3.2 Status of the Stocks

The thresholds used to determine the status of Atlantic HMS are fully described in Chapter 3 of the 1999 Tunas, Swordfish, and Shark FMP and Amendment 1 to the Billfish FMP, and are presented in Figure 3.1. These thresholds are based on the thresholds described in a paper describing the technical guidance for implementing National Standard 1 of the Magnuson-Stevens Act (Restrepo *et al*., 1998). These thresholds will not change as a result this Final Consolidated HMS FMP.

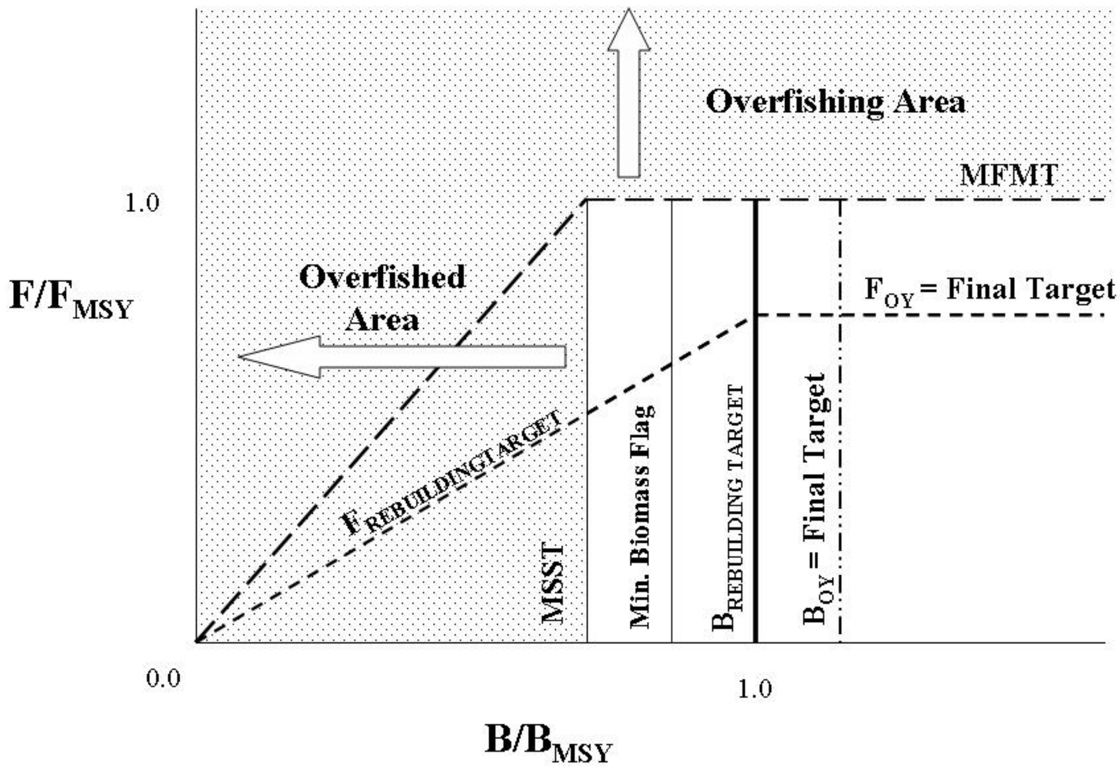

Figure 3.1 Illustration of the status determination criteria and rebuilding terms.

In summary, a species is considered overfished when the current biomass (B) is less than the minimum stock size threshold ($B < B_{MSST}$). The minimum stock size threshold (MSST) is determined based on the natural mortality of the stock and the biomass at maximum sustainable yield (B_{MSY}). Maximum sustainable yield (MSY) is the maximum long-term average yield that can be produced by a stock on a continuing basis. The biomass can be lower than B_{MSY}, and the stock not be declared overfished as long as the biomass is above B_{MSST}.

Overfishing may be occurring on a species if the current fishing mortality (F) is greater than the fishing mortality at MSY (F_{MSY}) ($F > F_{MSY}$). In the case of F, the maximum fishing mortality threshold is F_{MSY}. Thus, if F exceeds F_{MSY}, the stock is experiencing overfishing.

If a species is declared overfished or has overfishing occurring, action to rebuild the stock and/or prevent further overfishing is required by law. A species is considered rebuilt when B is greater than B_{MSY} and F is less than F_{MSY}. A species is considered healthy when B is greater than or equal to the biomass at optimum yield (B_{OY}) and F is less than or equal to the fishing mortality at optimum yield (F_{OY}).

In summary, the thresholds to use to calculate the status of Atlantic HMS, as described in the 1999 FMP and Amendment, are:

- Maximum Fishing Mortality Threshold (MFMT) = F_{limit} = F_{MSY};
- Overfishing is occurring when $F_{year} > F_{MSY}$;
- Minimum Stock Size Threshold (MSST) = B_{limit} = (1-M)B_{MSY} when M < 0.5 = 0.5B_{MSY} when M >= 0.5 (for billfish, the specific MSST values are: blue marlin = 0.9B_{MSY}; white marlin = 0.85B_{MSY}; west Atlantic sailfish = 0.75B_{MSY});
- Overfished when B_{year}/B_{MSY} < MSST;
- Biomass target during rebuilding = B_{MSY};
- Fishing mortality during rebuilding < F_{MSY};
- Fishing mortality for healthy stocks = 0.75F_{MSY};
- Biomass for healthy stocks = B_{OY} = ~1.25 to 1.30B_{MSY};
- Minimum biomass flag = (1-M)B_{OY}; and
- Level of certainty of *at least* 50 percent but depends on species and circumstances.

This final Consolidated HMS FMP does not change these threshold levels. The current status of Atlantic HMS is provided in the table below. Numerous stock assessments are expected to occur in 2006 that could change this status. Those species expected to have new stock assessments in the near future are: LCS (the review workshop – last of three – June 5-9, 2006); marlin (May 15-19, 2006); BFT (June 12-18, 2006); swordfish (September 4-8, 2006); and SCS (first workshop of three early 2007). The results of the LCS stock assessment will not be considered complete until the review workshop document is finalized, likely in summer 2006.

