spadefish.pdf
http://www.dnr.sc.gov/cwcs/pdf/Atlanticspadefish.pdf

Pg. 1:
"Maximum abundance of spadefish larvae occurred in these coastal waters between June and August when water temperatures were greater than or equal to 28°C and where salinities ranged from 26.7 to 31.3 parts per thousand (ppt)."

Bar jack: *Caranx ruber*

Vulnerability:	Low to medium vulnerability (SAFMC). Vulnerable (Roffer and Hall, 2015, this document – life cycle dependent on coral reef ecosystem).
Depth Range:	18 – 73 m
Temperature Range:	Need information
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? "Low to medium vulnerability. However, detailed life history and movement patterns are lacking for the species and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding, schooling and movement associated with structural shelf habitats."

Ecosystem considerations? "Bar jack use shelf ecosystems extensively and if pelagic and benthic habitats are affected by changes in ocean currents, water temperature, or pH, the essential habitat for the species would effectively be reduced, which could lead to impacts at the populations level."

Linkages to other fisheries? "Effort shifts associated with impacts in shelf waters, could result in increased effort on other managed snapper grouper species or even the deepwater complex" and "If climate change affects other managed species including coastal migratory pelagic and fisheries for other snapper grouper species, effort could shift to bar jack"

Known climate-related concerns? "Changes in ocean temperature, ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to bar jack"

Social and economic concerns? "Considerations would arise if pelagic changes are great enough to result in shifts among shelf fisheries"

Management Risk? Little Management risk

2. No SEDAR document available

3. Florida Museum of Natural History
http://www.flmnh.ufl.edu/fish/gallery/descript/barjack/barjack.html

"The bar jack is found from New Jersey through Bermuda, in most of the Gulf of Mexico, the Caribbean, and the West Indies. It is uncommon in the northern Gulf of Mexico. There has been an unconfirmed capture of a bar jack in Rio de Janeiro, Brazil. It is the most common *Caranx* in the West Indies and Bahamas."

"The bar jack usually lives in clear, shallow waters over coral reefs. It is typically found in schools varying in size from a few fish to many. Occasionally the bar jack is seen swimming alone. Juveniles may be observed under patches of Sargassum mats. Schools of larger fish also occur under large Sargassum on occasion."

Bigeye tuna: *Thunnus obesus*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature, chlorophyll and oxygen that is likely changed by climate change.
Depth Range:	0 – 250 m, usually 0 – 50 m; capable of diving to depths of more than 1200 m
Temperature Range:	3 – 29 °C; prefer 16.9 – 22.3 °C (Boyce et al., 2008); 11 – 23 °C (Sharp, 1979); 13 – 29 °C (Fish Base)
Salinity Range:	Need information
Oxygen Rage:	0.5 – 1.0 ml/l (Sharp, 1979, Lowe et al., 2000)
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. NOAA Fisheries Atlantic Highly Migratory Species
   http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch6.pdf

Pg. 14 – 15:
"Distribution: Scientific knowledge of Atlantic bigeye tuna is limited. Its range is almost the entire Atlantic from 50° N to 45° S. It is rarely taken in the Gulf of Mexico (W. J. Richards, pers. comm.). Although its distribution with depth in the water column is varied, it is regularly found in deeper waters than are other tuna - to a depth of 250 m. Smaller fish are probably restricted to the tropics, while larger individuals migrate to temperate waters. There is probably one population in the Atlantic (ICCAT, 1997). Young bigeye tuna form schools near the sea surface, mixing with other tuna such as yellowfin and skipjack tuna (Collette and Nauen, 1983)."

"Life history: Bigeye tuna probably spawn between 15° N and 15° S. A nursery area is known to exist in the Gulf of Guinea (Richards, 1967) off the coast of Africa where larvae have been collected below the 25° C isotherm (Richards and Simmons, 1971). Peak spawning here occurs in January and February, whereas in the northwestern tropical Atlantic spawning occurs in June and July (SCRS, 1978 and 1979). The collection of larvae in U.S. waters has not been confirmed (W. J. Richards, pers. comm.)."

"Habitat associations: Juvenile bigeye form schools near the surface, mostly mixed with other tuna such as yellowfin and skipjack. These schools often associate with floating objects, whale sharks and sea mounts (SCRS, 1997)."

"Essential Fish Habitat (EFH) for Bigeye Tuna:
- Spawning, eggs and larvae: At this time, available information is insufficient for the identification of EFH for this life stage within the U.S. EEZ; although it can not be identified as EFH under the Magnuson-Stevens Act because it is located outside the

U.S. EEZ, the Gulf of Guinea, off the coast of Africa, is identified as important habitat for spawning adults, eggs and larvae.

- Juveniles/Subadults (<100 cm FL): In surface waters from southeastern Georges Bank to the boundary of the EEZ to Cape Hatteras, NC at 35° N from the 200 m isobath to the EEZ boundary; also, in the Blake Plateau region off Cape Canaveral, FL, from 29° N south to the EEZ boundary (28.25° N) and from 79° W east to the EEZ boundary (approximately 76.75° W).
- Adults (≥100 cm FL): In pelagic waters from the surface to a depth of 250 m: from southeastern Georges Bank at the EEZ boundary to offshore Delaware Bay at 38° N, from the 100 m isobath to the EEZ boundary; from offshore Delaware Bay south to Cape Lookout, NC (approximately the region off Cape Canaveral, FL), from 29° N south to the EEZ boundary (28.25° N), and from 79° W east to the EEZ boundary (76.75° W)."

4. Sharp, G.D.,1978. Behavioral and physiological properties of tunas and their effects on vulnerability to fishing gear. Academic Press, Inc. ISBN 0-12-639180-7. Pp 412.

Estimated lower O_2 tolerance (10 minute levels, ml O_2/L H_2O) is 0.52 (measured) and 0.65 (estimated value).

5. Sharp, G.D.,1979. Areas of potentially successful exploitation of tunas in the Indian Ocean with emphasis on surface methods. Rome, FAO, IOFC/DEV/79/47:55 pp.

Temperature Range: 11 – 23 °C
Dissolved oxygen values tolerances for 10 minutes by fish measuring between 50 and 75 cm: 0.5 – 1.0 ml/l

6. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic, Pacific and Indian Ocean Bigeye tuna extract from "Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage."

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Bigeye tuna	*Thunnus obesus*	3	29	9.25	26.45	16.95	22.32	17.20	28

7. Fish Base http://www.fishbase.org/summary/Thunnus-obesus.html

"Marine; pelagic-oceanic;" "depth range 0 - 250 m (Ref. 168), usually 0 - 50 m (Ref. 89423). Subtropical; 13°C - 29°C (Ref. 168); 45°N - 43°S, 180°W - 180°E".

Reference 168: Collette, B.B. and C.E. Nauen, 1983. FAO Species Catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. Rome: FAO. FAO Fish. Synop. 125(2):137 p.

Reference 89423: McMillan, P.J., L.H. Griggs, M.P. Francis, P.J Marriott, L.J. Paul, E. Mackay, B.A. Wood, H. Sui and F. Wei, 2011. New Zealand fishes. Volume 3: A field guide to common species caught by surface fishing. New Zealand Aquatic Environment and Biodiversity Report No. 69. 145 p.

7. FAO http://www.fao.org/fishery/topic/16082/en

"Tuna and their environment
Important environmental parameters for tuna are the sea surface temperature, the quantity of dissolved oxygen in the water and the salinity. Lower thermal boundaries vary between 10°C for temperate tunas and 18°C for tropical tunas (see above; Brill, 1994). The minimum oxygen requirement is estimated between 2 to 2.7 ml/l for principal market tuna species except for bigeye tuna which can tolerate oxygen concentrations as low as 0.6 ml/l (Sharp, 1978; Lowe, 2000). Most tunas tend to concentrate along thermal discontinuities such as oceanic fronts (Sund, 1981)."

"Bigeye tuna are capable of diving to depths of more than 1200 m (record of 1800 m, Schaefer, Comm. pers.)."

Reference: Dagorn L., K.N. Holland, J-P. Hallier, M. Taquet, G. Moreno, G. Sancho, D. G. Itano, R. Aumeeruddy, C. Girard, J. Million and A. Fonteneau. Deep diving behavior observed in yellowfin tuna (*Thunnus albacares*). Aquat. Living Resour. (2006)19, 85–88.Sharp, G.D., 1978. Behavioural and physiological properties of tunas and their effects on vulnerability to fishing gears. pp 397-450 In G.D. Sharp and A.E. Dizon (eds), The physiological ecology of tunas, Academic Press, New York: 485 p.

Lowe, T.E., R.W. Brill, and K.L. Cousins, 2000. Blood oxygen-binding characteristics of bigeye tuna (*Thunnus obesus*), a high-energy-demand teleost that is tolerant of low ambient oxygen. Marine Biology, 136: 1087-1098.

8. Additional references: T. E. Lowe, R. W. Brill, K. L. Cousins. 2000. Blood oxygen-binding characteristics of bigeye tuna (*Thunnus obesus*), a high-energy-demand teleost that is tolerant of low ambient oxygen. Marine Biology, Volume 136, Issue 6, pp 1087-1098. Lowe 2000 Tuna Oxygen.pdf http://link.springer.com/article/10.1007/s002270000255

Black drum: *Pogonias cromis*

Vulnerability:	Vulnerable (ASMFC). Migrations affected by increasing water temperatures. Uses estuaries and coastal bays for nurseries.
Depth Range:	1 – 50 m
Temperature Range:	12 – 32 °C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC
Management authorities: ASMFC - NJ, DE, MD, VA, NC, SC, GA, FL

Climate vulnerability? Yes, migrations affected by increasing water temperatures. "Black drum distribution spans from Argentina to Maine. This species is tolerant of a wide range of temperatures and salinities. Black drum along the Atlantic Coast of the United States are all of a common stock and undergo extensive south to north spawning migrations to the Delaware and Chesapeake Bays, likely influenced by increasing water temperatures. However, black drum also spawn from south Florida to North Carolina during different time periods, supporting recruitment to the coastal stock. Increased frequency of catastrophic weather events due to climate change, such as hurricanes, has the potential to impact survival of YOY fish that use estuaries and coastal bays as nurseries. However, black drum is a relatively early-maturing, fecund and long-lived species, so recruitment over time should not be significantly impacted by these events."

Ecosystem considerations? Yes for food and No for environment. "Ecosystem changes are more likely to decrease black drum's vulnerability to climate change. Estuarine habitat used for growth and development is likely to increase due to rising sea levels. Tolerance to a wide range of environmental conditions will likely allow black drum to compete more effectively for this increasing habitat than more vulnerable species. Black drum diet relies heavily on zooplankton (larvae) and mollusk species (adults) and if climate change-related declines in these prey species occur, increased competition will increase black drum's vulnerability to climate change."

Linkages to other fisheries? Vulnerability is tied to habitat rather than temperature range. "If black drum are more available there may be increasing effort in the black drum fishery. Changes in other fisheries are unlikely to influence black drum vulnerability."

Known climate-related concerns? "Depending on the location on the Atlantic coast, short to long term concerns are the availability of viable estuarine habitat, increasing prevalence of coastal development, and/or poor water quality."

Social and economic concerns? Little, primarily a recreational fishery.

Management Risk? Low. “Management system can readily respond if there’s an expansion in range and/or increases in abundance and fishery effort in order to constrain F. The Management Board can easily add states into which the stock’s range is expanding.”

2. No SEDAR document available

3. Animal Diversity Web – University of Michigan, Museum of Zoology
http://animaldiversity.org/accounts/Pogonias_cromis/

“The Drum are most common in water temperatures ranging from 12-32 degrees Celsius.” (Virginia Tech Database 1996)

“Black Drum adults are generally found in areas with sandy or soft bottom. This species also stays in close proximity to oyster beds and clam shell beds.”

“During the colder months, the Black Drum go from the shallow areas to deeper bays. Extreme drops in water temperature have been known to wipe out many Drum at once.”

4. IUCN Red List: http://www.iucnredlist.org/details/193269/0 (Least Concern)
Depth limit (meters): 1-50 m

Black sea bass: *Centropristis striata*

Vulnerability: Vulnerable (SAFMC & MAFMC & ASMFC)
Depth Range: 0 – 110 m but mainly above 50m
Temperature Range: 7 – 27 °C
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes - SAFMC & MAFMC & ASMFC
Management authorities: Regional: MAFMC, Inter-State: ASMFC - MA, RI, CT, NY, NJ, DE, MD, PRFC, VA, NC

Climate vulnerability? "Display range shifts and changes in timing and spatial pattern of seasonal migration in response to climate change. Whether or not these changes will result in overall increased or decreased productivity across the entire stock is unclear."

Ecosystem considerations? "Changes to estuarine nursery and other inshore habitats may affect growth, maturity, and subsequent productivity of the stock. They use nearshore and shelf ecosystems extensively, if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex may be reduced, prey may be reduced, both which have impacts at the populations level."

Linkages to other fisheries? "Range of black sea bass is expanding to the north. There is potential for decreased effort on other species (summer flounder, scup, tautog, winter flounder) as fishermen switch to newly available sea bass, particularly in the recreational fishery. One example is decreased availability of SNE lobster may cause pot fishermen to increase effort on black sea bass."

Known climate-related concerns? "Main concerns are range expansion along the coast and ability to estimate abundance. States and their fishermen in the expanding northern range are seeking larger total quotas (Long-term concern)."

Social and economic concerns? Increased/decreased economic opportunities in the expanding/shifting areas.

Management Risk? Low. Able to add states to its black sea bass board. Management is still complex because of joint management and that Council membership does not represent the entire range.

2. SEDAR Stock Assessment – SEDAR2_SAR1_BSBcomplete.pdf:

Pg. 7:
"Two populations, separated by Cape Hatteras, North Carolina, have been reported to occur along the Atlantic coast, although, genetic similarities suggests that this is one stock (Robert W. Chapman, pers. com.). Black seabass in the Gulf of Mexico are considered to be a separate subspecies." "Black seabass occur in depths of 2 to 120 m, but most adults are found in 20 to 60 m. Although black seabass north of Cape Hatteras are migratory, tagging studies indicate movements of black seabass south of Cape Hatteras are limited and less well-defined (Ansley and Davis 1981, Collins et al. 1996)."

"Black sea bass spawn from January through July along the southeastern U.S. coast. Some spawning does occur in October-November, however, fall spawning is not observed every year. The greatest percentage of females in spawning condition occurs during March through May." "Eggs are pelagic and hatch in 75 hours at 16°C and 38 hours at 23°C. Larvae are also pelagic and have been found in inlets, bays and offshore waters. Larvae become demersal at approximately 13-mm TL. Juveniles have been recorded from bays, estuaries, inlets and nearshore waters."

3. SEDAR Stock Assessment – SEDAR2_SAR1_BSBcomplete.pdf: 2011

Additional references from above stock assessment:

a. SEDAR25-RD22 Black sea bass, *Centropristis striata*, life history and habitat characteristics (second edition). Drohan et al. 2007

b. SEDAR25-RD33 Southeastern US Deepwater reef fish assemblages, habitat characteristics, catches, and life history summaries. Parker and Mays, 1998

c. Steimle, F.W., C.A. Zetlin, P.L. Berrien, S. Chang. 1999. Black sea bass, *Centropristis striata*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-143. 50 p.

4. NOAA Technical Memorandum NMFS-NE-143: Essential Fish Habitat Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics http://www.nefsc.noaa.gov/publications/tm/tm143/tm143.pdf

"For adult black sea bass, bottom temperatures about 6-7.5°C or above are a critical factor in habitat use and distribution (Colvocoresses and Musick 1984). In the NEFSC groundfish survey, adults were most commonly collected at water temperatures of 9-12°C in the winter and spring. The temperature distribution in the summer when black sea bass occurred in shallow (10-20 m) coastal areas was bimodal with peaks at about 10 °C and 25 °C. During the fall, adults were collected at 7-27°C; most fish were collected at 13-21°C with a secondary peak at about 25-27 °C; fish were collected mostly in relatively shallow water (< 50 m)."

5. IUCN Red List: http://www.iucnredlist.org/details/16435325/0 (Least concern)
   Depth limit (meters): 1 – 110 m

6. Distribution of Fish on the Northeast U.S. Shelf Influenced by both Fishing and Climate http://www.nefsc.noaa.gov/press_release/pr2014/scispot/ss1414/

“Scientists studying the distribution of four commercial and recreational fish stocks in Northeast U.S. waters have found that climate change can have major impacts on the distribution of fish, but the effects of fishing can be just as important and occur on a more immediate time scale.”

“The researchers found that black sea bass, scup, and summer flounder exhibited significant poleward shifts in distribution in at least one season. The shifts in black sea bass and scup were related to temperature, while the shift in summer flounder was related to a decrease in fishing pressure and an expansion of the population age structure.”

Blackfin tuna: *Thunnus atlanticus*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015 this document). Distribution affected by temperature and oxygen.
Depth Range:	50 m – ? m
Temperature Range:	Prefers above 21 °C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Florida Museum of Natural History, accessed October 12, 2015
http://www.flmnh.ufl.edu/fish/gallery/descript/blackfintuna/blackfintuna.html

"Habitat
Occurring in oceanic waters in close proximity to the coastline, the blackfin tuna prefers clean water and warm temperatures, usually seaward from the continental shelf. It is a strongly schooling, migratory fish, often forming large mixed schools with skipjack tuna (Katsuwonus pelamis). During the summer months, the blackfin tuna migrates to temperate waters remaining above 70°F (21°C). It is most abundant off the Florida coast during autumn, winter, and spring."

"Reproduction
Spawning occurs in April through November off the Florida coast, and June to September in the Gulf of Mexico, well offshore in the blue oceanic waters of the Florida current as well as in the coastal waters of northern Brazil. The fish release sperm and eggs into the water column where fertizilation occurs. The buoyant eggs produce pelagic larvae, little else is known about the eggs. These larvae are found in the open ocean at depths ranging from the surface down to 164 feet (50m)."

4. Fish Base http://www.fishbase.org/summary/144

"Marine; pelagic-oceanic;" "depth range 50 - ? m. Tropical; 20°C - ? (Ref. 168)"

Reference 168: Collette, B.B. and C.E. Nauen, 1983. FAO Species Catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. Rome: FAO. FAO Fish. Synop. 125(2):137 p.

Blue crab: *Callinectes sapidus*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Narrow pH tolerance, recruitment effected by wind driven circulation along relative strong salinity and temperature dependences.
Depth Range:	Need information
Temperature Range:	Growth occurs when above 15 °C; temperatures above 33 °C are lethal
Salinity Range:	3 – 15 ppt
Oxygen Range:	Need information
pH Range:	6 – 8. Less than 6 is lethal

2013: $74,384,932.00, tonnes: 24,639.4
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Management document for Gulf States Marine Fisheries Commission
http://www.gsmfc.org/publications/GSMFC%20Number%20096.pdf

"Native range of the blue crab is from Nova Scotia to northern Argentina and includes Bermuda and the Antilles. The species occurs almost exclusively in state waters, where it occupies a variety of habitats in fresh, brackish, and shallow oceanic waters."

"Mating may take place year round in brackish areas of the estuary while spawning occurs in high salinity nearshore waters. Larval forms are principally oceanic until the megalopae are transported back into the estuary. Juvenile crabs are widely distributed in estuaries. Adults show a differential distribution by sex and salinity with females commonly found in high salinity waters and males in waters of low salinity. Extensive alongshore migration northward by Gulf of Mexico blue crabs has been documented along the Florida west coast."

"Essential habitat for blue crab includes all habitats required during its life cycle, including offshore waters used for spawning and larval development and estuarine nursery grounds. Nursery habitats of critical concern include intertidal marshes, sub-tidal grass beds, and unvegetated, soft sediment shoreline habitats."

"The blue crab supports one of the largest commercial and recreational fisheries in the Gulf of Mexico."

"The blue crab possesses unique life history characteristics which should be considered in management of the species. Blue crabs are an 'r-selected' species meaning they are highly productive, short lived, and fast-growing. This indicates that they can sustain high exploitation rates and recover rapidly should overfishing ever occur. Populations are limited by postsettlement biotic processes that influence survival of small juveniles. Protection of essential habitat must be an integral part of the management strategy, and policies should address sources of juvenile blue crab mortality.”

“Habitat and hydrological changes occurring in other Gulf coastal states could have detrimental impacts on blue crabs. Orth and van Montfrans (1990) found a significant relationship between blue crab production and total vegetated habitat for the combined Gulf states. Other investigators have shown positive correlations between yield of estuarine species other than blue crab and extent of vegetated habitat (Turner 1977, Nixon 1980, Deegan et al. 1986). The impact of marsh loss on blue crab production may not be initially evident. Biological productivity increases temporarily in deteriorating marshes (Gagliano and Van Beek1975), possibly due to an increase in "edge" (marsh-water) habitat and in detrital input to the estuarine food web. However, biological productivity will eventually decrease as the conversion of marsh habitat to open water continues and suitable marsh habitat of appropriate salinity regimes declines below the critical point. Low salinity marsh is an important nursery habitat for juvenile blue crabs and increased salinity may adversely impact the species (Rounsefell 1964). Marsh management by means of levees and weirs, or other water control structures, is usually detrimental to fisheries in the short term because of interference with migratory cycles of estuarine dependent species (Herke 1979, Herke et al. 1987, Herke and Rogers 1989). During the course of their life cycle, blue crabs utilize all salinity regimes of an estuary and disruption of estuarine salinity gradients in association with physical habitat alteration could have adverse impacts on blue crab populations.”

“Changes in the amount and timing of freshwater inflow may have a major effect on that segment of the blue crab life cycle taking place in the estuary. Wetlands are maintained by rivers that transport sediment and nutrients. Reduction in freshwater inflow denies the nutrients to wetlands that are necessary for healthy growth. Activities affecting freshwater inflow include leveeing of rivers (eliminating overflow into surrounding marshes), damming of rivers, channelization, and pumping water for redistribution.”

“Orth and van Montfrans (1990) established a quantitative relationship between blue crab production and habitat. Turner and Boesch (1988) examined the relationship between wetland area and fisheries yields and found evidence of decreased fishery production following wetland losses and increased fishery production following wetland gains. These data suggest loss of habitat may be a significant factor in determining blue crab production.”

“The life history of the estuarine-dependent blue crab involves a complex cycle of planktonic, nektonic, and benthic stages which occur throughout the estuarine-nearshore marine environment. A variety of habitats within the estuarine environment are occupied depending upon the particular physiological requirements of each life history stage (Perry et al. 1984). These habitats can be divided into offshore and estuarine phases. Female blue crabs are catadromous; they migrate from hyposaline waters to higher-salinity water to spawn and hatch their eggs. The high-salinity, oceanic water not only serves as habitat for the spawning female but ensures larval development, increases dispersal capabilities, decreases osmoregulatory stress, and reduces predation. Fertile eggs hatch into free-swimming larvae (zoeae) which pass through a series of molts. Newly-hatched blue crab larvae normally develop through seven zoeal stages before transforming into a megalopal stage. Megalopae return to the estuary where they metamorphose into the first crab stage. The estuarine phase is perhaps the most critical because all postsettlement growth and the major components of the reproductive cycle occur there. Male blue crabs usually remain within the estuary during their entire postsettlement life. Juvenile and adult blue crabs exhibit wide seasonal and areal distribution within estuaries. Laughlin (1979) concluded that the temporal and spatial distribution of *C. sapidus* in the Apalachicola estuary appeared to be determined by complex interactions of abiotic, trophic, and other biotic factors which have different significance with respect to season and area".

"Size at maturity is highly variable, and a number of factors appears to influence maturation size. Temperature exerts control on maximum size by affecting incremental growth and molt interval. Tagatz (1968b) suggested that differences in growth per molt and molt interval within juvenile size groups may account for observed variation in size at recruitment to adult populations. Morphological changes associated with maturation also contribute to variability in size."

"Megalopae are abundant in the offshore neuston and thus susceptible to wind-driven transport mechanisms. Although no clear environmental variables were associated with high settlement events in some northern Gulf estuaries, wind-driven and tidal circulation processes appeared to influence megalopal recruitment in Mississippi (Perry et al. 1995) and Alabama (Rabalais et al. 1995a). Onshore winds coupled with equatorial (Mobile Bay) and tropic (Mississippi Sound) tides were correlated with the majority of peak events in these northern Gulf estuaries. Estuarine systems in the northern Gulf of Mexico are generally meteorologically dominated (Ward 1980), and subtidal exchanges resulting from wind driven circulation may account for a substantial portion of the volume flux in coastal bays (Swenson and Chuang 1983,Smith1977). Winds can reverse or accentuate the effect of tides and can be a very effective mechanism in moving megalopae into estuarine areas. In addition to metecological forcing, Johnson and Perry (1999) noted that intrusion of Loop Current eddies onto the shelf in the northern Gulf may alter shelf circulation patterns and influence recruitment and settlement."

4. Blue Crab Life Cycle, 2006, Steven C. Zinski.
   https://www.bluecrab.info/lifecycle.html

"Water temperature requirements vary and are considered important, but no optimal range is reported."

"When air temperatures drop below 50°F (10°C), adult crabs leave shallow, inshore waters and seek deeper areas where they bury themselves and remain in a state of torpor throughout the winter. Blue crab growth is regulated by water temperature.

Growth occurs when water temperatures are above 59°F (15°C). Water temperature above 91°F (33°C) is lethal. Blue crabs are susceptible to sudden drops in temperature."

"Salinity is important, but requirements vary by life stage. Generally optimum is 3-15 parts per thousand (ppt)."

Water pH: Tolerance range is pH 6-8. Less than 6 is lethal.

Blue runner: *Caranx crysos*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015 this document). Range is thought to be related to increasing sea temperatures in the North Atlantic Ocean.
Depth Range:	1 – 100 m
Temperature Range:	Need information
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. SAFMC: http://safmc.net/fish-id-and-regs/blue-runner

"Blue runner was removed from the snapper grouper complex, effective January 27, 2014. Therefore, no federal regulations are in effect for this species."
See the final rule:
http://sero.nmfs.noaa.gov/sustainable_fisheries/s_atl/sg/2013/am27/documents/pdfs/sa_am27_fr.pdf

4. Florida Fish and Wildlife Conservation Commission, Blue Runner Draft Rule, September 5, 2013: 4DBlueRunnerDraftRule-presentation.pdf
http://myfwc.com/media/2615478/4DBlueRunnerDraftRule-presentation.pdf

"This document summarizes a proposed draft rule that would create a new rule chapter for blue runner, 68B-61, Florida Administrative Code (FAC), in order to manage the fishery in state and federal waters. The South Atlantic Fishery Management Council (SAFMC) recently approved an amendment to remove blue runner (*Caranx crysos*) from the federal snapper grouper fishery management plan (FMP). The SAFMC approved this amendment, in part, because FWC requested to regulate blue runner harvest in federal waters of the Atlantic. A new species chapter for blue runner would be required to establish state regulations in rule (taken from existing Florida Statutes) and extend them into adjacent federal waters."

Pg. 2:
"Blue runner are commonly harvested for use as live bait and food. Known as one of the hardiest of live baits, it is a top choice among recreational anglers targeting large pelagics such as king mackerel, sailfish, and wahoo, and is also commonly used in bottom fishing for reef fish species."

"Commercially, blue runner are primarily caught for live bait or as bycatch in the Spanish mackerel fishery."

5. IUCN Red List: http://www.iucnredlist.org/details/154807/0 (Least concern)

“It has a depth range of 0-100 m and juveniles are found beneath floating Sargassum mats.”

“Range is thought to be related to increasing sea temperatures in the North Atlantic (Stebbing et al. 2002).”

“In the western Atlantic this species is recorded from Nova Scotia (Canada), Brazil, Bahamas, throughout the Caribbean (including Antilles) and the Gulf of Mexico.”

“Swaby et al. (1996) state that Blue Runner are common enough in the western Atlantic, to be caught commercially for food and bait. A study by Rountree (1990) found this species to be the second most abundant species off South Carolina, U.S.A. and a study by D'anna et al. (1999) found this species to be one of the most abundant fish in the Gulf of Castellammare, northwest Sicily.”

“The Blue Runner is a pelagic species which forms schools primarily inshore; it is not thought to be common around reefs (FAO 2002). It has a depth range of 0-100 m and juveniles are found beneath floating Sargassum mats. These mats provide this species both with prey and protection from predators. It feeds on shrimps, fishes and other invertebrates. Two spawning peaks have been identified for this species, the main occurring in June, July and August, with a secondary peak in October (Swaby et al. 1996). However, it has also been suggested that spawning occurs throughout the year (McKenney et al. 1958; Goodwin and Finucane 1985).”

6. Florida Fish and Wildlife Conservation Commission
http://myfwc.com/wildlifehabitats/profiles/saltwater/jacks/blue-runner/

“Juvenile blue runners are found offshore while adults are found nearshore in schools, but sometimes range inshore as well. Blue runners spawn offshore from January through August. Young form schools associated with floating objects, and have been observed living inside the bell of jellyfish. Adults feed on fish, shrimp, and squid.”

Bluefish: *Pomatomus saltatrix*

Vulnerability:	Moderate vulnerability (ASMFC & MAFMC)
Depth Range:	Primarily 0 – 20 m
Temperature Range:	Adults: generally above 14 – 16 °C; Eggs and larvae: 18 – 24 °C
Salinity Range:	Eggs: Greater than 31 ppt; larvae: 30 – 32 ppt
Oxygen Rage:	Need information
pH Range:	Need information

2013: $1,205,862.00, 1,116.7 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC & MAFMC
Management authorities? Regional: NEFMC, MAFMC, SAFMC, Interstate: ASMFC, State: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? Moderate vulnerability. Highly migratory, open ocean species with a wide range. There is no evidence that their growth, recruitment, or productivity are highly sensitive to temperature or ocean acidification.

Ecosystem considerations? Will be affected by changes in the forage fish populations.

Linkages to other fisheries? Forage fish populations may be impacted by climate change effects, but to what extent is unclear. The bluefish fishery provides supplemental income for operators that make most of their income in other fisheries. If changes in other fisheries cause increased political pressure to allow for currently prohibited relaxation of harvest controls on bluefish, then it is conceivable that the resulting diminished stock size would correspond to increased vulnerability to environmental stressors, e.g., climate change.

Known climate-related concerns? Bluefish are associated with warm water temperatures (generally above 14° C), which is important as a short-term influence on the availability of bluefish to the fisheries (rec. and commercial). Need more information on coastal age length keys (annual research priority), but no short-term climate change concerns given the migratory nature of the species.

Social and economic concerns? No. Recreational fishery, or supplemental income to operators involved in more profitable fisheries.

Management Risk? No

2. No SEDAR document available

3. ASMFC Bluefish Fact Sheet: http://www.asmfc.org/uploads/file/bluefishHabitatFactsheet.pdf

"Eggs are pelagic and highly buoyant, and are released in open ocean waters with temperatures ranging from 18-22°C and salinities greater than 31 ppt. Larvae develop into juveniles in continental shelf waters and eventually move to estuarine and nearshore shelf habitats. Larvae are generally found close to the surface of oceanic waters with temperatures from 18-24°C and salinity levels in the range of 30-32 ppt. Larvae migrate to the surface at night and down as far as four meters deep in daylight hours."

"Adult and juvenile bluefish are found primarily in waters less than 20 m deep along the Atlantic coast. Adults use both inshore and offshore areas of the coast and favor warmer water temperatures, although they are found in a variety of hydrographic environments. Adults are not found in the Mid-Atlantic Bight when temperatures drop below 14-16°C."

Blueline tilefish - *Caulolatilus microps*

Vulnerability: Low or minimal vulnerable **(**SAFMC**)**
Depth Range: 46 – 256 m
Temperature Range: 13.8 – 18.0 °C, with upwellings of 6 – 9 °C
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC Deepwater Complex
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

1. SAFMC – Deepwater complex

Climate vulnerability? "Deepwater species would generally have low or minimal vulnerability to impacts of climate change. However, detailed life history, movement and migration patterns are lacking for the species and true vulnerability may depend on the magnitude of change in bottom temperature or deepwater and oceanic currents that would eventually impact spawning, feeding and movement."

Ecosystem considerations? "Deepwater species using shelf edge to deepwater ecosystems extensively. Therefore, if deepwater habitat including coral and live bottom species are affected by changes in ocean water pH, the essential habitat for species in the deepwater complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level"

Linkages to other fisheries? "If climate change affects the deepwater fishery effort could shift to other managed species including coastal migratory pelagics and shallower water snapper grouper species." "If climate change impacts near-shore, shelf pelagic and benthic habitats, there could be an increase in fishing effort on the deepwater complex. A significant increase in fishing effort on the deepwater complex could also result in increased bycatch in depths where mortality is high."

Known climate-related concerns? "Changes in deepwater currents, bottom ocean temperatures or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species."

Social and economic concerns? "Considerations would only arise if changes are great enough to reach the deepwater ecosystems".

Management Risk? "Given the timescales being discussed as to impacting deepwater habitats, the existing Council management system has a long-term working relationship with the fishermen and should be able to respond to management needs associated with such change."

2. SEDAR Stock Assessment – S32_SA-BLT_SAR_FINAL_11.26.2013.pdf

Pg. 50:
"Blueline tilefish inhabit the shelf edge and upper slope reefs at depths of 46-256m (Sedberry et al. 2006) and temperatures between 15-23°C, where they construct burrows in relatively soft, sandy sediments at 91-150m depth (Able, et al. 1987). Primarily used for predator avoidance, they can be occupied by up to three individuals as well as other species. Blueline tilefish are considered opportunistic predators that feed on prey associated with substrate (crabs, shrimp, fish, echinoderms, polychaetes, etc.) (Ross 1982). They are considered relatively sedentary and are not thought to undertake north-south migrations along the coast. Based on what is known about the geographic range from landings data and other sources, it is recommended to have two stock jurisdictions: Gulf of Mexico and South Atlantic."

Pg. 54:
"The earliest study in the region on reproduction in female blueline tilefish found that spawning off the Carolinas takes place between April and October, with data from North Carolina showing peaks in May-June and September-October (Ross and Merriner 1983). The spawning season coincides with rapid increases and decreases in day length, which is a more conservative cue than bottom temperatures at shelf edge habitats given that the seasonal profile of temperature can be masked by cold-water intrusions from deeper areas and meandering of the Gulf Stream (Ross and Merriner 1983)."

3. SAFMC NMFS Distribution of Deep-water Commercial Fisheries Species-Golden Crab, Tilefish, Royal Red Shrimp – in Deep-water Habitats off Eastern Florida from Submersible and ROV Dives. By John Reed, Harbor Branch Oceanographic Institute. 2010 SAFMC NMFS Golden Crab Tilefish REPORT.pdf
http://www.safmc.net/managed-areas/pdf/2010%20SAFMC%20NMFS%20Golden%20Crab%20Tilefish%20REPORT.pdf

"Blueline tilefish were reported off central eastern Florida at bottom temperatures of 13.8-18.0°C (Able et al., 1987 b); however, Avent and Stanton (1979) recorded average temperatures of 12-18°C at similar sites on the upper slope with occasional upwellings to 10°C and even as low as 6-9°C."

Pg. 13:
Multiple depth ranges for tilefish.

Brown shrimp: *Farfantepenaeus aztecus*

Vulnerability:	Vulnerable (SAFMC)
Depth Range:	1 – 100 m (as per the southeast Area Monitoring and Assessment Program- SEAMAP - annual trawl survey), but not reflective of trends in inshore estuaries
Temperature Range:	4.4 – 35.0 °C
Salinity Range:	5 – 69 ppt; minimum salinity of 0.8 ppt; salinity optimum of 19 ppt
Oxygen Rage:	Decreased abundance below below 3.0 ml/l
pH Range:	Need information

2013: $15,582,468.00, 2,885.4 tonnes: (http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? "Yes – Less significant than White. But significant die offs of the population occurring when temperatures are sustained at a very low level for an extended time period. These events facilitate the closure of first state (SC and or GA) then federal waters off that state. Changing climate could result in increased extreme episodic events such as winter die offs."

Ecosystem considerations? "Changes in pelagic and benthic estuarine habitat would reduce the essential habitat and productive capacity of penaeid shrimp populations"

Linkages to other fisheries? "Prey to a wide variety of species in in estuarine and near-shore and offshore habitats"

Known climate-related concerns? No answer in SAFMC

Social and economic concerns? "Commercial shrimp fishery is one of the most economically important commercial fisheries in the southeast. While not overfished, the white shrimp resource in the South Atlantic region is periodically decimated by severe winter cold kills, especially offshore of Georgia and South Carolina. Significant economic impact to the commercial shrimp and potentially the inshore recreational fishery may result if climate change results in increased episodic events which reduce water temperatures to the level where winter kills of overwintering white shrimp occur more frequently"

Management Risk? No answer in SAFMC

2. No SEDAR document available

3. Fish and Wildlife Service, Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic): White Shrimp. FWS/OBS-82/11.27, September, 1984: 82_11-001.pdf
http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-001.pdf

Pg. 11:
"Brown shrimp have been collected at water temperatures as low as 2°C (36°F), but few are normally taken below 10°C (50°F), with highest catches taken above 20°C (68°F) (Swingle 1971; Christmas and Langley 1973). Temperatures of 4.4°C (40°F) or less may cause mass narcosis and mortality (Gunter and Hildebrand 1951). Kutkuhn (1966) reported that shrimp taken in waters of greater than 32.2°C (90°F) are usually flaccid and highly sensitive to stresses induced by handling. This is consistent with the observations of Zein- Eldin and Aldrich (1965) that growth and survival were both reduced above 32.2°C (90°F) with a suggested maximum tolerable temperature for postlarvae of just over 35°C (95°F)."

"Optimum temperature for larval development has been reported as 28° to 30°C (82° t o 86°F) (Cook 1965). Estuarine recruitment of postlarval penaeids was recorded by Christmas et al. (1966) only at temperatures of greater than 12°C (54°F)."

Salinity
"Postlarval brown shrimp have been captured in salinities from essentially fresh (Swingle 1971) to 69 ppt (Simmons 1957), but few have been taken in waters of less than 5 ppt (Loesch 1976; Christmas and Langley,1973). Venkataramaiah et al. (1972) successfully reared brown shrimp at 1.7 ppt, but had no survival at 0.5 ppt. These findings coincide closely with those of Gunter et al. (1964), who suggested a minimum salinity of 0.8 ppt. Tagging studies by White and Boudreaux (1977) indicated that heavy freshwater introduction in to marsh nursery areas may cause juveniles to migrate to deeper water or laterally towards offshore shallows (i.e. to higher salinity habitats) earlier than under normal hydrographic conditions. White and Boudreaux also discussed the fishery implications of such early migration. The field observations of Barrett and Gillespie (1973) led them to suggest a salinity optimum of 19 ppt for brown shrimp."

Substrate and System Features
"Field observations have repeatedly suggested that postlarval brown shrimp recruit in greatest abundance to soft bottom, shallow areas of estuaries in or near marshes or seagrass beds (Christmas et al. 1966)."

Other Environmental Requirements
"Trent et al. (1976) attributed decreased brown shrimp abundance at altered marsh sites in West Bay, Texas, to low dissolved oxygen conditions (below 3.0 ml/l, from May 20 to August 12). Detailed laboratory studies of oxygen consumption by brown shrimp

and the interaction of oxygen consumption with temperature, salinity, and body size are presented by Bishop et al. (1980)."

Additional References:

1) Severe winter cold kills: http://safmc.net/resource-library/shrimp
2) Temperature and salinity dependent in 'About the Species': http://www.fishwatch.gov/seafood_profiles/species/shrimp/species_pages/brown_shrimp.htm
3) Temperature effect but no salinity effect: 2005 Effect of salinity and temperature on thermal tolerance of brown shrimp *Farfantepenaeus aztecus* (Ives) (Crustacea, Cenaeidae); fdiaz@cicese.mx, http://www.sciencedirect.com/science/article/pii/S030645650500094X

Butterfish: *Peprilus triacanthus*

Vulnerability: Low to medium vulnerability (SAFMC)
Depth Range: 0 – 420 m
Temperature Range: 4.4 – 21.6 °C
Salinity Range: 5 – 32 ppt
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – MAFMC
Management authorities? Fed: NOAA and MAFMC

Climate vulnerability? Low to medium vulnerability. Migratory and primary response to climate change will be to shift their distribution.

Ecosystem considerations? Medium-Low: Migratory so will shift their distribution. Ocean acidification may affect prey abundance.

Linkages to other fisheries? Shifting target to other species, increasing effort in other fisheries.

Known climate-related concerns? “Some parties have suggested that it may make sense to leave more MSB in the water as prey to buffer other changes that are occurring.”

Social and economic concerns? Not detailed.

Management Risk? Low

2. No SEDAR document available

3. NOAA Technical Memorandum NMFS-NE-145: Essential Fish Habitat Source Document: Butterfish, *Peprilus triacanthus*, Life History and Habitat Characteristics: tm145.pdf

“Butterfish are eurythermal (4.4-21.6ºC; Fritz 1965; Schaefer 1967; Horn 1970a) and euryhaline (5-32 ppt; Musick 1972).”

Pg. 10:
“Butterfish spend the winter near the edge of the continental shelf in the Middle Atlantic Bight and migrate inshore in spring to waters off southern New England and into the Gulf of Maine. During the summer, butterfish range from the Gulf of Maine to the South Atlantic Bight where they are found from sheltered bays and estuaries (Table 3) across the shelf to depths of 200 m and greater.”

Table below: Adults: From surface waters to depths of 270-420 m.

Table 1. Summary of life history and habitat characteristics for butterfish, *Peprilus triacanthus*. *

Life Stage	Geographic Location	Habitat	Substrate	Temperature	Salinity
Eggs (0.68-0.82 mm diameter)	Cape Sable, Nova Scotia to Florida; in spring along edge of continental shelf from Georges Bank to Cape Hatteras; found progressively closer to coast from south to north as water temperatures increase. Commonly occur in the saline parts of bays and estuaries from MA to NY and Chesapeake Bay in spring and summer.	Surface waters from continental shelf into estuaries and bays; collected to about 60 m deep in shelf waters. Common in high salinity zone of estuaries and bays from MA through VA. MARMAP Survey: collected in surface waters in 10-1250 m of water.		Literature: 12.8-22.5°C; MARMAP Survey: 6-26°C; most eggs collected between 11-17°C	Estuarine to full seawater; about 25-33 ppt
Larvae (2.6-16 mm SL)	Cape Sable, Nova Scotia to Cape Kennedy, FL; most abundant in central Middle Atlantic Bight in summer, but absent in the winter. Commonly occur in bays and estuaries from MA to NY and Chesapeake Bay in summer and fall.	Surface waters from continental shelf into estuaries and bays; collected to about 60 m deep in shelf waters; common in high salinity zone of estuaries and bays; may spend day deeper in the water column and migrate to the surface at night. MARMAP Survey: collected in surface waters in water 10-1750 m deep.		Literature: 4.4-27.9°C. MARMAP Survey: 7-26°C; most eggs collected between 9-19°C	6.4-37.4 ppt
Juveniles (16 mm SL-120 mm FL)	Cape Sable, Nova Scotia to Florida; most abundant in Middle Atlantic Bight in summer and near the edge of continental shelf in winter. Commonly occur in bays and estuaries from MA to VA from spring through fall; less abundant in bays and estuaries in the Gulf of Maine and in the South Atlantic Bight.	From surface waters to depth on continental shelf; into coastal bays and estuaries; common in inshore areas, including the surf zone, and in high salinity and mixed salinity zones of bays and estuaries. NEFSC Trawl Survey: collected on continental shelf in 10-330 m of water; most collected in < 120 m	Larger individuals found over sandy and muddy substrates.	4.4-29.7°C; survival reduced below 10°C	3.0-37.4 ppt
Adults (> 120 mm FL)	Cape Sable, Nova Scotia to Florida; most abundant inshore in Middle Atlantic Bight in summer and near the edge of continental shelf in winter; most abundant north of Cape Cod in summer and fall; commonly occur in bays and estuaries from MA to VA from spring through fall; less abundant in bays and estuaries in the Gulf of Maine and in the South Atlantic Bight; do not migrate far offshore in South Atlantic Bight.	From surface waters to depths of 270-420 m on continental shelf; into coastal bays and estuaries; common in inshore areas, including the surf zone, and in high salinity and mixed salinity zones of bays and estuaries. NEFSC Trawl Survey: collected on continental shelf in 10-360 m of water; most collected in < 180 m.	Schools found over sandy, sandy-silt, and muddy substrates.	4.4-26.0°C; survival reduced below 10°C	3.8-33.0 ppt
Spawning Adults	At least the Gulf of Maine to the South Atlantic Bight (SAB); most abundant in Middle Atlantic Bight; in SAB between Cape Hatteras and Cape Kennedy. Common in Long Island Sound, some Long Island bays, and Chesapeake Bay in spring and summer. In NY Bight, caught from May-August.	Spawning occurs on continental shelf, inshore areas, and in bays and estuaries (rarely in bays and estuaries north of Cape Cod). Spawning adults common in Long Island Sound and bays and estuaries of Long Island. In NY Bight, caught between 3-145 m.		Spawning does not occur at < 15°C	

Caribbean spiny lobster: *Panulirus argus*

Vulnerability:	Moderately susceptible (SAFMC). Very Vulnerable (Roffer and Hall, 2015, this document suggest that it should be ranked as a highly vulnerable species as their life history is liked to coral reef habitat and flow of larvae depend on favorable northward currents from the Caribbean Sea to the Gulf of Mexico and South Atlantic regions).
Depth Range:	1 – 90 m
Temperature Range:	Greater than 14°C; spawning at 24°C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

2013: $3,447,507.00, 221.0 tonnes: (http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under own section
Management authorities? Fed: NOAA; Regional: SAFMC & GMFMC; State: NC, SC, GA, FL

Climate vulnerability? “Moderately susceptible to climate change”

Ecosystem considerations? “Live in a presently changing benthic environment. As the coral reef and live/hard bottom habitat distribution and quality change or are impacted, so will the species essential habitat potentially affecting their movement, spawning, growth to maturity and possibly even level of production”.

Linkages to other fisheries? No information in SAFMC

Known climate-related concerns? “As the coral reef and live/hard bottom habitat distribution and quality change or are impacted, so will the species essential habitat potentially affecting their movement, spawning, growth to maturity and possibly even level of production”

Social and economic concerns? “The directed fisheries for spiny Lobster are off Florida primarily in the Florida Keys. Changes or loss of the tropical corals in the reef systems resulting from a changing climate could significantly reduce the present level of production in the population.”

Management Risk? Low

2. SEDAR Stock Assessment – S8DAR2_CaribLobFinal.pdf

Pg. 38:
"Caribbean spiny lobster (*Panulirus argus*) changes habitats several times during its ontogenetic development, moving from planktonic phyllosoma larvae to pelagic swimming puerulus larvae to adults, which may utilize a variety of benthic habitats (Arce & de León, 2001; Cruz et al., 2001)."

Migration: "In higher latitudes, the shallow waters that *P. argus* occupies during the summer become turbid and cold, initiating the diurnal migration of thousands of lobsters. *P. argus* is highly susceptible to severe winter cooling and will exhibit reduced feeding and locomotion at temperatures below 14ºC; molting individuals usually perish under these conditions. Caribbean spiny lobsters migrate in single-file queues to deeper water in order to evade the stresses of the cold and turbid waters. *P. argus* may migrate for periods of six hours to five days and cover distances as far as 30-50km (Herrnkind, 1985)."

Pg. 39:
"Reproduction in *P. argus* occurs almost exclusively in the deep reef environment once mature individuals have made the permanent transition from the shallow seagrass nursery to the ocean coral reef system."

"Spawning is seasonal in some areas of the Caribbean, in Cuba it peaks in the spring and summer (March-July) with a subsidiary peak in early autumn (September), though berried females may be found year round (Kanciruk and Hernkind, 1976; Arce and de León). More southern areas of the Caribbean may show spawning peaks that extend into October or November (Castano & Cadima, 1993; Gallo et al. 1998). Spawning has been correlated with water temperature, with an optimal temperature of 24°C in the Florida Keys. In the US Caribbean, spawning occurs throughout the year without a strong seasonal pattern (Bohnsack et al 1992)."

"Temperature, maturation state, season, and sex have all been shown to affect the growth of the spiny lobster, *P. argus* (Arce & de León, 2001)."

Pg. 40:
"Larger animals such as sharks and finfish are known to prey on adult lobsters (Herrnkind, 1980)."

3. SEDAR Workshop Working Papers – S8DW_05.pdf

Pg. 5:
"The rate of oxygen consumption in *P. argus* is dependent upon the temperature, the degree of crowding within the den, feeding and size of the lobster; oxygen consumption is not determined by the concentration of the oxygen in the water as some studies show that oxygen uptake remained the same in both hypoxic and aerated water (Phillips, Cobb and George, 1980)." [Pg. 6: More information on spawning vs. temperature.]

4. IUCN Red List: http://www.iucnredlist.org/details/169976/0 (Data Deficient).
Depth limit (meters): 1 – 90 m

"The timing of moulting is affected by water temperature/ geographic region (M.J. Butler, A.C. Cockcroft, A.B. MacDiarmid and R.A.Wahle pers. comm. 2008)."

Cobia: *Rachycentron canadum*

Vulnerability: Moderately vulnerable (SAFMC & MAFMC & ASMFC)
Migrations associated with specific sea surface temperature.
Depth Range: Need information
Temperature Range: 25° C preferred
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Moderately vulnerable. The estuarine dependent life history exposes early life stages to loss or degradation of estuarine habitat. As adults, climate change could affect current, temperature and productivity in the offshore pelagic habitats impacting migration, schooling behavior, prey availability or spawning.

Ecosystem considerations? Estuarine dependence of key prey of Cobia, changes or loss of habitat associated. Year class strength possibly correlated with ocean temperature and increased ocean temperatures could affect survival and distribution of larvae along shelf. As with king mackerel, upwelling event may affect the movement and availability and increased occurrence may have long-term impacts on the population.

Linkages to other fisheries? Shifting effort onto cobia from declining mackerel fishery. Affect on prey species.

Known climate-related concerns? Increase in episodic upwelling events has been noted by fishermen to affect the movement/migration and availability, resulting in long-term impacts.

Social and economic concerns? No social or economic concerns exist at present. Future: distribution, availability and production levels may change affecting fisheries targeting cobia.

Management Risk? Low

2. SEDAR Stock Assessment – S28_SAR_SACobia_WithAddendumFinal_5.16.2013.pdf: 2013, revised May 2013

Pg. 19:
"Therefore, the RP (Review Panel) concluded that the stock is not overfished and is not undergoing overfishing."

Pg. 49:
“Maximum age of cobia in the Atlantic stock is 16 years. Maximum age in the Gulf is lower, age 11.” “Because cobia will migrate due to changes in water temperature, cobia’s preferred water temperature, 25 °C, was used in the Pauly M calculation.”

Pg. 53:
“It has been well documented that cobia begin a “migration” or move into nearshore waters in the South Atlantic when temperatures reach 20-25 °C (Shaffer and Nakamura, 1989; Biesiot et al., 1994; Smith, 1995).”

Pg. 54:
“Previous samples were collected by recreational anglers from tournaments over a broad geographic area and time period leading researchers to conclude that the entire population was spawning over a period of several months. However, the GSI and temperature data suggest that cobia in the Southeast region may actually spawn for a much shorter period (30-45 days) that is brought on locally by critical temperatures (beginning at 20-25 and then subsiding over a 30-45 day period). This hypothesis is supported by the genetically distinct spawning aggregations identified in VA and in SC as reported in SEDAR28-DW01. If spawning were to occur over the extended season suggested in the literature, distinct population segments would not be identifiable. This may prove an important consideration in estimating the number of spawning days in a spawning season.”

Corals: *Anthozoa*

Vulnerability:	Very vulnerable (SAFMC). Heating and pH change.
Depth Range:	0 – 50 m
Temperature Range:	16 – 35 °C (coral bleaching and death common when temps sustained above 30 °C)
Salinity Range:	30 – 40 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Yes. The benthic species are or will be impacted by changing oceanographic conditions associated with a changing climate. Changes in ocean currents, temperature, acidification, and increased episodic events including upwelling, tropical and winter storms will affect the survival, growth, spawning and distribution of coral and live bottom species and species which depend on this habitat.

Ecosystem considerations? N/A

Linkages to other fisheries? 1) These species are managed as habitat and changes in their survival or distribution will reduce the function as essential habitat for many pelagic and reef/live bottom obligated species. 2) change in fisheries habitat/gear related impacts exacerbate climate related impacts on reef/live bottom habitats

Known climate-related concerns? Changes in overall ocean currents, temperature, acidification, and increased episodic events including upwelling, tropical and winter storms could affect the survival, growth, spawning and distribution of coral and live bottom species.

Social and economic concerns? Climate related impacts on these habitats could translate to reduction in availability of managed or prey populations, which could result in significant social and economic impacts to recreational and commercial fisheries

Management Risk? Yes, inability to adjust management to address climate related impacts could have significant long-term impacts

2. No SEDAR document available

3. Florida Museum of Natural History: Ichthyology
http://www.flmnh.ufl.edu/FISH/southflorida/coral/Habitat.html

"Optimal temperature for coral growth is 73-77°F (23-25°C). Seawater temperatures can be tolerated between 61-95°F (16-35°C), with optimal coral growth occurring at temperatures of 73-77°F (23-25°C)."

"Corals require salinities between 30 and 40 parts per thousand."

4. Coral Reef Alliance: http://coral.org/coral-reefs-101/coral-reef-ecology/what-do-coral-reefs-need-to-survive/

"Corals rarely develop in water deeper than 165 feet (50 meters)."
Warm water temperature: "Reef-building corals require warm water conditions to survive. Different corals living in different regions can withstand various temperature fluctuations. However, corals generally live in water temperatures of 68–90° F or 20–32°C."

5. Texas A&M University: Ocean World: Coral Reefs: The rainforests of the sea.
http://oceanworld.tamu.edu/students/coral/coral2.htm

"Reefs grow best in sunny, shallow, clear water. The water must be clear and shallow so that the reef can get lots of sunlight. They rarely grow deeper than 40m and they prefer salt water, doing poorly in areas where there is a lot of river runoff due to the freshwater as well as the silt which can cover a reef or muddy the water blocking the sunlight. The best temperature for coral reefs is between 25 and 31° C and the best salinity is between 34 and 37 parts per 1000. The appropriate temperatures and salinities are most often found in the tropics."

Reference 28: Achituv, Y. and Dubinsky, Z. 1990. Evolution and Zoogeography of Coral Reefs Ecosystems of the World. Vol. 25:1–8.

Reference 106: Caribbean coral reefs may disappear within 20 years: Report. IANS. news.biharprabha.com. Retrieved 3 July 2014.

6. 2004 Effects of global climate change on marine and estuarine fishes and fisheries; http://link.springer.com/article/10.1007/s11160-004-6749-0

7. NOAA declares third ever global coral bleaching event
http://www.noaanews.noaa.gov/stories2015/100815-noaa-declares-third-ever-global-coral-bleaching-event.html

Deepsea golden crab: *Chaceon fenneri*

Vulnerability:	Low or minimal vulnerability (SAFMC)
Depth Range:	240 – 915 m in US waters, general records say 350 – 500 m
Temperature Range:	7.14 °C – 15 °C (Lowest/highest reported)
Salinity Range:	Annual mean salinity: 35.0 – 35.5; peak in numbers of crabs at 35.1 ppt
Oxygen Rage:	Need information
pH Range:	Need information

2013: $2,104,249.00, 374.9 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC

Climate vulnerability? "Golden Crab being a deepwater species, would generally have low or minimal vulnerability to impacts of climate change. However, detailed life history is lacking for the species and true vulnerability may depend on the magnitude of change in bottom temperature or deepwater currents that would eventually impact spawning, feeding and movement."

Ecosystem considerations? "Deepwater species using deepwater coral ecosystems extensively. Therefore, if deepwater coral species are affected by changes in ocean water ph, the essential habitat for this species would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level."

Linkages to other fisheries? "There are no direct impacts to other fisheries considering participants primarily participate in the fishery almost exclusively." "Unless new entrants are allowed into the fishery other fisheries shouldn't affect this fishery."

Known climate-related concerns? "Changes in deepwater currents or increased of episodic events like upwelling have been raised as a potential concern"

Social and economic concerns? "Considerations would only arise if changes are great enough to reach the deepwater ecosystems."

Management Risk? Low

2. No SEDAR document available

3. SAFMC NMFS Distribution of Deep-water Commercial Fisheries Species-Golden Crab, Tilefish, Royal Red Shrimp – in Deep-water Habitats off Eastern Florida from Submersible and ROV Dives. By John Reed, Harbor Branch Oceanographic Institute. 2010 SAFMC NMFS Golden Crab Tilefish REPORT.pdf http://www.safmc.net/managed-areas/pdf/2010%20SAFMC%20NMFS%20Golden%20Crab%20Tilefish%20REPORT.pdf

Pg. 9:
"Golden crabs are distributed in deep water, along the outer continental shelf, from the Chesapeake Bay into the Straits of Florida and the Gulf of Mexico (NOAA, 2010; Manning & Holthuis, 1984, 1989) where the Gulf Stream is essential to its larval distribution (NOAA, 2010). The maximum abundance of golden crabs is in the South Atlantic Bight (NOAA, 2010)."

"Depth records from golden crab fisheries for the southeastern U.S. range from 240 to 915 m (Kendall, 1990; Wenner, 1990; Wenner and Barans, 1990). In general, most records for golden crab occur between 350 and 500 m (Manning and Holthuis 1984)."

"The lowest temperature reported for crab trappings was 7.14°C (Wenner et al., 1987) and the highest temperature was 15°C (Wenner and Barrans 1990)."

Pg. 51: Results of survey:
"The total bottom temperature range of all the dives was 5.6 to 16.7°C from the annotation records; however, the annual mean temperature range of the golden crab distribution was 7 to 11°C with peaks in abundance at 9-10°C (Fig. 23). The range of annual mean salinity for the crab distribution was only 35.0 to 35.5 and showed a peak in numbers of crabs at 35.1. The range of annual mean current range for the crab was 0.05 to 0.13 m s-1 (0.1-0.26 knot)."

Dolphin: *Coryphaena hippurus*

Vulnerability:	Low vulnerability (SAFMC). Vulnerable (Roffer and Hall, 2015 this document – Temperature and Gulf Stream dependent.)
Depth Range:	0 – 85 m
Temperature Range:	Greater than 20°C for common dolphin; Spawning at water temperatures greater than 21°C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability?: "Low vulnerability". "They are dependent on ocean currents and temperature and subsequently affected directly by changes associated with climate change."

Ecosystem considerations? "Changes in the distribution or availability of pelagic Sargassum habitat could also affect dolphin or species dependent on them as prey."

Linkages to other fisheries? "Reduction in dolphin availability or population could affect species which rely on dolphin as prey including but not limited to dolphin, billfish, wahoo and other pelagic species."

Known climate-related concerns? "Concerns include changes in overall ocean currents, temperature, acidification, and increased episodic events including upwelling, tropical and winter storms, which, in combination, affect the survival, growth, spawning and subsequent distribution of coral and live bottom species."

Social and economic concerns? "Significant reduction in dolphin availability or population resulting from climate change may have a significant impact on the primarily recreational fishery."

Management Risk? Not answered in SAFMC

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/154712/0 (Least concern)
   Depth limit (meters): 0 – 85 m

"Spawning is year-round at water temperatures greater than 21°C, and spawning occurs in the open water when water temperature rises."

4. SAFMC files: http://safmc.net/sites/default/files/habitat-ecosystem/pdf/FEP/VolumeII/VolII_DW%20and%20CalicoScallop.pdf

"The common dolphin, *Coryphaena hippurus*, is an oceanic pelagic fish found worldwide in tropical and subtropical waters. They are generally restricted to waters warmer than 20°C (Oxenford 1997)."

Eastern oyster: *Crassostrea virginica*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Although can tolerate wide range of environmental conditions (e.g. tolerance for low dissolved oxygen and wide ranges in salinity and temperature) makes it resilient. Susceptible to drought (e.g. Apalachicola Bay)
Depth Range:	Need information
Temperature Range:	3 – 32+ °C
Salinity Range:	0 – 36+ ppt
Oxygen Rage:	Can survive for 5 days in 1 mgL-1
pH Range:	Need information

2013: $9,351,786.00, 733.9 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Ecosystem Status Report For The Gulf Of Mexico, NOAA Technical Memorandum NMFS-SEFSC-653. GoM_EcoStatusReport_NMFS-SEFSC-653-1.pdf

Pg. 13:
"Oyster reefs create important habitat for more than 200 species including a multitude of fish and invertebrates. When feeding, adult oysters filter large volumes of water – up to 1500 times the volume of an individual per hour. Through the active filtration of water, oysters play a critical role in maintaining the quality and clarity of estuarine waters."

4. NOAA Fisheries - South Carolina Department of Natural Resources http://www.dnr.sc.gov/marine/pub/seascience/oyster.html

"Oysters are considered a keystone species in most estuaries along the Atlantic and Gulf coasts, and self-sustaining populations play an essential role in the ecology of these estuaries."

"Eastern oysters display a wide range of survival strategies. They are both colonizers and ecosystem engineers and have a high reproductive potential. The species' ability to adapt to a wide range of environmental conditions (e.g. tolerance for low dissolved oxygen and wide ranges in salinity and temperature) makes it resilient. Eastern oysters inhabit a naturally-variable environment, and evidence suggests that past local extirpations and colonizations have been common over geologic time. There are some threats that may be significant at a regional or local level. However, while the species encounters many threats throughout its range, none are considered to be overwhelmingly dominant or advancing at a rate that would threaten the viability of the species throughout its full range. Based on the available information, the BRT therefore concluded that the long term persistence of eastern oysters throughout their range is not at risk now or in the foreseeable future.”

Gag grouper: *Mycteroperca microlepis*

Vulnerability:	Very vulnerable (SAFMC). Year class strength has been positively correlated with ocean temperature and increased ocean temperatures could affect survival and distribution of larvae along shelf and into estuaries
Depth Range:	33 – 167 m
Temperature Range:	13 – 19 °C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

2013: $2,586,948.00, 267.8 tonnes: (http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Very vulnerable to the impacts of climate change. Gag life history exposes life stages utilizing a wide range of estuarine, nearshore, and offshore benthic and pelagic habitats

Ecosystem considerations? Changes or loss of seagrass in NC and FL and oyster reef habitat in SC and GA would potentially limit availability of juvenile habitat for settlement and early development. Year class strength has been positively correlated with ocean temperature and increased ocean temperatures could affect survival and distribution of larvae along shelf and into estuaries

Linkages to other fisheries? Gag effort shift to other species. Shelf habitat change impact to most snapper grouper complex.

Known climate-related concerns? Life stages dependent on inshore estuarine, near-shore shelf and shelf edge benthic habitats and offshore pelagic habitats. This makes the species susceptible to impacts associated with climate change. Increased episodic events associated with a changing climate including upwelling, may impact the resource, habitat and fishery.

Social and economic concerns? Yes, impacts to inshore estuarine, near-shore shelf and shelf edge benthic habitats and offshore pelagic habitats could affect availability, resulting in economic loss.

Management Risk? Little Management risk

2. SEDAR Stock Assessment – S10DW15 SEUSlifehist.pdf:

Pg. 8:
"Gag spawn in outer continental shelf waters with bottom temperatures similar those at which northern anchovy spawn (13-19°C; Hunter and Macewicz 1985)."

3. SEDAR Stock Assessment – S10 SAR Gag updated ALL.pdf:

Pg. 44:
"Juvenile gag were examined in shallow seagrass beds located on the northwest coast of Florida." "Maximum age of gag in Gulf of Mexico is 31 years (SEDAR10-DW2) while estimates in the South Atlantic range from 26 (SEDAR10-DW15) to 30 years (SEDAR10-DW31)."

Pg. 50:
"Spawning season in the South Atlantic was estimated to extend from mid-January to early May (with a peak in March-April), corresponding to a 114 d spawning duration (SEDAR10-DW15). In the eastern Gulf of Mexico the spawning season was estimated to extend from late January to mid-April (with a peak in March), corresponding to a 91 d spawning duration (SEDAR10-DW3)."

"Gag are known to be protogynous hermaphrodites (female first, changing to male later in life). Consequently, sexual maturity is reported for females only."

Pg. 53:
"Information suggests an ontogenetic movement to deeper waters; smaller gag (late juvenile to early adult) exhibit relatively high site fidelity with localized movements on the order of a few km. Gag then make larger along-shelf movements upon reaching depths of the mid to outer shelf (mature adults). There is some evidence that upon reaching older ages and outer shelf depths, associated with spawning habitats, gag again exhibit higher site fidelity (Coleman et al. 1996)."

Pg. 149:
"3) It was proposed that the index working group examine the possibility of including environmental variables in computation of indices. Variables discussed included wave height, sea surface temperature, surface currents and hurricane impact. The group considered that other model parameters, particularly the spawner-recruit relationship, might be a meaningful way to include environment variables in assessment models."

4. SEDAR Stock Assessment - SEDAR 33 SAR- Gag Stock Assessment Report FINAL_sizereduced.pdf

Pg. 274:
Integrated Ecosystem Assessments:

“One of the primary concerns for gag grouper on the West Florida Shelf is the presence of sporadic red tide events, which are thought to cause increased mortality in some years. This issue in particular was noted because of a well-observed severe red tide event in 2005, and an associated large decline in abundance indices for gag and other species thought to be susceptible to mortality from red tide events. It is unknown whether mortality occurs via direct toxicity, or from some indirect effect of red tide such as hypoxia. Red snapper are well-known to be affected by hypoxia; for example, low dissolved oxygen concentrations are documented to affect both juvenile and adult stages (Szedlmayer and Shipp 1994, Gallaway et al. 1999). The large drop in gag abundance indices coincident with a major documented red tide event provides good evidence that adult gag grouper are indeed affected by similar processes.”

“Other environmental perturbations in addition to hypoxia have the potential to affect populations of demersal fishes. The passage of hurricanes, for example, appears to affect movement and site-fidelity of red snapper (Patterson et al. 2001). Periodic upwelling events and associated reductions in temperature and increases in nutrients have been documented to contribute to mass mortality of fishes and macroinvertebrates, potentially in association with the development of near-anoxic conditions (Collard and Lugo- Fernández 1999; Collard et al. 2000). Temperature reductions also appear to contribute to seasonally-dynamic movement patterns (Topping and Szedlmayer 2011).”

5. IUCN Red List: http://www.iucnredlist.org/details/14050/0 (Least concern)
   Depth range: 33 – 167 m

Golden Tilefish: *Lopholatilus chamaeleonticeps*

Vulnerability:	Quite vulnerable **(**MAFMC**)**
Depth Range:	79 – 540 m
Temperature Range:	Prefer 7 – 17 °C (MAFMC); Prefer 9 – 14 °C, recorded at 8.6 – 15.4 °C (2010 SAFMC NMFS Golden Crab Tilefish REPORT.pdf)
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – MAFMC & SAFMC
Management authorities? Fed: NOAA & MAFMC & SAFMC; Regional: SAFMC State: NC, SC, GA, FL, VA

1a. MAFMC – Golden Tilefish

Climate vulnerability? "Tilefish are likely quite vulnerable to climate change. Tilefish are considered to have an unique spatial and temporal behavior and generally restricted to a relatively narrow band of approximately 262-1771 feet deep and 46-62°F, known as the "warm belt" on the outer continental shelf and upper slope of the northwest Atlantic coast. The productivity of this species is sensitive to water temperatures. Temperature plays a role in the distribution of eggs, larvae, juvenile, and adult distribution. Because tilefish migrate little or not at all, they are particularly sensitive to changes in environmental factors"

Ecosystem considerations? "Nothing is known about the diets and feeding habits of tilefish larvae, but they probably prey on zooplankton. Tilefish feed on a variety of food items such as species of crabs, mollusks, annelid worms, polychaetes, sea cucumbers, anemones, tunicates and fish bones, shrimp, sea urchins and several species of fishes. While tilefish are sometimes preyed upon by spiny dogfish and conger eels, by far the most important predator of tilefish is other tilefish. There will likely be impacts to tilefish if the spatiotemporal overlap between tilefish and prey, is reduced as tilefish appears to migrate little or not at all. Adult tilefish require sediments in which they can burrow within a stable, moderate temperature regime. Tilefish burrows provide habitat for numerous other species of fish and invertebrates and in this respect they are similar to "pueblo villages."

Linkages to other fisheries? "The directed commercial fishery for tilefish is prosecuted by longline gear. Incidental landings mostly by otter trawls and a few gillnet vessels also occur. Otter trawls have limited effectiveness in this fishery because of the habitat preferred by tilefish. Otter trawls are only effective where the bottom is firm, flat, and free of obstructions. Effort that was once in the tilefish fishery could potentially shift to other longline fisheries." "The tilefish fishery is managed using an IFQ program.

Participation in the fishery would require the purchase of quota shares or lease of quota pounds."

Known climate-related concerns? "Yes, it has been recommended (SAW/SARC) that the influence of water temperature and other environmental factors on the trend in the commercial fishery CPUE index of stock abundance needs to be explored."

Social and economic concerns? "The current tilefish fishery is conducted by a relatively small number of vessels (10). A few of those vessels (5) account for more than 70 percent of the total tilefish landings and the bulk of their revenues is derived from tilefish fishing. If the stock distribution changes away from the typical fishing grounds, vessel may have to travel further to catch tilefish, which could increase fishing costs".

Management Risk? "The risk of not having a responsive, adaptive governance system is an inability to respond to crisis in these fisheries. A failure to respond to crisis could result in biological or social and economic harm."

1b. SAFMC – Golden Tilefish

Climate vulnerability? "Golden tilefish would generally have low or minimal vulnerability. However, detailed life history, movement and migration patterns are lacking for the species and true vulnerability may depend on the magnitude of change in bottom temperature or deepwater and oceanic currents that would eventually impact spawning, feeding and movement."

Ecosystem considerations? "Golden tilefish use distinct and limited deepwater soft sediment habitat at all life stages. Therefore, if the limited deepwater habitat is affected by changes in ocean currents, ocean temperature of ocean water ph, the essential habitat for golden tilefish would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level."

Linkages to other fisheries? "If efforts shifts to deepwater associated with impacts in shelf waters, could result in increased effort on the deepwater species including golden tilefish."
"If climate change affects other managed species including coastal migratory pelagic and shallower water snapper grouper species, effort could shift to the deepwater species including golden tilefish"

Known climate-related concerns? "Changes in deepwater currents, bottom ocean temperatures or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species.

Social and economic concerns? "Considerations would only arise if changes are great enough to reach deepwater ecosystems"

Management Risk? "The existing Council management system should be able to respond the management needs associated with a change associated with shifting fisheries. However, if changes result in significant change in the ability of the habitat to support various life stages of this deepwater species, even Council management may not be able to ensure long-term sustainability.".

2. SEDAR Stock Assessment – SEDAR4_FinalSAR 200606a.pdf
SEDAR4_DW_Carib_report.pdf

Pg. 23:
"Life history information for the eight deep water species of the Snapper Grouper complex of the Atlantic coast of the Southeastern U.S. is difficult to obtain or interpret."

Reference:
Pauly, Daniel. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39:175-192.

3. SEDAR Stock Assessment – tilefish_SAR_FINAL.pdf

Pg. 7:
"Tilefish species of the genus *Caulolatilus*, plus the great northern tilefish (also known as golden tilefish or simply tilefish) (*Lopholatilus chamaeleonticeps*), were listed in the original Reef Fish FMP in 1981 as "Species included in the Fishery but Not in the Management Unit". Species on this list were included in the FMP for purposes of data collection. They were considered to be species that were not normally targeted, but were taken incidentally to the directed fishery."

Pg. 50:
"Tilefish (*Lopholatilus chamaeleonticeps*) have fairly distinct sediment (habitat), depth, and temperature preferences (Nelson and Carpenter 1968, Able et al. 1982, Katz et al. 1983, S22-DW-05). These results together with tagging results suggest adult movements are minimal (Katz et al. 1983, Grimes 1983)."

Pg. 179:
"Tilefish are known to survive in a very narrow range of temperatures." [*no ref]*

References for above statements:
Nelson, W.R. and J.S. Carpenter. 1968. Bottom longline explorations in the Gulf of Mexico. Com. Fish. Rev. 30:57-62.

Able, K.W., Grimes, C.B., Cooper, R.A., and J.R. Uzmann. 1982. Burrow construction and behavior of tilefish, *Lopholatilus chamaeleonticeps*, in the Hudson Submarine Canyon. Env. Biol. Fish. 7:199-205.

Katz, S.J., Grimes, C.B. and K.W. Able. 1983. Delineation of tilefish, *Lopholatilus*

chamaeleonticeps, stocks along the United States east coast and in the Gulf of Mexico. Fish Bull. 81:41-50.

4. SAFMC NMFS Distribution of Deep-water Commercial Fisheries Species-Golden Crab, Tilefish, Royal Red Shrimp – in Deep-water Habitats off Eastern Florida from Submersible and ROV Dives. By John Reed, Harbor Branch Oceanographic Institute. 2010 SAFMC NMFS Golden Crab Tilefish REPORT.pdf http://www.safmc.net/managed-areas/pdf/2010%20SAFMC%20NMFS%20Golden%20Crab%20Tilefish%20REPORT.pdf

"Golden tilefish can also endure abrupt temperature changes from upwelling to below 8.0°C for a short time (Able et al., 1993). In general, golden tilefish are known to prefer temperatures of 9-14°C (Grimes et al., 1986; Matlock et al., 1991) and were recorded off eastern Florida at temperatures of 8.6-15.4°C (Able et al., 1993)."

Pg. 13:
Multiple depth ranges for tilefish.

Goliath grouper: *Epinephelus itajara*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document) Vulnerable to cold water stresses (Gilmore et al. 1978), low dissolved oxygen or red tide, and very specific mangrove habitat requirements that are susceptible to climate change.
Depth Range:	33 – 167 m
Temperature Range:	13 – 19 °C
Salinity Range:	Greater than 5 ppt
Oxygen Rage:	Greater than 3 mg/L
pH Range:	Need information

1. No Rapid Assessment Profile available

2. SEDAR Stock Assessment – SEDAR6_SAR1_Goliathall.pdf: 2004

Pg. 10:
"Study of goliath grouper in mangrove creeks and tidal passes indicates that those caught by crab traps and fish traps and by hooks were primarily ages 1-6 years old (having 1-6 annuli present on otoliths and fin spines). Most of those fish were less than 100 cm TL, while fish from wrecks and reef habitats were greater than 150 cm TL. It was therefore assumed that most of the fish on wrecks and reefs were at least 6 years old."