Table 3.3 Stock Assessment Summary Table. Source: SCRS, 2004 and 2005, Cortes, 2002, and Cortes *et al.* 2002.

Species	Current Relative Biomass Level	Minimum Stock Size Threshold	Current Relative Fishing Mortality Rate	Maximum Fishing Mortality Threshold	Outlook**
West Atlantic Bluefin Tuna	$SSB_{01}/SSB_{MSY} = 0.31$ (low recruitment); 0.06 (high recruitment) $SSB_{01}/SSB_{75} = 0.13$ (low recruitment); 0.13 (high recruitment)	$0.86SSB_{MSY}$	$F_{01}/F_{MSY} = 2.35$ (low recruitment scenario) $F_{01}/F_{MSY} = 4.64$ (high recruitment scenario)	$F_{year}/F_{MSY} = 1.00$	Overfished; overfishing is occurring.
East Atlantic Bluefin Tuna	$SSB_{00}/SSB_{70} = 0.86$	*Not estimated*	$F_{00}/F_{max} = 2.4$	*Not estimated*	Overfished; overfishing is occurring.*
Atlantic Bigeye Tuna	$B_{03}/B_{MSY} = 0.85$-1.07	$0.6B_{MSY}$ *(age 2+)*	$F_{02}/F_{MSY} = 0.73$-1.01	$F_{year}/F_{MSY} = 1.00$	Overfished; overfishing is occurring.
Atlantic Yellowfin Tuna	$B_{01}/B_{MSY} = 0.73$ - 1.10	$0.5B_{MSY}$ *(age 2+)*	$F_{01}/F_{MSY} = 0.87$-1.46	$F_{year}/F_{MSY} = 1.00$	Approaching an overfished condition.
North Atlantic Albacore Tuna	$B_{00}/B_{MSY} = 0.68$ (0.52-0.86)	$0.7B_{MSY}$	$F_{00}/F_{MSY} = 1.10$ (0.99 - 1.30)	$F_{year}/F_{MSY} = 1.00$	Overfished; overfishing is occurring.
South Atlantic Albacore Tuna	$B_{02}/B_{MSY} = 1.66$ (0.74-1.81)	*Not estimated*	$F_{02}/F_{MSY} = 0.62$ (0.46-1.48)	*Not estimated*	Not overfished; overfishing not occurring.*
West Atlantic Skipjack Tuna	*Unknown*	*Unknown*	*Unknown*	$F_{year}/F_{MSY} = 1.00$	Unknown
North Atlantic Swordfish	$B_{02}/B_{MSY} = 0.94$ (0.75 - 1.26)	*Unknown*	$F_{01}/F_{MSY} = 0.75$ (0.54 - 1.06)	$F_{year}/F_{MSY} = 1.00$	Overfished; overfishing not occurring
South Atlantic Swordfish	*Unknown*	*Unknown*	*Unknown*	$F_{year}/F_{MSY} = 1.00$	Unknown
Blue Marlin	$B_{00}/B_{MSY} = 0.4$ (0.25 – 0.6)	$0.9B_{MSY}$	$F_{99}/F_{MSY} = 4.0$ (2.5 – 6.0)	$F_{year}/F_{MSY} = 1.00$	Overfished: overfishing is occurring
White Marlin	$B_{01}/B_{MSY} = 0.12$ (0.06 – 0.25)	$0.85B_{MSY}$	$F_{00}/F_{MSY} = 8.28$ (4.5 – 15.8)	$F_{year}/F_{MSY} = 1.00$	Overfished: overfishing is occurring

Species	Current Relative Biomass Level	Minimum Stock Size Threshold	Current Relative Fishing Mortality Rate	Maximum Fishing Mortality Threshold	Outlook**
West Atlantic Sailfish	*Unknown*	$0.75B_{MSY}$	*Unknown*	*Not estimated*	Overfished: Overfishing is occurring
Spearfish	*Unknown*	*Unknown*	*Unknown*	*Not estimated*	*Unknown*
LCS	B_{01}/B_{MSY} = 0.46-1.18	$0.8B_{MSY}$	F_{01}/F_{MSY} = 0.89 – 4.48	F_{year}/F_{MSY} = 1.00	Overfished; Overfishing is occurring
Sandbar	B_{01}/B_{MSY} = 3.25E4-2.22	$0.85B_{MSY}$	F_{01}/F_{MSY} = 0.0015 – 2.45	F_{year}/F_{MSY} = 1.00	Not overfished; Overfishing is occurring
Blacktip	B_{01}/B_{MSY} = 0.79-1.66	$0.8B_{MSY}$	F_{01}/F_{MSY} = 0.13 – 1.72	F_{year}/F_{MSY} = 1.00	Not overfished; No overfishing occurring
SCS	B_{01}/B_{MSY} = 1.38-2.39	$0.5 B_{MSY}$ to $0.8B_{MSY}$	F_{00}/F_{MSY} = 0.24 - 0.78	F_{year}/F_{MSY} = 1.00	Not overfished; No overfishing F_{2000} = > F_{OY}
Pelagic sharks	*Unknown*	*Unknown*	*Unknown*	*Unknown*	*Unknown****

* South Atlantic albacore and East Atlantic bluefin tuna are not found in the U.S. EEZ.
** Based on "Sustaining and Rebuilding", National Marine Fisheries Service, 2004, - Report to Congress - The Status of U.S. Fisheries, August 2005.
*** Section 3.2.5 provides more information on the results of the stock assessment conducted by the SCRS in 2004 for blue and shortfin mako sharks and the stock assessment conducted by COSEWIC in 2005 for porbeagle sharks.

3.2.1 Atlantic Swordfish

3.2.1.1 Life History and Species Biology

Swordfish are members of the family *Xiphiidae*, in the suborder *Scombroidei*. Atlantic swordfish (*Xiphias gladius*) are one of the largest and fastest predators in the Atlantic Ocean, reaching a maximum size of 530 kg (1165 lb). Like other highly migratory species, they have developed a number of specialized anatomical, physiological, and behavioral adaptations (Helfman *et al*., 1997). Swordfish are distinguished by a long bill that grows forward from the upper jaw. This bill differs from that of marlins (family *Istiophoridae*) in that it is flattened rather than round in cross section, and smooth rather than rough. Swordfish capture prey by slashing this bill back and forth in schools of smaller fish or squid, stunning or injuring their prey in the process. They may also use the bill to spear prey, or as a defense during territorial encounters. Broken swordfish bills have been found embedded in vessel hulls and other objects (Helfman *et al.*, 1997).

Atlantic swordfish are usually found in surface waters but occasionally dive as deep as 650 meters. These large pelagic fishes feed throughout the water column on a wide variety of prey including groundfish, pelagics, deep-water fish, and invertebrate. Swordfish show extensive diel migrations and are typically caught on pelagic longlines at night when they feed in surface waters (SCRS, 2004). They are capable of migrating long distances to maximize prey availability and, as noted above, can prey upon various trophic levels during their daily vertical migrations (NMFS, 1999). As adults and juveniles, swordfish feed at the highest levels of the trophic food chain, implying that their prey species occur at low densities. The foraging behavior of swordfish reflects the broad distribution and scarcity of appropriate prey; they often aggregate in places where they are likely to encounter high densities of prey, including areas near current boundaries, convergence zones, and upwellings (Helfman *et al*., 1997).

Swordfish move thousands of kilometers annually and are distributed globally in tropical and subtropical marine waters. Their broad distribution, large spawning area, and prolific nature have contributed to the resilience of the species in spite of the heavy fishing pressure being exerted on it by many nations. During their annual migration, North Atlantic swordfish follow the major currents which circle the North Atlantic Ocean (including the Gulf Stream, Canary and North Equatorial Currents) and the currents of the Caribbean Sea and Gulf of Mexico. The primary habitat in the western north Atlantic is the Gulf Stream, which flows northeasterly along the U.S. coast, then turns eastward across the Grand Banks. North-south movement along the eastern seaboard of the United States and Canada is significant (NMFS, 2003). They are found in the colder waters during summer months and all year in the subtropical and tropical area (SCRS, 2003). Additional information on life history relating to habitat can be found in Section 3.3, Essential Fish Habitat, as well as the 1999 FMP for Atlantic Tunas, Swordfish, and Sharks.

Like most large pelagic species, swordfish have adapted body contours that enable them to swim at high speeds. Their streamlined bodies are round or slightly compressed in cross section (fusiform), and their stiff, deeply forked tails minimize drag. This streamlined physical form is enhanced by depressions or grooves on the body surface into which the fins can fit during swimming. The extremely small second dorsal and anal fins of the swordfish may function like the finlets of tuna, reducing turbulence and enhancing swimming performance. Their method of respiration, known as ram gill ventilation, requires continuous swimming with the mouth open to keep water flowing across the gill surfaces, thereby maintaining an oxygen supply. This respiratory process is believed to conserve energy compared to the more common mechanism whereby water is actively pumped across the gills (Helfman *et al*., 1997). In addition to the benefits of speed and efficiency, their search for prey is aided by coloring that provides camouflage in pelagic waters. This shading is darker along the dorsal side and lighter underneath, enhanced by silvery tones.

Swordfish exhibit other physiological characteristics that enable them to extend their hunting range. For example, swordfish can maintain elevated body temperatures, conserving the heat generated by active swimming muscles. Swordfish have developed a heat exchange system that allows them to swim into colder, deep water in pursuit of prey. Because warm muscles contract faster than cool ones, heat conservation is believed to enable these predatory fishes to channel more energy into swimming speed. The internal temperatures of these fishes remain fairly stable even as they move from surface waters to deep waters. Swordfish have also adapted specialized eye muscles for deep water hunting. Because their eye muscles do not have the ability to contract, they produce heat when stimulated by the nervous system, locally warming both the brain and eye tissues (Helfman *et al*., 1997). With this modification, swordfish are able to hunt in the frigid temperatures of deep-water ocean environments without experiencing a decrease in brain and visual function that might be expected under such harsh conditions.

Juvenile swordfish are characterized as having exceptionally fast growth during the first year (NMFS, 1999). Swordfish exhibit dimorphic growth, where females show faster growth rates and attain larger sizes than males. Young swordfish grow very rapidly, reaching about 130 cm lower jaw-fork length (LJFL) by age two. Swordfish are difficult to age, but 53 percent of females are considered mature by age 5, at a length of about 130 cm LJFL (SCRS, 2003; SCRS, 2004). Approximately 50 percent of males attain maturity by 112 cm LJFL (Arocha, 1997). All males are mature by 145 to 160 cm LJFL (37 to 50 kg ww), approximately age five, and all females are mature by 195 to 220 cm LJFL (93 to 136 kg ww), approximately age nine. In general, swordfish reach 140 cm LJFL (33 kg ww) by age three and are considered mature by age five. Individual females may spawn numerous times throughout the year (NMFS, 1999).

Swordfish stocks consist of several age classes, a condition that may serve as a buffer against adverse environmental conditions and confer some degree of stability on the stocks. Swordfish are also at a high trophic level, which may make the species less vulnerable to short-term fluctuations in environmental conditions (NMFS, 1999).

When ICCAT's Standing Committee on Research and Statistics (SCRS) scientists assess the status of Atlantic swordfish, the stock is split between the North Atlantic, South Atlantic, and Mediterranean Sea. The SCRS continues to examine existing information, including spawning data, tagging information, genetic studies, and abundance indices to better define stock structure. For the purposes of domestic management, the swordfish population is considered to consist of two discrete stocks divided at 5° N.