Habitat: Pg. 10-11
"Felicia Coleman further reported that there are indications that the amount of mangrove habitat in Florida has declined over time, thereby potentially reducing nursery habitat. There is a student at FSU working on a project to compare historical coastal mangrove coverage to present-day coverage. A student at the University of Florida is evaluating the relative impact of sea-level rise on mangrove distribution."

"It was noted that black mangrove habitat is newly developing along the Louisiana coast. Although our studies indicate that goliath grouper use primarily red mangrove habitat, goliath grouper occur and have historically occurred along the coasts of Louisiana and Texas; what habitat is used by juvenile goliath grouper in those areas is not known."

"In the southeastern Gulf of Mexico, adult goliath grouper are often observed on offshore wrecks. Information on their distribution and abundance on natural habitat is more limited, possibly because these sites are visited less frequently by many of the dive groups that make and report observations. Goliath grouper may be concentrated around wrecks (isolated areas of high relief) and more spread out on low-relief natural habitat."

“The number of offshore wrecks has increased over time, thereby potentially increasing the amount of available offshore habitat available for the fish, or simply concentrating the fish on isolated structures.”

Pg. 12:
Predators: “Sharks are the only known natural predator on adult or larger juvenile goliath grouper.”

3. SEDAR Stock Assessment – S23_SAR_complete_and_final.pdf: March 2011

Pg. 39:
“They are known to be very sensitive to low temperatures (Sadovy and Eklund 1999; Koenig and Coleman, 2009). Information used in the early 1990s to describe the decline of goliath grouper stocks included region-wide declines in distribution and abundance, a restriction in range, and the extirpation of known spawning aggregations.”

“While adult goliath grouper appear to be more generalist with regards to habitat requirements, juveniles have a high affinity for estuarine and fringing red mangrove (*Rhizophora mangle*) habitat (Koenig et al. 2007). Within the mangrove habitat, juvenile goliath grouper show site fidelity to high complexity sites, microhabitats within the larger mangrove shoreline (undercuts, overhangs, solution holes and dead submersed trees) with a patchy distribution, resulting also in a patchy occurrence of juveniles (Frias-Torres 2006).”

“The lack of such high quality mangrove habitat may be a population bottleneck for goliath grouper (Frias-Torres 2006; Koenig et al 2007).”

Pg. 40:
“Episodic natural mortality events (caused by red tides, cold kills, etc.) were also discussed. Episodic events kill selectively determinate life history phases. Red tides caused by the dinoglagellate *Karenia brevis* kill mostly adults (57 % of carcasses recovered during the 2003 and 2005 red tides were larger than 1200 mm TL; Frias-Torres unpub. data). Cold kills triggered by weather fronts kill mostly juveniles (e.g. 2008 and 2010), as the inshore mangrove nursery habitats are the first to experience low water temperatures for longer periods.”

Pg. 46:
“Goliath grouper have very specific habitat requirements throughout their life history, from juvenile to adults. The availability of fringing red mangrove (*Rhizophora mangle*) nursery habitat is a bottleneck for population recovery in goliath grouper; limited availability also limits population recruitment and juvenile growth (Frias-Torres 2006; Koenig et al. 2007). The quality of the mangrove habitat is also critical. Juvenile goliath grouper show a preference for highly structured, erosional, old mangrove sites, specifically undercuts, overhangs, submerged dead trees and limestone solution holes adjacent to fringing red mangrove shorelines (Frias-Torres 2006). After ontogenetic migration from the juvenile inshore habitat to the adult offshore habitat, adult goliath

grouper show a preference for high relief habitat, either reef ledges or artificial reefs, but rarely coral reefs (Figure 7, Koenig and Coleman 2009). Site fidelity is found in both juveniles (Frias-Torres et al 2007) and adults (Sadovy and Eklund 1999) and for adult spawning aggregation sites (Sadovy and Eklund 1999)."

Pg. 47:
"Habitat requirements are limited by water quality as well as structure. Preliminary research shows goliath grouper are strongly affected by decreases in water quality, specifically low dissolved oxygen (DO < 3 mg/L) (Koenig et al 2007)."

"Juveniles can tolerate a wide range of salinities (Smith 1971), but are limited by very low salinities (< 5 ppt). Both juvenile and adult goliath groupers are extremely sensitive to low temperatures, and will die during severe cold weather events (Gilmore et al. 1978). Due to the nearshore life history of goliath grouper, knowledge of water quality in estuarine and coastal waters is critical if we want to comply with all the EFH monitoring and protection requirements of the Magnuson-Stevens Act."

4. UCN Red List: http://www.iucnredlist.org/details/195409/0 (Critically Endangered)

"Habitat: "inshore to about 100 m in reef, mangrove, seagrass, and estuarine habitats" (Sadovy and Eklund 1999)."

"Juveniles live in shallow bays, holes, below undercut ledges in swift tidal creeks draining mangrove swamp, rivers and estuaries while adults live around structures in, near, and offshore (Bullock et al. 1992, Gerber et al. 2005, Koenig et al. 2007). Juveniles exhibit high site fidelity to mangrove habitat for 5-6 years, then emigrate to offshore reefs at body length of about 1 m TL (Koenig et al. 2007)."

"Juvenile distribution in mangroves depends on local water quality, particularly dissolved oxygen content (>4 ppm) and mid-range salinities (>10 ppt) (www.bio.fsu.edu/coleman_lab/goliath_grouper.html, accessed on 31st Dec 2005)."

"During a survey of the freshwater fish of southern Florida from 1976 to 1983, no E. itajara was collected although the salinity-tolerant juveniles could be found in shallow, coastal waters (Loftus and Kushlan 1987). In 181 sites, presence of mangrove areas appears to be important for juveniles (Sadovy and Eklund 1999). Koenig et al. (2007) demonstrated the high nursery value of mangrove to juveniles."

Threats: "Life history characteristics of *E. itajara* make this species highly vulnerable to overfishing (Bullock et al. 1992). *Epinephelus itajara* is of significant commercial and recreational interest. Loss of critical juvenile habitat (i.e., mangroves) would also threaten this species" (Sadovy and Eklund 1999; www.bio.fsu.edu/coleman_lab/goliath_grouper.html, accessed on 31st Dec 2005).

"*Epinephelus itajara* is apparently vulnerable to stresses caused by cold water (Gilmore et al. 1978) or red tide — it was recorded that populations of *E. itajara* were much reduced during a red tide in 1971 and dead individuals over 45 kg were often observed (Smith 1976). During an outbreak of red tide in Florida in March 2003, eleven large dead Goliath Grouper (sized 305 mm to 2,057 mm) washed up near the Sanibel Island Causeway (www.sefsc.noaa.gov/redtidegrouper.jsp, accessed on 4th Jan 2006)."

Gray triggerfish: *Balistes capriscus*

Vulnerability:	Medium vulnerability (SAFMC)
Depth Range:	0 – 55 m
Temperature Range:	Breeding after waters reach 21°C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? “Medium vulnerability. However, detailed life history, movement and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats.”

Ecosystem considerations? “Gray triggerfish use shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level.”

Linkages to other fisheries? “If climate change affects the gray triggerfish fishery, effort may shift to other managed species including coastal migratory pelagic and fisheries for other species in the snapper grouper complex”. “Effort shifts associated with impacts in shelf waters, could result in increased effort on other managed snapper grouper species in the complex. Increased effort associated with a shift could increase the vulnerability of the species if coupled with reduced habitat or productive capacity also associated with climate change.”

Known climate-related concerns? “Changes in ocean currents, increases in ocean temperature and the increase of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species.”

Social and economic concerns? “Considerations would only arise if changes are great enough to result in shift in targeted shelf species or shift to targeting species in deepwater ecosystems.”

Management Risk? Low

2. SEDAR Stock Assessment – SEDAR9_SAR1 GOM Gray Triggerfish.pdf

Pg. 17:
"Ingram (2001) reports gray trigger to have high site fidelity based on tagging. Therefore, seasonal changes in abundance due to emigration/immigration should not be the cause of changes in CPUE."

Pg19: Information on reproduction

Pg. 22: Habitat
"Eggs of Gulf gray trigger incubate in demersal nests between within 12 to 58 hours, after which they enter the plankton (Thresher, 1984)."

3. Florida Museum of Natural History
http://www.flmnh.ufl.edu/fish/gallery/descript/graytriggerfish/graytriggerfish.html

"Preferring hard bottoms, reefs, and ledges, the gray triggerfish is abundant in nearshore and offshore locations. This fish inhabits bays, lagoons, and seaward reefs to depths of 180 feet (55 m). The adults drift along the bottom either alone or in small groups, while the juveniles drift at the surface with sargassum."

Breeding: "During July through September after water temperatures reach 70°F (21°C), gray triggerfish build their nests on the bottom substrate."

Greater amberjack *Seriola dumerili*

Vulnerability: Medium vulnerability (SAFMC)
Depth Range: 18 – 73 m
Temperature Range: Spawning coincides with the increase from 19 to 24 °C
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? “Medium vulnerability. However, detailed life history and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding, schooling and movement associated with structural shelf habitats.”

Ecosystem considerations? “Uses shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH**,** the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level.”

Linkages to other fisheries? “If climate change affects other managed species including coastal migratory pelagic and fisheries for other snapper grouper species, effort could shift to greater amberjack. Effort shifts associated with impacts in shelf waters, could result in increased effort on other managed snapper grouper species or even the deepwater complex.”

Known climate-related concerns? “Changes in ocean temperature, ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species.”

Social and economic concerns? “Considerations would only arise if changes are great enough to result in shift among shelf or movement to deepwater ecosystems.”

Management Risk? Low. The existing Council management system should be able to respond the management needs associated with such change.

2. No SEDAR document available

3. Florida Museum of Natural History
   http://www.flmnh.ufl.edu/fish/Gallery/Descript/GreaterAmberjack/GreaterAmberjack.html

"Subtropical species, often associated with rocky reefs, floating debris, and wrecks at depths ranging from 60-240 feet (18-73m). It has also been reported at inshore locations off the coast of Florida. Studies have shown that some greater amberjack populations are full time residents along the gulf and Atlantic coasts of Florida while other populations migrate from the South Atlantic Bight into inshore waters during certain times of the year."

"Greater amberjack congregate in schools when they are young, however this schooling behavior decreases as the fish grows older. The oldest fish are primarily solitary."

"Opportunistic predators, feed on benthic and pelagic fishes as well as squid and crustaceans. Fish commonly preyed upon by the greater amberjack include the bigeye scad (*Selar crumenophthalmus*) and sardines (*Sardinella aurita*, and *Sardinella pilchardus*). Juvenile greater amberjacks feed on plankton such as decapod larvae and other small invertebrates."

"Predators include larger fishes and seabirds including the yellowfin tuna (*Thunnus albacares*), European hake (*Merluccius merluccius*), brown noddy (*Anous stolidus*), and sooty tern (*Sterna fuscata*)."

"Popular game fish as well as a commercially caught species."

4. Natural spawning of greater amberjack (*Seriola dumerili*) kept in captivity in the Canary Islands
   http://www.sciencedirect.com/science/article/pii/S004484860500414X
   http://dx.doi.org/10.1016/j.aquaculture.2005.06.031

"Spawning took place between April and October, coinciding with the increase in temperature from 19 to 24 °C."

5. FishBase – http://www.fishbase.org/Summary/1005
   Depth range 1 - 360 m (Ref. 1), usually 18 - 72 m (Ref. 2).

References:
1. Randall, J.E., 1995. Coastal fishes of Oman. University of Hawaii Press, Honolulu, Hawaii. 439 p
2. Cervigón, F., 1993. Los peces marinos de Venezuela. Volume 2. Fundación Científica Los Roques, Caracas,Venezuela. 497 p.

Gulf flounder: *Paralichthys albigutta*

Vulnerability:	Low vulnerability (Roffer and Hall, 2015 this document). Vulnerability associated with changing substrates if high sediment loads were to occur from increased stream flow.
Depth Range:	0 – 128 m
Temperature Range:	8 – 32.5 °C
Salinity Range:	6 – 60 ppt, although majority found above 20 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. FWC – Gulf Flounder http://myfwc.com/fishing/saltwater/recreational/flounder/

"Flounder inhabit a wide variety of coastal habitats including brackish water rivers, tidal creeks, bays, estuaries, beaches, muddy or sandy bottoms and near-shore rocky bottoms**."**

4. The Flounder Fishery of the Gulf of Mexico, US. A Regional Management Plan - Gulf States Marine Fisheries Commission. GSMFC Number 083, Oct 2000: GSMFC Number 083.pdf

Pg. 19:
"Gulf (*Paralichthys albigutta*) and southern flounder (*P. lethostigma*) range throughout the Gulf of Mexico from Florida to Mexico. Their habitats, distribution, and abundance change with life history stages and seasonal movements (Sections 3 and 4). They are euryhaline and found in freshwater, brackish water, and saltwater. Gulf and southern flounder are the two most commonly sought species in the Gulf of Mexico because of their larger maximum size. Southern flounder are most common from Mobile Bay, Alabama, to Brownsville, Texas. Gulf flounder are more abundant in the eastern Gulf along the Florida coast."

"Southern flounder have been found to occur in a variety of habitats (Sections 3 and 4). They prefer muddy substrates and are relatively abundant in areas where the substrate is composed of silt and clay sediments. Gulf flounder have been found in association with firm or sandy substrates which are more common in the eastern Gulf of Mexico. The apparent substrate preference of gulf flounder may be more an effect of salinity selection, rather than substrate selection. Estuaries with low freshwater inflow result in higher salinities, low sediment loads, lower turbidity, and firmer substrates."

Pg. 29: Of note is the depth range (m) for the Gulf Flounder: “Shallow to deep to 128” m.

Species	Common Name	Geographic Distribution	Maximum Size (mm)	Depth Range (m)	Notes
Paralichthys albigutta (Jordan & Gilbert 1882)	Gulf flounder	North Carolina to S Florida and the Gulf of Mexico to S Texas and the Bahamas. More common along Florida's Gulf coast and NE Gulf of Mexico (not reported from Mississippi and Louisiana inshore waters)	380 TL	Shallow to deep to 128	Robins et al. 1986. Prefers hard or sandy bottom habitat (Gutherz 1967, Topp & Hoff 1972)
Paralichthys lethostigma (Jordan & Meek 1884)	Southern flounder	North Carolina to N Mexico through Gulf of Mexico. Absent south of Loxahatchee River to south of Caloosahatchee Estuary, Florida	910 TL	Shallow to mid depth to 66	Prefers muddy bottom habitat (Topp & Hoff 1972; Stokes 1977). A single specimen was collected in Florida Bay (FWC/FMRI unpublished data)

Pg. 33:
“Gulf flounder have been shown to tolerate a wide range of temperatures (8°-32.5°C) and salinities ranging from 6‰-60‰ (Table 3.4). However, most researchers report the majority of gulf flounder are found in salinities above 20‰ (Gunter 1945, Simmons 1957, Springer and Woodburn 1960).” “Like southern flounder, adult gulf flounder spend a portion of the year in bays and estuaries and emigrate into deeper waters in the Gulf of Mexico, where spawning takes place during the fall and winter (Ginsburg 1952). The appearance of juvenile gulf flounder in the bays and estuaries begins in January and peaks in March (Stokes 1977).”

Pg. 37/38:
“Table 3.2: Salinities and temperatures at which gulf flounder were collected by area and author. NA = not available or reported.”

State	Salinity (‰)	Temperature (°)	Area	Author(s)
Texas	25.0-35.2 (one of twelve at 9.6)	15.4-30.3	Coastal area	Gunter 1945
	Sharply limited above 45; occasionally found to 60	NA	Laguna Madre	Simmons 1957

(table continues on next page)

State	Salinity (‰)	Temperature (°)	Area	Author(s)
	Above 16.0	Juvenile recommended at 16.0 (as low as 13.8; adults from 10.0-31.0	Aransas Bay	Stokes 1977
Florida	30.7 (n=1)	23.0	Manatee River	Murdock 1957
	13.7-33.7 (very few below 20.0)	11.2-32.5	Tampa Bay	Springer & Woodburn 1960
	37.9	23.0-28.1	Florida Keys	Springer & McErlean 1962
	33.0-36.0	13.0-29.0	St. Andrews Bay	Vick 1964
	7.7-24.7	11.0-30.8	St. Johns River	Tagatz 1967
	33.4-35.7	15.9-27.0	Florida Shelf near Tampa Bay	Topp & Hoff 1972
	17.5-31.5	8.3-30.6	Cedar Key	Reid 1954
	12.0-35.0	13.0-32.0	St. Andrews Bay	Naughton & Saloman 1978
	1.0-37.0 (95%>20.0)	14.0-32.0	Tampa Bay	FWC/FMRI unpublished data
	2.0-38.0 (80%>20)	14.0-33.0	Charlotte Harbor	
	1.0-34.0 (37%>20)	11.0-31.0	Choctawatchee Bay	
	21.0-42.0	16.0-34.0	Florida Bay	
Alabama	6.0-35.0 (rarely below 20)	7.2-31.7	Gulf Beaches/ Perdido Bay	ADCNR/MRD unpublished data
North Carolina	27.5-37.8	9.4-29.5	Beaufort estuaries	Tagatz & Dudley 1961
	Postlarvae: 22.0-35.0	8.0-16.0	Estuary	Williams & Deubler 1968
	Juveniles: 6.0-35.0 (rarely below 20.0)	NA	Pamlico Sound adjacent estuaries	Powell & Schwartz 1977
	30.2-34.5	NA	Newport River	Turner & Johnson 1973

Gulf kingcroaker (kingfish): *Menticirrhus littoralis*

Vulnerability:	Vulnerable (Roffer and Hall, 2015, this document). Seasonal migrations related to temperature. Sensitive to changes in sediment load.
Depth Range:	0 – 50 m
Temperature Range:	Need information
Salinity Range:	Greater than 21 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/46105545/0 (Least concern)
   Depth limit (meters): 1 – 50 m

"This species occurs in coastal waters over sand and sandy mud bottoms and is most abundant in the surf zone, especially juveniles. It sometimes enters estuaries, but rarely occurs in salinities lower than 21 ppt. It feeds on bottom-dwelling organisms, mainly worms and crustaceans (Chao 2002)."

4. South Carolina Dept. of Natural Resource:
   http://www.dnr.sc.gov/cwcs/pdf/Kingfish.pdf

Pg. 2:
"None of the kingfishes are considered threatened or endangered; however, there are concerns in South Carolina regarding by-catch mortality."

"The prevalence of kingfish in near shore, shallow, coastal waters make these species excellent indicators of the health of this ecosystem. In addition, kingfish are a forage item in the near shore oceanic waters for another species of conservation concern, the bottlenose dolphin."

Pg. 2:
"Kingfish prefer near shore, shallow coastal waters with a muddy-sand bottom as well as high salinity bays and estuaries along the coast. The Gulf kingfish favor higher energy areas, such as sand bars, with wave action. The breaking waves suspend small crabs (mole crabs) and other crustaceans that the kingfish feed upon. Gulf kingfish feed by waiting beyond the wash (off-shore where the waves break) for a prey to pass. The same strategy is used at offshore sand bars. The other two kingfish species prefer slightly deeper water with a sandy mud bottom."

"Kingfish can also be found in areas that have sufficient benthic infauna. These animals that live in the sediment, such as polychaetes (sea worms), mollusks (clams and snails) and crustaceans (amphipods, sea-lice) represent an important food source to kingfish. Southern kingfish appear to move south in the winter to areas with warmer water temperatures. They return to South Carolina's waters in the spring as temperatures moderate (Wenner and Sedberry 1989). The gulf and northern kingfish are believed to have a similar migration pattern."

"Kingfish are consistently found in penaeid shrimp fishery by-catch along the southeast coast (unpub. data); this incidental catch can result in death for many kingfish juveniles."

"Poor water quality from increased nutrient runoff and sewage discharges can cause oxygen depletion in kingfish habitat. Dredging offshore sand bars could eliminate some habitat as well as stir up sediments. Elimination of sand bars reduces the amount of high-energy habitat for the gulf kingfish and impacts the benthic infauna that forms the diet of all three species. During dredging activities, sediments and sediment bound chemical toxicants become suspended in the water column. Turbidity that accompanies dredging activities may impact the respiratory lamellae in the gills of the all fishes, resulting in affects similar to terrestrial animals breathing dust."

4. Florida Fish and Wildlife Conservation Commission: http://myfwc.com/media/194748/kingfishes.pdf

Pg. 2:
"Gulf kingfish fed on bivalve siphons, cumaceans, mysids, copepods, amphipods, and polychaetes (McMichael and Ross 1987)."

Gulf menhaden: *Brevoortia patronus*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). "Specific decadal and inter-annual responses in the recruitment of Gulf menhaden to local meteorological and hydrological regimes imposed by the coupling of Atlantic Multi-decadal Oscillation (AMO) and North Atlantic Oscillation (NAO) phases and by El Nino Southern Oscillation (ENSO) events" (Sanchez-Rubio and H. Perry, 2015).
Depth Range:	0 – 50 m
Temperature Range:	5 – 25 °C for larvae and juveniles; eggs = 14 – 22 °C
Salinity Range:	6 – 36 ppt. Larvae require low salinity to complete metamorphosis
Oxygen Rage:	Mean lethal dissolved oxygen = 0.4 mg/l
pH Range:	Need information

1. No Rapid Assessment Profile available

2. SEDAR Report: S32A_GoM_Menhaden_SAR_Final_9.26.2013.pdf:

Pg. 43-47:
Habitat:
"Gulf menhaden range throughout the Gulf of Mexico from the Yucatan Peninsula to Tampa Bay, Florida; however, they are most abundant in the north-central Gulf (Christmas et al. 1982). Gulf menhaden are found in a wide range of salinities, from offshore to freshwater, since their life cycle includes offshore spawning, mostly during winter, with recruitment to and maturation in coastal rivers, bays, bayous, and other nearshore habitats. Upon maturation, the fish return to offshore waters to complete the life cycle. While juveniles and adults are typically found in open water with non-vegetated bottoms, larvae and early juveniles are often found associated with estuarine marsh edges where adequate forage and protection from predators can be found (Reintjes 1970). Upon entering estuaries, post-larvae occupy quiet, low salinity waters to bottom depths of 6.6 ft (Fore and Baxter 1972b). After transformation, most juvenile menhaden remain in nearshore estuaries until they are approximately 100 mm FL (Lassuy 1983)."

"Larvae arrive in the upper estuaries in the early spring after riding the prevailing currents from the offshore spawning grounds (June and Chamberlin 1959, Christmas et al. 1982, Minello and Webb 1997)."

"The Gulf of Mexico is bordered by 207 estuaries (Buff and Turner 1987) that extend from Florida Bay, Florida, to the Lower Laguna Madre, Texas. Perret et al. (1971) reported 5.62 million ha of estuarine habitat in the five Gulf States including 3.2 million ha of open water and 2.43 million ha of emergent tidal vegetation (Lindall and Saloman 1977) and includes 1 million ha of salt marsh (USEPA 1992). Emergent vegetation is not evenly distributed along the Gulf coast with the majority of the Gulf's salt marshes (63%) being located in Louisiana. These areas provide structure for protection and foraging areas to larval and early juvenile Gulf menhaden (Minello and Webb 1997)."

Salinity:
"Offshore spawning necessitates that Gulf menhaden eggs and larvae be euryhaline. Gulf menhaden eggs and larvae have been collected in waters with salinities ranging from 6-36 ppt (Fore 1970, Christmas and Waller 1975); 88% of the eggs were collected from waters over 25 ppt. Collections of eggs and larvae were made throughout the Gulf of Mexico at the peak of spawning from waters ranging in salinity from 20.7-36.6 ppt (Table 2.1; Christmas et al. 1982). As the larvae move inshore, they require low salinity waters to complete metamorphosis from the larval body form to the deeper–bodied juvenile/adult form. June and Chamberlin (1959) observed that arrival in estuaries may be essential to the survival of larvae and their metamorphosis to juveniles based on food availability and lower salinities. Combs (1969) found that gonadogenesis occurred only in menhaden larvae that arrived in euryhaline, littoral habitats."

"The value of low salinity marsh habitat to juvenile Gulf menhaden is well known, but not well documented. Only a few studies have looked at the dependence of nektonic menhaden on low salinity marshes as nursery habitat. Gunter and Shell (1958) reported that young menhaden enter upper marshes with salinities around 0.9 ppt at Grand Lake, part of the Mermentau River Basin, Louisiana. Copeland and Bechtel (1974) investigated the environmental parameters associated with several commercial and recreational species and reported juvenile Gulf menhaden were most frequently collected in primary rivers and secondary streams at salinities ranging from 0-15 ppt. The authors point out that these low salinity waters supported the greatest numbers of juvenile menhaden (Copeland and Bechtel 1974). Likewise, Chambers (1980) found a similar relationship among young Gulf menhaden and both freshwater and low salinity, brackish areas in the upper Barataria Basin of Louisiana."

"Tolan and Nelson (2009) determined that after examining a number of abiotic factors in three tidal streams in the Matagorda Bay estuary, Texas, salinity was the driving factor in determining fish assemblages. Juvenile and sub-adult Gulf menhaden were found be the most abundant species in all three tidal creeks over the course of their study and community responses were based on the prevailing salinity regime more than dissolved oxygen."

"Recent observations by Haley et al. (2010) found larval and juvenile menhaden up to 79 river miles upstream on the Alabama River, near the Claiborne Lock and Dam. Although the authors did not record station salinities, the drought situation that occurred during their sampling season may have pushed the salt wedge, and consequently associated ichthyoplankton, farther upriver than during 'normal' years."

Temperature:
"Gulf menhaden occupy a wide range of habitats; therefore, temperature may be more critical to egg development than to juveniles and adults, although Gulf menhaden are

occasionally victims of large fish kills related to freeze events (Hildebrand and Gunter 1951, McEachron et al. 1994)."

"Turner (1969) collected eggs and larvae from stations off northern Florida at surface water temperatures ranging from 11.0°C (February) to 18°C (March). In southern Florida, samples were taken from 16°C (January) to 23°C (March), and in Mississippi Sound, temperatures ranged from 10°C (January) to 15°C (December)."

"Larval and juvenile menhaden have been collected in Gulf estuaries at temperatures ranging from 5-35°C (Table 2.1; Christmas and Waller 1973, Perret et al. 1971, Swingle 1971). Reintjes and Pacheco (1966) cited references indicating that larval menhaden may suffer mass mortalities when water temperatures are below 3°C for several days or fall rapidly to 4.5°C. Likewise, juvenile and adult menhaden suffer cold kills during periods of freezing winter conditions, especially in narrow or shallow tidal areas."

Dissolved Oxygen (DO)
"Large fish kills occur in summer as well, often resulting from plankton blooms and low dissolved oxygen (DO) or hypoxic conditions. Mass fish mortalities, which include Gulf menhaden, attributed to low DO concentrations have occurred in most Gulf estuaries (Crance 1971, Christmas 1973, Etzold and Christmas 1979)."

"Post-larvae and juveniles are frequently killed by anoxic conditions in backwaters (e.g., dead-end canals) during summer. Hypoxic and anoxic conditions may also occur in more open estuarine areas as a result of phytoplankton blooms. In Louisiana, west of the Mississippi River delta, low DOs in nearshore Gulf waters may serve to concentrate schools of Gulf menhaden closer to shore as they avoid hypoxic areas known as the 'dead zone'. The 'dead zone' results from increased levels of nutrient influx from freshwater sources coupled with high summer water temperatures, strong salinity-based stratification, and periods of reduced mixing (Justic et al. 1993). Most life history stages of Gulf menhaden, from eggs to adults, occur inshore (i.e., inshore of the 10 fathom curve) of areas where historically the hypoxic zone 'sets up' by midsummer. Gulf menhaden appear to be only moderately susceptible to low DOs and probably move out of hypoxic areas, resulting in displacement rather than mortality."

"Preliminary analyses of menhaden logbook data suggest that, during some years, exceptionally low catches of Gulf menhaden off the central Louisiana coast may have been a result of hypoxic waters impinging upon nearshore waters in midsummer (Smith 2001). The close association that Gulf menhaden have with estuaries during summer tends to decrease the effects these offshore hypoxic areas have on the population."

Habitat Elasticity:
"O'Connell et al. (2004) examined the fish assemblages that occurred in the Lake Pontchartrain estuary from roughly 1950-2000 using museum specimens and collections. Over the 50 years of records, they found that although the estuary had deteriorated substantially in environmental quality, Gulf menhaden did not change in their frequency or position within the estuary while a number of other species had.

Overall the assemblage shifted from a croaker-dominated complex to an anchovy-dominated complex, suggesting that Gulf menhaden are very elastic in their ability to handle changing environmental conditions, both short and long-term (O'Connell et al. 2004)."

Table 2.1 Optimum temperature and salinity conditions for the egg and larval stages based on the habitat suitability indices (HSI) for Gulf menhaden (Christmas et al. 1982).

Life History Stage	Salinity (ppt)	Temperature (°C)
eggs/yolk-sac larvae (marine)	25-36*	14-22*
feeding larvae (marine)	15-30*	15-25*
feeding larvae/juveniles (estuarine)	5-13*	5-20*

*lowest mean monthly winter value

3. SEDAR Stock Assessment – Atlantic Menhaden 2003 Stock Assessment Report.pdf:

Pg39:
"An additional source of mortality are fish "kills", which occur when schools of menhaden enter enclosed inshore bodies of water in such large numbers that they consume all available oxygen and suffocate. The mean lethal dissolved oxygen concentration for menhaden has been reported to be 0.4 mg/l (Burton et al. 1980). Bluefish are known to follow (or even chase) schools of menhaden inshore, feeding on them, and may contribute to their mortality by preventing them from leaving an area before the oxygen supply is depleted. High water temperatures, which increase the metabolic rate of the fish, accelerate oxygen depletion."

4. SEDAR Stock Assessment – SEDAR20-ASMFC_Menhaden_SAR.pdf

Pg. 43:
"Stone (1976) conducted a series of stepwise regressions of gulf menhaden, B. patronus, catch and effort related to a wide range of environmental data (air temperature, water temperature, rainfall, tides, and wind speed and direction). Not unexpectedly, several significant correlations were found including minimum and mean air temperature, maximum water temperature, and wind direction at several locations, resulting in an R2 value of 0.86. Subsequently Guillory refined much of this work to forecast Louisiana gulf menhaden harvest (Guillory et al. 1983; Guillory 1993). As a congener of gulf menhaden, Atlantic menhaden might be expected to respond to similar environmental factors."

"Govoni (1997) demonstrated an inverse relationship between freshwater discharge from the Mississippi River on gulf menhaden recruitment. Subsequent analyses have shown this relationship continues to hold (Vaughan et al. 2000; and subsequent revisiting). This approach was applied to Atlantic menhaden using freshwater inflow to Chesapeake Bay from the major rivers in Maryland and Virginia without obtaining statistically significant results, presumably because the freshwater inflow to

Chesapeake Bay does not dominate the recruitment success of Atlantic menhaden as it does for gulf menhaden affected by Mississippi River flow. Although not statistically significant in Chesapeake Bay, recruitment strength is negatively correlated with freshwater flow in spring and positively correlated with Secchi depth (Houde and Harding 2009). Overall, recruitment of menhaden to Chesapeake Bay tends to be low in years when late winter early spring conditions are dominated by climatic patterns characterized by high precipitation and freshwater flow (Kimmel et al. 2009)."

5. Population biology and life history of the North American menhadens, *Brevoortia spp*. Mar. Fish. Rev. 53(4): 3-19. mfr5342.pdf

Pg. 4:
"Menhaden are estuarine dependent, marine migratory species. Spawning generally occurs during the cooler months in the marine environment, and larvae undergo early growth and development at sea. About 1-2 months later, those larvae that have been transported shoreward enter estuarine bays, sounds, and streams, and metamorphose into juveniles. Menhaden juveniles (young-of-the-year) normally reside in estuarine areas until the following fall or early winter when many migrate into marine waters. Adults generally occur in nearshore oceanic waters and frequently reside in large estuarine systems."

6. FishBase: http://www.fishbase.org/summary/1589

Depth range 0 – 50 m
(Reference: Whitehead, P.J.P., 1985. FAO Species Catalogue. Vol. 7. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. FAO Fish. Synop. 125(7/1):1-303. Rome: FAO.)

7. G. Sanchez-Rubio and H. Perry. 2015. Climate-related meteorological and hydrological regimes and their influence on recruitment of Gulf menhaden (Brevoortia patronus) in the northern Gulf of Mexico. Fish. Bull. 113:391–406 (2015).
Online publication date: 14 August 2015. doi: 10.7755/FB.113.4.3
"Abundances of Gulf menhaden (Brevoortia patronus) in the northern Gulf of Mexico (GOM) are heavily influenced by physical and biological processes that affect refuge and food availability. This study identified specific decadal and interannual responses in the recruitment of Gulf menhaden to local meteorological and hydrological regimes imposed by the coupling of Atlantic Multidecadal Oscillation (AMO) and North Atlantic Oscillation (NAO) phases and by El Nino Southern Oscillation (ENSO) events".

Harvestfish: *Peprilus paru*

Vulnerability:	Need more information to determine status
Depth Range:	50 – 70 m
Temperature Range:	Need information
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. IUCN Red List http://www.iucnredlist.org/details/154624/0 (Least concern)
   Depth limit (meters): 50 – 70 m

"This species has a large distribution around the western Atlantic. Although this species is harvested as a food source, this threat is not known across its entire range, and there is no evidence that the population is in decline."

"The American Harvestfish (*Peprilus paru*) is known from Florida, the Gulf of Mexico, and the coasts of Venezuela, Trinidad, and the Antilles. It may infrequently be found in the western Caribbean, but is absent from the Bahamas. Along the Atlantic coast, it extends from its northerly limit of Chesapeake Bay, south to Uruguay and Argentina (R. Haedrich pers. comm. 2008)."

"Pelagic species, found to occur all year round in large schools within coastal bays. Juvenile forms are found in shallow coastal waters under floating weeds or in association with the *Scyphomedusae*, *Chrysaora quinquecirrha* (Mansueti 1963). Adults will feed on jellyfish, small fish, worms, and crustaceans, while juveniles are primarily plankton feeders."

"Commercially harvested in the inshore waters of eastern Florida, the northeastern part of the Gulf of Mexico, western Venezuela, the Guianas, and occasionally the Campeche Bank. All fishing activity uses otter trawls. This species is marketed fresh and frozen and exported predominantly to Japan. With the exception of a period in the 1960s, landings of this species were historically low until the 1990s, when the fishery off Venezuela developed. At present, harvesting of this species as a food source is not considered to be a major threat to the overall population."

"There are no species-specific conservation measures in place for the American Harvestfish. However, its distribution may cover a number of marine protected area designations."

Hogfish: *Lachnolaimus maximus*

Vulnerability:	Low to medium vulnerability (SAFMC). Very vulnerable (Roffer and Hall, 2015 this document - "Changes in ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species." Dependent on coral reef ecology. Their extended planktonic larval phase (30 – 40 days) suggests that current changes would have substantial impact on recruitment.)
Depth Range:	3 – 30 m (observed deeper than 60 m); IUCN lists 40 m
Temperature Range:	Optimum tank requirements: 22 – 28 °C; Spawning requires narrow temperature range: 24 – 27 °C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Optimum tank requirements: 8.1 – 8.4

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under own section as Scamp
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? "Hogfish would generally have low to medium vulnerability to impacts of climate change. However, detailed life history and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats."

Ecosystem considerations? "Hogfish use nearshore (off Florida) and shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level."

Linkages to other fisheries? "If climate change affects other managed species including coastal migratory pelagic and fisheries for other snapper grouper species, effort could shift to target hogfish." "Effort shifts associated with impacts in near-shore waters, could result in increased effort on the shelf for other managed snapper grouper species or even the deepwater complex."

Known climate-related concerns? "Changes in ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species."

Social and economic concerns? "Considerations would only arise if changes are great enough to result in shift among shelf or movement to deepwater ecosystems".

Management Risk? Low – "The existing Council management system should be able to respond the management needs associated with such change".

2. SEDAR Stock Assessment – SEDAR6_SAR2_hogfishall.pdf

Pg. 14:
"The Florida hogfish fishery is an economically-important part of the snapper-grouper complex of about 60 exploited reef fishes. As a consumer of shrimp, crabs and clams, hogfish play an essential ecological role within the larger multispecies reef fish community in the Florida coral reef ecosystem comprised of about 350 reef fishes and macroinvertebrates. Concern about the sustainability of the hogfish fishery has prompted a more in depth look at the status of the stock."

"Hogfish are protogynous (i.e., female first) hermaphrodites that live to a maximum age of 23 years."