3.2.1.2 Stock Status and Outlook

The most recent assessment of North and South Atlantic swordfish stocks was conducted in 2002. In that assessment, updated CPUE and catch data through 2001 were examined. Sex and age-specific (North Atlantic) and biomass standardized catch rates (North and South Atlantic) from the various fleets were updated. The updated North Atlantic CPUE data showed similar trends to previous years, and also showed signs of improvement in stock status since 1998. In particular, the recruitment index (1997 – 2001) and the catch-at-age used in the 2002 North Atlantic assessment showed signs of substantially improved recruitment (age one), which has manifested in several age classes and the biomass index of some fisheries, and have allowed for increases in spawning biomass and a more optimistic outlook. The strong recruitments of the late 1990s promoted improvement in spawning stock biomass and should result in further improvement, if these year classes are not heavily harvested. The CPUE patterns in the South Atlantic by fleet showed contradictory patterns. Lack of important CPUE information from some fleets fishing in the South Atlantic prevented the SCRS from reconciling these conflicts (SCRS, 2004).

North Atlantic Swordfish (all weights are given in whole weight)

An updated estimate of maximum sustainable yield from production model analyses is 14,340 mt (range 11,500 to 15,500 mt). Since 1997, North Atlantic swordfish catches have been estimated to have remained below 14,340 mt, but the most recent years are provisional and probably represent underestimates. Details of catches for recent years are presented below in section 3.2.1.3. The biomass at the beginning of 2002 was estimated to be 94 percent (range: 75

to 124 percent) of the biomass needed to produce MSY. This estimate is up from an estimate of 65 percent of MSY in the 1998 assessment. The 2001 fishing mortality rate was estimated to be 0.75 times the fishing mortality rate at MSY (range: 0.54 to 1.06). The replacement yield for the year 2003 and beyond was estimated to be about the MSY level. As the TAC for North Atlantic swordfish for 2002 was 10,400 mt, it was considered likely that biomass would increase further under those catch levels. The TAC set for 2003 – 2005 was 14,000 mt (ICCAT Recommendation 02 – 02). Given recent fishing mortality patterns, the spawning biomass likely will increase largely owing to the very large recruitments estimated for 1997 – 2000 (SCRS, 2005). Further, given that recent (2002 – 2003) reported catch has been below estimated replacement yield, the North Atlantic swordfish biomass may have already achieved the B_{MSY} level. However, noting the uncertainties inherent in the assessment, the SCRS warned against large increases over the current TAC (SCRS, 2004). The next assessment is scheduled for 2006.

South Atlantic Swordfish

The SCRS noted that reported total catches have been reduced since 1995, as was recommended by the SCRS. SCRS had previously expressed serious concern about the trends in stock biomass of South Atlantic swordfish based on the pattern of rapid increases in catch before 1995 that could result in rapid stock depletion, and in declining CPUE trends of some bycatch fisheries. For the 2002 stock assessment, standardized CPUE series were available for three fleets, the targeted fishery of European Community (EC) - Spain, and the bycatch fisheries of Chinese Taipei and Japan. There was considerable conflict in trends among the three CPUE series and it is unclear which, if any, of the series tracks total biomass. It was noted that there was little overlap in fishing area among the three fleets, and that the three CPUE trends could track different components (or cohorts) of the population. To address this possibility, an age-structured production model was run as a sensitivity test. For the base case production model, the Committee selected the bycatch CPUE series combined using a simple unweighted mean and the targeted CPUE series. Due to some inconsistencies in the available CPUE trends reliable stock assessment results could not be obtained (SCRS, 2004). As stated above, the next assessment is scheduled for 2006.

Reported catches of Atlantic swordfish, including discards for the period 1950 – 2004 can be found in Figure 3.2. Estimated fishing mortality rate relative to the F_{MSY} for the period 1959 – 2001 can be found in Figure 3.3. Annual yield for North Atlantic swordfish relative to the estimated MSY can be found in Figure 3.4. A summary of Atlantic swordfish stock status can be found in Table 3.4

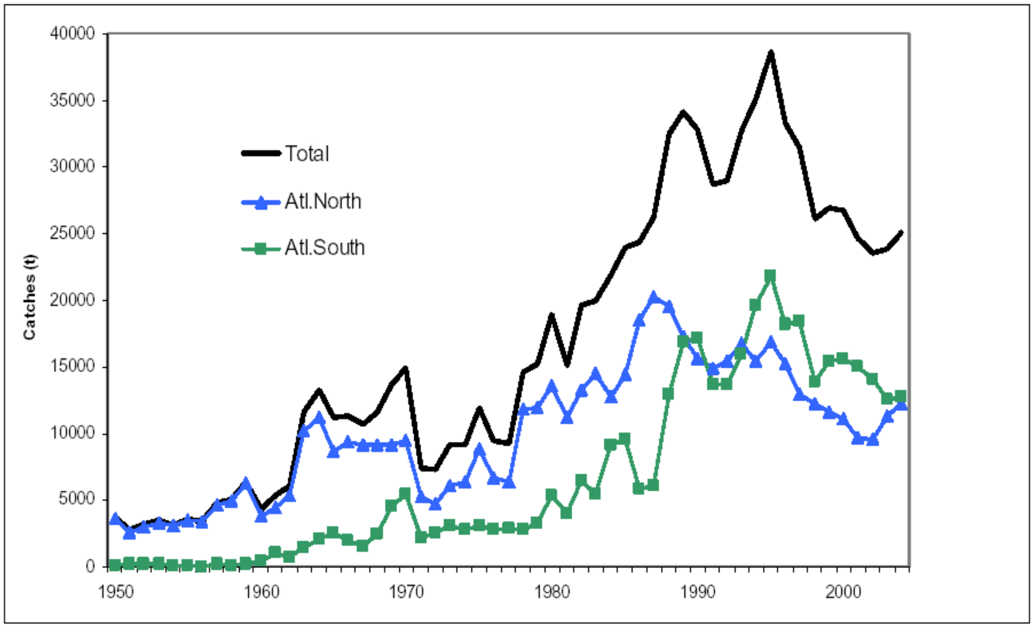

Figure 3.2 Reported catches (mt whole weight) of Atlantic Swordfish, including discards for 1950-2004. Source: SCRS, 2005.

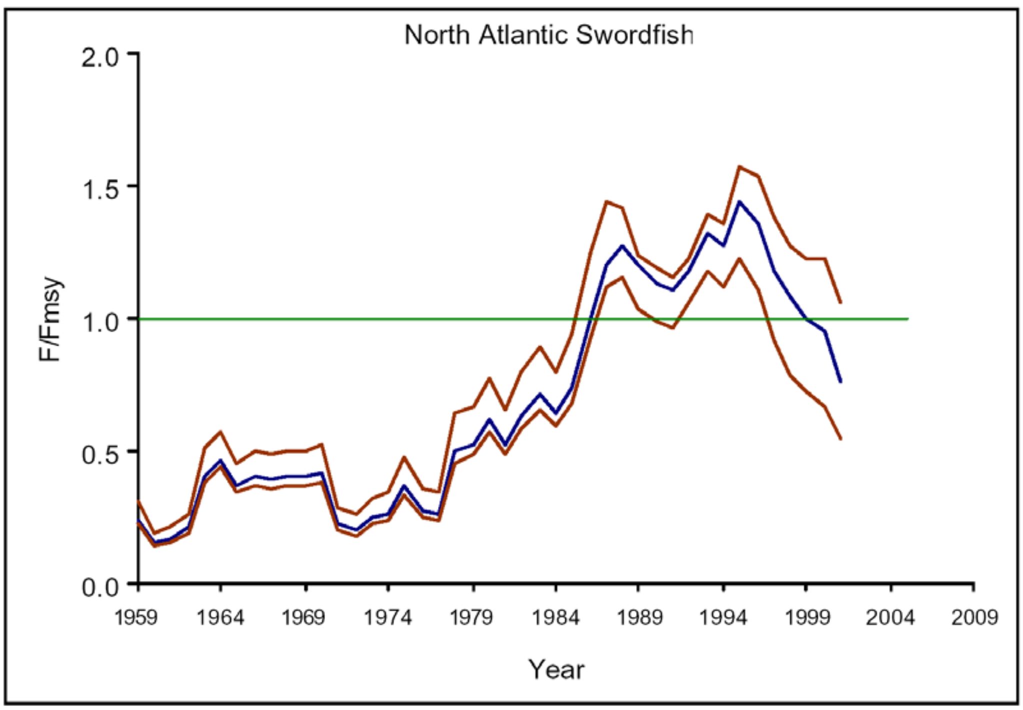

Figure 3.3 Estimated fishing mortality rate relative to FMSY (F/FMSY) for the period 1959-2001 (median with 80 percent confidence bounds based on bootstrapping are shown). Source: SCRS 2004.

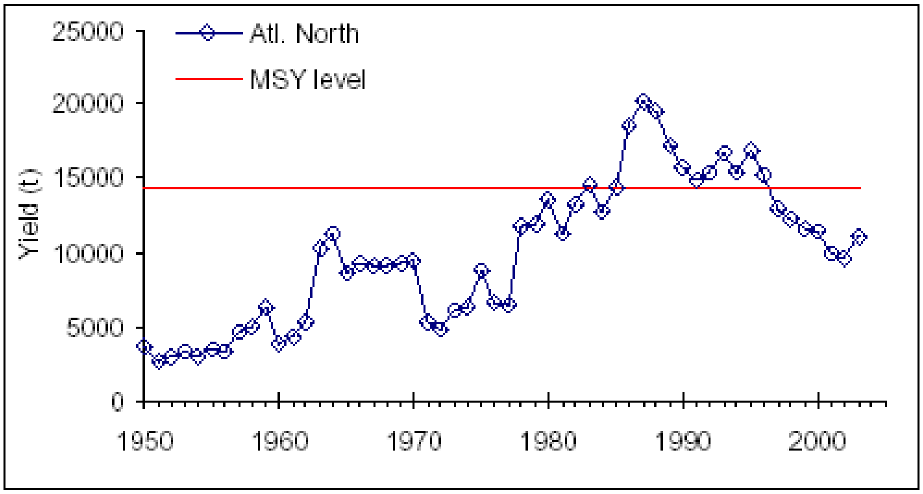

Figure 3.4 Annual yield (mt) (whole weight) for North Atlantic swordfish relative to the estimated MSY level. Source: SCRS 2004

Table 3.4 Atlantic Swordfish Stock Summary (weights given in mt ww). Source: SCRS, 2005.

ATLANTIC SWORDFISH SUMMARY		
	North Atlantic	**South Atlantic**
Maximum Sustainable Yield[1]	14,340 t (11,580-15,530)[4]	Not estimated
Current (2004) Yield[2]	12,283 t	12,779 t
Current (2002) Replacement Yield[3]	about MSY	Not estimated
Relative Biomass (B_{2002}/B_{MSY})	0.94 (0.75 - 1.24)	Not estimated
Relative Fishing Mortality		
F_{2001}/F_{MSY}[1]	0.75 (0.54 - 1.06)	Not estimated
F_{2000}/F_{max}	1.08	Not estimated
$F_{2000}/F_{0.1}$	2.05	Not estimated
$F_{2000}/F_{30\%SPR}$	2.01	Not estimated
Management Measures in Effect	Country-specific TACs [Rec. 02-02]; 125/119 cm LJFL minimum size.	TAC target [Ref. 02-03]; 125/119 cm LJFL minimum size [Rec. 02-02].

[1] Base Case production model results based on catch data 1950-2001.
[2] Provisional and subject to revision.
[3] For next fishing year.
[4] 80% confidence intervals are shown.

3.2.1.3 Effect of Regulations

ICCAT Catch limits (all weights in this section are given in whole weight)

The total allowable catch in the North Atlantic in 2002 was 10,400 mt (10,200 mt retained and 200 mt discarded). The reported landings were about 9,000 mt and the estimated discards were about 535 mt. The total allowable catch in the North Atlantic in 2003 was 14,000 mt (13,900 mt retained and 100 mt discarded). The reported landings in 2003 were about 10,800 mt and the estimated discards were about 460 mt. The total allowable catch in the North Atlantic in 2004 was 14,000 mt. The reported landings in 2004 were 11,867 mt with discards totaling an estimated 417 mt. Reports for year 2004 are considered provisional and subject to change (SCRS, 2005).