Pg. 17:
"In Florida, hogfish are primarily found in the warm subtropical and tropical waters of the coral reef ecosystem; however, hogfish have a recorded range from Nova Scotia, Canada, to northern South America, to Bermuda, the Caribbean Sea and the Gulf of Mexico. In the coral reef ecosystem hogfish are primarily associated with shallow (i.e., 3-30 m), low relief (<1.5 m) mixed hardbottom-seagrass and patch reef environments (Robins and Ray 1986, Randall 1996)."

"In Florida, juvenile hogfish have been reported from Florida Bay in winter and spring (Tabb and Manning 1961), in Biscayne Bay Thalassia beds during summer (Roessler 1964), and in the Marquesas region during July (C. Messing, pers. comm.). Larger mature fish are normally found on the reefs, although hogfish are often encountered where gorgonian covered low-relief hardbottoms are found (FISHBASE www.fishbase.org 2003, Franklin et al. 2003). Such observations suggest ontogenetic migrations occur between the shallow coastal lagoons that serve as nursery areas for juveniles that ultimately migrate to the offshore coral reef and hardbottom habitats as mature adults."

3. SEDAR Stock Assessment – SEDAR37_Hogfish_SAR.pdf

Pg. 27:
"Distribution
Hogfish occur in tropical, subtropical and warm temperate waters of the Atlantic Ocean (Brazil to Bermuda), and throughout the Gulf of Mexico and Caribbean Sea. After a planktonic larval phase (30 – 40 days), juvenile Hogfish settle nearshore in estuaries, seagrass beds or shallow reef habitats (Davis, 1976; Colin, 1982; Ault et al. 2003), and gradually move offshore with growth (Collins and McBride 2011). Adults are typically

associated with hard bottom, reef habitats, and individuals have been observed as deep as 65 m (Collins and McBride 2011). Hogfish are visual predators that feed primarily during daylight hours on benthic invertebrates (Randall and Warmke, 1967), so their depth range is likely limited by light availability and food sources"

Pg. 30:
"Maximum Age
Hogfish have been aged to 23 years (McBride and Richardson, 2008). As monandric, protogynous hermaphrodites, the oldest and largest fish are male. The oldest female aged to date was 10 years of age (685 mm FL; Collins and McBride 2011); all fish older than 10 are expected to be male."

"Spawning Season
Peak spawning activity for this species has been repeatedly demonstrated to occur during the winter and spring months (Davis 1976; Colin, 1982; Claro et al., 1989; McBride and Johnson, 2007; Collins and McBride, 2008; Munoz et al 2010). These studies have demonstrated that spawning activity occurs predominantly during the months of December through April, and begins (and ends) slightly earlier in the Florida Keys than on the West Florida shelf (Davis, 1976; McBride et al., 2008). Large Hogfish collected in deeper water (> 30 m) on the west Florida shelf have shown evidence of a more protracted spawning season, and approximately 50% of females were reproductively active during all months except September (Collins and McBride 2008)."

Pg. 34:
"EFH, Habitat Quality and Ontogenetic Shifts
Juvenile Hogfish typically settle in polyhaline estuarine seagrass beds or nearshore reef habitats after a pelagic larval phase (Davis, 1976; Colin, 1982). As fish increase in size, they are assumed to leave shallow inshore areas and move gradually into deeper water (Davis, 1976; Collins and McBride 2011). Adults are most common over reef and hard bottom habitats that provide structural cover, and have been observed at depths >60 m. Their distribution is likely limited by light penetration and habitat and prey availability. Healthy benthic invertebrate infauna and epifauna are critical diet items (e.g., bivalves, crustaceans, echinoderms; Randall and Warmke, 1967), and severe red tides that cause widespread invertebrate die-off can result in Hogfish departure or mortality (A Collins, personal observation)."

"Movements and Migrations
There are little data regarding the movement patterns of Hogfish. Hogfish tagged in the Florida Keys as part of a telemetry study were shown to have high site fidelity and restricted home ranges (Lindholm et al., 2006). Further, Colin (1982) and Muñoz et al. (2010) reported high site fidelity and restricted home ranges during the spawning season for Hogfish at specific sites in Puerto Rico and the FLK, respectively. Although further study is needed regarding home range size and site fidelity outside of spawning periods, consistent sex ratios observed throughout the year (Collins and McBride 2011) suggest that Hogfish maintain home ranges and territories for extended periods. Removal of the dominant male does not appear to necessitate harem relocation; rather

it is more likely that one of the females will transition to male or that a nearby male will fill the void."

4. Florida Museum of Natural History
   https://www.flmnh.ufl.edu/fish/Gallery/Descript/Hogfish/Hogfish.html

"Geographical Distribution
In the western Atlantic Ocean, the hogfish occurs from Bermuda and North Carolina, south through the Caribbean Sea and northern Gulf of Mexico, continuing to the north coast of South America. It is very common off Florida and the islands of the Caribbean in shallow waters. Juveniles are often found in seagrass beds in Florida Bay."

"Habitat
This fish is commonly found over open bottoms and coral reefs at depths ranging from 10-100 feet (3-30m). The hogfish is often encountered in areas where gorgonians are abundant. The hogfish is widely distributed along the edges of the reef, forming small groups. It prefers locations with hard sand and rock bottoms near shallow patch reefs just inshore and offshore from the main reef structure. Larger individuals occur in the main reef area while smaller fish reside among the patch reefs."

"Reproduction
Hogfish are protogynous hermaphrodites. Females, upon reaching larger size and through social dominance, can transform into fully functional males. This often occurs at 3 years of age and lengths of approximately 14 inches (35.5 cm). In waters off south Florida, peak spawning occurs during the months of February and March. Hogfish schools consist of groups of females dominated by a larger male, referred to as a harem. The male guards his harem, spawning exclusively with the females within it. Spawning occurs in later afternoon and early evening. This event involves male courtship of the female, followed by a rush towards the surface. The male and female release gametes into the surrounding water where fertilization takes place. The fertilized, pelagic eggs rapidly develop into larvae, hatching approximately 24 hours after fertilization occurs. This larvae stage lasts several weeks until they grow into juveniles and settle out of the water column, onto suitable habitat. Juvenile hogfish have an oval profile and are compressed laterally. Reddish in color with faint vertical bands, they are commonly observed around seagrass beds."

5. IUCN Red List http://www.iucnredlist.org/details/11130/0(Considered Vulnerable)
   Depth Range: 3 – 40 m

"Population
In the past *Lachnolaimus maximus* had moderate abundance over shallow west Atlantic coral reefs, but is now depleted in many areas due to fishing. Large populations are maintained at only a few sites including Los Roques (Venezuela), Bermuda and at some sites in the Florida Keys (J.H. Choat pers. comm. 2008). Overall the population has declined over most of its range."

“Habitat and Ecology
Lachnolaimus maximus is found on coral reefs at 3-40 m depth, especially sandy outer reef slopes. Juveniles are most common in shallow seagrass, and inshore reef habitats.”

“It is a monadric protogynous hermaphrodite (McBride and Johnson 2007) with a very slow rate of sex change (several months that occurs post spawning). It has an extended spawning season from January to May. In Florida, females attain sexual maturity at two years 26.0 cm (FL), sexual transition at three to five years but recorded in individuals up to 13 years. Reproductive aggregations have been observed in Los Roques (J.H. Choat pers. comm. 2008).”

“Major Threat(s)
Coral reefs of the Caribbean had been heavily damaged by disease, coastal development, coral bleaching, and over-fishing. It is predicted that reefs away from population centres will remain healthy in the future, unless the adverse predictions for global climate change, of more tropical storms and bleaching occur (Andrews et al. 2004). *Lachnolaimus maximus* is also a common species within the aquarium trade.”

6. Florida Fish and Wildlife Conservation Commission: hogfish.pdf
   http://myfwc.com/media/194726/hogfish.pdf

“Peak spawning occurs during February and March in south Florida and may vary due to a narrow temperature requirement, 24°C–27 °C (Colin 1982).”

7. Fresh Marine: Hogfish http://www.freshmarine.com/hogfish.html

“Ideal Marine Aquarium Environment.
Hogfish are Hardy fish and can tolerate wide changes in water conditions. However, optimum water conditions required by Hogfish are the temperature of 72-83°F; a Specific gravity of 1.020-1.025; and the pH of 8.1-8.4. Moreover, your tank must have ample Corals, Rocks, and Caves for Hogfish to hide as well as to provide it Reef type environment.”

King mackerel: *Scomberomorus cavalla*

Vulnerability: Vulnerable (SAFMC).
Very vulnerable (Roffer and Hall, 2015, this document. Dependency on temperatures. Likely to expand northerly range as water warms.)
Depth Range: 23 – 34 m
Temperature Range: 20 to 29 °C
Salinity Range: Larvae: 26.9–35 ppt
Oxygen Rage: Need information
pH Range: Need information

2013: $6,090,887.00, 1,017.6 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Yes - early life stages to variability of current, temperature and productivity

Ecosystem considerations? Yes – prey is estuarine dependent; Year class strength correlated with ocean temperature. Increased ocean temperatures affect survival and distribution of larvae along shelf; upwelling events affect the movement and availability i.e. long term impacts

Linkages to other fisheries? Yes – re-directed effect on snapper grouper complex

Known climate-related concerns? Increase in episodic upwelling events affects movement/migration, i.e. availability

Social and economic concerns? Significant loss of productivity and/or availability

Management Risk? Little Management risk - management can adapt quickly

2. SEDAR Stock Assessment – S5_SAR1_complete.pdf

Pg. 58:
Pauly, Daniel. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39:175-192.

Table 1: Estimated natural mortality parameters (M) for king mackerel based on the Pauly method, by Migratory Unit and sex, for various temperature values.

Migratory Group			Temperature (°Celsius)		Expected M	
	L infinity	k	20	22	20°C	22°C
Male Atlantic	94	0.19	-0.97257	-0.92841	0.366929	0.383499
	127	0.15	-1.21119	-1.16702	0.289036	0.302088
Male Gulf	111	0.14	-1.21876	-1.1746	0.286855	0.299809
	103	0.25	-0.81852	-0.77435	0.428043	0.447372
Female Atlantic	121	0.13	-1.29132	-1.24715	0.26678	0.278827
Female Gulf	142	0.14	-1.28748	-1.24331	0.267806	0.279899
	138	0.17	-1.15247	-1.10831	0.306516	0.320357

3. SEDAR Stock Assessment – SEDAR16_final_SAR.pdf

Pg. 24:
"US fisheries exploited two groups or stocks of king mackerel, one from the Gulf of Mexico and the other from the Atlantic, but that there was considerable mixing between them, at least during part of the year in South Florida. During the winter (November 1 to March 31) the Flagler-Volusia County line in Florida separated the two groups, and, in the summer (April 1 to October 31), the Monroe-Collier County line in Florida separated the two groups."

Pg. 99:
"King mackerel, like many other scombrids, undertake seasonal migrations. For example, catch per unit of effort is correlated with water temperature in the eastern Gulf and Atlantic waters of the US southeast, and fishery dependent data clearly demonstrate an increase in fish availability in winter off south Florida (Fable et al. 1981; Trent et al. 1987). As water temperatures warm in spring, fish migrate northward and return to summer spawning grounds (Powers and Eldridge 1983; Sutter et al. 1991; Schaefer and Fable 1994)."

4. SEDAR Stock Assessment – SEDAR_38_SA_SAR.pdf: 2014

Pg. 48: Review of Working Papers:
"SEDAR38-DW-07: Analysis of environmental factors affecting king mackerel landings along the east coast of Florida:
In winter king mackerel from both the Gulf and Atlantic stocks migrate to warmer southeast and south Florida waters, an area known as the "mixing zone", where water and air temperatures are moderated by the Florida current. Changes in temperature regimes within this mixing zone may have measurable and predictable effects on the composition of stocks within the mixing zone along with the migration and persistence of Atlantic and GOM stocks into the southeast and south Florida. Several environmental drivers could influence the temperature regimes, including meteorologically significant seasonal weather patterns such as historically cold winters as well as regionally significant climatological (e.g. El Nino & La Nina) and summer upwelling events; and

such information should be considered for incorporation into fisheries models. A comparison of mean Dec. and Jan. surface water temperatures off Cape Canaveral, FL with monthly king mackerel landings suggested a positive relationship."

Pg. 282:
"Integrated Ecosystem Assessment Ad-Hoc Working Group: Overview-
… Specifically, King mackerel are recognized to be isothermic, with an adult temperature preference of ~ 20 ºC (Beaumarige 1973), where latitudinal migration patterns result from seasonal temperature changes (see SEDAR 16 SAR). Off west-central Florida, strong associations were observed between recreational catch statistics derived from seasonal tournaments and environmental conditions including water clarity and presence of baitfish (see Wall 2006). Climate change has been recognized as an important environmental stressor where increasing water temperatures have altered distributions of important fishery populations in the Gulf of Mexico, as well as the Northeast Atlantic (Pinsky et al. 2013), for taxa including Atlantic mackerel (see Overholtz et al. 2011)."

Ref 2: Malin L. Pinsky, Boris Worm, Michael J. Fogarty, Jorge L. Sarmiento, and Simon A. Levin. Marine Taxa Track Local Climate Velocities. Science 13 September 2013: 341 (6151), 1239-1242. [DOI:10.1126/science.1239352]

Pg. 341:
"Environmental/Ecosystem considerations:
None of the three environmental indices [mean SST, degree days >72°C, and an index of upwelling] showed any substantial correlation with CPUE residuals or with recruitment deviations. Furthermore an exhaustive exploration of the correlation between handline CPUE and temperature metrics (Harford et al 2014) was explored and no clear correlation was found. This does not indicates that environmental factors are not important in king mackerel population dynamics, it simply means that, of the metrics explored- mean SST, degree days >72°C, and an index of upwelling, none of them were significantly correlated with CPUE deviations or recruitment deviations. Other environmental factors such as freshwater runoff, water quality, predator-prey interactions, etc. should be explored in the future and may be important indicators of recruitment. Nonetheless, even if the explicit environmental mechanism is not known or explicitly modeled, the estimated recruit deviations are a product of the environment. Essentially they represent all of the factors not explicitly considered that determine recruitment in a given year."

5. IUCN Red List http://www.iucnredlist.org/details/170339/0 (Least concern)

"Larvae are encountered in surface waters of 26.3–31°C and 26.9–35 ppt."

6. Florida Museum of Natural History: http://www.flmnh.ufl.edu/fish/gallery/descript/kingmackerel/kingmackerel.html

"King mackerels occur in depths between 75.5 - 111.5 feet (23 - 34 m). Dependent upon warm temperatures, king mackerel can migrate along the east coast of the U.S. The Gulf of Mexico and Atlantic populations migrate separately, with the division lines being in Volusia-Flagler counties of southeast Florida in November through March and in Monroe-Collier counties of southwest Florida during April through October."

7. NOAA Fish Watch
http://www.fishwatch.gov/seafood_profiles/species/mackerel/species_pages/king_mackerel.htm

"They are a "coastal pelagic" species, meaning they live in the open waters near the coast in water 115 to almost 600 feet deep. King mackerel prefer warm waters and seldom enter waters below 68 degrees F. They migrate with seasonal changes in water temperature and with changes in food availability. Swimming in large schools, they migrate to the northern part of their range in the summer and to the southern part in the winter."

Additional References:

1) Temperature tolerance in 'Location and Habitat':
http://www.fishwatch.gov/seafood_profiles/species/mackerel/species_pages/king_mackerel.htm
2) Exploitation, population, density, temperature, and prey availability: Shepard et al. Page: 528.
http://www.ingentaconnect.com/content/umrsmas/bullmar/2010/00000086/00000003/art00002
3) Potential source for temperature dependency: 2010 Shepard; Trends in Atlantic Contribution to Mixed-Stock King Mackerel Landings in South Florida Inferred from Otolith Shape Analysis;
http://www.tandfonline.com/doi/pdf/10.1577/C09-014.1

Northern kingcroaker or kingfish: *Menticirrhus saxatilis*

Vulnerability:	Need more information to determine status
Depth Range:	1 – 128 m
Temperature Range:	Need information
Salinity Range:	Juveniles enter tidal rivers and creeks with salinities less than 1%.
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. IUCN Red List http://www.iucnredlist.org/details/46105847/0 (Least concern).
   Depth limit (meters): 0 – 128 m

"Shallow coastal waters over sand to sandy mud bottoms and is rather common in the surf zone and in estuaries. It is typically found with other *Menticirrhus spp*. in the surf zone (J. Tolan pers. comm. 2014). It has been recorded down to 128 m depth (Castro-Aguirre in press). Juveniles may enter tidal rivers and creeks of low salinity (less than 1%). It feeds mainly on crustaceans and polychaetes, but detritus has also been found in stomach contents (Chao and Musick 1977)."

4. South Carolina Dept. of Natural Resources:
   http://www.dnr.sc.gov/cwcs/pdf/Kingfish.pdf

Pg. 1:
"It is difficult to obtain reliable estimates of the landings because neither group of fishermen separates landings by species. For example, all three kingfishes are listed as "king whiting" in the commercial statistics of the National Marine Fisheries Service (NMFS Commercial Fisheries Statistics 2005) for the east coast. The recreational statistics are also problematic due to confusion of the species by port samplers and creel clerks."

Pg. 2:
"None of the kingfishes are considered threatened or endangered; however, there are concerns in South Carolina regarding by-catch mortality."

"The prevalence of kingfish in near shore, shallow, coastal waters make these species excellent indicators of the health of this ecosystem. In addition, kingfish are a forage item in the near shore oceanic waters for another species of conservation concern, the bottlenose dolphin."

“Kingfish prefer near shore, shallow coastal waters with a muddy-sand bottom as well as high salinity bays and estuaries along the coast. The Southern and Northern kingfish species prefer slightly deeper water with a sandy mud bottom.”

“Kingfish can also be found in areas that have sufficient benthic infauna. These animals that live in the sediment, such as polychaetes (sea worms), mollusks (clams and snails) and crustaceans (amphipods, sea-lice) represent an important food source to kingfish. Southern kingfish appear to move south in the winter to areas with warmer water temperatures. They return to South Carolina’s waters in the spring as temperatures moderate (Wenner and Sedberry 1989).”

“Kingfish are consistently found in penaeid shrimp fishery by-catch along the southeast coast (unpub. data); this incidental catch can result in death for many kingfish juveniles.”

“Poor water quality from increased nutrient runoff and sewage discharges can cause oxygen depletion in kingfish habitat. Dredging offshore sand bars could eliminate some habitat as well as stir up sediments. During dredging activities, sediments and sediment bound chemical toxicants become suspended in the water column. Turbidity that accompanies dredging activities may impact the respiratory lamellae in the gills of the all fishes, resulting in affects similar to terrestrial animals breathing dust.”

Other reef fish:

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Life history dependent on coral reef ecosystem.
Depth Range:	0 – 50 m (as per coral reefs)
Temperature Range:	Minimum temperature: 18 °C; optimal: 26–27 °C (as per coral reefs)
Salinity Range:	Optimal: 34 – 37 ppt (as per coral reefs)
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

Reef fish are vulnerable to climate change due to their high degree of association with the coral reef ecosystem. There are multiple species to species interactions as functions of their habitat and age structure. Environmental factors affecting reef fish are water pH, coral bleaching, thermal stress and turbidity from coastal run-off.

Included in this category are reef fish such as aquarium fish, angelfish, boxfish, goatfish, grunts, wrasses, jacks, scups, porgies, squirrelfish, surgeonfish, triggerfish and filefish.

3. Comprehensive Annual Catch Limit (ACL) amendment for the U.S. Caribbean, October 25, 2011
   http://www.caribbeanfmc.com/fmp%20ACLS/final%202011_Caribbean_ACL_Amendment_FEIS_102511.pdf

Pg. 242
"Stresses affecting each of these resources [reef fish, spiny lobster, conch resources, and coral and reef associated plants and invertebrates] include directed fishing mortality, habitat loss and degradation, increasing demand for food and feed, and environmental changes (e.g., hurricanes, changes in temperature, climate change, etc.). For example, how global climate changes will affect Caribbean fisheries is unclear. Climate change can affect marine ecosystems through ocean warming by increased thermal stratification, reduced upwelling, and sea level rise; and through increases in wave height and frequency, loss of sea ice, and increased risk of diseases in marine biota. Decreases in surface ocean pH due to absorption of anthropogenic CO2 emissions may impact a wide range of organisms and ecosystems, particularly organism that absorb calcium from surface waters, such as corals and crustaceans (IPCC 2007, and references therein)."

"The status of many of these species is not regularly assessed, as they are not considered undergoing overfishing. Even if overfishing is not occurring, MSRA requires NOAA Fisheries and/or the Councils to implement conservation and management measures to prevent these species to become overfished."

Pinfish: *Lagodon rhomboids*

Vulnerability:	Minimal vulnerability (Roffer and Hall, 2015, this document) Euryhaline and eurythermal
Depth Range:	0 – 92 m
Temperature Range:	10 – 35 °C
Salinity Range:	0 – 75 g/L (ppt)
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/170250/0 (Least concern)
   Depth limit (meters): 0 – 92 m

"The Pinfish occupies vegetated bottoms, occasionally over rocky bottoms and in mangrove areas over a wide depth range (zero to 92 m)." "Recruitment of young Pinfish in shallow water areas takes place in late fall, winter, and spring, with a peak in late winter and early spring (Hansen 1970, Darcy 1985)."

4. Southern Regional Aquaculture Center, 2011
   http://fisheries.tamu.edu/files/2013/09/SRAC-Publication-No.-7210-Species-Profile-Pinfish-Lagodon-rhomboides.pdf

Pg. 1:
"Pinfish tolerate water temperatures ranging from 50 to 95 °F (10 to 35 °C) and salinities from 0 to 75 g/L (ppt)."

5. Smithsonian Marine Station at Fort Pierce
   http://www.sms.si.edu/irlspec/Lagodo_rhombo.htm

Temperature:
"Pinfish are considered to be quite tolerant of wide temperature fluctuations. Fish in shallow areas may experience seasonal high temperatures up to 35 °C and lows of 12 °C or less. Cold tolerance is increased with acclimation time to the cooler temperature (Reber & Bennett 2007)." Reference: Reber, CM & WA Bennett. 2007. The influence of thermal parameters on the acclimation responses of pinfish *Lagodon rhomboides* exposed to static and decreasing low temperatures. J. Fish Biol. 71: 833-841.

Salinity:
"Studies examining the influence of salinities ranging from 0 to 60 ppt on juvenile pinfish have found that the highest rates of growth and survival occur at estuarine salinities of 15 to 30 ppt (Shervette et al. 2007)."

Reference: Shervette, VR, Ibarra, N & F Gelwick. 2007. Influences of salinity on growth and survival of juvenile pinfish *Lagodon rhomboides* (*Linnaeus*). Environ. Biol. Fish. 78: 125-134.

6. North Carolina Division of Marine Fisheries (DMF):
   http://portal.ncdenr.org/web/mf/pinfish

Habitat:
"Pinfish are found around pilings, rocks and vegetated areas in shallow waters from Cape Cod, Mass., to Yucatan, Mexico, including the Gulf of Mexico, Bermuda and the northern coast of Cuba."

Eating habits:
"Pinfish eat shrimp, fish eggs, insect larvae, worms, amphipods and plants."

7. Florida Fish and Wildlife Conservation Commission:
   http://myfwc.com/wildlifehabitats/profiles/saltwater/porgy/pinfish/

"These fish spawn offshore. Pinfish are popular live bait**.** Pinfish are notorious for stealing bait."

Pink shrimp: *Farfantepenaeus duorarum*

Vulnerability:	Very vulnerable (SAFMC). Significant die offs of the population occurring when low temperatures are sustained.
Depth Range:	1 – 100 m
Temperature Range:	12 – 38 °C
Salinity Range:	0.5 – 43 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability?: "Very! Significant die offs of the population occurring when temperatures are sustained at a very low level for an extended time period. These events facilitate the closure of first state (SC and or GA) then federal waters off that state. Changing climate could result in increased extreme episodic events such as winter dies offs."

Ecosystem considerations? "Changes in pelagic and benthic estuarine habitat would reduce the essential habitat and productive capacity of penaeid shrimp populations".

Linkages to other fisheries? "Prey to a wide variety of species in in estuarine and near-shore and offshore habitats".

Known climate-related concerns? No answer in SAFMC

Social and economic concerns? "Commercial shrimp fishery is one of the most economically important commercial fisheries in the southeast. While not overfished, the white shrimp resource in the South Atlantic region is periodically decimated by severe winter cold kills, especially offshore of Georgia and South Carolina." "Significant economic impact to the commercial shrimp and potentially the inshore recreational fishery may result if climate change results in increased episodic events which reduce water temperatures to the level where winter kills of overwintering white* shrimp occur more frequently."

Management Risk? No answer in SAFMC

2. No SEDAR document available

3. Habitat Suitability Index Models: Pink Shrimp
http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-076.pdf

"Williams and Deubler (1968) found postlarval pink shrimp at salinities of 0.50 to 36.73 parts per thousand (ppt) , and Tabb et al. (1962) collected postlarvae in salinities of 12 to 43 ppt. Williams (1960) observed significantly poorer survival (62.5%, p=0.05) of juvenile pink shrimp (35 to 100 mm or 1.4 to 3.9 inches TL) at 10 ppt than at higher salinities. Percent survival at 15 to 30 ppt did not differ significantly (p = 0.05)."

"Temperature is one of the principal factors governing growth and survival of pink shrimp (Perez Farfante 1969). Aldrich (1964) reported zero survival of grooved postlarval shrimp at 3° and 43°C (37° and 109°F), regardless of the salinity. Copeland and Bechtel (1974) reported catches of pink shrimp at temperatures of 5° to 38°C (41 ° to 100°F); optimum catches were at 20° to 38°C (68° to 100°F). Williams (1955b) collected juveniles at 4° to 35°C (39° to 95°F) in North Carolina, but the shrimp were almost completely narcotized at water temperatures below 10°C (50°F). Eldred et al. (1961) believed that the minimum survival temperature for pink shrimp in Florida waters was near 12°C (54°F)."

Quahog clam: *Mercenaria mercenaria*

Vulnerability:	High vulnerability (MAFMC)
Depth Range:	Need information
Temperature Range:	9 – 31 °C
Salinity Range:	Eggs: 20 – 32.5 ppt; adult lower tolerance is 10 ppt
Oxygen Rage:	Need information
pH Range:	Larvae pH optimum: 7 and 8.75. Adults: this range is broader

2013: $5,931,853.00, 364.8 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – MAFMC
Management authorities? Fed: NOAA and MAFMC; State: NY, NJ

Climate vulnerability?: "High vulnerability. Temperature plays a strong role in larval growth, settlement, metamorphosis, and survival to juveniles. For both juvenile and adult temperature significantly affects growth and physiology. Sessile (non-mobile) nature" makes them "particularly sensitive to changes in environmental factors, and may be negatively impacted by climate change."

Ecosystem considerations? "Planktivorous siphon feeders, preyed upon by rock crabs, sea stars, and fish predators (such as cod, haddock, sculpins, and ocean pout). Ranges have started to shift (fishermen reports)."

Linkages to other fisheries? "Highly specialized in processing/vessels/gear, and fishery product is not highly substituted. A large capital investment is needed to retrofit vessels to participate in these fisheries. The fisheries have already been consolidating participation and ownership as a result of ITQ implementation."

Known climate-related concerns?. "Quahogs range is shifting northward and offshore to cooler, deeper waters."

Social and economic concerns? "If the distribution of ocean quahogs stocks shift, the fisheries will follow the distribution of the stocks", 1) "Vessels, ports, and processors could shift as the species distributions shifts, which is costly, given large capital investment in processing facilities and homeports. 2) transportations costs would increase as vessels must travel further to catch and return ocean quahogs to their processors and homeports."

Management Risk? "The risk of not having a responsive, adaptive governance system is an inability to respond to crisis in these fisheries. This may result in significant biological or social and economic harm."

2. No SEDAR document available

3. Smithsonian Marine Station at Fort Pierce
   http://www.sms.si.edu/irlspec/mercen_mercen.htm

Temperature:
"Ansell (1968) found growth is optimized at a temperature of 20 °C, with no growth occurring above 31 °C or below 9 °C. At 4 °C, Mercenaria enter "hibernation", but are able to survive somewhat lower temperatures. Maximum growth of larvae is achieved at water temperatures between 22.5 - 36.5 °C, with a minimum temperature requirement of at least 12.5 °C."

Salinity:
"Bivalves are unable to emigrate from the adverse environmental conditions which occur when salinity drops. The tolerance of *M. mercenaria* to decreases in salinity INCREASES with the age of the clam, but is inversely proportional to temperature. Thus, development and survival rates decrease sharply when salinity is low and temperature is high (Barile et al. 1986). Eggs develop normally within the range of 20 - 32.5 ppt. Over 35 ppt, only 1% of eggs develop to the larval stage; at salinity below 17.5 ppt, none do. Maximum growth of larvae is achieved at salinities between 21 - 30 ppt. Below 15 ppt, growth ceases and larval mortality is high. Adults able to withstand long periods of low salinity due primarily to their ability to close their valves. Adults have been shown to survive salinity as low as 10 ppt for up to 4-5 weeks, and are able to balance their internal osmotic conditions with that of the external medium. However, extended valve closure leads to decreased growth rates and reproductive capacity (Barile et al. 1986)".

Oxygen:
"Oxygen levels of at least 0.5 mg/L are required for normal development of embryos. Below this level, at approximately 0.2 mg/L, 100% mortality occurred (Morrison 1971). At 0.34 mg/L, development proceeded only to the trochophore stage, with no subsequent shell formation. Larval growth was poor below 2.4 mg/L, but was optimized above 4.2 mg/L."

pH:
"Davis (1969) found that in larvae, the pH optimum was between 7 and 8.75. In adult hard clams, this range is broader."

Queen conch: *Strombus gigas (lobatus gigas)*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015 this document). Life history dependent on coral reef and sea grass ecosystems. Warm temperatures exert negative impact on spawning. Changes in pH negatively impact shellfish.
Depth Range:	0 – 77 m
Temperature Range:	Spawning: 28 – 30 °C; veligers can be grown at 24 – 32 °C; Optimal culturing = 28 °C; Growth in Bermuda: 16 – 30 °C
Salinity Range:	Veligers can be grown at 26 to 40 ppt, Optimal culturing = 36 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. SEDAR Stock Assessment – S14SAR3 Queen Conch Report.pdf

Pg. 28:
“Distribution and Habitat
Queen conch occur throughout the Caribbean from the Orinoco River in Venezuela into the southern Gulf of Mexico, in the nearshore waters of the Caribbean islands to south Florida and Bermuda. Usually, conch are found in discrete aggregations that may include hundreds of thousands of individuals. Conch are found in shallow, clear water of oceanic or near-oceanic salinities at depths generally less than 75 meters and most often in water less than 30 meters deep. Conch are likely limited to that depth range by limits in seagrass and algae cover. Seagrass meadows, coral rubble, algal plains, and sandy substrates are the preferred habitat.”

Pg. 30:
“Reproduction
Queen conch are dioecious and fertilization is internal. Both males and females may copulate with multiple individuals over the spawning season. Multiple males may fertilize individual egg masses from a single female (Steiner and Siddall, pers. comm. in CFMC/CFRAMP, 1999). An additional complicating aspect of conch reproduction is the ability of females to store eggs for several weeks (D’Asaro, 1965). Stoner et al. (1992) found that spawning increased as a linear function of bottom water temperature, but declined during and after the warmest period. They suggest that photoperiod plays an important role in the timing of conch reproduction. Several authors have noted differences in spawning season at various locations throughout the species range.”

Pg. 32:
“Migration/dispersal
Embryonic development of conch proceeds rapidly, although the duration is temperature dependent. The larval shell develops within 24 hours and the free swimming veliger larvae emerge from the eggs within 72 hours. The queen conch larval

phase has been estimated to be less than a month in the wild (Davis, 1994). Hatchery reared larvae usually require 16 to 40 days to become competent and metamorphose (pers. obs.). Both observations suggest the potential for long distance transport by surface currents."

"Once conch settle to the benthos, dispersal ability is greatly reduced. In a mosaic of benthic habitats, dispersal will be dependent upon the extent of suitable habitat. Sandt and Stoner (1993) report movement of juvenile conch from unvegetated areas to adjacent seagrass meadows at approximately 35-54 mm shell length. Stoner and Ray (1996) found evidence of migration of juvenile conch from shallow water nursery sites to deeper water areas as the conch matured. In the Bahamas, adult conch were observed to move seasonally from sand plains to hard bottom areas (Stoner and Sandt, 1992). Glazer et al. (2003) tracked adult conch with sonic tags for one year to estimate seasonal movement and home ranges in the Florida Keys. They report home ranges of <1 to approximately 60 hectares with most individuals moving over home ranges of less than eight hectares."

3. Caribbean Fisheries Management Council: Queen conch Management Plan: QCfmpj96.pdf. http://www.caribbeanfmc.com/fmp_queen_conch1.html

Pg. 1:
"Queen conch (*Strombus gigas*) resources occur throughout the Caribbean Sea and in the Atlantic Ocean northward to Bermuda, but populations in certain areas are decidedly overfished and in need of management. Conch are edible marine gastropods that move inshore and aggregate along areas of the insular platform to spawn. Therefore, they are extremely vulnerable to harvest especially during the spawning season."

Pg. 7-11:
"Conch generally occur on expanses of shelf in tropical or subtropical waters from a few inches in depth up to about 250 feet [77 m]. This is a limiting factor to population size in most insular areas of the Caribbean, such as Puerto Rico and the U.S. Virgin Islands, where shelf areas are narrow"

"Another limiting factor to the abundance and distribution of queen conch is habitat condition, specially at the time of juvenile settlement (see Section 2.6). Unique sets of conditions are required for successful and sustained settlement in nursery grounds (Stoner et al., 1994)."

"The abundance of queen conch larvae could be related to physical environmental phenomena such as currents, affected by quality and quantity of food which during the critical larval period could play a role in population size (Iversen and Jory, 1985; e.g., more food, better survival). Smaller islands generally have a low rate of stream discharge compared to large islands and continental land masses with rivers carrying heavy sediment loads and concentrations of nutrients to fertilize the shelf area. Consequently, waters of the Caribbean eastern island arc are exceptionally clear with low biological productivity. The result is a low volume of phytoplankton for conch larvae to feed upon. In summation, a combination of narrow shelves, and clear waters that attract divers but are low in productivity, and habitat conditions are factors that could limit the population size of conch on insular platforms of the Caribbean (Iversen and Jory, 1985)."

"Reproduction and early development
Queen conch generally spawn during the summer (Randall, 1964; D'Asaro, 1965; Brownell, 1977), however, in some areas reproductive activity may occur throughout the year (Blakesley, 1977; Stoner et al., 1992)."

"The spawning season for the queen conch extends for May and November in Puerto Rico (Appeldoorn et al., 1987) and spawning has been reported between February and November in the U.S.V.I. (Randall, 1964; Coulston et al., 1987). Peak spawning activity in the management area appears to occur from May through September. Maximum spawning in a controlled experiment conducted off La Parguera, Puerto Rico occurred during August and coincided with maximum temperatures (Appeldoorn, 1993). Migration to sandy areas and into shallower water have been reported as indications of the beginning of the spawning season in many of the areas where queen conch occur (Hesse, 1979; Weil and Laughlin, 1984; Appeldoorn, 1985; Coulston et al., 1987; Stoner et al., 1992). Queen conch aggregate during the spawning period (Appeldoorn, 1988b). This aggregating behavior in addition to the migration to shallower waters make the queen conch an easy target for fishers (both commercial and recreational). This vulnerability has rendered them susceptible to overfishing."

"The reproductive behavior of queen conch has been scantly described (Randall, 1964). Sexes are separate and fertilization is internal in the queen conch and copulation can precede spawningby several weeks (D'Asaro, 1965). Spawning begins when the female has selected the proper substrate. Egg masses generally are produced in clean coral sand with low organic content (D'Asaro, 1965, Brownell and Stevely, 1981, Davis et al., 1984), although queen conch occasionally have been observed laying eggs in seagrasses (Randall, 1964)."

"Production of egg masses has been correlated to temperature and weather conditions. Maximum number of egg masses occurred when the highest temperatures and longest photoperiods were recorded; stormy weather decreases egg laying activity (Davis et al., 1984; Stoner et al., 1992). This results in potentially reduced recruitment to the adult population."

"The information available still does not make it clear if most recruitment to specific areas is local or of a remote origin. A case can be made for local recruitment since laboratory reared larvae in controlled experiments have been shown to be competent for only 6 days. However, information is lacking regarding the physical environment (e.g., currents and water circulation) surrounding the larvae (i.e., in 6 days larvae can be transported a long distance depending on the current). Posada and Appeldoorn (1994) conclude that although larvae are found far offshore, the majority of the larvae are retained locally (i.e., within the area where they are spawned). Davis et al. (1993) reported that queen conch veligers "could be transported 43 km per day (26 miles) or 900 km (540 miles) during the 3 week larval period."

“Little is known about juveniles in the wild. Juveniles are found buried in the sediment, the burial depth changing with size.”

“Important juvenile life history factors for which information is needed include: habitat conditions for settlement and metamorphosis; relationship between temperature and feeding; abundance and distribution of smaller sizes in the wild (i.e., 50-60 mm); and the effect of currents (surface to bottom) and water circulation on the distribution of larvae.”

Pg. 12:
“Movement and Migration
Although veligers maintain their position in the upper water column where they feed upon phytoplankton, their ultimate distribution is largely determined by currents that transport the larvae. Since two to three weeks are required for the larvae to settle to the bottom, they may be transported a considerable distance from the locus where the eggs were hatched.”

Pg. 14-15:
“Habitat
Queen conch commonly occur on sandy bottoms that support the growth of seagrasses, primarily turtle grass (Thalassia testudinum), manatee grass (Syringodium filiforme), shoal grass (Halodule wrightii), and epiphytic algae upon which they feed (Randall, 1964). They also occur on gravel, coral rubble, smooth hard coral or beach rock bottoms and sandy algal beds. They are generally restricted to waters where light can penetrate to a depth sufficient for plant growth. Queen conch are often found in sandy spurs that cut into offshore reefs.”

“Queen conch larvae require certain substrate conditions to metamorphose and settle to the bottom. Habitat condition at this stage seems critical although the requirements are largely unknown. In laboratory experiments, it has been shown that larvae are competent (i.e., have the ability to metamorphose) for 6 days. If the appropriate settling habitat is not found during that time period, larvae die. Juvenile conch are found in sandy areas and seagrass beds (Randall, 1964; Sandt and Stoner, 1993). Still, very little is known about the size distribution of conch in relation to specific habitat requirements”

4. Harbor Branch Oceanographic Institution, Aquaculture Division, Ft. Pierce, Florida, October 2005 QueenConch.pdf
http://www2.ca.uky.edu/wkrec/QueenConch.pdf

Pg. 1:
“Queen conch form large spawning aggregations. Fertilization is internal. The typical 6- to 8-month egg-laying season is March to October, with most activity occurring from

July to September when water temperatures are the warmest (82 to 86 °F; 28 to 30 °C)."

Pg. 6:
"Optimal culturing temperature is 82 °F (28 °C) and 36 ppt salinity. However, veligers can be grown at temperatures of 75 to 90 °F (24 to 32 °C) and salinities of 26 to 40 ppt."

5. National Marine Fisheries Service, NOAA: Queen Conch, *Strombus gigas* (*Linnaeus* 1758) Status Report: ID236_Queen_Conch_Final_Status_Report.pdf http://www.cio.noaa.gov/services_programs/prplans/pdfs/ID236_Queen_Conch_Final_Status_Report.pdf [summary of the information gathered for the ESA review for queen conch]

Pg. 10-12:
"Queen conch inhabit a range of habitat types during their life cycle. During the planktonic life stage, queen conch larvae (veliger) feed on phytoplankton. Larvae must receive the right amount of nutrition during this stage or development can be delayed (Brownell 1977). To metamorphose into juveniles, veligers most often settle in seagrass areas, which have sufficient tidal circulation, and high macroalgae production. The success of nursery areas are influenced by physical and oceanographic processes, level of larvae retention and settlement, predator abundance, and related survivorship (Stoner et al. 1998; Stoner et al. 2003)."

"Juveniles occur primarily in back reef areas (i.e., shallow sheltered areas, lagoons, behind emergent reefs or cays) of medium seagrass density, depth between 2 to 4 m, strong tidal currents (at least 50 cm/s; Stoner 1989b) and frequent tidal water exchanges (Stoner and Waite 1991; Stoner et al. 1996). Posada et al. (1997) stated that the most productive nurseries for the queen conch tended to occur in shallow (< 5-6 m deep) seagrass meadows. However, there are, certain exceptions, such as in Florida, where many juveniles are found on shallow algal flats, or on certain deep banks such as in Pedro Bank, Jamaica. Seagrass is thought to provide both nutrition and protection from predators (Ray and Stoner 1995; Stoner and Davis 2010). Jones and Stoner (1997) found that optimal nursery habitat occurred in areas of medium density seagrass, particularly along the seagrass gradient. In the Bahamas, juveniles were only found in areas within 5 km from the Exuma Sound inlet, emphasizing the importance of currents and frequent tidal water exchange that affects both larval supply and growth of their algal food (Jones and Stoner 1997). Juveniles generally remain buried within the soft substratum until they approach a year in age. They emerge and then move to sand-algal plains with areas of mixed seagrass."

"While juveniles appear to have specific habitat requirements, adults can tolerate a wider range of environmental conditions (Stoner et al. 1994). Adults prefer sandy algal flats but can also be found on gravel, coral rubble, smooth hard coral or beach rock bottoms (Torres-Rosado 1987; CFMC 1996a; Acosta 2001; Stoner and Davis 2010). Adult queen conch are rarely, if ever, found on soft bottoms composed of silt and/or mud, as well as areas with high coral cover (Acosta 2006). In Florida, reproducing queen conch generally preferred coarse sand substrates, rather than reef, coral rubble, or seagrass habitats (Glazer and Kidney 2004)."

"Adult conch are often found in shallow, clear water of oceanic or near-oceanic salinities at depths generally less than 75 m and are most often found in waters less than 30 m (McCarthy, 2008). It is believed that depth limitation is based mostly on light attenuation limiting their photosynthetic food source (Randall 1964; McCarthy 2008)."

"The average home range size for an individual queen conch is variable and has been measured at 5.98 ha in Florida (Glazer et al. 2003), 0.6 to 1.2 ha in Barbados (Phillips et al. 2011), and 0.15 to 0.5 ha in the Turks and Caicos Islands (Hesse 1979). Glazer et al. (2003) found that there was no significant difference in movement rate, site fidelity, or size of home range between adult males and females." "In general, adult conch do not move very far from their feeding grounds during their reproductive season (Stoner and Sandt 1992). The movements of adult conch are further associated with factors like change in temperature, expanding available food, resources, and predation."

Pg. 23:
"Habitat Stressors
All different life stages of the queen conch have very specific habitat requirements. Most of the information on larval requirements is derived from larvae raised in aquaculture. These include adequate phytoplankton food source, water exchange, moderate densities and presence of metamorphosis inducing cues (Creswell 1994). Juveniles need food, structure, adequate water exchange, and the right bottom composition and sediment composition to bury (Stoner 2003). Adult conch, now generally found in deeper waters, require feeding habitats and habitats to aggregate and breed. Feeding habitats are primarily hard bottom substrates with macroalgae while breeding habitats are associated with clean, low organic content, and coarse sand (Randall 1964; Stoner et al. 1992). If any of these life stages' habitat requirements becomes disrupted, the whole life cycle would be imbalanced. Decreased larval survival could mean failure of a juvenile year class, reducing replenishment of the adult population that is most likely already subject to high fishing pressure. Low densities of adults are then unable to reproduce, which creates a positive feedback loop toward reduced recruitment."

"Eutrophication can cause algal blooms in coastal areas. These algal blooms use up localized supplies of oxygen and decrease light penetration to the benthic habitats. Seagrass habitats depend on light and oxygen, and if these elements are reduced and seagrass dies, juvenile conch survival will be lower, as they depend on seagrass structure and nutrition to make it through the initial vulnerable phase of their life history."

"Increased sedimentation as a result of coastal influxes also poses a problem for conch. Adult conch aggregation habitats are characterized by coarse, low organic content sand, and if these shallow, coastal areas are subject to deposition of fine sediment or sediment with high organic content, these habitats could become unsuitable (Appeldoorn and Baker, 2013). For example, the main island of Trinidad does not have a significant queen conch population, likely due to low salinities and high turbidity associated with continental rivers and streams (CITES 2012). In addition, habitat loss (e.g., construction and heavy sedimentation from coastal erosion) was identified by Gore and Llewellyn (2005) as a possible factor that contributed to the species decline in the British Virgin Islands."

"Deep water habitats that currently support mesophotic populations or spawning stocks could be negatively affected if ocean acidification that promotes dissolution of aragonite occurs at a shallower depth (Doney 2006) (see Section 3.9). The carbonate compensation depth (boundary between calcification and dissolution) is projected to shift closer to the surface by 50 to 200 m (Doney 2006). Conch that are in deeper water habitats would then be subjected to either lower calcification rates and thinner shells, or in the worst case scenario, dissolution of their shells."

"This could then subject adults that would normally be protected from a majority of predators to increased risk of predation. This could also divert a significantly higher portion of their energy budget to calcifying and maintaining their shell, detracting from other life processes such as reproduction. Protecting favorable habitat for each of these three life stages (larvae, juvenile, and adult) is critical in ensuring the sustainability of the queen conch in the Caribbean (Appeldoorn et al. 2011)."

Pg. 27:
"Climate Change implications
Two aspects of climate change are likely to impact queen conch: increasing sea temperatures and acidification. Queen conch utilize calcium carbonate in shell building; the effects of increasing acidification can affect shell production in one of two ways that are not mutually exclusive. The first is through the reduction of available carbonate for calcium carbonate production due to increasing amounts of carbon dioxide in the sea. When carbon dioxide dissolves, it combines with water to form carbonic acid, which subsequently forms bicarbonate ions and 2 hydrogen ions. These 2 hydrogen ions will bind with naturally occurring carbonate to form more bicarbonate ions and result in less carbonate available for calcium carbonate production. In response, the conch will utilize more energy in shell formation, at a cost to growth rate, in producing hydrogen ions (Doney 2006). Alternatively, the conch could use less calcium carbonate in shell making which would result in a less dense and thus weaker shell (Doney 2006). In addition, the composition of conch shells is 99% aragonite (Kamat et al. 2000), which is more soluble than calcite. Because solubility is influenced by pH, the saturation rate of aragonite is decreased as CO_2 increases, which makes the conch shell susceptible to dissolution (Doney 2006; Kamat et al. 2000)."

"Changing climate may also have other, more subtle effects that could impact larval dispersal and habitat availability. Currents are expected to be affected under future climates (Liu et al. 2012) that could change the rate and condition of larval dispersal. Effects of these changes are not known; results could be either positive or negative to conch populations. Habitat may transition as a result of climate change and impact the settlement. Sea surface temperatures are expected to increase in the next 100 years and potential impacts to thermal thresholds or disassociation of contaminants from the substrate are not known. The increase in surface water temperature could influence the timing of conch reproduction. Hurricane activity has been found to negatively impact queen conch populations by reducing number as found in Turks and Caicos post two major hurricanes (DEMA 2012). If the frequency/intensity of extreme weather conditions increases with sea surface temperatures, similar reductions in the local queen conch populations may occur."

6. Randall, J.E. 1964. Contributions to the Biology of the Queen Conch, Strombus Gigas. Bulletin of Marine Science, Vol. 14(2), pp. 246-295 (50) http://www.ingentaconnect.com/content/umrsmas/bullmar/1964/00000014/00000002/art00005

Pg. 19:
"They concluded that *S. gigas* grows during a large fraction of the Bermuda sea temperature range of approximately 16° to 30°C. "

Red drum: *Sciaenops ocellatus*

Vulnerability:	Vulnerable (Roffer and Hall, 2015, this document). "Larval and juvenile red drum have more narrow temperature and salinity preferences than adults and changes to these environmental conditions during critical developmental stages are likely to impact survival and recruitment."
Depth Range:	0 – 27 m
Temperature Range:	4 – 34 °C
Salinity Range:	3.5 – 35 ppt; adults usually stay in saltwater of 30 – 35 ppt
Oxygen Rage:	lethal – 0.4 mg/l
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes - ASMFC
Management authorities: Fed: NOAA; Regional: NEFMC, MAFMC, SAFMC; Inter-state: ASMFC; States: ME, NH, MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? "Widely distributed species; tolerant of a wide range of temperatures and salinities. Larval and juvenile red drum do have more narrow temperature and salinity preferences than adults and changes to these environmental conditions during critical developmental stages are likely to impact survival and recruitment."

Ecosystem considerations? "Ecosystem changes have the potential to make red drum more vulnerable to climate change. Climate change-related declines in prey species of many other competing predators, such as menhaden and shrimp, are likely to increase competition and decrease survival".

Linkages to other fisheries? "Decreases in abundance may influence anglers to target other species. Impacts to other estuarine species and habitat, such as loss of habitat, degradation of water quality, and prey to climate related changes could impact vulnerability, but this currently is not a significant concern".

Known climate-related concerns? "Ecosystem changes."

Social and economic concerns? "Any concerns would likely be similar to other predominately recreational fisheries, such as expenditures associated with recreational trips."

Management Risk? "Ecosystem changes in estuarine habitats could impact species at juvenile and larval stages".

2. SEDAR Stock Assessment - Atlantic Red Drum Stock Assessment Report-SEDAR 18.pdf

Pg. 8:
"The management unit is defined as the red drum (*Sciaenops ocellatus*) resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundaries of the Exclusive Economic Zone. The selection of this management unit is based on the biological distribution of the species along the Atlantic coast and historical patterns which have identified fisheries for red drum extending north through New Jersey." "The management area is the entire Atlantic coast distribution of the resource from Florida through New Jersey. The management area is divided into a southern region which includes the waters of the Atlantic coast of Florida north to the North Carolina/South Carolina border. The northern region extends from the North Carolina/South Carolina border north through New Jersey (ASMFC 2002)." The tables in document show history of red drum management in each area.

Pg. 27:
"Separate growth models and estimates of natural mortality were provided for the two regions/stocks, based on observed differences in the life history characteristics over the two areas. The oldest fish aged in the north region was 62 years, with numerous fish aged in their 50s. The oldest fish aged in the south region was 38 years.
There is little evidence of significant migration by red drum."

3. SEDAR Stock Assessment - S18-RD59.pdf

Pg. 1:
"Ultrasonic telemetry was used to measure temporal and spatial patterns of movements in sub-adult red drum *Sciaenops ocellatus*, within a salt marsh-estuarine system. The data showed that fish exhibited a high degree of site fidelity and a variety of individual movement patterns, ranging from little or no movement to regular forays related to tidal and diel cycles."

4. IUCN Red List: http://www.iucnredlist.org/details/193270/0 (Least concern)
   Depth limit (meters): 0 – 27 m

5. Florida Museum of Natural History: Ichthyology
   http://www.flmnh.ufl.edu/fish/gallery/Descript/RedDrum/RedDrum.html

"Red drums can tolerate a wide range of temperatures, anywhere from 39-93°F (4-34°C). Reds can also tolerate wide ranges of salinity. Although they have been known to travel into fresh waters as well as into very high saline waters (up to 50 ppt), adults usually stay in saltwater of 30-35 ppt."

Red porgy: *Pagrus pagrus*

Vulnerability:	Medium vulnerability (SAFMC)
Depth Range:	18 – 183 m
Temperature Range:	13 – 25 °C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under own section
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? "Medium vulnerability to impacts of climate change. However, detailed life history and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats."

Ecosystem considerations? "Use shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level.

Linkages to other fisheries? "Effort shifts associated with impacts in shelf waters could result in increased effort on other managed snapper grouper species or even the deepwater complex", and vice versa.

Known climate-related concerns? "Changes in ocean temperature, ocean currents or increase in episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species."

Social and economic concerns? "Only arise if changes are great enough to result in shift amongst shelf or movement to deepwater ecosystems"

Management Risk? Low

2. SEDAR Stock Assessment - SEDAR1_AR1_SEporgy.pdf

"Tagging studies show neither long-range migrations nor extensive local movements of adult red porgy (Manooch and Hassler 1978), and there is no circumstantial or anecdotal information to suggest such movements. Peak spawning occurs in March and April (Manooch 1976)."

3. NOAA Technical Report NMFS Circular 412: NOAA Technical Report NMFS Circular 412. 1978. http://www.fao.org/docrep/017/ap922e/ap922e.pdf

Pg. 7:
“Red porgy are commonly found at depths ranging from 18 to 183 m.
In the western Atlantic, red porgy commonly occur over very irregular and low profile, hard bottom. Bottom water temperatures ranged from 13° to 25° C.”

Red snapper: *Lutjanus campechanus*

Vulnerability:	Medium vulnerability (SAFMC). Changes in ocean currents or increase of episodic events like upwelling, hypoxia, tropical storms are potential concerns.
Depth Range:	Need information
Temperature Range:	13 – 32 °C
Salinity Range:	33 – 37 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under own section
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Medium vulnerability. However, detailed life history, movement and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats.

Ecosystem considerations? Use shelf ecosystems extensively. If pelagic and benthic habitat including coral and live bottom species are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced, which could lead to impacts at the populations level.

Linkages to other fisheries? Effort shifts equal increased effort on other managed snapper grouper species or even the deepwater complex. “However, red snapper is overfished and evaluated annually to determine if any harvest can be allowed. The recent resulting fisheries are short commercial and recreational times that would unlikely be impacted in the short term by population or habitat effects of climate change. Given the red snapper harvest is limited if allowed at all and controlled to ensure long-term rebuilding is not compromised, the species isn’t as vulnerable to effects of climate change.”

Known climate-related concerns? Changes in ocean currents or increase of episodic events like upwelling are potential concerns affecting habitat essential to the managed species.

Social and economic concerns? Only arise if changes are great enough to shift amongst shelf and deepwater ecosystems

Management Risk? Low

2. SEDAR Stock Assessment – SEDARUpdateRedSnapper2014_FINAL_9.15.2015.pdf.

Pg. 90:
"Episodic Events: Gulf of Mexico red snapper populations are often impacted by a variety of episodic environmental perturbations of varying temporal and spatial scales. In the northern Gulf of Mexico, the seasonal occurrence of hypoxia can potentially effect red snapper populations. Although we are not aware of large-scale mortality of red snapper in association with summer hypoxic events, reductions in dissolved oxygen concentrations greatly reduce habitat quality. In Alabama, catch-per-unit-effort of juvenile (age-0 and age-1) red snapper within trawl samples declined significantly from July to August, likely in association with bottom dissolved oxygen concentrations that were 0 ppm (Szedlmayer and Shipp 1994). Further, an examination of essential fish habitat for juvenile red snapper indicated that recent increases in the real extent of hypoxia in the northern Gulf of Mexico may have reduced habitat carrying capacity for juvenile red snapper by an average of 19% (Gallaway et al. 1999). Hypoxia can also impact older red snapper, although the occurrence of offshore oil platforms within areas impacted by hypoxia may provide some vertical refugia (Stanley and Wilson 2004). In addition to direct effects on red snapper, hypoxia may alter the dynamics of shrimp trawl fishery and, subsequently, the quantity of bycatch-related mortality of juvenile red snapper. Macal (2002) found that shrimping effort off of Louisiana shifted offshore during years of extensive hypoxia, potentially increasing the overlap between shrimping effort and juvenile red snapper populations and associated bycatch mortality. It is important to note, however, that these potential impacts may be offset by recent reductions in overall shrimping effort."

Pg. 91:
"Other environmental perturbations in addition to hypoxia have the potential to affect red snapper populations. Hurricanes can also affect red snapper populations, although hurricane-related impacts appear to relate primarily to movement and site fidelity of red snapper. In a study on artificial reefs in the north-central Gulf of Mexico, the occurrence of Hurricane Opal in 1995 greatly increased not only the probability that red snapper would move away from their original tagging location, but also significantly influenced the distance of red snapper movement (Patterson et al. 2001). Periodic upwelling events and associated reductions in temperature and increases in nutrients have been documented to contribute to mass mortality of fishes and macro-invertebrates, potentially in association with the development of near-anoxic conditions (Collard and Lugo- Fernández 1999; Collard et al. 2000). Temperature reductions also appear to contribute to seasonally-dynamic movement patterns (Topping and Szedlmayer (2011a SEDAR31-RD22). Large- scale pollution events such as the Deep Water Horizon oil spill, can result in impacts that are both direct (e.g., acute–phase mortality) and indirect (e.g., bioaccumulation through the food web) (Sumaila et al. 2012)."

3. US Fish and Wildlife: http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-083.pdf

“Red snapper have been taken at 13-32 °C (Rivas 1970; Roe 1976). One of a sample of seven red snapper died at 12.5 °C near the lower tolerance limit in a laboratory test (Moore 1973). The upper tolerance limit is about 33.5 °C (Rivas 1970). A salinity of 60 ppt was lethal to all red snapper in a laboratory test, but they survived exposure to about 45 ppt without serious effects (Huff and Burns 1981). They are marine fish and have been taken in waters of 33-37 ppt (Mosel et al., 1966).”

Rock shrimp: *Sicyonia brevirostris*

Vulnerability:	Low/Minimal Vulnerability (SAFMC). Vulnerable (Roffer and Hall, 2015 this document – Distribution affected by Gulf Stream and coastal upwelling.)
Depth Range:	24 – 65 m, although been found in 183 m
Temperature Range:	Need information
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

2013: $1,997,211.00, 336.0 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC

Climate vulnerability?: Low/Minimal - Deepwater species. "However, detailed life history, movement and migration patterns are lacking for the species and true vulnerability may depend on the magnitude of change in bottom temperature or deepwater and oceanic currents that would eventually impact spawning, feeding and movement."

Ecosystem considerations? - No answer in SAFMC

Linkages to other fisheries? – "If climate change affects the deepwater fishery, effort could shift to other managed shrimp species and potentially in other regions". "Climate change impacts on near-shore shelf pelagic and benthic habitats impacting penaeid shrimp could result in some vessels increasing effort on the deepwater shrimp fishery. A significant increase in fishing effort on the deepwater shrimp fishery could also result in increased bycatch in depths where mortality is high."

Known climate-related concerns? – "Changes in deepwater currents, bottom ocean temperatures or increased episodic events like upwelling have been raised as a potential concerns affecting habitat essential to managed species."

Social and economic concerns? "Vessels' dependence on landings from the South Atlantic rock shrimp fishery is relatively low on average, with most dependent on revenue from the Gulf shrimp fishery, the South Atlantic penaeid shrimp fishery and non-shrimp landings. If climate change results in increased cold weather events resulting kills of overwintering white shrimp, vessels may a shift effort into other penaeid or deepwater shrimp fisheries."

Management Risk? "Given the timescales being discussed as to impacting deepwater habitats, the existing Council management system has a long-term working relationship with the fishermen and should be able to respond the management needs associated with such change".

2. No SEDAR document available

3. NOAA Fish Watch
   http://www.fishwatch.gov/seafood_profiles/species/shrimp/species_pages/rock_shrimp.htm

"Rock shrimp are found from Norfolk, Virginia, south through the Gulf of Mexico to Mexico's Yucatan Peninsula. They mainly live on sand bottoms in water 80 to 215 feet deep, although they've been found in depths of 600 feet. Rock shrimp are active at night and burrow in the sand during the day. Larval rock shrimp grow and develop in coastal estuaries and travel back to offshore areas as they mature."

"The rock shrimp's growth and development depends on factors such as season, water temperature, population density, size, and sex. For example, they grow faster in the summer and females grow slightly faster than males."

"Rock shrimp, like most shrimp species, are highly productive." "Rock shrimp spawn year-round in offshore waters; spawning peaks between November and January. Individual females can spawn three or more times in one season." "Rock shrimp have a short life span, between 20 and 22 months."

"Abundance estimates are not as meaningful for shrimp management as they are for management of most other seafood species. Rock shrimp reproduce at high rates and have a short life span. The abundance of rock shrimp is primarily influenced by environmental conditions and available habitat rather than catch rates. Scientists and managers monitor the status of the resource by collecting data on historic harvests and catch rates."

"Habitat loss due to pollution and physical alteration are potential threats to shrimp populations."

4. SAFMC Ecosystem Habitat Plan
   http://www.safmc.net/habitat-ecosystem/pdf/HabitatPlan178-190.pdf

Pg. 1:
"Seasonal temperature initiates maturation." "Spawning season for rock shrimp is variable with peak spawning beginning between November and January and lasting 3 months. Individual females may spawn three or more times in one season. Peak spawning activity seems to occur monthly and coincides with the full moon (Kennedy et al. 1977)."

“Larval and Postlarval Phases
Kennedy et al. (1977) found rock shrimp larvae to be present year round with no trend relative to depth, temperature, salinity, and length or moon phase. The development from egg to postlarvae takes approximately one month. Subsequently the development from postlarvae to the smallest mode of recruits takes two to three months. The major transport mechanism affecting planktonic larval rock shrimp is the shelf current systems near Cape Canaveral, Florida (Bumpus 1973). These currents keep larvae on the Florida Shelf and may transport them inshore in spring.”

Pg. 2:
“Rates of growth in rock shrimp are variable and depend on factors such as season, water temperature, shrimp density, size, and sex.”

“Rock shrimp (*Sicyonia brevirostris*) are found in the Gulf of Mexico, Cuba, the Bahamas, and the Atlantic Coast of the U.S. up to Virginia (SAFMC 1993) (Figure 22). The center of abundance and the concentrated commercial fishery for rock shrimp in the south Atlantic region occurs off northeast Florida south to Jupiter Inlet (Figure 23). Although rock shrimp are also found off North Carolina, South Carolina, and Georgia and are occasionally landed in these states, no sustainable commercially harvestable quantities of rock shrimp comparable to the fishery prosecuted in the EEZ off Florida are being exploited. Rock shrimp live mainly on sand bottom from a few meters to 183 m (600 ft), occasionally deeper (SAFMC 1993). The largest concentrations are found between 25 and 65 m (82 and 213 ft).”

Pg. 5:
“For rock shrimp, essential fish habitat consists of offshore terrigenous and biogenic sand bottom habitats from 18 to 182 meters in depth with highest concentrations occurring between 34 and 55 meters. This applies for all areas from North Carolina through the Florida Keys. Essential fish habitat includes the shelf current systems near Cape Canaveral, Florida which provide major transport mechanisms affecting planktonic larval rock shrimp. These currents keep larvae on the Florida Shelf and may transport them inshore in spring. In addition the Gulf Stream is an essential fish habitat because it provides a mechanism to disperse rock shrimp larvae.”

“A description of shrimp habitat and recommendations to protect habitat were contained in the shrimp management plan (SAFMC 1993). The bottom habitat on which rock shrimp thrive is thought to be limited. Kennedy et al. (1977) determined that the deepwater limit of rock shrimp was most likely due to the decrease of suitable bottom habitat rather than to other physical parameters including salinity and temperature. Cobb et al. (1973) found the inshore distribution of rock shrimp to be associated with terrigenous and biogenic sand substrates and only sporadically on mud. Rock shrimp also utilize hard bottom and coral or more specifically Oculina coral habitat areas. This was confirmed with research trawls capturing large amounts of rock shrimp in and around the Oculina Bank HAPC prior to its designation.”

“Other than Kennedy et al. (1977), no characterization of habitat essential to rock shrimp or bycatch in the rock shrimp fishery has been conducted. A list of species associated with the benthic habitat inhabited by rock shrimp was compiled from research trawling efforts (1955-1991) that captured harvestable levels of rock shrimp. In addition, Kennedy et al. (1977), during research efforts sampling the major distribution area of rock shrimp off the east coast of Florida, compiled a list of crustacean and molluscan taxa associated with rock shrimp benthic habitat.”

Pg. 9:
“No essential fish habitat-habitat areas of particular concern have been identified for rock shrimp however, deep water habitat (e.g. the rock shrimp closed area/proposed expanded Oculina Bank HAPC) may serve as nursery habitat and protect the stock by providing a refuge for rock shrimp.”

Royal red shrimp: *Hymenopenaeus robustus*

Vulnerability:	Low/Minimal vulnerability (SAFMC) Vulnerable (Roffer and Hall, 2015 this document suggests that the effect of variable coastal upwelling appears to play a substantial role in this shrimps catchability.)
Depth Range:	180 – 730 m; move inshore into 75 m during cold spell
Temperature Range:	5 – 15 °C
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

2013: $1,860,808.00, 425.4 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC

Climate vulnerability?: Low/Minimal - Deepwater species. "However, detailed life history, movement and migration patterns are lacking for the species and true vulnerability may depend on the magnitude of change in bottom temperature or deepwater and oceanic currents that would eventually impact spawning, feeding and movement."

Ecosystem considerations? No answer in SAFMC

Linkages to other fisheries? "If climate change affects the deepwater fishery, effort could shift to other managed shrimp species and potentially in other regions". "Climate change impacts on near-shore shelf pelagic and benthic habitats impacting penaeid shrimp could result in some vessels increasing effort on the deepwater shrimp fishery. A significant increase in fishing effort on the deepwater shrimp fishery could also result in increased bycatch in depths where mortality is high."

Known climate-related concerns? "Changes in deepwater currents, bottom ocean temperatures or increased episodic events like upwelling have been raised as a potential concerns affecting habitat essential to managed species."

Social and economic concerns? "Vessels' dependence on landings from the South Atlantic rock shrimp fishery is relatively low on average, with most dependent on revenue from the Gulf shrimp fishery, the South Atlantic penaeid shrimp fishery and non-shrimp landings. If climate change results in increased cold weather events resulting kills of overwintering white shrimp, vessels may a shift effort into other penaeid or deepwater shrimp fisheries."

Management Risk? "Given the time scales being discussed as to impacting deepwater habitats, the existing Council management system has a long-term working relationship with the fishermen and should be able to respond the management needs associated with such change".

2. No SEDAR document available

3. SAFMC NMFS Distribution of Deep-water Commercial Fisheries Species-Golden Crab, Tilefish, Royal Red Shrimp – in Deep-water Habitats off Eastern Florida from Submersible and ROV Dives. By John Reed, Harbor Branch Oceanographic Institute. 2010 SAFMC NMFS Golden Crab Tilefish REPORT.pdf http://www.safmc.net/managed-areas/pdf/2010%20SAFMC%20NMFS%20Golden%20Crab%20Tilefish%20REPORT.pdf

Pg. 16:
"The highest concentrations of royal red shrimp are off northeast Florida (St. Augustine shrimping grounds) and in the northeastern Gulf of Mexico (Perez Farfante, 1977). The depth range for royal red shrimp on the upper continental slope is 180-730 m with the largest concentrations between 256 and 500 m (Anderson and Lindner, 1971; Perez Farfante, 1977; Anonymous, 2010). There is a moderate commercial fishery in 73-750 m depths (Williams and Wigley, 1977)."

Temperature Preferences: "In the Gulf of Mexico and southeast U.S., royal red shrimp are found in a temperature range of 5-15°C and are commercially rich between 9-12 °C, and usually after a 2-3 day cold upwelling they move inshore to 75 m depths (Perez Farfante, 1977; Unknown 2010)."

Substrate Preferences: "Royal red shrimp have a substrate preference of black terrigenous silt off Mississippi Delta; calcareous mud off Tortugas and silty sand (green mud) off N.E. Florida (Perez Farfante, 1977)."

Scamp grouper: *Mycteroperca phenax*

Vulnerability: Medium vulnerability (SAFMC)
Depth Range: 30 – 100 m
Temperature Range: Greater than 8.6°C
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under own section as Scamp
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? “Medium vulnerability”. “However, detailed life history, movement and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats.”

Ecosystem considerations? “Scamp use shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level.”

Linkages to other fisheries? “Effort shifts associated with impacts in shelf waters, could result in increased effort on other managed snapper grouper species or even the deepwater complex.” “If climate change affects other managed species including coastal migratory pelagic and fisheries for other snapper grouper species, effort could shift to scamp.”

Known climate-related concerns? “Changes in ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species.”

Social and economic concerns? “Considerations would only arise if changes are great enough to result in shift among shelf or movement to deepwater ecosystems”

Management Risk? Low

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/132729/0 (Least concern)
Depth limit (meters): 30 – 100 m

“Scamp aggregate to spawn. Spawning locations and time of spawning overlaps with gag. Fishery-independent sampling revealed that: (1) spawning probably occurred during the late afternoon and evening, and (2) higher proportions of scamp spawned around new moon and full moon.”

“Major Threat(s): Oculina coral formations are threatened by bottom trawling, and aggregations (both spawning and feeding) of scamp are strongly associated with this habitat. Since there are no signs of overfishing, the major current threat is habitat destruction; Oculina banks are very fragile and easily destroyed.”

1. Fish Base http://www.fishbase.se/summary/Mycteroperca-phenax.html

“Found over ledges and high-relief rocky bottoms in the eastern Gulf of Mexico; at low-profile bottoms at depths of 30 to 100 m in North Carolina; this species was the most abundant grouper in areas of living Oculina coral formations at depths of 70 to 100 m off the east coast of Florida. This species apparently moved inshore when bottom temperature fell below 8.6°C. Juveniles found in shallow water at jetties and in mangrove areas.”

5. All Fishing Guide: http://www.allfishingbuy.com/Fish-Species/Scamp-Grouper.htm

“[Juveniles found] sometimes fairly close to shore, but generally sticks to deep reefs and ledges offshore. Juveniles inshore are in estuaries and bays, adults in deeper water inshore and offshore in reefs, wrecks, jetties, pilings to depths over 300 feet.”

“Feed mainly on fishes, but crustaceans and octopus are also occasionally eaten. If it moves and fits in its mouth, it is dinner.”

Sheepshead: *Archosargus probatocephalus*

Vulnerability:	Need more information to determine status
Depth Range:	0 – 15 m
Temperature Range:	5 – 35.1°C, Tampa Bay juveniles 12.8 – 32.5°C
Salinity Range:	0 – 35 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. South Carolina Dept. of Natural Resources: SC_DNR_Sheepshead.pdf
http://portal.dnr.sc.gov/cwcs/pdf/Sheepshead.pdf

Pg. 1-2:
"Sheepshead can have a total lifespan of 20 to 25 years, and typically reach sexual maturity at age 2 (Render and Wilson 1992)."

"Sheepshead are serial spawners; they spawn multiple times within a season. Females are capable of producing anywhere from 1,100 to 250,000 eggs per spawning event, depending on age and location (Render and Wilson 1992; Tucker and Barbera 1987). Spawning has been documented to occur in coastal waters from late winter through early spring through the mid-Atlantic and Gulf of Mexico, with hatching of eggs occurring within 28 to 40 hours from time of fertilization, depending on water temperature."

Pg. 2:
"Sheepshead are found in waters ranging from Nova Scotia to the Gulf of Mexico, and southward to Brazil (Manooch 1984). Populations of sheepshead occurring in South America and in parts of the Gulf of Mexico are regarded as two separate subspecies. Sheepshead are year-round residents from about South Carolina through the Gulf of Mexico, and most abundant to the north between April through November. They are found in coastal waters, bays and estuaries, and are tolerant of low salinity brackish waters as well."

"Sheepshead are most frequently encountered near some type of structure like pilings, jetties, oyster reefs, artificial reefs and coastal live bottom. Their close association with manmade reefs in South Carolina is documented as far back as the mid 1800's (Holbrook 1860). As a consistently popular species sought after by serious recreational anglers, their year-round presence in South Carolina waters can be documented through SCDNR creel survey data. This data indicates that the ten-year averages of the monthly percentage of annual sheepshead landings from surveying private boat anglers at coastal boat landings is relatively constant year-round. The data was collected as part of South Carolina's State Recreational Fisheries Statistics Survey (SC SRFSS) program."

Pg. 3:
Habitat and natural community requirements:
"Sheepshead commonly occur in estuarine, nearshore, and coastal waters throughout the southeastern United States (Jennings 1985). They are encountered throughout a diverse range of ecosystems, including brackish mangroves, salt marshes and nearshore waters, particularly around pilings, jetties and other structures. Recreational anglers fishing on manmade and naturally occurring reefs in nearshore and offshore waters frequently target this species (Stanley and Wilson 2000). Juveniles are found predominately in estuaries and adults in offshore waters."

"Their presence has been documented on subtidal and intertidal oyster reef habitats and on intertidal flats in the southeastern United States (SAFMC 1998). Adults are found in nearshore and offshore waters along the entire coast, where suitable bottom habitat and structure exists. Grimes et al. (1982) noted their presence on shallow water live bottom habitats off North Carolina and South Carolina, where limited vertical relief and a rich invertebrate community often exist."

Pg. 4:
"Sheepshead readily recruit to South Carolina's marine artificial reefs, from 5 to 56 km (3 to 35 miles) offshore, but are most commonly noted by divers on reefs in the 9 m (30 feet) to 18 m (60 feet) range. Larger fish seem to move offshore as water temperatures drop in the fall and winter months, and remain closely associated with reef structure (pers. obs.). It is not uncommon for divers to encounter very large sheepshead taking refuge or resting inside openings found in various reef structures."

"Any impacts to the health of South Carolina's estuarine habitats, or degradation of water quality in these areas could also have negative consequences for the success of larval recruitment and settlement from coastal spawning populations of sheepshead, or the health of juveniles and sub-adults inhabiting estuarine waters and bottoms. Alterations to water quality parameters can impact the health of many marine-spawning species like sheepshead that can only be successful if they are physiologically, thermally and salinity adapted (Sea Grant 1976). Introduction of toxins and pollutants such as PCBs into coastal waters can also have a disruptive effect on juvenile fishes with potentially long-term impacts on life cycles (Thomas 1990)."

4. IUCN Red List: http://www.iucnredlist.org/details/170223/0 (Least concern)
   Depth limit (meters): 0 – 15 m

"Variety of habitats, including seagrass beds, rocky outcroppings, artificial structures (jetties, oil platforms, piers), and reefs (Jennings 1985, Sedberry 1987, Schwartz 1990). This is not a true migratory species, but move to offshore spawning grounds into the Gulf of Mexico and the Atlantic with the onset of cool weather and return to inshore waters in the spring after spawning (Jennings 1985, Tremain et al. 2003, Munyandorero et al. 2006, Anderson et al. 2008)."