The total allowable catch in the South Atlantic in 2002 was 14,620 mt. The reported landings for 2002 were about 13,660 mt and reported discards were 1 mt. The total allowable catch in the South Atlantic in 2003 was 15,631 mt. The reported landings for 2003 were about 10,900 mt and reported discards were estimated to be less than 1 mt. The total allowable catch in the South Atlantic in 2004 was 15,776. The reported landings in 2004 were 12,778 mt with discards totaling an estimated 1 mt. Reports for year 2004 are considered provisional and subject to change (SCRS, 2005).

ICCAT Minimum size limits (all weights in this section are given in whole weight)

There are two minimum size options that are applied to the entire Atlantic: 125 cm LJFL with a 15 percent tolerance for undersized fish, or 119 cm LJFL with zero tolerance and evaluation of the discards. In the absence of size data, these calculations could not be updated or examined for 2004. In 2000, the percentage of swordfish reported landed (throughout the Atlantic) less than 125 cm LJFL was about 21 percent (in number) overall for all nations fishing in the Atlantic. If this calculation is made using reported landings plus estimated discards, then the percentage less than 125 cm LJFL would be about 25 percent. The SCRS noted that this proportion of small fish did not increase very much even though recruitment in the North has been at a high level in recent years (SCRS, 2005). Literature Cited.

Domestic Regulations

The domestic commercial swordfish fishery is governed by a limited access permit system with three types of permits: directed swordfish, incidental swordfish, and swordfish handgear. Anglers must also possess either a HMS Angling category permit or a CHB permit to for fish for, retain, or possess a North Atlantic swordfish. Only commercial permit holders may sell swordfish. Details of the permitting programs, including the number of permit holders can be found in section 3.9. Data on commercial catches and landings of North Atlantic swordfish are captured through observer programs, logbook reports, and dealer reports. Additional information on commercial catches, landings, and discards can be found in Chapter 0 of this document. Approximately 154,000 square miles of the Atlantic, Gulf and Caribbean have been closed to pelagic longline fishing in an effort to reduce bycatch and discards of Atlantic HMS including juvenile swordfish. Effects of the area closures on bycatch and discards can be found in Chapter 4. Recreational landings of North Atlantic swordfish are captured through mandatory tournament reports (if a tournament is selected for reporting), mandatory self-reporting of non-tournament landings, and various surveys, including the Marine Recreational Fisheries Statistics Survey and the Large Pelagics Survey. .

The United States has implemented minimum legal size regulations for Atlantic swordfish that correspond to the ICCAT 119 cm minimum size limit. Domestic minimum sizes include: the 47" lower jaw fork length, 29" cleithrum to keel length, or 33 lbs. Vessels with commercial directed and handgear swordfish permits are not constrained by trip limits when the fishery is open. Directed swordfish permit holders are limited to 15 swordfish per vessel per trip when the directed swordfish fishery is closed. Incidental commercial permit holders are limited to two swordfish per trip, except for vessels deploying squid trawl gear, which may retain five. There is a recreational bag limit of one North Atlantic swordfish per person per trip, up to a maximum of three per vessel, regardless of the length of the trip.

3.2.1.4 Recent and Ongoing Research

(The following information was taken directly from the 2005 U.S. National Report to ICCAT)

In 2005, data from observer samples were compared against self-reported information from the U.S. large pelagic mandatory logbook reporting system, and estimates of discard mortality of swordfish, billfish, sharks and other species from the U.S. fleet were developed from that analysis for the 2005 SCRS. Estimates of small swordfish bycatch for 2002 – 2004 were compared to the average levels estimated for the late 1990's and were found to be substantially lower. Reported and observed swordfish catches, and size and catch rate patterns through 2004 were examined in support of monitoring the recovery of north Atlantic swordfish. Standardized indices of abundance were updated for the Western North Atlantic using data from the U.S. pelagic longline fleet (SCRS/2005/085). Collaborative research between various ICCAT nations and Venezuelan scientists continues on estimating the age-structure of the catch of swordfish. Results of this research will be available for the next assessment of north Atlantic swordfish. Scientists from the United States collaborated with Brazilian scientists to improve catch rate standardization procedures by offering a course on the topic in Brazil in mid-2005. Central to this collaboration is development of fisheries research capacity in Brazil through graduate student training and of stronger scientific cooperation between Brazil and the United States.

Research on measures to mitigate the interactions between pelagic longline and bycatch of marine turtles continued under a cooperative research program involving the US Atlantic pelagic longline fishery. The Northeast Distant Fishery Experiment was conducted from 2001 through 2003 on the high seas of the Western Atlantic Ocean, in an area off New Foundland known as the Grand Banks. Results of this research which was focused on reducing mortality of marine turtles interacting with pelagic longlines was recently published (Watson, *et.al.* 2005. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. (Can. J. Fish. Aquat. Sci.. 62(5): 965-981). Additional cooperative research in the Gulf of Mexico was carried out in 2004 and in additional regions in 2005.

3.2.2 Atlantic Bluefin Tuna

All text, figures and tables for this section are from the SCRS 2004 and 2005 Reports and the U.S. National Report to ICCAT, 2005. All weights are reported as whole weights unless indicated as otherwise.

3.2.2.1 Life History and Species Biology

Atlantic bluefin tuna are distributed from the Gulf of Mexico to Newfoundland in the West Atlantic, from roughly the Canary Islands to south of Iceland in the East Atlantic, and throughout the Mediterranean Sea. Historically, catches of bluefin were made from a broad geographic range in the Atlantic and Mediterranean.

Atlantic bluefin tuna can grow to over 300 cm and reach more than 650 kg. The oldest age considered reliable is 20 years, based on an estimated age at tagging of two years and about 18 years at liberty, although it is believed that bluefin tuna may live to older ages. Bluefin tuna are, thus, characterized by a late age at maturity (thus, a large number of juvenile classes) and a long life span. These factors contribute to make bluefin tuna well adapted to variations in recruitment success, but more vulnerable to fishing pressure than rapid growth species such as tropical tuna species. Bluefin tuna in the West Atlantic generally reach a larger maximum size compared to bluefin caught in the East Atlantic.