5. Smithsonian Marine Station at Fort Pierce
http://www.sms.si.edu/IRLSpec/Archos_probat.htm

“[Sheepshead are] common on the Atlantic and Gulf coasts of the United States. Its range extends from Cape Cod, Massachusetts south through Florida and the Gulf of Mexico to Brazil. Wanderers are occasionally observed as far north as Nova Scotia. It is absent from Bermuda, the West Indies and the Bahamas (Jennings 1985).”

“Larvae hatch after 40 hours in water temperatures of approximately 25 °C (77 °F).”

“Temperature:
Archosargus probatocephalus have been collected from waters ranging in temperature from 5 - 35.1°C (41 - 95.2 °F)(Perret 1971; Johnson 1978). Tampa Bay Juveniles have been collected at temperatures ranging from 12.8 - 32.5 8°C (55.0 - 90.5 °F)(Springer and Woodburn 1960).”

“Salinity:
Sheepshead are a euryhaline species and have been collected from waters in where salinity ranged from 0 - 35 parts per thousand (ppt) (Springer and Woodburn 1960; Kelly 1965; Perret 1971; Perret and Caillouet 1974).”

“Sheepshead are not truly migratory, but do move to offshore spawning grounds with the onset of cooler water temperatures in late fall and winter (Gilhen et al. 1976; Jennings 1985), and return to nearshore waters and estuaries after spawning takes place in spring. Music and Pafford (1984) found that tagged sheepshead in Georgia never moved more than 100 km (62.5 miles) from their tagging sites, with emigrating fishes leaving estuaries for nearshore reefs close to the sites where they were initially tagged.”

Reference for above statements:
1. Perret, W. S. 1971. Cooperative Gulf of Mexico estuarine inventory study. Phase 4, Biology. Pages 31-69. La. Wildl. Fish. Comm. 171 pp.
2. Johnson, D.G. 1978. Development of fishes in the mid-Atlantic Bight: an atlas of egg, larval, and juvenile stages. Vol. 4. Carangidae through Ephippidae. U.S. Fish Wildl. Serv. FWS/OBS- 78/12. 311 pp.
3. Jennings, C.A. 1985. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) - Sheepshead. U.S. Fish and Wildlife Service Biological Reports 82(11.29). U.S. Army Corps of Engineers, TR EL-82-4. 10 pp.

6. SAFMC, http://safmc.net/fish-id-and-regs/sheepshead

“The mouth is medium sized, with strong incisors and molars that enable the fish to pick up and crush shellfish and urchins. Sheepshead are saltwater fish, although they are often found in brackish waters of coastal rivers.”

“Sheepshead range from Nova Scotia to Cedar Key, Florida along the Atlantic coast of North America. Two subspecies may occur in the western Gulf of Mexico and in the South Atlantic to Rio de Janeiro. During the spawning season, Sheepshead swim in schools and appear to prefer sandy shores. The dark, pelagic eggs are deposited near shore.”

“Effective April 16, 2012, sheepshead have been removed from the snapper grouper management complex and federal regulations are no longer in effect for this species.”

7. North Carolina Division of Marine Fisheries (DMF): http://portal.ncdenr.org/web/mf/07-sheepshead-ssr-2015

“Stock Status – Unknown– Sheepshead are a highly sought after recreational fish and captured in many commercial fisheries. In North Carolina, the commercial landings in 2014 were above the ten year average, while the recreational landings decreased 45% from the ten year average. For recreationally caught sheepshead in 2014, the mean length was 13 inches and the average fish weighed 2.3 pounds.”

Status of Fishery Management Plan (FMP) – No fishery management plan has been developed. Sheepshead were removed from the South Atlantic Fishery Management Council’s (SAFMC) Snapper Grouper Fishery Management Plan in 2012.

“Habits and Habitats - Sheepshead are found in coastal waters year-round in North Carolina waters based on recreational catches. Sheepshead are generally found from inshore brackish waters to offshore around rock and hard substrate. During the winter, adult sheepshead migrate to oceanic waters to spawn. Spawning occurs February through May. After the spawning season, sheepshead typically return to inshore waters.”

Skipjack tuna: *Katsuwonus pelamis*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature, chlorophyll and oxygen that is likely changed by climate change.
Depth Range:	0 – 260 m
Temperature Range:	14.7 – 33 °C; prefer 18.8 – 26.2 °C (Boyce et al., 2008); 20 – 32 °C (Sharp, 1979); 14.7 – 30 °C (Florida Museum of Natural History)
Salinity Range:	Need information
Oxygen Rage:	2.5 – 3.0 ml/l (Sharp, 1979)
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Climate change vulnerability of skipjack tuna

Muhling, B.A., Y. Liu, S.-K. Lee, J.T. Lamkin, M.A. Roffer, F.E Muller-Karger, and J.F. Walter III. 2015. Potential impact of climate change on the Intra-Americas Sea: Part-2. Implications for Atlantic bluefin tuna and skipjack tuna adult and larval habitats. J. Mar. Syst. 148: 1-13.: muhling_etal_2015_jms-1.pdf
http://www.sciencedirect.com/science/article/pii/S0924796315000226

Abstract:
"Increasing water temperatures due to climate change will likely have significant impacts on distributions and life histories of Atlantic tunas." "Results showed marked temperature-induced habitat losses for both adult and larval bluefin tuna on their northern Gulf of Mexico spawning grounds. In contrast, habitat suitability for skipjack tuna increased as temperatures warmed." "This work suggests that influences of climate change on highly migratory Atlantic tuna species are likely to be substantial, but strongly species-specific. While impacts on fish populations remain uncertain, these changes in habitat suitability will likely alter the spatial and temporal availability of species to fishing fleets, and challenge equilibrium assumptions of environmental stability, upon which fisheries management benchmarks are based."

4. NOAA Fisheries Atlantic Highly Migratory Species
http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch6.pdf

Pg. 18 – 19:
"Distribution: Skipjack tuna are circumglobal in tropical and warm-temperate waters, generally limited by the 15° C isotherm. In the west Atlantic skipjack range as far north as Newfoundland (Vinnichenko, 1996) and as far south as Brazil (Collette and Nauen, 1983). Skipjack tuna are an epipelagic and oceanic species and may dive to a depth of 260 m during the day. Skipjack tuna is also a schooling species, forming aggregations

associated with hydrographic fronts (Collette and Nauen, 1983). There has been no trans-Atlantic recovery of tags; eastern and western stocks are considered separate (ICCAT, 1997)."

"Life history: Skipjack tuna spawn opportunistically in equatorial waters throughout the year, and in subtropical waters from spring to early fall (Collette and Nauen, 1983). Larvae have been collected off the east coast of Florida from October to December (Far Seas Fisher. Res. Lab., 1978) and in the Gulf of Mexico and Florida Straits from June to October (Houde, pers. comm.). However, most spawning takes place during summer months in the Caribbean, off Brazil (with the peak in January through March), in the Gulf of Mexico (April to May), and in the Gulf of Guinea (throughout the year) (SCRS, 1978/79; Richards, 1967)."

"Habitat associations: Aggregations of skipjack tuna are associated with convergences and other hydrographic discontinuities. Also, skipjack tuna associate with birds, drifting objects, whales, sharks and other tuna species (Colette and Nauen, 1983). The optimum temperature for the species is 27° C, with a range from 20° to 31° C (ICCAT, 1995)."

"Essential Fish Habitat (EFH) for Skipjack Tuna:
- Spawning, eggs and larvae: In offshore waters, from the 200 m isobath out to the EEZ boundary, from 28.25° N south around peninsular Florida and the Gulf Coast to the U.S./Mexico border.
- Juveniles/subadults (<45 cm FL): In pelagic surface waters from 20° to 31° C in the Florida Straights off southeastern Florida, from the 25 m isobath to the 200 m isobath, from 27.25° N south to 24.75° N southwest of the coast of Key Largo, FL.
- Adults (> 45 cm FL): In pelagic surface waters from 20° to 31° C in the Mid-Atlantic Bight, from the 25 m isobath to the 200 m isobath, from 71° W, off the coast of Martha's Vineyard, MA, south and west to 35.5° N, offshore Oregon Inlet, NC."

5. Sharp, G.D.,1978. Behavioral and physiological properties of tunas and their effects on vulnerability to fishing gear. Academic Press, Inc. ISBN 0-12-639180-7. Pp 412.

Estimated lower O_2 tolerance (10 minute levels, ml O_2/L H_2O) is 2.45 (measured) and 2.89 (estimated value).

6. Sharp, G.D.,1979. Areas of potentially successful exploitation of tunas in the Indian Ocean with emphasis on surface methods. Rome, FAO, IOFC/DEV/79/47:55 pp.

Temperature Range: 20 – 32 °C
Dissolved oxygen values tolerances for 10 minutes by fish measuring between 50 and 75 cm: 2.5 – 3.0 ml/l

7. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic, Pacific and Indian Ocean Skipjack tuna extract from “Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage.”

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Skipjack tuna	*Katsuwonus pelamis*	14.7	33	16.90	28.76	18.84	26.23	11.86	23

8. Florida Museum of Natural History, accessed October 12, 2015
https://www.flmnh.ufl.edu/fish/Gallery/Descript/SkipjackTuna/SkipjackTuna.html

“Habitat
The skipjack tuna is an epipelagic fish, occurring in waters ranging in temperature from 58-86°F (14.7 to 30°C). While skipjacks remain at the surface during the day, they may descend to depths of 850 feet (260 m) at night. Skipjacks have a tendency to school, often under drifting objects or marine mammals. Skipjacks exhibit many types of schooling behavior, sometimes schooling with drifting objects, sharks, or whales. They may swim slowly in circular paths or travel in a single direction. These schools may consist only of skipjack, or other tuna species may be present. Skipjack often divide into schools based upon their size. This may be because the smaller fish cannot maintain the same top speeds of larger fish. Small fish may school while feeding, whereas larger fish (greater than 8 inches (20 cm)) tend to feed alone.”

“Reproduction
Skipjack are oviparous. In warm equatorial waters, skipjack spawn year-round while further away from the equator, spawning season is limited to the warmer months.”

Southern flounder: *Paralichthys lethostigma*

Vulnerability:	Vulnerable (Roffer and Hall, 2015, this document). Estuary and ocean dependent for life cycle. Any change in estuarine ecosystem will impact southern flounder. Recruitment to estuaries likely a function of favorable/unfavorable currents that are probably affected by climate change.
Depth Range:	0 – 66 m
Temperature Range:	5 – 35 °C
Salinity Range:	0.0 - 60.0 ppt
Oxygen Rage:	Need information
pH Range:	Need information

2013: $11,345,676.00, 1,983.5 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. IUCN Red List http://www.iucnredlist.org/details/202632/0 (Least concern)

"*Paralichthys lethostigma* is distributed from North Carolina to Jupiter Inlet, Florida, and from Caloosahatchee estuary, Florida, to Texas or northern Mexico."

"*P. lethostigma* is an estuarine-dependent species which inhabits riverine, coastal and estuarine waters, and prefers muddy or silty substrates (Reagan and Wingo 1985). Individuals can tolerate wide temperature (~ 5-35°C) and salinity ranges (~ 0.0-60.0‰), and often enter freshwater. Tagging studies showed that tagged southern flounder are recaptured close to the tagging site within a year after they are released (Wenner et al. 1990, Monaghan 1992, Scharf et al. 2008). The distribution of *P. lethostigma* in Florida appears to be substrate related - it is typically associated with mud or silt substrates, while P. albigutta is found over sandy substrates (FWRI 2010)."

Economic: "*P lethostigma* is the single most valuable finfish in the North Carolina fishery (Takade-Heumacher and Batsavage 2009)."

"After spawning, juveniles recruit to estuaries where they remain for two years before becoming sexually mature and joining adults stocks. *P. lethostigma* spawns offshore between November and March in the U.S. South Atlantic**.** In the Gulf of Mexico, adults move out of the estuaries to spawn in the Gulf of Mexico from October to February (Reagan and Wingo 1985)."

"This is a major commercial and recreational flatfish species throughout its range, though it is a component of much larger commercial fisheries in the Atlantic, off the coast of North Carolina. Management of this species is the responsibility of the respective states in the Gulf and on the Atlantic. Cooperation is achieved amongst states through entities such as the Mid-Atlantic Fishery Management Council and the Gulf of Mexico Fishery Management Council."

"In the Atlantic, Southern Flounder is considered a Depleted Stock by the State of North Carolina, the only state which generates stock assessments for this species. It has been considered overfished since 1991, and there is no clear trend in abundance despite reduced fishing pressure and increases in estimates of Standing Stock Biomass (SSB)."

"In the eastern and central Gulf of Mexico, stock assessments are performed by the states of Florida and Louisiana. In both states, these assessments are performed for all flounder species, and trends appear to be stable. However the status of *P. lethostigma* in particular is unknown. It does not appear to be the dominant component of flounder catches east of the Mississippi river delta, where it is replaced by *P. albigutta*."

"In the western Gulf of Mexico, where *P. lethostigma* comprises the large majority (95%) of all flounder species, assessments are performed in the state of Texas. Analysis of long-term population trends in Texas found that that both juveniles and adults have been continuously declining, with rates of decline in abundance of juveniles estimated at 1.3% per year, while those for adults are nearly double, estimated at 2.5% per year. These declines have been attributed to commercial and recreational over harvesting as well as by-catch mortality from the shrimp trawl fishery."

"In addition to being commercially important, *P. lethostigma* is heavily impacted by by-catch mortality, primarily from shrimp trawling. This threat is not clearly understood, however declines in abundance in both the Western Gulf of Mexico and off the coast of North Carolina have been attributed to shrimp trawling. In Texas, shrimp trawling is considered to be a major contributor to declines in abundance."

"Several factors are of great concern with regards to the status *P. lethostigma*: It is known to have been overfished in parts of its range and is dependent on management efforts in order to sustain its population. In the absence of a Gulf-wide assessment of this species, and given that it has been systematically overfished throughout its range, particularly in the Atlantic, and given that the impact of by-catch mortality is substantial but unquantifiable at this time, *P. lethostigma* is listed as Least Concern in view of the large extent of occurrence, large number of subpopulations, large population size, and lack of major threats. Trend over the past 10 years or three generations is uncertain but likely relatively stable, or the species may be declining but not fast enough to qualify for any of the threatened categories under Criterion A (reduction in population size)."

4. The Flounder Fishery of the Gulf of Mexico, US. A Regional Management Plan - Gulf States Marine Fisheries Commission. GSMFC Number 083, Oct 2000: GSMFC Number 083.pdf
http://www.gsmfc.org/publications/GSMFC%20Number%20083.pdf

Pg. 19:
"Gulf (*Paralichthys albigutta*) and southern flounder (*P. lethostigma*) range throughout the Gulf of Mexico from Florida to Mexico. Their habitats, distribution, and abundance change with life history stages and seasonal movements (Sections 3 and 4). They are euryhaline and found in freshwater, brackish water, and saltwater. Gulf and southern flounder are the two most commonly sought species in the Gulf of Mexico because of their larger maximum size. Southern flounder are most common from Mobile Bay, Alabama, to Brownsville, Texas."

"Southern flounder have been found to occur in a variety of habitats (Sections 3 and 4). They prefer muddy substrates and are relatively abundant in areas where the substrate is composed of silt and clay sediments. Estuaries with low freshwater inflow result in higher salinities, low sediment loads, lower turbidity, and firmer substrates."

Pg. 29: Of note is the depth range (m) for the Southern Flounder: "Shallow to mid depth to 66" m.

Species	Common Name	Geographic Distribution	Maximum Size (mm)	Depth Range (m)	Notes
Paralichthys albigutta (Jordan & Gilbert 1882)	Gulf flounder	North Carolina to S Florida and the Gulf of Mexico to S Texas and the Bahamas. More common along Florida's Gulf coast and NE Gulf of Mexico (not reported from Mississippi and Louisiana inshore waters)	380 TL	Shallow to deep to 128	Robins et al. 1986. Prefers hard or sandy bottom habitat (Gutherz 1967, Topp & Hoff 1972)
Paralichthys lethostigma (Jordan & Meek 1884)	Southern flounder	North Carolina to N Mexico through Gulf of Mexico. Absent south of Loxahatchee River to south of Caloosahatchee Estuary, Florida	910 TL	Shallow to mid depth to 66	Prefers muddy bottom habitat (Topp & Hoff 1972; Stokes 1977). A single specimen was collected in Florida Bay (FWC/FMRI unpublished data)

Pg. 33:
"Southern flounder are able to acclimate to temperatures from 5.0°-35.0°C and salinities ranging from 0.0‰-60.0‰ (Table 3.2)."

Pg. 34/35: “Table 3.2: Salinities and temperatures at which southern flounder were collected by area and author. NA = not available or reported.”

State	Salinity (‰)	Temperature (°)	Area	Author(s)
Texas	Adults: 2.0-36.2 (few above 25.0) Juvenile recruitment: 19.6-30.0	Adults: 9.9-30.5 Juvenile recruitment: 14.5-21.6	Coastal area	Günter 1945
	Sharply limited above 45; occasionally found to 60	Not reported	Laguna Madre	Simmons 1957
	6.0-36.0	Juvenile recruitment: 16.0 (as low as 13.8, adults from 10.0-31.0)	Aransas Bay	Stokes 1977
Louisiana	0.0-30.0	5.0-34.9	Coastal area	Perret etal. 1971
	3.3-26.0	6.2-31.0	Coastal area	Dunham 1972
	1.5-26.0	14.0-35.0	Caminada Bay	Wagner 1973
	2.5-7.0	10.0-11.0	Vermilion Bay	Perret & Caillouet 1974
	0.3-8.9	8.0-30.7	Vermilion Bay	Juneau 1975
	0.0-0.9	15.0-34.9	Lakes Pontchartrain & Maurepas	Tarver & Savoie 1976
	0.3-31.9	10.4-29.8	Coastal area	Burdon 1978
	5-20	10.4-29.8	Coastal area	Barret et al. 1978
Mississippi	19.9-37.9	13.3-28.0	Coastal area	Franks et al. 1972
	0.0-36.2	5.0-34.9	Coastal area	Etzold & Christmas 1979
Alabama	0.0-30.0	8.0-32.0	Mobile Bay/ Little Lagoon	ADCNR/MRD unpublished data
Florida	0.0-30.2	12.0-31.0	St. Johns River	Tagatz 1967
Georgia	Often enter fresh water	Eurythermal in shallow waters	Estuary	Dahlberg 1972
	New recruits in least saline portion of distribution	Not reported	Salt marsh estuary	Rogers et al. 1984
South Carolina	0.8-34.8	7.2-30.8	Charleston Harbor, Stono, Edisto, and Coosaw rivers	Wenner et al. 1990

(table continues on next page)

State	Salinity (‰)	Temperature (°)	Area	Author(s)
North Carolina	0.0-35.0 (most in upper portion of estuary less than 11.0)	7.0-29.0	Pamlico Sound & adjacent waters	Powell 1974
	0.0-28.0 (most found in 5.0-18.0)	NA	Pamlico/ Albermarle Peninsula	Epperly 1984
	0.0-33.6	7.2-31.8	Beaufort estuaries	Tagatz & Dudley 1961
	Postlarvae: 0.2-35.0	8.0-16.0	Estuary	Williams & Deubler 1968
	Juveniles: 0.0-35.0 (most below 17.0)	NA	Pamlico Sound/ adjacent estuaries	Powell & Schwartz 1977
	0.6-33.4	NA	Newport River	Turner & Johnson 1973

5. Distribution of Fish on the Northeast U.S. Shelf Influenced by both Fishing and Climate http://www.nefsc.noaa.gov/press_release/pr2014/scispot/ss1414/

"Scientists studying the distribution of four commercial and recreational fish stocks in Northeast U.S. waters have found that climate change can have major impacts on the distribution of fish, but the effects of fishing can be just as important and occur on a more immediate time scale."

"The researchers found that black sea bass, scup, and summer flounder exhibited significant poleward shifts in distribution in at least one season. The shifts in black sea bass and scup were related to temperature, while the shift in summer flounder was related to a decrease in fishing pressure and an expansion of the population age structure."

Southern kingcroaker (kingfish): *Menticirrhus americanus*

Vulnerability:	Need more information to determine status
Depth Range:	0 – 110 m
Temperature Range:	8.0 – 37.3°C; T/S tolerance is greater than the northern and gulf kingfish
Salinity Range:	GOM stock: 2.0 – 36.0 ppt, majority above 20.0 ppt
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/195075/0 (Least concern)
   Depth limit (meters): 0 – 110 m

4. NOAA Fisheries Bulletin 82: Distribution, Length-weight relationship, and length-frequency data of southern kingfish, *Menticirruhus Americanus*, in Mississippi: http://fishbull.noaa.gov/82-2/crowe.pdf (crowe.pdf)

Gulf of Mexico stock:
Pg. 4:
"Salinity Range
Southern kingfish were captured in waters ranging in salinity from 2.0 to 36.0 ppt, with the majority found above 20.0 ppt."

"Temperature Range
Young-of-the-year and adult southern kingfish were captured in waters with bottom temperatures ranging from 8.0°C in December to 37.3°C in August. The largest catches were taken in waters ranging from 20.0° to 30.0°C. Larval and postlarval fish (0.5-20.0 mm SL) were found from May through November in the shallow inshore waters and northern tidal zones of the barrier islands at temperatures ranging from 12.0° to 37.3°C. The bottom water temperatures where southern kingfish were taken for the fall groundfish cruise ranged from 22.4° to 25.5°C (average of 23.2°C) and for the spring cruise ranged from 22.4° to 25.5°C (average of 22.3°C)."

5. South Carolina Dept. of Natural Resources: DNR_Kingfish.pdf
   http://www.dnr.sc.gov/cwcs/pdf/Kingfish.pdf

Pg. 1:
"Both commercial and recreational fishers harvest the southern kingfish throughout this species' range. It is difficult to obtain reliable estimates of the landings because neither group of fishermen separates landings by species. For example, all three kingfishes are listed as "king whiting" in the commercial statistics of the National Marine Fisheries Service (NMFS Commercial Fisheries Statistics 2005) for the east coast. The

recreational statistics are also problematic due to confusion of the species by port samplers and creel clerks."

Pg. 2:
"None of the kingfishes are considered threatened or endangered; however, there are concerns in South Carolina regarding by-catch mortality."

"The prevalence of kingfish in near shore, shallow, coastal waters make these species excellent indicators of the health of this ecosystem. In addition, kingfish are a forage item in the near shore oceanic waters for another species of conservation concern, the bottlenose dolphin."

Habitat and natural community requirements:
"Kingfish prefer near shore, shallow coastal waters with a muddy-sand bottom as well as high salinity bays and estuaries along the coast." The Southern and Northern kingfish species "prefer slightly deeper water with a sandy mud bottom."

Pg. 3:
"Kingfish can also be found in areas that have sufficient benthic infauna. These animals that live in the sediment, such as polychaetes (sea worms), mollusks (clams and snails) and crustaceans (amphipods, sea-lice) represent an important food source to kingfish. Southern kingfish appear to move south in the winter to areas with warmer water temperatures. They return to South Carolina's waters in the spring as temperatures moderate (Wenner and Sedberry 1989). The gulf and northern kingfish are believed to have a similar migration pattern."

"Kingfish are consistently found in penaeid shrimp fishery by-catch along the southeast coast (unpub. data); this incidental catch can result in death for many kingfish juveniles."

"Poor water quality from increased nutrient runoff and sewage discharges can cause oxygen depletion in kingfish habitat. Dredging offshore sand bars could eliminate some habitat as well as stir up sediments. During dredging activities, sediments and sediment bound chemical toxicants become suspended in the water column. Turbidity that accompanies dredging activities may impact the respiratory lamellae in the gills of the all fishes, resulting in affects similar to terrestrial animals breathing dust."

6. Florida Fish and Wildlife Conservation Commission: FWC_kingfishes.pdf
http://myfwc.com/media/194748/kingfishes.pdf

Pg. 1:
"Southern kingfish are reported to be voracious bottom feeders that eat a variety of organisms. Juvenile kingfish feed on copepods, bivalve siphons, mysids, amphipods, polychaetes, and cumaceans (Music and Pafford 1984). Larger fish fed on various crabs, isopods, fishes, amphipods, and polychaetes (Bearden1963; McMichael 1981). McMichael and Ross1987) found that northern kingfish in the northern Gulf of Mexico fed on isopods, crabs, fishes, polychaetes, amphipods, mysids, and cumaceans.

Similarly, gulf kingfish fed on bivalve siphons, cumaceans, mysids, copepods, amphipods, and polychaetes (McMichael and Ross 1987).”

Spanish mackerel: *Scomberomorus maculatus*

Vulnerability:	Vulnerable (ASMFC, SAFMC). Very vulnerable (Roffer and Hall, 2015 this document – Distribution strongly affected by water temperature.)
Depth Range:	0 – 200 m
Temperature Range:	21 – 31 °C
Salinity Range:	32 – 36 ppt
Oxygen Rage:	Need information
pH Range:	Need information

2013: $4,682,106.00, 1,581.7 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC, SAFMC

1a. ASMFC:
Management authorities? Fed: NOAA; Regional: SAFMC; Interstate: ASMFC; State: NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? Warm water, highly migratory species. no evidence that their growth, recruitment, or productivity are highly sensitive to temperature or ocean acidification. Warming ocean temperatures may cause a northward range shift**.**

Ecosystem considerations? Affected by changes in forage fish populations

Linkages to other fisheries? Cascade effects in forage fish populations -> affect prey such as coastal sharks and dolphins

Known climate-related concerns? 1) Climate change impacts on squid, shrimp, and forage fisheries could impact the Spanish mackerel fisheries. 2) increased range expansion due to warmer waters could increase fishing pressure.

Social and economic concerns? Possibly higher portion of income for some fisherman.

Management Risk? Low

1b. SAFMC:
Management authorities? Fed: NOAA; Regional: SAFMC and GMFMC; Interstate: ASMFC; State: NC, SC, GA, FL

Climate vulnerability? Estuarine dependent life history - early life stages exposed to loss or degradation of estuarine habitat; changes in river flow as they emigrate from the nursery grounds; adults – changes in currents, temperature and productivity in the offshore pelagic habitats impacting migration, schooling behavior, prey availability or spawning."

Ecosystem considerations? Estuarine dependent of key prey of Spanish mackerel, changes or loss of habitat associated. Year class strength possibly correlated with ocean temperature and increased ocean temperatures could affect survival and distribution of larvae along shelf. As with king mackerel, upwelling event may affect the movement and availability and increased occurrence may have long-term impacts on the population.

Linkages to other fisheries? Shifting effort on snapper grouper complex. Affect on prey species.

Known climate-related concerns? Increase in episodic upwelling events has been noted by fishermen to affect the movement/migration and availability, creates long-term impacts.

Social and economic concerns? Significant impact on direct impacted harvesters, dealers and processors, and secondarily consumers.

Management Risk? Low

References:
1) Growth rate linked with environmental factors:
http://icesjms.oxfordjournals.org/content/64/9/1785.short

2. SEDAR Stock Assessment – S17SAR1 Spanish Mackerel Final.pdf

Pg. 31:
"Based on the 2003 Stock Assessment on Spanish and King Mackerel Stocks by the Mackerel Stock Assessment Panel, the stock exploitation status was Not Overfishing. The stock biomass status was Not Overfished."

Pg. 66:
"The spawning season of Spanish mackerel is progressively longer from north to south, primarily due to water temperature. In lower Chesapeake Bay, Cooksey (1996) found partially spent, gravid, and running ripe females from June through August. Off the Carolinas and Georgia, females spawn from May through August (Finucane and Collins 1986; Schmidt et al. 1993), perhaps as late as September based on the presence of larvae (Collins and Stender 1987). Off the Atlantic coast of Florida, spawning females have been collected during April through September (Beaumariage 1970; Powell 1975; Finucane and Collins 1986), and as late as October in some years (Klima 1959)."

"Spawning appears to take place on the inner continental shelf."

3. FWC http://myfwc.com/fishing/saltwater/recreational/spanish-mackerel/

“Spanish mackerel are a pelagic, fast swimming fish that are prevalent throughout Florida’s coastal waters when water temperatures exceed 70°F. To remain in warm water, Spanish mackerel migrate out of the northern parts of the state in the fall of the year and return in April with the warming waters.”

4. IUCN Red List http://www.iucnredlist.org/details/170323/0 (Least concern)

“This species is oceanic pelagic. It is distributed from near the edge of the continental shelf to shallow coastal waters, often of low salinity and high turbidity. It is also found in drop-offs, and shallow or gently sloping reef and lagoon waters. It inhabits coastal waters at depths to 200 m (Collette 2001), but is more frequently caught in areas less than 100 m depth.”

5. Smithsonian Marine Station at Fort Pierce: http://www.sms.si.edu/irlspec/Scombe_macula.htm

Physical Tolerance:
“Temperature: Earll (1883) reported that Spanish mackerel are rarely reported from waters cooler than 18ºC. They are typically collected from waters ranging from 21 - 31 ºC (70 - 88 ºF). Water temperatures in excess of 25ºC triggers spawning in Spanish mackerel (Hoese 1907; Beaumariage 1970).”

“Temperature and salinity are governing factors in the geographic distribution of mackerels, with the northern range of Spanish mackerel extending to the 20ºC isotherm within the 18m depth contour (Munro 1943; Berrien and Finian 1977a).”

Salinity:
“All life history stages of Spanish mackerel typically inhabit waters where salinity fluctuates between 32 – 36 ppt. (Godcharles and Murphy 1986). Spanish mackerel tend to avoid both freshwater and low salinity waters near river mouths (Earl 1883), though it has been documented that some juveniles inhabit waters where salinity has dropped below 18 ppt (Springer and Woodburn 1960).”

“Juveniles are collected from low salinity (12.8 – 19.7 ppt) estuaries as well as from high salinity beaches, suggesting that at least some Spanish mackerel utilize estuaries as nursery grounds (Springer and Woodburn 1960).”

Spiny dogfish: *Squalus acanthias*

Vulnerability:	Low vulnerability (MAFMC) – highly migratory Unknown (ASMFC) - nursery habitat and inshore estuarine habitat for juveniles and adults could be at risk Vulnerable (Roffer and Hall, 2015 this document - migrations are governed by temperature changes, thus distributional shifts and catchability are affected by climate change).
Depth Range:	1 – 500 m (vertical migrators)
Temperature Range:	7 – 15 °C
Salinity Range:	Mean salinity = 33.5 ppt
Oxygen Rage:	29 – 36 ppt
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC & MAFMC

1a. MAFMC
Management authorities? Fed: NOAA, Inter-state: ASMFC, NEFMC, MAFMC; States: ME, NH, MA, RI, CT, NY, NJ, DE, MD, VA, NC, SC, GA, FL

Climate vulnerability? "Low vulnerability to climate change. They are highly migratory and distributional shifts are the most likely response to changes in localized conditions."

Ecosystem considerations? "Generalist predators and are likely to respond to changes in forage availability by shifting diet or by relocating"

Linkages to other fisheries? "Low value fishery that provides supplemental income for operators that make most of their income in other fisheries. If spiny dogfish stock conditions improve, whether from climate change or any other cause, then there is likely to be more supplemental income for those operators. If stock conditions worsen or the stock shifts such that is less available to U.S. vessels, then that portion of their income will decrease and their dependence on other fisheries will increase." "If changes in other fisheries cause increased political pressure to allow for currently prohibited relaxation of harvest controls on spiny dogfish, then it is conceivable that the resulting diminished stock size would correspond to increased vulnerability to environmental stressors, e.g., climate change"

Known climate-related concerns? "Nearshore water temperature has been implicated as being an important short-term influence on the availability of spiny dogfish to the commercial fishery."

Social and economic concerns? “Supplemental income to operators involved in more profitable fisheries. If climate change is the basis for changing the relative importance of this fishery in communities, then there will be social and economic impacts”

Management Risk? Low

1b. ASMFC

Climate vulnerability? “Extent to which dogfish would be affected by climate change is unknown. However, the quality and availability of nursery habitat and inshore estuarine habitat for juveniles and adults would likely be negatively affected by climate change. Reductions in these habitats could lead to reduced productivity of the affected stocks. Growth and migration patterns may be affected as well by climate change, but the anticipated direction and magnitude of that change is unclear at this time.”

Ecosystem considerations? “In many ecosystems, dogfish contribute significant predation pressure. If dogfish are affected by climate change, ripples could be felt among multiple prey stocks and throughout the ecosystem. However, the effects of disturbing predator-prey interactions are complicated and thus difficult to predict.”

Linkages to other fisheries? “If spiny dogfish’s range is reduced, fishermen in the New England region would likely switch their effort to other species in the area (groundfish, most notably).” “It is suspected that changes in the Atlantic cod fishery have forced fishermen to focus their effort on spiny dogfish. As other species’ ranges are reduced due to climate change, fishermen may target spiny dogfish more.”

Known climate-related concerns? “None”

Social and economic concerns? “None”

Management Risk? Low. “Management is capable of responding to climate change due to annual specification-setting processes”

2. No SEDAR document available

3. NOAA Technical Memorandum NMFS-NE-203: Essential Fish Habitat Source Document:Spiny Dogfish, *Squalus acanthias*, Life History and Habitat Characteristics, 2007
http://www.nefsc.noaa.gov/publications/tm/tm203/tm203.pdf

Pg. 11:
“Worldwide, spiny dogfish favor the temperature range of 7-15°C (Compagno 1984). Compagno (1984) contends their migrations are governed by temperature changes. Migrations may be over great distances in order to seek out preferred conditions.” “The mean salinity in locations where they are caught is 33.5 ppt.”

“Spiny dogfish undergo daily vertical migrations. In a midwater trawl study of offshore basins of Nova Scotia, which reach depths of 275 m, juvenile and adult dogfish were found near the bottom in daylight and rose to 150 m at night, possibly following their copepod prey (Sameoto et al. 1994).”

“The spring and fall distributions of adult spiny dogfish relative to bottom water temperature, depth, and salinity based on NEFSC bottom trawl surveys from the Gulf of Maine to Cape Hatteras are shown in Figure 14. During the spring they were found over a temperature range of 3-14°C; most were found from 6-10°C. They were spread over a depth range between 1-500 m. They were found in a salinity range of 29-36 ppt, with the highest catches and occurrences, relative to the trawls, at 34-35 ppt. During the autumn, they were found over a temperature range of 5-18°C, with the majority between 6-16°C. Their autumn depth ranged from 11-400 m, with some higher catches between 21-40 m. They were found over a salinity range of 30-35 ppt, with the majority between 32-34 ppt.”

Pg. 20:

Table 4. Summary of habitat parameters for spiny dogfish based on the pertinent literature.

Life Stage	Depth	Substrate	Salinity	Temperature/Season
Spawning Adults [1]	Outer continental shelf, 41-400 m.	Pelagic or demersal	Oceanic	Late fall to winter
Juveniles	As in adults	Juveniles are mainly pelagic.	Oceanic	See adults
Adults [2]	In eastern Long Island Sound, 25-40 m. On the Scotian Shelf depth range 36-364 m, preferred depths 36-53 and 128-180 m. Off New Zealand caught at 100-300 m.	Adults are demersal at times, swimming over areas of sand, silt, and mud where food is available. In eastern Long Island Sound, they are found in areas of sand, sand waves, mud, and transitional sand-mud bottoms. On the Scotian Shelf, glacial till, sand and gravel, sand, silt, and clay. Off New Zealand, sand or silt-mud bottoms.	On the Scotian Shelf, salinity range 31-34 ppt, preferred 33.5 ppt. In eastern Long Island Sound, mean salinity 30-32 ppt.	In Long Island Sound, 7-13°C in spring and autumn. Scotian Shelf in summer, range 3-11°C, preferred 6-9°C. Off New Zealand 6.5-10 °C.

4. Shark Info – International Media Services
http://www.sharkinfo.ch/SI2_99e/sacanthias.html

"Generally prefer a water temperature ranging between 7 and 15 degrees."

Spot: *Leiostomus xanthurus*

Vulnerability:	Need more information to determine status
Depth Range:	0 – 50 m
Temperature Range:	5/10 – 35 °C
Salinity Range:	0 – 37 ppt; juveniles in low salinity tidal creeks
Oxygen Rage:	Lower tolerance of 0.8mg/L (5% mortality); 0.6 mg/L = 95% mortality
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC
Management authorities? Fed: NOAA; Regional: SAFMC; Interstate: ASMFC; State: NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? "Spot may display range shifts and changes in timing and spatial pattern of seasonal migration in response to climate change. Whether or not these changes will result in overall increased or decreased productivity across the entire stock is unclear"

Ecosystem considerations? "Climate-induced changes to estuarine nursery and other inshore habitats may affect growth, maturity, and subsequent productivity of the stock."

Linkages to other fisheries? "As spot can be considered a forage fish similar to croaker, impacts to croaker habitat and abundance could impact the abundance other commercial important species." "As there is evidence of bycatch of spot in shrimp fisheries, changes to the shrimp trawl fishery may have impacts on abundance."

Known climate-related concerns? "Possible impacts to the species is annual rainfall and freshwater flows to estuarine habitats, as well as coastal development and loss of habitat in coastal areas"

Social and economic concerns? "Primarily a near-shore recreational fishery, in some instances primarily for bait."

Management Risk? "Possible concerns center on the need for more updated stock assessment and lack of management measures along the coast, and the ability to response effectively to changes to the stock"

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/193267/0 (Least concern)
   Depth limit (meters): 0 – 50 m

“Spawning takes place in the ocean from fall to early spring and post-larvae are subsequently transported into estuaries, where they develop into juveniles in low salinity tidal creeks.”

4. Smithsonian Marine Station at Fort Pierce
http://www.sms.si.edu/IRLSpec/Leiosto_xanthu.htm

Temperature:
“Mass mortality of spot was observed at water temperatures of 5 – 10 ºC, but larvae and postlarvae may be more tolerant of widely ranging temperatures than are older fish (Hildebrand and Cable 1930; Hodson et al. 1981a).

Under laboratory conditions (Hettler and Powell 1981) reported spawning occurred at 17-25ºC. Spot embryos do not develop at temperatures below 14ºC; however, larvae can tolerate temperatures as low as 5 ºC. (Hettler and Clements 1978). Burton (1979) reported symptoms of cold stress in juveniles held at 5ºC.”

“Upper thermal tolerance for postlarvae and juvenile spot is approx. 35 ºC, depending on the size and general condition of fish, as well as the temperature they have been acclimated to. Generally, as acclimation temperatures increase, the critical thermal maximum also increases (Hodson et al. 1981a).”

Salinity:
“Low salinity does not appear to be necessary for proper development and metamorphosis to the juvenile stage; however, it may affect survivorship of larvae (Powell and Gordy 1980). Perez (1969) found that spot tended to be more active under lab conditions when salinity changed quickly, suggesting that they may actively try to avoid areas where salinity levels change rapidly.”

Dissolved Oxygen:
“Postlarval and juvenile spot have intermediate tolerance to hypoxic conditions in comparison to other estuarine species (Burton et al 1980). Exposure of 90 mm TL spot to 0.8mg/L for 96 hours resulted in 5% mortality; however, lowering the concentration to 0.6 mg/L resulted in 95% mortality.”

5. Animal Diversity Web: University of Michigan
http://animaldiversity.org/accounts/Leiostomus_xanthurus/

“They can tolerate a wide range of temperatures (35-95 degrees F) and salinity (freshwater-37 ppt.)**”**

Spotted seatrout: *Cynoscion nebulosus*

Vulnerability:	Vulnerable (ASMFC). Warming water temperatures likely to allow seatrout to expand their range northward. Spawning temperature controlled. Oxygen sensitive.
Depth Range:	1 – 18 m
Temperature Range:	15 – 27 °C
Salinity Range:	15 – 35 ppt
Oxygen Rage:	Greater than 4 ppm in aquaculture ponds
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC
Management authorities? Fed: NOAA; Regional: SAFMC; Interstate: ASMFC; State: NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? "Warm-water species and at the northern extent of their range often experience "cold kill" events, which will be reduced as those areas experience fewer winter extreme temperatures. Warming water temperatures may allow seatrout to expand their range northward, although they are not a highly migratory species".

Ecosystem considerations? "Will be affected by climate change induced changes in their forage base"

Linkages to other fisheries? "Outside of bycatch in commercial fishing, declines in abundance of spotted seatrout in the recreational sector may cause increased interest among angler for other estuarine finfish", and vice versa.

Known climate-related concerns? "None"

Social and economic concerns? "Little knowledge of any unique social or economic concerns regarding the spotted seatrout fishery. Any concerns would likely be similar to other predominately recreational fisheries, such as expenditures associated with recreational trips."

Management Risk? N/A

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/193266/0 (Least concern).
   Depth limit (meters): 1 – 18 m

4. Smithsonian Marine Station at Fort Pierce:
http://www.sms.si.edu/irlspec/Cynosc_nebulo.htm

"In Florida, spawning is strongly influenced by temperature and salinity. Tabb (1958) reported that spawning in south Florida begins when water temperatures near 25ºC (77 ºF), but stopped when water temperatures rose over 28 ºC (82.4 ºF). Data from the Everglades, reported by Jannke (1971), is in agreement, with large-scale spawning occurring when water temperature reached 24ºC (75.2 ºF), but becoming reduced when water temperatures were above 30 ºC (86 ºF)."

"Young spotted seatrout were collected from the west coast of Florida where water temperatures ranged from 12 -29 ºC (53.6 – 84.2 ºF), while in the Everglades, young seatrout were collected in waters from 16 – 32 ºC (60.8 – 89.6ºF) (Jannke 1971). Tabb (1958) reported optimum temperatures for adult spotted seatrout as 15-27 ºC (59 – 80.6 ºF). Taniguchi (1980) reported optimum larval temperature ranges from 23-33 ºC (73.4 – 91.4 ºF) in south Florida."

"Adults and juveniles have similar preferences for salinity (Johnson and Seaman 1986), but abrupt salinity changes have adverse effects of spotted seatrout (Tabb 1966). *Cynoscion nebulosus* is found in waters where salinity ranges from 0-37 parts per thousand (ppt) (Herald and Strickland 1949; Tabb 1966; Jannke 1971). Tabb (1966) reported that seatrout abundance peaks at salinities ranging from 15-35 ppt. Spawning generally peaks when salinity in the home estuary is high, typically 30 – 35 ppt (Johnson and Seaman 1986)."

"In a Texas study, Wohlschlag and Wakeman (1978) reported optimum salinity for 17.4-43.5 cm (6.8 – 17.1 inches) fish was 20 ppt. Seatrout reportedly had difficulty maintaining swimming speed at salinities below 10 ppt, or above 45 ppt. Taniguchi (1982) reported 100% survival of eggs and larvae when salinity was 19-38 ppt."

"Oxygen requirements are partially dependent on salinity and temperature conditions in the environment. At an optimum temperature of 28 ºC (82.4 ºF) and salinity of 20 ppt, Wohlschlag and Wakeman (1978) reported hourly oxygen consumption was 214 – 574 mg O2/kg body weight; but was 148 – 502 mg O2/kg body weight when temperature was raised to 30 ºC."

"In aquaculture ponds, larval spotted seatrout died when dissolved oxygen in Texas ponds dropped below 4 ppm (Colura et al. 1976)."

Striped mullet: *Mugil cephalus*

Vulnerability:	Vulnerable (Roffer and Hall, 2015, this document). Susceptible to temperature increases and oxygen decrease.
Depth Range:	Need information
Temperature Range:	5 – 34.9 °C
Salinity Range:	0 – 35 ppt
Oxygen Rage:	Greater than 4.0 ppm
pH Range:	Need information

2013: $4,014,610.00, 2,015.4 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. GSMFC Number 033 – Gulf States Marine Fisheries Commission, No 33, 1995

Pg. 15:
"Striped mullet, *Mugil cephalus*, is the largest and most abundant species of mullet found in the Gulf of Mexico. Mullet are highly fecund, and spawning occurs offshore in large aggregations following mass spawning migrations from early to mid-winter. Larvae return to estuaries to grow and usually complete their life cycle by their second or third year. Because mullet are a schooling fish, they are easy prey for a wide variety of other fish, birds, and mammals, and they may subjected to numerous pollutants as they feed on bottom sediments. Mullet range throughout the Gulf and are found in a wide variety of habitats. They are most common in estuaries with moderate salinities and temperatures; however, juveniles and adults can tolerate salinities ranging from 0.0 ppt to in excess of 35 ppt and temperatures from 5.0° to 34.9°C (Perret et al. 1971)."

Pg. 27:
"The life cycle of striped mullet is typical of many estuarine-dependent species. Adults spawn offshore (Arnold and Thompson 1958), and larvae and postlarvae are transported to estuaries by various mechanisms (Ditty and Shaw 1996). Juveniles generally mature in estuarine or nearshore waters and complete the cycle when they reach maturity."

Pg. 39:
"Striped mullet are euryhaline and have been collected from salinities ranging from 0 ppt to 75 ppt in the Gulf (Breuer 1957, Simmons 1957, Franks 1970, Moore 1974, Collins 1981, Nordlie et al 1982). Perret et al. (1971) collected mullet (15 to 465 mm 1L) from salinities ranging from 0ppt to over 30ppt with largest catches taken from 5.0ppt to 19.9ppt."

“Kilby (1949) collected young striped mullet from temperatures ranging from 13° to 34.5°C, and Franks (1970) reported mullet from 16° to 33°C. Perret et al. (1971) collected mullet with trawls and seines from temperatures ranging from 5.0° to 34.9°C. Eggs survived best at 22°C (Nash et al. 1974) and 22.7°-23.3°C (Sylvester and Nash 1975). Larvae preferred slightly higher temperatures, 24°-28°C (Babaian and Zaitsev 1964), 24.5°-25.3°C (Sylvester and Nash 1975) and 22.8°-23.5°C (Sylvester et al. 1975). Optimum temperatures for juveniles less than 50 mm SL were 30°-32.5°C and 19.5°-20°C for fish 50 to 130 mm SL (Collins 1985). Older juveniles tended to have thermal tolerances similar to adults with a range from about 10.4° to 33.0°C (Sylvester et al. 1974, Martin and Drewry 1978). The lowest water temperature from which mullet were reported was 4.5°C (Moore 1976). Moore (1974) collected a striped mullet from 36°C and noted that 37°C was probably their upper critical temperature.”

“Sylvester et al. (1975) observed that mullet eggs and larvae apparently cannot live in waters with dissolved oxygen (DO) levels below 4.0 ppm. Survival was greatest at 5.0 ppm and above for eggs and 7.9 ppm for larvae. They noted that these levels were at or above saturation, but there was no evidence of gas bubble disease. Although sizes were not given, Collins (1985) reported survival of fish in cages at a DO concentration of 4.4 ppm with temperature at 29°C and salinity at 28ppt.”

Summer flounder: *Paralichthys dentatus*

Vulnerability: Medium – high vulnerability (MAFMC)
Depth Range: 10 – 160 m
Temperature Range: 2 – 27 °C
Salinity Range: 3 – 33 ppt.
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC & MAFMC
Management authorities? Fed: NOAA; Regional: MAFMC, Interstate: ASMFC, State: MA, RI, CT, NY, NJ, DE, MD, PRFC, VA, NC

1a. ASMFC

Climate vulnerability? "Summer flounder may display range shifts and changes in timing and spatial pattern of seasonal migration in response to climate change. Whether or not these changes will result in overall increased or decreased productivity across the entire stock is unclear."

Ecosystem considerations? "Climate-induced changes to estuarine nursery and other inshore habitats may affect growth, maturity, and subsequent productivity of the stock."

Linkages to other fisheries? "As summer flounder constitutes a significant commercial and recreational fishery, other valuable demersal species may be targeted in commercial sector, whereas striped bass, and black sea bass may be targeted more in the recreational sectors." "The abundance and distribution of other valuable commercial and recreational species could impact fishing pressure on summer flounder."

Known climate-related concerns? "Expansion of biological range and distribution".

Social and economic concerns? "Summer Flounder is a valuable commercial and recreational fishery that many within the fishery are significantly depend on. As such changes to the fishery due to climate change could have significant social and economic impacts".

Management Risk? "If management can not respond timely to climate change then fisheries may not be utilized to their full potential (coastwide quotas may not be fully harvested) and due to the political importance of the species other governance bodies may take over management."

1b. MAFMC

Climate vulnerability? Summer flounder "are likely to have medium - high vulnerability to climate change". "Observed shifts in distribution that may be due in part to climate related changes"

Ecosystem considerations? "Ecosystem considerations may make the species more vulnerable to climate change, depending on effects on predator and prey." "Competition for these habitats may also become an issue if the species distribution shifts."

Linkages to other fisheries? "Effort shifts to other species in areas with less [summer flounder]; Effort shifts from other species in areas with increased [summer flounder] abundance; Changes in bycatch composition and/or interactions with protected resources."

"Could changes in other fisheries influence the vulnerability of this species to climate change?" "This is very possible, given predator/prey relationships and potential shifts in fishery effort. Decreased prey or increased predator abundance within the range of [summer flounder] could increase the vulnerability of these species to climate change. Likewise, increased prey or decreased predator abundance could have the opposite effect. Climate change could lead to effort shifts as mentioned, which may cause increased or decreased fishing pressure on [summer flounder]"

Known climate-related concerns? "Recent stock assessment results and on-the-water observations suggest that the summer flounder stock has shifted to the northeast in recent years. This shift may represent either a range expansion or a range shift, or both. This may be related to climate change and/or expansion due to rebuilding, etc.".

Social and economic concerns? "Summer flounder has been managed under "conservation equivalency" since the early 2000s, resulting in state-by-state targets as a percentage of the total harvest limit, using 1998 as the allocation base year. Although this approach is currently being re-evaluated and the Commission has moved to regional targets for 2014, stakeholders have become accustomed to each state receiving a certain percentage of the harvest limits. Changes to this management approach and to the 1998 base year have been suggested to address changes in fish distribution and availability; however, there is resistance to potential changes due to perceived socioeconomic impacts to some states. Certain states or regions may benefit from shifts in distribution, while other states may experience detrimental socioeconomic effects."

"Shifts in species distribution/abundance can lead to increased search costs for fishermen and/or having to travel farther to find fish. This can greatly increase costs of trips, especially given the high price of fuel."

“Similarly, regulations and state-specific quotas restricting where fish can be landed (i.e., summer flounder commercial fishery) can lead to fishermen having to travel farther to find fish and bring them to a port where they can be landed.”

Management Risk? “Overfishing could result from a variety of causes related to ineffective response to climate change. For example, assessments could overestimate biomass, or changes in distribution combined with outdated regional or state-by-state management measures and quotas could result in increased fishing mortality in areas of increased abundance.”

“Underfishing (socioeconomic consequences) could result from causes similar to those described above. If the management system includes barriers to efficient targeting of fish where they are currently distributed, this could result in economic/social losses.”

“Similarly, increased costs of operation could be amplified by insufficient response to climate related changes (especially with inflexible landings structure, high search costs, etc.). Political and legal conflicts are already occurring as the result of changes in distribution, availability, and abundance. Allocation conflicts are and will be a huge issue. An inability to react in a timely manner to the changing needs of the fishery will exacerbate this problem.”

2. No SEDAR document available

3. IUCN Red List: http://www.iucnredlist.org/details/154983/0 (Least concern)
   Depth limit (meters): 10 – 160 m

“Bottom dwelling species and generally prefers muddy or sandy substrates. This species is concentrated in bays and estuaries from late spring to the early autumn, however the larger specimens remain further offshore at depths of 70-155 m or deeper. This species has also been found in salt marshes and seagrass beds with muddy or silty substrates. This species is also occasionally found in freshwater rivers (Bigelow and Schroeder 2002).”

4. NOAA Technical Memorandum NMFS-NE-151: Essential Fish Habitat Source Document: Summer Flounder, *Paralichthys dentatus*, Life History and Habitat Characteristics. http://www.nefsc.noaa.gov/publications/tm/tm151/tm151.pdf

Pg. 24:
Adults:
“NEFSC groundfish data shows a seasonal shift in offshore adult summer flounder occurrence with bottom temperatures (Figure 34): most adults are caught over a range of temperatures from 9-26°C in the fall, from 4-13°C in the winter, from 2-20°C in the spring, and from 9-27°C in the summer. Massachusetts inshore trawl survey data also shows a seasonal shift in adult occurrence with bottom temperature (Figure 30). In the spring, most adults occur at a range of temperatures from 6-17°C, while in the fall they occur at temperatures from 14-21°C” [more information available here].

Salinity:
“Adult summer flounder return inshore to coastal waters in April through June, and are often found in the high salinity portions of estuaries [e.g., Abbe (1967) in Delaware, Tagatz and Dudley (1961) and Powell and Schwartz (1977) in North Carolina; Dahlberg (1972) in Georgia]. However, the adult summer flounder’s distribution may be due more to substrate preference than salinity preference.”

Salinity values under juveniles section only:
Pg. 18:
“However, Turner and Johnson (1973) reported that summer flounder of all ages occurred in the Newport River, North Carolina, at salinities of 3-33 ppt. Data from 1987-1991 trawl surveys from Pamlico Sound show that almost all individuals were collected in the sound while few were found in the adjacent sub-estuaries with lower salinities such as the Pamlico and Neuse Rivers (Able and Kaiser 1994).”

There is a habitat characteristic section that covers temperature, salinity, dissolved oxygen, light, water currents, sub-strate and predation for eggs, larvae/juveniles on pages 15-24.

Swordfish: *Xiphias gladius*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature, chlorophyll and oxygen that is likely changed by climate change.
Depth Range:	0 – 650 m, diving as deep as 900 m
Temperature Range:	2 – 30 °C; prefer 14.5 – 22.8 °C (Boyce et al., 2008); Prefer 18 – 22 °C, tolerance: 5 – 27 °C (NOAA); spawn in 24°C or warmer (Dewar 2011)
Salinity Range:	Spawning salinity: 33.8 – 37.4 ppt
Oxygen Rage:	Concentration at maximum depths ranged from 0.5 to 5.1 ml/L
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. NOAA Fisheries Atlantic Highly Migratory Species
   http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch6.pdf

Pg. 21-25:
"Distribution: Swordfish are circumglobal, ranging through tropical, temperate and sometimes cold water regions. Their latitudinal range is from 50° N to 40-45° S in the west Atlantic, and 60° N to 45-50° S in the east Atlantic (Nakamura, 1985). The species moves from spawning grounds in warm waters to feeding grounds in colder waters. In the western north Atlantic two movement patterns are apparent: some fish move northeastward along the edge of the U.S. continental shelf in summer and return southwestward in autumn; another group moves from deep water westward toward the continental shelf in summer and back into deep water in autumn (Palko et al., 1981). Swordfish are epipelagic to mesopelagic, and are usually found in waters warmer than 13° C. Their optimum temperature range is believed to be 18° to 22° C but they will dive into 5° to10° C waters at depths of up to 650 m (Nakamura, 1985). Swordfish migrate diurnally, coming to the surface at night (Palko et al.,1981). Carey (1990, in Arocha, 1997) observed different diel migrations in two groups of fish: swordfish in neritic (shallow, near-coastal) waters of the northwest Atlantic were found in bottom waters during the day and moved to offshore surface waters at night. Swordfish in oceanic waters migrated vertically from a daytime depth of 500 m to 90 m at night."

"Life history: First spawning for north Atlantic swordfish occurs at four to five years of age (74 kg) in females. Most spawning takes place in waters with surface temperatures above 20° to 22° C, between 15° N and 35° N (Arocha, 1997; Palko et al., 1981). In the western north Atlantic spawning occurs in distinct locations at different times of the year: south of the Sargasso Sea and in the upper Caribbean spawning occurs from December to March, while off the southeast coast of the United States it occurs from April through August (Arocha, 1997)."

“Larvae have been found in largest abundance from the Straits of Florida to Cape Hatteras, NC and around the Virgin Islands. Larvae are associated with surface temperatures between 24° and 29° C. The Gulf of Mexico is believed to serve as a nursery area (Palko et al., 1981).”

“Habitat associations: In the winter in the north Atlantic, swordfish are restricted to the warmer waters of the Gulf Stream, while in the summer their distribution covers a larger area. Distribution is size and temperature related, with few fish under 90 kg found in waters with temperatures less than 18° C. Larvae are restricted to a narrow surface temperature range, and are distributed throughout the Gulf of Mexico, in areas of the Caribbean, and in the Gulf Stream along the U.S. coast as far north as Cape Hatteras, NC. Concentrations of adult swordfish seem to occur at ocean fronts between water masses associated with boundary currents, including the Gulf Stream and Loop Current of the Gulf of Mexico (Arocha, 1997).”

“Essential Fish Habitat for Atlantic Swordfish:

- Spawning, eggs and larvae: From offshore Cape Hatteras, NC (approximately 35° N) extending south around peninsular Florida through the Gulf of Mexico to the U.S./Mexico border from the 200 m isobath to the EEZ boundary; associated with the Loop Current boundaries in the Gulf and the western edge of the Gulf Stream in the Atlantic; also, all U.S. waters of the Caribbean from the 200 m isobath to the EEZ boundary.
- Juveniles/subadults (≤180 LJFL): In pelagic waters warmer than 18° C from the surface to a depth of 500 m, from offshore Manasquan Inlet, NJ at 40° N, east to 73° N, and south to the waters off Georgia at 31.5° N, between the 25 and 2,000 m isobaths; offshore Cape Canaveral, FL (approximately 29° N) extending from the 100 m isobath to the EEZ boundary (south and east) around peninsular Florida; in the Gulf of Mexico from Key West to offshore Galveston, TX (95° W) from the 200 m isobath to the EEZ boundary, with the exception of the area between 86° W and 88.5° W, where the seaward boundary of EFH is the 2,000 m isobath.
- Adults (>180 LJFL): In pelagic waters warmer than 13° C from the surface to 500 m deep, offshore the U.S. east and Gulf coasts from the intersection of the 100 m isobath and the EEZ boundary southeast of Cape Cod, MA to south and offshore Biscayne Bay, FL at 25.5° N, from the 100 to 2,000 m isobath or the EEZ boundary, which ever is closer to land; from offshore Tampa Bay, FL at 85° N to offshore Mobile Bay, AL at 88° N between the 200 and 2,000 m isobaths; from offshore south of the Mississippi River delta, 89° N to offshore waters south of Galveston, TX, 95° N from the 200 m isobath to the EEZ boundary”

4. Florida Museum of Natural History, accessed October 12, 2015
   https://www.flmnh.ufl.edu/fish/Gallery/Descript/Swordfish/Swordfish.html

“Habitat
Generally an oceanic species, the swordfish is primarily a midwater fish at depths of 650-1970 feet (200-600 m) and water temperatures of 64 to 71°F (18-22°C). Although

mainly a warm-water species, the swordfish has the widest temperature tolerance of any billfish, and can be found in waters from 41-80°F (5-27°C). The swordfish is commonly observed in surface waters, although it is believed to swim to depths of 2,100 feet (650 m) or greater, where the water temperature may be just above freezing. One adaptation which allows for swimming in such cold water is the presence of a "brain heater," a large bundle of tissue associated with one of the eye muscles, which insulates and warms the brain. Blood is supplied to the tissue through a specialized vascular heat exchanger, similar to the counter current exchange found in some tunas. This helps prevent rapid cooling and damage to the brain as a result of extreme vertical movements."

"Reproduction
Swordfish have been observed spawning in the Atlantic Ocean, in water less than 250 ft. (75 m) deep. Estimates vary considerably, but females may carry from 1 million to 29 million eggs in their gonads. Solitary males and females appear to pair up during the spawning season. Spawning occurs year-round in the Caribbean Sea, Gulf of Mexico, the Florida coast and other warm equatorial waters, while it occurs in the spring and summer in cooler regions. The most recognized spawning site is in the Mediterranean, off the coast of Italy. The height of this well-known spawning season is in July and August, when males are often observed chasing females."

5. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic, Pacific and Indian Ocean Swordfish extract from "Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage."

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Swordfish	*Xiphias gladius*	2	30	8.89	27.86	14.57	22.83	18.97	18

6. Fish Base http://www.fishbase.org/summary/226

"Marine; pelagic-oceanic;" "depth range 0 - 800 m (Ref. 9354), usually 0 - 550 m (Ref. 54934). Temperate; 5°C - 27°C (Ref. 43); 61°N - 50°S, 180°W - 180°E (Ref. 54934)".

"Oceanic but sometimes found in coastal waters (Ref. 9354). Generally above the thermocline (Ref. 9354), preferring temperatures of 18°C to 22°C (Ref. 9987). Larvae are frequently encountered at temperatures above 24 °C (Ref. 9702). Migrate toward temperate or cold waters in the summer and back to warm waters in the fall."

“Are batch spawners (Ref. 51846). Spawning takes place in Atlantic during spring in southern Sargasso Sea. Migrate to cooler waters to feed (Ref. 4689).”

“In the Atlantic Ocean, spawning occurs in the upper water layer at depths between 0 and 75 m, at temperatures around 23°C, and salinity of 33.8 to 37.4 ppt.” “Spawning appears to occur in all seasons in equatorial waters, but is restricted to spring and summer at higher latitudes (Ref. 30448).”

References for above Fish Base statements:

Reference 9354: Collette, B.B., 1995. *Xiphiidae*. Peces espada. p. 1651-1652. In W. Fischer, F. Krupp, W. Schneider, C. Sommer, K.E. Carpenter and V. Niem (eds.) Guia FAO para Identification de Especies para lo Fines de la Pesca. Pacifico Centro-Oriental. 3 Vols. FAO, Rome.

Reference 54934: FAO-FIGIS, 2005. A world overview of species of interest to fisheries. Chapter: *Xiphias gladius*. Retrieved on 14 July 2005, from www.fao.org/figis/servlet/species?fid=2503. 4p. FIGIS Species Fact Sheets. Species Identification and Data Programme-SIDP, FAO-FIGIS

Reference 43: Nakamura, I., 1985. FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fish. Synop. 125(5):65p. Rome: FAO.

Reference 9987: Frimodt, C., 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books, Osney Mead, Oxford, England. 215 p.

Reference 9702: Nakamura, I., 1997. *Xiphiidae*. Swordfishes. In K.E. Carpenter and V. Niem (eds.) FAO Identification Guide for Fishery Purposes. The Western Central Pacific.

Reference 4689: Nakamura, I., 1986. *Xiphiidae*. p. 1006-1007. In P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (eds.) Fishes of the north-eastern Atlantic and the Mediterranean. UNESCO, Paris. Vol. 2.

Reference 30448: Nishikawa, Y. and S. Ueyanagi, 1974. The distribution of the larvae of swordfish, *Xiphias gladius*, in the Indian and Pacific oceans. p. 261-264. In Proceedings of the international billfish symposium, Kailua-Kona, Hawaii, 9-12 August, 1972. Part. 2. Review and contributed papers. US Department of Commerce, NOAA Technical Report, NMFS SSRF 675.

7. FAO http://www.fao.org/fishery/topic/16082/en

"Swordfish make large vertical excursions, coming close to the surface at night and diving as deep as 600 m during the day ((Carey and Robison, 1981); Sedberry and Loefer, 2001), even 900 m (Takahashi et al., 2003)."

References for above FAO statements:

Carey, F.G. and B.H. Robison, 1981. Daily patterns in the activities of swordfish, *Xiphias gladius*, observed by acoustic telemetry. Fish. Bull. U.S., 79: 277-291.

Sedberry, S.R. and J.K. Loefer, 2001. Satellite telemetry tracking of swordfish, *Xiphias gladius*, off the eastern United States. Mar. Biol. 139: 355-360.

Takahashi, M., H. Okamura, K. Yokawa and M. Okazaki, 2003. Swimming behaviour and migration of a swordfish recorded by an archival tag. Marine and Freshwater Research 54 (4): 527-534.

8. Neilson JD, Loefer J, Prince ED, Royer F, Calmettes B, et al. (2014) Seasonal Distributions and Migrations of Northwest Atlantic Swordfish: Inferences from Integration of Pop-Up Satellite Archival Tagging Studies. PLoS ONE 9(11): e112736. doi:10.1371/journal.pone.0112736 http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0112736

Pg. 6:
"Swordfish in the northwest Atlantic experience considerable variation in sea surface temperatures concurrently, ranging from about 5 to 30°C."

9. Dewar, H., Prince, E. D., Musyl, M. K., Brill, R. W., Sepulveda, C., LUO, J., Foley, D., Orbesen, E. S., Domeier, M. L., Nasby-Lucas, N., Snodgrass, D., Michael Laurs, R., Hoolihan, J. P., Block, B. A. and McNaughton, L. M. (2011), Movements and behaviors of swordfish in the Atlantic and Pacific Oceans examined using pop-up satellite archival tags. Fisheries Oceanography, 20: 219–241. doi: 10.1111/j.1365-2419.2011.00581.x: Dewar 2011 Swordfish Tagging Pacific Atlantic.pdf http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2419.2011.00581.x/abstract;jsessionid=E19CA7678894393200A5EAB6BBF820A3.f02t02?userIsAuthenticated=false&deniedAccessCustomisedMessage=

Pg. 219:
"Temperature did not appear to influence daytime depths, and swordfish tolerated both extremely low temperatures (4°C) and rapid and dramatic temperature changes (>20°C). Temperature did appear to influence the nighttime depths in the Pacific where fish typically remained in the surface mixed layer. In contrast, in the warm tropical Atlantic this was not the case, and nighttime depths were much deeper. In all areas, nighttime depth increased around the full moon."

Pg. 230:
“Oxygen concentration at maximum depths ranged from 0.5 to 5.1 ml L^{-1} (0.7–6.9 mgL^{-1}, or 7–84% saturation, converted using temperatures at depth) with the two lowest values encountered at lower latitudes off Baja California, Mexico and in the CPO. In the EPO, nine of 21 estimates were 1 mL L^{-1}or less (1.2 mg L^{-1}, or 13% saturation).”

Pg. 235:
“There has been considerable speculation about the motivations for basking. Based on an increase in surface behavior in areas with a pronounced oxygen minimum zone, Carey and Robison (1981) suggested that basking allowed recovery from anaerobic debt after foraging in oxygen-poor water. Takahashi et al. (2003) reported that basking was more prevalent during the first days after fish entered cooler waters, suggesting that swordfish return to the surface to thermally recharge. The relationship we observed between basking and temperature was complex. Basking was observed in both warm tropical and cool temperate waters, did not always occur daily under similar thermal conditions, decreased in frequency as minimum daytime temperatures dropped and fish moved offshore, and did not occur in a regular pattern as do the thermoregulatory ascents to the warm surface waters observed in bigeye tuna and other species (Carey and Scharold, 1990; Holland et al., 1992; Schaefer and Fuller, 2002; Musyl et al., 2004; Schaefer et al., 2007).”

“Swordfish spawn primarily in waters 24°C or warmer (Grall and de Sylva, 1983; Nakamura, 1985) and the shift in vertical movement occurred at or close to this temperature.”

Tomtate (grunt): *Haemulon aurolineatum*

Vulnerability: Medium vulnerability (SAFMC)
Depth Range: 10 – 100 m
Temperature Range: Greater than 12.2 °C
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under Grunt Complex
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? "The grunt complex would generally have medium vulnerability to impacts of climate change. However, detailed life history and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats".

Ecosystem considerations? "The grunt complex species use shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, ph, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level."

Linkages to other fisheries? "If climate change affects other managed species including coastal migratory pelagic and fisheries for other snapper grouper species, effort could shift to the grunt complex". "Effort shifts associated with impacts in shelf waters, could result in increased effort on other managed snapper grouper species or even the deepwater complex"

Known climate-related concerns? "Changes in ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species."

Social and economic concerns? "Considerations would only arise if changes are great enough to result in shift among shelf or movement to deepwater ecosystems"

Management Risk? "The existing Council management system should be able to respond the management needs associated with such change."

2. No SEDAR document available

3. South Atlantic Fishery Management Council
http://safmc.net/FishIDandRegs/FishGallery/Tomtate/

“One of the smallest of the grunts, the tomtate are not highly regarded by fishermen, however it is an important food for larger fish-eating reef fishes.”

“The tomtate is distributed from Cape Hatteras to Brazil, including the Gulf of Mexico, the Central American coast and the Caribbean. Preferred habitat is rough bottom areas, which are scattered over the otherwise smooth plain of the continental shelf. tomtates are seldom in waters less than 54°F (12.2°C).” “All fish over the age of 5 are capable of reproducing. Spawning takes place in the spring.” “tomtates feed on small, bottom-dwelling bottom invertebrates.”

4. Texas Parks and Wildlife Department.
http://txmarspecies.tamug.edu/fishdetails.cfm?scinameID=Haemulon%20aurolineatum

“Habitat: Gulf, sandy bottoms and seagrass beds near reefs”

5. IUCN Red List: for *Haemulon striatum* (Striped Grunt/Common tomtate)
http://www.iucnredlist.org/details/155163/0 (Data deficient)
Depth limit (meters): 10 – 100 m
“Coral reef-associated species.”

6. Encyclopedia of Earth http://www.eoearth.org/view/article/156650/

Threats: “Studies at the Saba Reef, one of the richest fish assemblages in the Caribbean Basin, have indicated the chief threats to *Haemulon aurolineatum* and other reef fishes are overfishing and the residual impacts of the particular chemical dispersant used by the USA in the aftermath of the Deepwater Horizon oil spill; this chemical has high persistence and known toxicity to a gamut of marine fauna. Studies by Burke et al. suggest that concentrations of dispersant and other water pollutants are of particular concern in critical lagoon nurseries; these studies suggest that the toxicity of residual dispersant may be much more significant to reef fishes than the actual petroleum release of an underwater oil spill. The dispersant used in the Deepwater Horizon oil spill, Corexit 9500, is known to be much more toxic than the petroleum chemicals it is meant to disperse; moreover, the combined toxicity of Corexit 9500 and petroleum is more toxic to juvenile fish than either chemical set by itself.”
Reference: J.S.Burke, W.J.Kenworthy and L.L.Wood. 2009. Ontogenetic patterns of concentration indicate lagoon nurseries are essential to common grunts stocks in a Puerto Rican bay. Worldwide Science.org (purchase)

“Conservation Status: Tomtates are not considered to be a taxon at risk by the IUCN; however, this lack of designation carries little meaning, since the IUCN has not evaluated threats to the species.”

Vermilion snapper: *Rhomboplites aurorubens*

Vulnerability:	Medium vulnerability (SAFMC)
Depth Range:	40 – 300 m
Temperature Range:	Need information
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

2013: $3,881,834.00, 538.9 tonnes:
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? Medium vulnerability. However, detailed life history, movement and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats.

Ecosystem considerations? Use shelf ecosystems extensively. If pelagic and benthic habitat including coral and live bottom species are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced, leading to impacts at the populations level.

Linkages to other fisheries? Effort shifts could cause an increased effort on other managed snapper grouper species or even the deepwater complex, and vice versa.

Known climate-related concerns? Changes in ocean currents or increased of episodic events like upwelling are potential concerns affecting habitat essential to the managed species.

Social and economic concerns? If shelf habitat is affected by climate change economic impacts, it could cause reduction in availability or production.

Management Risk? Low

2. SEDAR Stock Assessment – SEDAR2_SAR2_VScomplete2.pdf:

“Most frequently caught snapper along the southeastern United States. The species inhabits depths of 18 to 122 m but is most abundant at depths less than 55 m. Tagging studies show neither long range migrations nor extensive local movements (unpublished MARMAP data), and there is no circumstantial or anecdotal information to suggest such movements. Vermilion snapper is a gonochorist (a species of distinct sex throughout the life span) that spawns from April to September, with peak spawning occurring during July and August. Eggs and larvae are pelagic; however, the length of time before settling out of the water column is unknown."

3. SEDAR Stock Assessment – S17SAR2 Vermilion Snapper Final.pdf: 2012_SAVSUpdate_Revised.pdf

Pg. 21:
"Vermilion snapper have a broad geographic range extending from North Carolina to Sao Paulo, Brazil including the Gulf of Mexico. Although adult vermilion snapper have a relatively small home range based on mark recapture studies, genetic studies have only found weak evidence for genetic stock structure in this species."

"Given the differences in the weight-length relationship, longevity, and weak genetic separation between the GOM and SA vermilion snapper, the DW Life History Work Group recommended keeping the GOM and SA management units separate for vermilion snapper. Recommendations for the AW were to keep the SA and GOM as separate stocks and use the jurisdiction set by the SAFMC (i.e., North Carolina through the east coast of Florida including Monroe County south of US 1 out to 83°West longitude)."

Pg. 144:
"The DW (Data Workshop) also noted positive correlation between the chevron trap index and mean summer bottom temperatures as recorded during MARMAP sampling, and it was recommended that the GLM approach include bottom temperature as a predictor variable."

"Explanatory variables considered, in addition to year (necessarily included), were bottom temperature (continuous variable), season (categorical variable), latitude (categorical variable), and depth (continuous variable)."

4. FishBase: http://www.fishbase.org/summary/Rhomboplites-aurorubens.html

"Marine; demersal; depth range 40 - 300 m, usually 40 - 100 m."[1]

Reference 1: Cervigón, F., 1993. Los peces marinos de Venezuela. Volume 2. Fundación Científica Los Roques, Caracas,Venezuela. 497 p

Wahoo: *Acanthocybium solandri*

Vulnerability:	Low Vulnerability (SAFMC) Very vulnerability (Roffer and Hall, 2015, this document - "They are dependent on ocean currents and temperature and subsequently affected directly by changes associated with climate change." Likely to move to other jurisdictions or spend more time in northern regions as result of range expansion).
Depth Range:	0-340 m (IUCN Ref: Nobrega et al. 2009). Wahoo larvae are pelagic and prefer shallow water less than 330 ft. (100 m) in depth (Florida Museum of Natural History).
Temperature Range:	17.5 – 27.5 °C for more than 90 % of time for tagged wahoo
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? "Low vulnerability to climate change. They are dependent on ocean currents and temperature and subsequently affected directly by changes associated with climate change."

Ecosystem considerations? "Changes in the ocean currents, temperature or distribution or availability of pelagic Sargassum habitat could affect wahoo."