Bluefin tuna in the West Atlantic are assumed to first spawn at age eight compared to ages four to five in the east Atlantic. Distribution expands with age; large bluefin are adapted for migration to colder waters. Bluefin tuna are opportunistic feeders, with fish, squid, and crustaceans common in their diet. In the West Atlantic, bluefin tuna are thought to spawn from mid-April into June in the Gulf of Mexico and in the Florida Straits. Juveniles are thought to occur in the summer over the continental shelf, primarily from about 35°N to 41°N and offshore of that area in the winter. In the East Atlantic, bluefin tuna generally spawn from late May to July depending on the spawning area, primarily in the Mediterranean, with highest concentrations of larvae around the Balearic Islands, Tyrrhenian Sea, and central and eastern Mediterranean where the sea-surface temperature of the water is about 24°C. Sexually mature fishes have also been recently observed in May and June in the eastern Mediterranean (between Cyprus and Turkey). Bluefin tuna are known to be highly migratory and the nature and extent of their ability to conduct transoceanic migrations are the subject of significant research (see section on Research below).

3.2.2.2 Stock Status and Outlook

The last full stock assessments for western Atlantic bluefin tuna were conducted in 2002 by the SCRS with the next scheduled for 2006. Although the next stock assessment will not be conducted until mid-2006, the 2005 SCRS reported a significant number of new research reports and studies (see Research Section below). The assessment results are similar to those from previous assessments (see

Table 3.5). They indicate that the spawning stock biomass (SSB) declined steadily from 1970 (the first year in the assessment time series) through the late 1980s, before leveling off at about 20 percent of the level in 1975 (which has been a reference year used in previous assessments). A steady decline in SSB since 1997 is estimated and leaves SSB in 2001 at 13 percent of the 1975 level. The assessment also indicates that the fishing mortality rate during 2001 on the SSB is the highest level in the series.

A noteworthy pattern of change in the fisheries since 1998 has been the trend of increase followed by a trend of decrease in catches to below TAC level. The reported total catches of western Atlantic bluefin tuna increased from about 2600 mt in 1998 to about 3,200 mt in 2002 and has subsequently fallen below 2,000 mt in 2004. The 2002 catches were the highest since 1981; however the 2004 catches were the lowest since 1982, when ICCAT catch restrictions were first established.

The Japanese longline fishery catch in the West Atlantic in 2003 was a substantial decrease from its 2002 catch level, but increased in 2004 to a level somewhat below its average catch from 1993 – 2002. This variation resulted from the adjustments made by Japan for previous quota overages. The Canadian reported landings remained at relatively stable levels over the past decade. Recent declines in U.S. landings have been attributed to a general lack of availability of large fish in the fisheries off the northeastern U.S. coast for the past several years.

Estimates of recruitment of age one fish have been generally lower since 1976. However, recruitment of age one fish in 1995 and 1998 is estimated to be comparable in size to some of the year classes produced in the first half of the 1970s. While the large decline in SSB since the early 1970s is clear from the assessment, the potential for rebuilding is less clear. Key issues are the reasons for relatively poor recruitment since 1976, and the outlook for recruitment in the future. One school of thought is that recruitment has been poor because the SSB has been low. If so, recruitment should improve to historical levels if SSB is rebuilt. Another school of thought is that the ecosystem changed such that it is less favorable for recruitment and thus recruitment may not improve even if SSB increases. To address both schools of thought, the SCRS considered two recruitment scenarios as described below and summarized in Table 3.5. (East Atlantic Bluefin tuna summary data are also provided for comparison purposes). For both scenarios, the assessment indicates that the fishing mortality on the western Atlantic bluefin resource exceeds F_{MSY} and the SSB is below B_{MSY} (thus overfished according to ICCAT's objective of maintaining stocks at the MSY-biomass level and as indicated in NMFS, Report to Congress, Status of Fisheries, 2005).

Table 3.5 Summary Table for the Status of West Atlantic Bluefin Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 8/~ 200 cm fork length
Spawning Sites	Primarily Gulf of Mexico and Florida Straits
Current Relative Biomass Level *Minimum Stock Size Threshold*	SSB_{01}/SSB_{75} (low recruitment) = .13 (.07-.20) SSB_{01}/SSB_{75} (high recruitment) = .13 (.07-.20) SSB_{01}/SSB_{msy} (low recruitment) = .31 (.20-.47) SSB_{01}/SSB_{msy} (high recruitment) = .06 (.03-.10) *$0.86B_{MSY}$*
Current Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{01}/F_{MSY} (low recruitment) = 2.35 (1.72-3.24) F_{01}/F_{MSY} (high recruitment) = 4.64 (3.63-6.00) *F/F_{MSY}* = 1.00
Maximum Sustainable Yield	Low recruitment scenario: 3,500 mt (3,300-3,700) High recruitment scenario: 7,200 mt (5,900-9,500)
Catch (2004) including discards	~2,000 mt
Short Term Sustainable Yield	Probably > 3,000 mt
Outlook	Overfished; overfishing continues to occur

Table 3.6 Summary Table for the Status of East Atlantic Bluefin Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 4-5
Spawning Sites	Mediterranean Sea
Current Relative Biomass Level	SSB_{00}/SSB_{1970} = .86
Current Relative Fishing Mortality Rate	F_{00}/F_{MAX} = 2.4
Maximum Sustainable Yield	Not estimated
Current (2004) Yield	26,961 mt
Replacement Yield	Not estimated
Outlook	Overfished; overfishing continues to occur.