Linkages to other fisheries? Unknown (SAFMC)

Known climate-related concerns? "Concerns include changes in overall ocean currents, temperature, acidification, and increased episodic events including upwelling, tropical and winter storms, which, in combination, affect the survival, growth, spawning and subsequent distribution of coral and live bottom species" – [direct quote from SAFMC for Wahoo]

Social and economic concerns? No answer in SAFMC

Management Risk? Limited Risk

2. No SEDAR document available

3. Florida Museum of Natural History
   http://www.flmnh.ufl.edu/fish/gallery/Descript/wahoo/wahoo.html

“The wahoo is pelagic, living in solitary or forming small, loose aggregations. They congregate near drifting objects including sargassum. Wahoo move with the changing seasons, traveling into cooler waters during warm summer months."

“Latitude appears to influence size, with average weight increasing with distance from the equator, apparently correlated to cooler temperatures.”

“Although wahoo are attracted to floating debris, their diet suggests they venture out to forage in open waters. Wahoo feed primarily upon other pelagic fishes, as well as squid. They have been recorded feeding on tunas, little tunny, porcupine fishes, flying fishes, dolphinfish, jacks, herrings, pilchards, scads, and lantern fishes, as well as many other species.”

“Spawning appears to occur over an extended period of time, at sites in the Caribbean Sea and near Florida. The simultaneous presence of wahoo at varying stages of maturity may indicate year-round spawning in some areas. In the western central Atlantic, wahoo spawn from May through August with peaks in activity during June and July. An average female may produce 60 million buoyant eggs per spawning. The size of wahoo at hatching is 2.5 mm. Little is known of the early life history of wahoo, however it is known that wahoo larvae are pelagic and prefer shallow water less than 330 ft. (100 m) in depth.”

“Sharks, including the silvertip shark (*Carcharhinus albimarginatus*) and other large predatory fish feed on the wahoo.”

4. Theisen T.C. & Baldwin, J.D. 2012. Movements and depth/temperature distribution of the ectothermic *Scombrid*, *Acanthocybium solandri* (wahoo), in the western North Atlantic. Mar Biol 159:2249-2258. DOI 10.1007/s00227-012-2010-x

“Pop-up satellite archival tags were deployed onto four wahoo during 2006 in the western North Atlantic”, “providing movement, depth, and temperature data collected over a total of 198 days.” “Wahoo spent >90 % of their time in water <200 m, and >90 % of their time in water between 17.5 and 27.5°C. Three fish made regular trips to depths >200 m. All four fish had significantly different depth distributions between the dark and light periods (Kruskal–Wallace test, $p<0.001$).” “This research improves an otherwise poor understanding of wahoo movements and depth/temperature distributions and suggests potential interactions with other members of the pelagic fish community, many of which are commercially important and either fully or over-exploited”

5. IUCN Red List http://www.iucnredlist.org/details/170331/0 (Least concern)
Depth Range: 0 – 340 m (Nobrega et al. 2009).
IUCN also reports lower depth limit of 15 m (??)

Weakfish: *Cynoscion regalis*

Vulnerability:	Vulnerable (ASMFC)
Depth Range:	0 – 55 m as per trawl fishery
Temperature Range:	9.5 – 30.8 °C; hatching of eggs was optimal: 18 – 24 °C
Salinity Range:	Adults: 6.6 – 32.3 ppt; juveniles = 0.1 – 32.3 ppt
Oxygen Rage:	Lower tolerance/movement blocked (Delaware River) = 1.0 – 2.3 ppm. Most abundant catches of juveniles in 4.2 – 7.4 ppm
pH Range:	Need information

2013: $312,528.00, 355.4 tonnes: (http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – ASMFC
Management authorities? Fed: NOAA, USFWS; Regional: NEFMC, MAFMC, SAFMC; Interstate: ASMFC; State: MA, RI, CT, NY, NJ, PA, DE, MD, DC, PRFC, VA, NC, SC, GA, FL

Climate vulnerability? "Weakfish recruitment and abundance have been linked to large scale climate cycles, and may be impacted if climate change alters those cycles. They are a migratory species that occur in moderate to warm waters, so they may have the opportunity to expand their range northward as water temperatures increase."

Ecosystem considerations? "Weakfish recruitment and abundance will be affected by changes in the zooplankton and forage fish populations, particularly menhaden"

Linkages to other fisheries? "Due to the decline in the fishery, weakfish have not been targeted much in the past decade. Any switching would have already occurred (most notably to menhaden or black drum)."

Known climate-related concerns? "None currently."

Social and economic concerns? "None"

Management Risk? "There is little risk due to the low numbers of weakfish that are currently landed."

2. No SEDAR document available

3. Fish and Wildlife Service, Biological Report 82(11.109): Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates

(Mid-Atlantic): 82_11-109.pdf
http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-109.pdf

Pg. 11: Depth:
"Adult weakfish migrate seasonally between inshore and offshore waters (Welsh and Breder 1923; Merriner 1973; Wilk 1976, 1979, 1980). Warming of coastal waters in spring prompts an inshore and northerly migration of adults from their wintering grounds to sounds, bays, and estuaries."

Pg. 12:
"As water temperatures decline in fall, weakfish form aggregations and move offshore and generally southward along the coast (Nesbit 1954; Massmann et al. 1958; .Wilk 1976; Wilk and Silverman 1976). A study of the winter trawl fishery off the Virginia and North Carolina coasts indicated that most weakfish were caught in the southern fishing area in between Ocracoke Inlet and Bodie Island, NC, at depths of 18-55 m (Pearson 1932). Some weakfish may remain in inshore waters throughout the winter from North Carolina southward (Goode 1884; Higgins and Pearson 1928; Hildebrand and Cable 1934)."

Pg. 17: Temperature:
"Weakfish eggs in all stages collected in Peconic Bay, NY, and Narragansett Bay, RI, at temperatures of 12-24°C (Perlmutter 1939; Herman 1963). Laboratory tests indicated that hatching of weakfish eggs was optimal between 18-24°C (Harmic 1958). Weakfish have been collected over a temperature range of 9.5 to 30.8°C (Massmann et al. 1958; Richards and Castagna 1970; Merriner 1976). Decreasing water temperatures in fall appear to initiate movement of most weakfish out of the estuaries to deeper water. Older weakfish appear to precede the young of the year in moving out of the estuaries (Hildebrand and Cable 1934; Massmann e t a l. 1958; Thomas 1971).

Pg. 18: Salinity:
"Weakfish are euryhaline and have been collected at salinities ranging of 0.1-32.3 ppt (Massmann et al. 1958; Richards and Castagna 1970; Wilk and Silverman 1976; Wilk et al. 1977). Harmic (1958) collected eggs and larvae in Delaware Bay at salinities of 12.1 to 31.3 ppt. Juveniles have been taken in salinities from 0.1 t o 31.7 ppt, but areas of most abundant catches had salinities of 2.0 ppt in June to 10.8 ppt in August (Massmann et al. 1958; Richards and Castagna 1970; Thomas 1971). Adults were collected over a salinity range of 6.6 to 32.3 ppt (Richards and Castagna 1970; Wilk and Silverman 1976; Wilk et al. 1977)."

Oxygen:
Information scarce. "Thomas (1971) reported that upriver movement of juvenile weakfish in Delaware River blocked by low oxygen concentrations (1.0-2.3 ppm). In areas of the most abundant catches of juvenile weakfish in Delaware Bay, mean dissolved oxygen ranged from 4.2 ppm in July to 7.4 ppm in October."

Reference for above statements:
Wilk, S. J., W. W. Morse, D. E. Ralph, and T. R. Azarovitz. 1977. Fishes and associated environmental data collected in the New York Bight, June 1974-June 1975. NOAA Tech. Rep. NMFS SSRF-716. 53 pp.

Thomas, D. L. 1971. The early life history and ecology of six species of drum (Sciaenidae) in the lower Delaware River, a brackish tidal estuary. Ichthyol. Assoc., Del. Prog. Rep. 3 (Part 111). 247 pp

Citation for Biological Report 82(11.109):
Mercer, L. P. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Mid-Atlantic)--weakfish. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.109). U. S. Army Corps of Engineers, TR EL-82-4. 17 pp

White grunt: *Haemulon plumierii*

Vulnerability: Medium vulnerability (SAFMC)
Depth Range: 0 – 35 m
Temperature Range: Lower limit: 13.8 °C (57°F kills in Key West in 1940)
Salinity Range: Need information
Oxygen Rage: Need information
pH Range: Need information

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC, under Grunt Complex
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability? “The grunt complex would generally have medium vulnerability to impacts of climate change. However, detailed life history and movement patterns are lacking for the complex and true vulnerability may depend on the magnitude of change in shelf ocean temperature and oceanic currents that would eventually impact spawning, feeding and movement associated with benthic shelf habitats”.

Ecosystem considerations? “The Grunt Complex species use shelf ecosystems extensively and if pelagic and benthic habitats including coral and live bottom are affected by changes in ocean currents, water temperature, pH, the essential habitat for species in the shallow water complex would effectively be reduced, prey associated with that habitat would be reduced which in combination could lead to impacts at the populations level.”

Linkages to other fisheries? “If climate change affects other managed species including coastal migratory pelagic and fisheries for other snapper grouper species, effort could shift to the grunt complex”. “Effort shifts associated with impacts in shelf waters, could result in increased effort on other managed snapper grouper species or even the deepwater complex”

Known climate-related concerns? “Changes in ocean currents or increased of episodic events like upwelling have been raised as a potential concern affecting habitat essential to the managed species.”

Social and economic concerns? “Considerations would only arise if changes are great enough to result in shift among shelf or movement to deepwater ecosystems”

Management Risk? “The existing Council management system should be able to respond the management needs associated with such change.”

2. No SEDAR document available

3. Florida Museum of Natural History
http://www.flmnh.ufl.edu/fish/Gallery/Descript/WhiteGrunt/WhiteGrunt.html

"The white grunt is commonly found from the shoreline to the outer reef edge to depths of 80 feet (24 m) and occasionally offshore over hard bottoms to depths of 115 feet (35 m). Juvenile white grunts reside inshore in seagrass beds, seeking the shelter among the spines of the long-spined sea urchin (*Diadema antillarum*). These juveniles organize into schools according to size. The white grunt feeds nocturnally, migrating off the reefs to open sandy, muddy, or grassy areas. Typically moving off the reef shortly after sunset and returning to the reef just prior to sunrise, large white grunts are the first to leave and last the return. This fish is considered a generalized carnivore, scavenging benthic crustaceans, mollusks, echinoderms, and small fishes. Grunts have also been observed to feed on material attached to pilings near offshore platforms. The small juvenile grunts pick plankton, primarily copepods, from the water column during daylight hours. Peak spawning occurs during much of the year with peaks occurring during May and June off Florida, August and September off Puerto Rico and in March and April off Jamaica."

4. Fish Base: http://www.fishbase.org/summary/Haemulon-plumierii.html
Depth range 3 - 40 m (Reference: Cervigón, F., 1993. Los peces marinos de Venezuela. Volume 2. Fundación Científica Los Roques, Caracas,Venezuela. 497 p.)

5. Smithsonian Marine Station at Fort Pierce
http://www.sms.si.edu/IRLSpec/Haemulon_plumierii.htm

"Temperature:
Although *Haemulon plumierii* is listed as a tropical to warm-temperate (de Silva ad Murphy 2001), Chapman et al. (1999) used genetic analysis to differentiate three geographically distinct lineages. The northern lineage occurs from Maryland/Virginia and Bermuda and the Carolinas south to the Florida Keys and Panama City (Hoese and Moore 1977, Robbins et al. 1986). It is genetically distinct from southern populations from the Florida Keys to Yucatan, Belize, and Puerto Rico and from Trinidad. The northern lineage is considerably more resistant to low temperature effects, and is capable of persisting in warm-temperate coastal waters."

"The existence of these distinct lineages helps explain the apparent disparity between the relatively broad distribution of *H. plumierii* and its occurrence in the historic records of animals succumbing to lethal cold water temperatures. Galloway (1941) lists white grunt as among the species stunned and killed by record low water temperatures (57°) in Key West in late January, 1940." Reference: Galloway JC. 1941. Lethal effect of the cold winter of 1939-40 on marine fishes at Key West, Florida. Copeia 1941:118-119.

“Salinity:
Although they are capable of thriving in oceanic reef environments as well as estuarine habitats, Lindeman and Toxey (2002) note that *Haemulids* in general are only rarely encountered at very low salinities.”

Reference for above: Lindeman KC and CS Toxey. 2002. *Haemulidae*: Grunts. Pp 1522-1529 in: Carpenter, K.E. (ed.) The living marine resources of the Western Central Atlantic. Volume 3: Bony fishes Part 2 (Opistognathidae to Molidae), sea turtles and marine mammals. FAO Species Identification Guide for Fishery Purposes and American Society of Ichthyologists and Herpetologists Special Publication No. 5. Rome, FAO.

White marlin: *Kajikia albidus*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution is affected by temperature, chlorophyll and oxygen, which are likely to be changed by climate change.
Depth Range:	0 – 150 m, usually 10 – 100 m
Temperature Range:	20 – 29 °C; prefer 24.8 – 26.8 °C (Boyce et al., 2008); Greater than 22 °C; spawning: 20 – 29 °C (FLMNH)
Salinity Range:	35 – 37 ppt
Oxygen Rage:	Lower hypoxic habitat boundary for billfish: 3.5 ml/l
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. Florida Museum of Natural History (FLMNH), accessed October 12, 2015
http://www.flmnh.ufl.edu/fish/gallery/descript/whitemarlin/whitemarlin.html

"Habitat
The white marlin is pelagic and oceanic, usually found in water over 325 feet (100 m) deep. It generally swims above the thermocline, in water of surface temperatures above 71°F (22°C), and salinities between 35-37 parts per thousand (ppt). White marlin often occur in oceanic currents that can flow between 0.5-2.3 mph (.8-3.7 kph). They are often associated with upwellings and weed lines, and frequent regions with benthic geographic features such as drop-offs, canyons, and shoals. White marlins do not tend to travel in schools, but are usually observed swimming alone or in pairs. While swimming they commonly display a technique known as "tailing," in which only the dorsal lobe of the caudal fin is visible above the surface of the water. Small aggregations of white marlin may be observed around schools of bait fish. Limited schooling may occur, designated by sex or size during certain periods of the year, but little is known of this behavior."

"Reproduction
Spawning only once per year, white marlin migrate to subtropical waters and spawn in early summer, in deep oceanic waters. In the western North Atlantic, spawning grounds have been identified northeast of Little Bahama Bank, northwest of Grand Bahama Island, and southwest of Bemuda. They spawn in deep, blue oceanic water, generally with high surface temperatures ranging from 20-29°C. It is believed that they spawn in pairs, as opposed to communal or mass spawning."

4. Fish Base http://www.fishbase.org/summary/219

"Marine; pelagic-oceanic;" "depth range 0 - 150 m (Ref. 43), usually 0 - 100 m (Ref. 55219)."

Ref. 43: Nakamura, I., 1985. FAO species catalogue. Vol. 5. Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. FAO Fish. Synop. 125(5):65p. Rome: FAO.

Ref. 55219: Florida Museum of Natural History, 2005. Biological profiles: white marlin. Retrieved on 26 August 2005, from www.flmnh.ufl.edu/fish/Gallery/Descript/WhiteMarlin/WhiteMarlin.html. Ichthyology at the Florida Museum of Natural History: Education-Biological Profiles. FLMNH, University of Florida.

6. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic white marlin extract from "Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage."

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
White marlin	*Tetrapturus albidus*	20	29	21.33	27.57	24.80	26.85	6.23	10

7. IUCN Red List: http://www.iucnredlist.org/details/170322/0 (Vulnerable)
Depth Range: 0 – 150 m

"This species was previously known as *Tetrapturus albidus* (Collette et al. 2006). There is a question as to whether this species is distinct from the Pacific Striped Marlin, Kajikia audax (Graves 1998, Collette et al. 2006, Hanner et al. 2011)."

"Range Description: Found throughout warm waters of the Atlantic from 45°N to 45°S including the Gulf of Mexico, Caribbean Sea, and Mediterranean (Nóbrega et al. 2009). Records from the Mediterranean Sea and from Bretagne, France seem to be based on a few straying individuals."

"Its distribution shows some seasonal variation, being most found in the highest latitudes only during warmer periods of the year (Ferreira and Hazin 2004). It is normally found in waters where the surface temperature is above 22°C, in waters over 300 m in depth and within a salinity range from 35–37% (Ferreira and Hazin 2004)."

"Previous reports have mentioned spawning of White Marlin off southeast Brazil in the same area where Blue Marlin spawn, but later in the year from April to June. Off southern Brazil (25–26ºS and 40–45ºW) White Marlin spawn from December to March. In the northwest Atlantic, White Marlin have been reported to spawn in the Gulf of

Mexico in June. Recent reports confirm that White Marlin also spawns offshore and north of the Antilles (19–23ºN and 60–70ºW) between April and July."

"Habitat and Ecology: This is a pelagic, oceanodromous species that usually occurs above the thermocline. Its distribution varies seasonally, reaching higher latitudes in both the north and south hemispheres only during the respective warm seasons. It is usually found in pelagic habitat in waters over 50 m depth with surface temperatures over 22°C and salinities of 35–37 ppt."

"It migrates into subtropical waters to spawn, with peak spawning occurring in early summer. The spawning areas are found in deep and blue oceanic waters, generally at high temperatures ranging from 20–29°C except in the south Atlantic gyrals, and high surface salinities (over 35 ppt)."

5. Prince et al. 2010. Ocean scale hypoxia-based habitat compression of Atlantic istiophorid billfish. Fisheries Oceanography 19:6, 448-462. Prince 2010 OMZ Tuna.pdf

Pg. 1:
"In the eastern tropical Pacific (ETP), the surface mixed layer is defined by a shallow thermocline above a barrier of cold hypoxic water, where dissolved oxygen levels are ≤ 3.5 mL L^{-1}. This thermocline (~25–50 m) constitutes a lower hypoxic habitat boundary for high oxygen demand tropical pelagic billfish and tunas (i.e., habitat compression)."

White shrimp: *Litopenaeus setiferus*

Vulnerability:	Very vulnerable (SAFMC). Significant die offs of the population occurring when temperatures are sustained at a very low level for an extended time period.
Depth Range:	1 – 100 m (as per the SEAMAP annual trawl survey), but not reflective of trends in inshore estuaries
Temperature Range:	8 °C = mortality; total mortality at 3 °C
Salinity Range:	Fast growth: 7 – 15 ppt; successfully reared at salinities of 18 to 34 ppt
Oxygen Rage:	Catches dropped when DO below 3.0 ml/l
pH Range:	Need information

2013: $28,982,724.00, tonnes: 4,302.5
(http://www.nmfs.noaa.gov/pls/webpls/MF_ANNUAL_LANDINGS)

1. Rapid Assessment Profiles:

Info on climate change susceptibility Yes – SAFMC
Management authorities? Fed: NOAA; Regional: SAFMC; State: NC, SC, GA, FL

Climate vulnerability?: "VERY! - Significant die offs of the population occurring when temperatures are sustained at a very low level for an extended time period. These events facilitate the closure of first state (SC and or GA) then federal waters off that state. Changing climate could result in increased extreme episodic events such as winter die offs."

Ecosystem considerations? "Changes in pelagic and benthic estuarine habitat would reduce the essential habitat and productive capacity of penaeid shrimp populations"

Linkages to other fisheries? "Prey to a wide variety of species in in estuarine and near-shore and offshore habitats"

Known climate-related concerns? - No answer in SAFMC

Social and economic concerns? "Commercial shrimp fishery is one of the most economically important commercial fisheries in the southeast. While not overfished, the white shrimp resource in the South Atlantic region is periodically decimated by severe winter cold kills, especially offshore of Georgia and South Carolina. Significant economic impact to the commercial shrimp and potentially the inshore recreational fishery may result if climate change results in increased episodic events which reduce water temperatures to the level where winter kills of overwintering white shrimp occur more frequently."

Management Risk? No answer in SAFMC

2. No SEDAR document available

3. Fish and Wildlife Service, Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic): White Shrimp. FWS/OBS-82/11.27, September 1984: 82_11-027.pdf
http://www.nwrc.usgs.gov/wdb/pub/species_profiles/82_11-027.pdf

Pg. 19-20:
"Water temperature directly or indirectly influences white shrimp spawning, growth, habitat selection, osmoregulation, movement, migration, and mortality. Spring water temperature increases trigger spawning, and rapid water temperature declines in fall portend the end of spawning (Lindner and Anderson 1956). Growth is fastest in summer and slow or negligible in winter. Water temperatures below 20°C inhibit growth of juvenile shrimp (Etzold and Christmas 1977) and growth is virtually nil at 16°C (St. Amant and Lindner 1966). Growth rates increase rapidly as temperatures increase above 20°C. Increased water temperature affects molting rate (Pérez-Farfante 1969). Good correlation between heating- degree-days and catch/effort ratio for penaeid shrimp was similar to correlations of yield-per-hectare versus latitude (Turner 1977). Temperature and food supply limited the growth of white shrimp postlarvae more than did salinity differences between 2 and 35 ppt (Zein-Eldin 1964)."

"White shrimp mortality was reported at water temperatures of 8°C and lower (Joyce 1965). Mortality of white shrimp is total at 3°C or lower, regardless of salinity. White shrimp survival at low temperatures depends on ambient temperature, the rate of temperature decline, the duration of low temperatures and salinity (Joyce 1965). The impact of low water temperature and low salinity on white shrimp was discussed by Music (1979) and Shiprnan (1983a). Adult white shrimp (> 90 mm long) may be more susceptible than juveniles to cold temperatures (Whitaker 1983a). Wiesepape (1975) found the 24-h LC_{50} (temperature causing 50% mortality in 24 h) to be 36° and 37°C for white shrimp acclimated at 29°and 34°C, respectively. Post larvae and 30-mm long juveniles have similar but higher resistance times than 50-mm juveniles."

"Adult white shrimp spawn offshore where salinities are at least 27 ppt. The larvae move shoreward and become second-stage postlarvae as they enter estuaries on flood tides. Juvenile white shrimp moved 160 km upstream into water of less than 1.0-ppt salinity waters in the St. Johns River, Florida (Joyce 1965). Juvenile white shrimp have even been recovered from Lake Monroe Power Station filter screens located 270 km from the mouth of the St. Johns River - especially when low rainfall and low river stages caused reverse tidal flow (Edwin Joyce, pers. comm., February 1984). The high calcium ion concentrations in the St. Johns River may explain the relative ease with which marine species enter and remain in low salinity waters (Joyce 1965). The lowest salinity in which white shrimp were recorded in the northern Gulf of Mexico was 0.42 ppt (Perez-Farfante 1969). Although field studies indicate that juvenile white shrimp prefer low salinities, laboratory studies have revealed that white shrimp appear to tolerate a wide range of salinities; they have been successfully reared at salinities of 18 to 34 ppt

(Perez-Farfante 1969). McKenzie (1981) cited several studies in which fast growth was reported for white shrimp at salinities of 7 to 15 ppt.

“White shrimp in Georgia move toward higher salinity waters as sexual development progresses, and most spawn offshore in the sea (Harris 1974).”

“Temperature - Salinity Interactions
Temperature-salinity tolerance ranges for white shrimp vary at different life stages, but the interactions are more pronounced at the extremes of tolerance. For example, Couch (1978) reported that broken-back syndrome (dorsal separation of third and fourth pleural plates on abdominal) appears after sudden drops in salinity (from 15 ppt to 3 ppt) in cold water (8°C). The critical thermal maxima for white shrimp are influenced largely by acclimation temperatures, and to a lesser extent by salinity and size of test animal (Laney 1973). Freshwater inflow may affect coastal water temperatures, which in turn affect the growth rates (White and Boudreaux 1977) and migration of white shrimp (Shipman 1983b). Spring spawning of white shrimp coincides with a rapid rise in bottom water temperatures in high salinity offshore waters (McKenzie 1981).”

“Substrate
White shrimp prefer shallow, muddy-bottom substrate. Landings of shrimp along the Louisiana coast were highest in areas where substrates were highly organic (Barrett and Gillespie 1973; Gaidry 1974). A relative higher linear correlation (R^2 = 0.69) between intertidal land area and average annual shrimp catch along Louisiana's inshore regions was reported by Turner (1977). The relation between inshore catches and hectares of vegetated estuarine habitat in the northeastern Gulf of Mexico (Tampa Bay, Florida, to Mobile Bay and Perdido Bay, Alabama) also showed a strong correlation (R^2 = 0.64). A direct relationship between commercial shrimp landings and intertidal vegetated areas and degrees latitude was reported by Turner (1977). The annual landings (kg/ha) in 1955-64 were 19.7 in North Carolina, 7.9 in South Carolina, 13 in Georgia, and 22.4 in east Florida. White shrimp undoubtedly composed most of the landings except in North Carolina. Southward fall migration probably account for the high landings from Florida waters. The area of nearshore soft sediments correlate well with white and brown shrimp distribution from Pamlico Sound, North Carolina to northern Florida (McKenzie 1981).”

“Temporal and spatial shifts by brown, white, and pink shrimp help reduce direct interspecific competition especially for certain substrate (Lassuy 1983). White shrimp burrow less deeply into muddy substrates and are more active in daylight than are brown or pink shrimp. Staggered seasonal recruitment of brown and white shrimp into south Atlantic estuaries would reduce competition (Baisden 1983).”

Pg. 21:
“Other Environmental Considerations
Trawl catches of white shrimp dropped below seasonal averages when dissolved oxygen was below 3.0 mg/l in altered, eutrophic canals associated with housing developments in West Bay, Texas (Trent et al. 1976). Maintaining suitable nursery

grounds ultimately may decide the future of the shrimp resources of the gulf coast (Christmas and Etzold 1977) and south Atlantic (McKenzie 1981; Etzold et al. 1983)."

Additional References:
1) Severe winter cold kills: http://safmc.net/resource-library/shrimp
2) Temperature and salinity dependent in 'About the Species': http://www.fishwatch.gov/seafood_profiles/species/shrimp/species_pages/white_shrimp.htm
3) 2005 Effect of water temperature on the immune response of white shrimp *Litopenaeus vannamei* to *Vibrio alginolyticus*; http://www.sciencedirect.com/science/article/pii/S0044848605003224
4) Fishery Management Plan for the Shrimp Fishery of the South Atlantic Region, June 1993. SAFMC. Page 19: environmental effects

Yellowfin menhaden: *Brevoortia smithi*

Vulnerability:	Vulnerable (Roffer and Hall, 2015, this document). Recruitment likely influenced by currents, wind, stream flow.
Depth Range:	0 – 50 m
Temperature Range:	Need information
Salinity Range:	Need information
Oxygen Rage:	Need information
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. FishBase: http://fishbase.org/summary/1591

"Marine; brackish; pelagic-neritic; depth range 0 - 50 m."
"Western Central Atlantic: Beaufort, North Carolina, to Indian River, Florida; Gulf of Mexico (Florida Bay to Louisiana, with possible break between Biscayne Bay and Florida Bay). Hybridize with *B. tyrannus* and *B. patronus* (Ref. 84218)."

Reference 84218: Whitehead, P.J.P., 1985. FAO Species Catalogue. Vol. 7. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. FAO Fish. Synop. 125(7/1):1-303. Rome: FAO.

4. Florida Fish and Wildlife Conservation Commission: menhaden.pdf
http://myfwc.com/media/195461/menhaden.pdf

Pg. 1:
"…Yellowfin menhaden range from Chandeleur Sound, Louisiana, southward to the Caloosahatchee River, Florida (presumably around the Florida peninsula), to Cape Lookout, North Carolina (Hildbrand 1948; Christmas and Gunter 1960)."

"Menhaden are estuarine-dependent species. Spawning occurs offshore and young move into estuarine nursery areas where they spend the early part of their lives. Maturing adults return to offshore waters to spawn (Lewis and Roithmayer 1981)."

"Menhaden are selective feeders throughout most of the larval stage. Juveniles and adults are omnivorous filter feeders (Ahrenholtz 1991). Deegan (1985) demonstrated that gulf menhaden have two mechanisms (microbial cellulase activity and a gizzard-like stomach) that allow digestion of detritus. Because of their high abundance and schooling behavior, menhaden are prey for a large number of piscivorous fish and birds (Overstreet and Heard 1982)."

Yellowfin tuna: *Thunnus albacares*

Vulnerability:	Very vulnerable (Roffer and Hall, 2015, this document). Distribution affected by temperature, chlorophyll and oxygen that are likely to be changed by climate change.
Depth Range:	0 – 100 m, but can dive to 1100 m.
Temperature Range:	7 – 31 °C; prefer 20.5 – 25.7 °C (Boyce et al., 2008); 23 – 32 °C (Sharp, 1979); 18 – 31 °C, spawning lower limit is 26 °C (Florida Museum of Natural History)
Salinity Range:	Larval distribution greater than 33 ppt
Oxygen Rage:	Intolerance of less than 2 ml/l (Collette and Nauen, 1983); 1.5 – 2.5 ml/l (Sharp, 1979)
pH Range:	Need information

1. No Rapid Assessment Profile available

2. No SEDAR document available

3. NOAA Fisheries Atlantic Highly Migratory Species
   http://www.nmfs.noaa.gov/sfa/hms/documents/fmp/tss_fmp/hmsch6.pdf

Pg. 19 – 21:
"Distribution: Atlantic yellowfin tuna are circumglobal in tropical and temperate waters. In the west Atlantic they range from 45° N to 40° S. Yellowfin tuna is an epipelagic, oceanic species, found in water temperatures between 18° and 31° C. It is a schooling species, with juveniles found in schools at the surface, mixing with skipjack and bigeye tuna. Larger fish are found in deeper water and also extend their ranges into higher latitudes. All individuals in the Atlantic probably comprise a single population, although movement patterns are not well known (SCRS, 1997; Collette and Nauen, 1983). There are possible movements of fish spawned in the Gulf of Guinea to more coastal waters off Africa, followed by movements toward the U.S. coast, at which time they reach a length of 60 to 80 cm (ICCAT, 1977). In the Gulf of Mexico yellowfin tuna occur beyond the 500 fathom isobath (Idyll and de Sylva, 1963)."

"Life history: Spawning occurs throughout the year in the core areas of the species' distribution - between 15° N and 15° S - and also in the Gulf of Mexico and the Caribbean, with peaks occurring in the summer (ICCAT, 1994; Richards, pers. comm.). Yellowfin tuna are believed to be multiple spawners (Houde, pers. comm.), and larval distribution appears to be limited to water temperatures above 24° C and salinity greater than 33 ppt (Richards and Simmons, 1971). Larvae have been collected near the Yucatan peninsula, and during September in the northern Gulf of Mexico along the Mississippi Delta (ICCAT, 1994)."

"Habitat associations: Adult yellowfin tuna are confined to the upper 100 m of the water column due to their intolerance of oxygen concentrations of less than 2 ml/l (Collette and Nauen, 1983). Association with floating objects has been observed, and in the

Pacific larger individuals often school with porpoises (Collette and Nauen, 1983). Juveniles are found nearer to shore than are adults (SCRS, 1994). In the Gulf of Mexico adults usually occur 75 km or more offshore, while in the Caribbean they are found closer to shore. Although there appears to be a year-round population in the southern part of the Gulf of Mexico (Idyll and de Sylva, 1963), in June there appears to be some movement from this region to the northern part, resulting in greater catches there from July to December."

"Essential Fish Habitat (EFH) for Yellowfin Tuna:

- Spawning, eggs and larvae: In offshore waters, from the 200 m isobath out to the EEZ boundary, from 28.25° N south around peninsular Florida and the Gulf Coast to the U.S./Mexico border, especially associated with the Mississippi River plume and the Loop Current. Also, all U.S. waters in the Caribbean from the 200 m isobath to the EEZ boundary.
- Juveniles/subadults (<110 cm FL): Pelagic waters from the surface to 100 m deep between 18° and 31° C from offshore Cape Cod, MA (70° W) southward to Jekyll Island, GA (31° N), between 500 and 2,000 m; off Cape Canaveral, FL from 29° N south to the EEZ boundary (approximately 28.25° N) and from 79° W east to the EEZ boundary (approximately 76.75° W); in the Gulf of Mexico from the 200 m isobath to the EEZ boundary.
- Adults (> 110 cm FL): (Identical to juveniles/subadults EFH): Pelagic waters from the surface to 100 m deep between 18° and 31° C from offshore Cape Cod, MA (70° W) southward to Jekyll Island, GA (31° N), between 500 and 2,000 m; off Cape Canaveral, FL from 29° N south to the EEZ boundary (approximately 28.25° N) and from 79° W east to the EEZ boundary (approximately 76.75° W); in the Gulf of Mexico from the 200 m isobath to the EEZ boundary."

4. Sharp, G.D.,1978. Behavioral and physiological properties of tunas and their effects on vulnerability to fishing gear. Academic Press, Inc. ISBN 0-12-639180-7. Pp 412.

Estimated lower O_2 tolerance (10 minute levels, ml O_2/L H_2O) is 1.49 (measured) and 2.32 (estimated value).

5. Sharp, G.D.,1979. Areas of potentially successful exploitation of tunas in the Indian Ocean with emphasis on surface methods. Rome, FAO, IOFC/DEV/79/47:55 pp.

Temperature Range: 23 – 32 °C
Dissolved oxygen values tolerances for 10 minutes by fish measuring between 50 and 75 cm: 1.5 – 2.5 ml/l

6. Boyce, D.G., Tittensor, D.P., Worm, B. 2008. Effects of temperature on global patterns of tuna and billfish richness. Marine Ecology Progress Series Vol. 355: 367-276. doi: 10.3354/meps07237. Boyce 2008 Tuna Billfish Temperature.pdf

Pg. 269:
Boyce, D.G et al. (2008) compiled temperature data in a table form from 18 species. Below is the Atlantic, Pacific and Indian Ocean yellowfin tuna extract from "Table 1. Overall (Min., Max.), and mean (Tmin, Tmax) temperature tolerances, preferences (Pmin, Pmax) and mean tolerance ranges (R) in °C for 18 species of tuna and billfish in the adult (> 5 yr) life stage."

		Min.	Max.	Tmin	Tmax	Pmin	Pmax	R	No. of sources
Yellowfin tuna	*Thunnus albacares*	7	31	16.35	27.73	20.53	25.79	11.37	29

7. Florida Museum of Natural History, accessed October 12, 2015
http://www.flmnh.ufl.edu/fish/gallery/descript/yellowfintuna/yellowfintuna.html

"Habitat
The yellowfin tuna is an epipelagic, oceanic fish, living above and below the thermocline, at temperatures of 65 to 88°F (18-31°C). It is generally found in the upper 330 feet (100 m) of the water column."

"Yellowfin are strong schoolers. Their tendency to school with organisms of the same size is stronger than the tendency to school by species. They often swim in mixed schools of skipjack, bigeye, and other tunas."

"Yellowfin will commonly school under drifting objects such as driftwood, patches of seagrass, boats, or dead marine mammals. There are many hypotheses addressing the reasons for schooling under such items. Yellowfin may be attracted to the object to feed on smaller prey which are foraging on the structure. The drifting object provides shade and shelter from predators. Yellowfin tuna may utilize the object as a substrate on which to lay their eggs or as a "cleaning station," where parasites are removed by other fishes. Also, the fish may view the object as a "schooling companion"."

"Yellowfin swimming further from the surface are less likely to school, and tend to scatter. There is perhaps less benefit to schooling in such cases, as there are fewer predators and little reason to attempt to obtain food at depth."

"Reproduction occurs year-round, but is most frequent during the summer months in each hemisphere. It is believed that 79°F (26°C) is the lower temperature limit for spawning. In the tropical waters of Mexico and Central America, it has been determined that yellowfin spawn at least twice a year."

8. Fish Base http://www.fishbase.org/summary/Thunnus-albacares.html

"Marine; brackish; pelagic-oceanic;" "depth range 1 - 250 m (Ref. 6390), usually 1 - 100 m (Ref. 55289). Tropical; 15°C - 31°C (Ref. 168); 59°N - 48°S, 180°W - 180°E".

Reference 6390: Kailola, P.J., M.J. Williams, P.C. Stewart, R.E. Reichelt, A. McNee and C. Grieve, 1993. Australian fisheries resources. Bureau of Resource Sciences, Canberra, Australia. 422 p.

Reference 55289: Florida Museum of Natural History, 2005. Biological profiles: yellowfin tuna. Retrieved on 26 August 2005, from www.flmnh.ufl.edu/fish/Gallery/Descript/YellowfinTuna/YellowfinTuna.html. Ichthyology at the Florida Museum of Natural History: Education-Biological Profiles. FLMNH, University of Florida.

Reference 168: Collette, B.B. and C.E. Nauen, 1983. FAO Species Catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tunas, mackerels, bonitos and related species known to date. Rome: FAO. FAO Fish. Synop. 125(2):137 p.

9. FAO http://www.fao.org/fishery/topic/16082/en

“Yellowfin tuna has been observed to dive at more than 1100 m (record of 1200 m, L. Dagorn et al., 2006).”

Reference: Dagorn L., K.N. Holland, J-P. Hallier, M. Taquet, G. Moreno, G. Sancho, D. G. Itano, R. Aumeeruddy, C. Girard, J. Million and A. Fonteneau. Deep diving behavior observed in yellowfin tuna (Thunnus albacares). Aquat. Living Resour. (2006)19, 85–88.

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