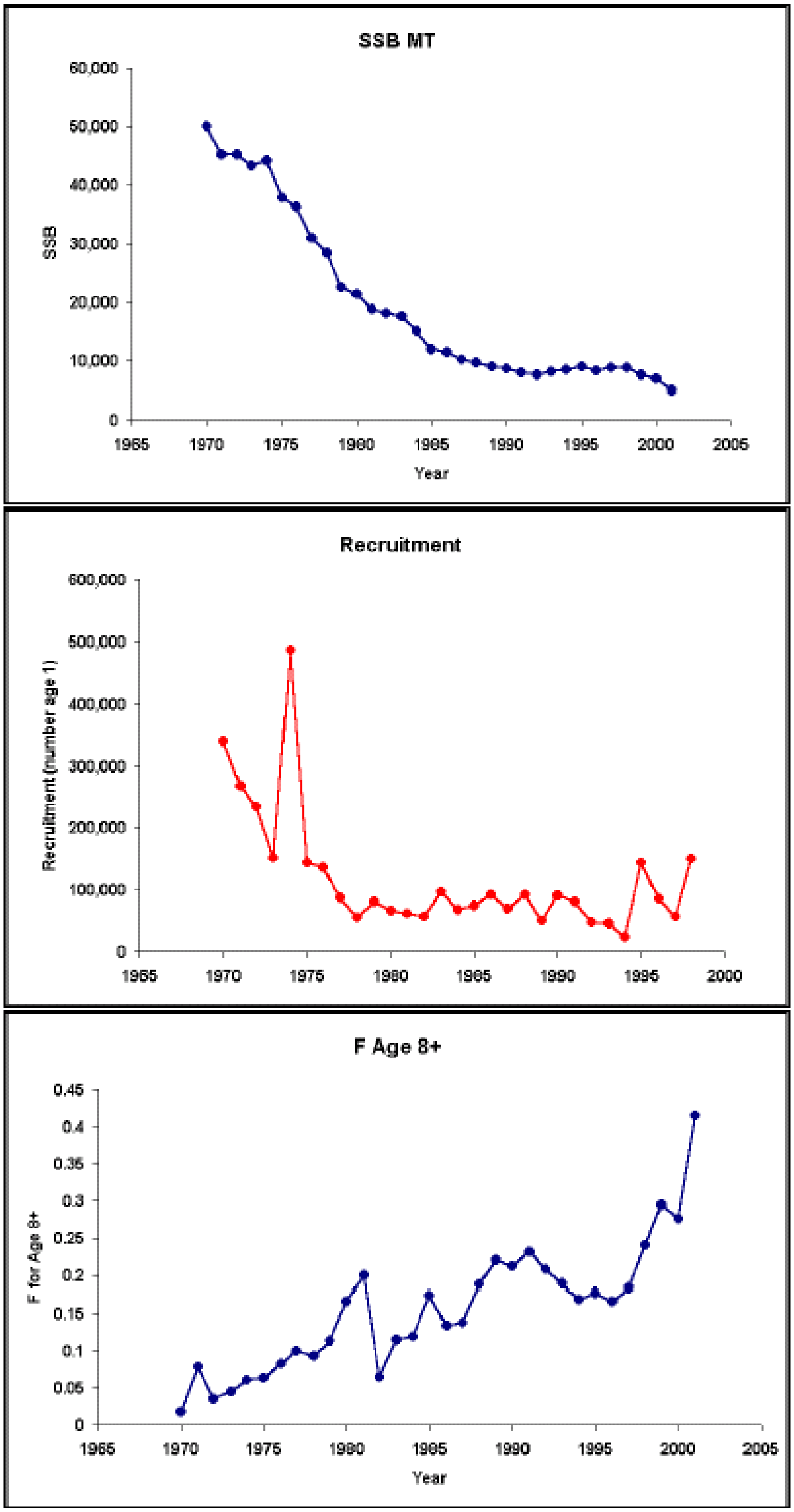

Figure 3.5 Western Atlantic bluefin tuna spawning biomass (t), recruitment (numbers) and fishing mortality rates for fish of age 8+, estimated by the Base Case VPA run. Source: ICCAT, 2004.

In general, the outlook for bluefin tuna in the West Atlantic is similar to the outlook reported based on the 2000 western Atlantic bluefin tuna assessment session. The assessment and projection results for the present assessment are somewhat less optimistic than in 2000 but the confidence in the strength of the 1994 year class has increased. Therefore, the increases associated with different levels of future catch projected for the short-term are smaller but are estimated more confidently. It should be noted that the 1995 year class was estimated to be strong in 2000, but it is now estimated to be only of average strength.

As noted by the previous assessment session, western Atlantic bluefin tuna catches have not varied very much since 1983 (the range over this period is 2,106 to 3,011 mt), and the estimated spawning stock size (Spawning Stock Biomass (SSB) measured as the biomass of fish age 8+) has been relatively stable, notwithstanding the indication of a decline in the most recent years. Thus, over an extended period of time, catches around recent levels have maintained stock size at about the same level, in spite of several past assessments that predicted the stock would either decline or grow if the current catch was maintained. This observation highlights the challenge of predicting the outlook for this stock.

In order to provide advice relative to rebuilding the western Atlantic bluefin resource, the SCRS conducted projections for two scenarios about future recruitment. One scenario assumed that future average recruitment will approximate the average estimated recruitment (at age one) since 1976, unless spawning stock size declines to low levels (such as the current level estimated in the assessment, but generally lower than estimates during most of the assessment history). The second scenario allowed average recruitment to increase with spawning stock size up to a maximum level no greater than the average estimated recruitment for 1970 to 1974. These scenarios are referred to as the low recruitment and high recruitment scenarios, respectively. The low and high recruitment scenarios implied that the B_{MSY} (expressed in SSB) is 42 percent and 183 percent of the biomass in 1975, respectively. With the current information, the SCRS could not determine which recruitment scenario is more likely, but both are plausible, and recommended that management strategies should be chosen to be reasonably robust to this uncertainty.

Table 3.7 below summarizes the results of projections of both scenarios at different catch levels. The projections for the low recruitment scenario estimated that a constant catch of 3,000 mt per year has an 83 percent probability of allowing rebuilding to the associated SSB_{MSY} by 2018. A constant catch of 2,500 mt per year has a 35 percent probability of allowing rebuilding to the 1975 SSB by 2018.

The results of projections based on the high recruitment scenario estimated that a constant catch of 2,500 mt per year has a 60 percent probability of allowing rebuilding to the 1975 level of SSB, and there is a 20 percent chance of rebuilding SSB to SSB_{MSY} by 2018. If the low recruitment scenario is valid, the TAC could be increased to at least 3,000 mt without violating ICCAT's rebuilding plan. If the high recruitment scenario is valid, the TAC should be decreased to less than 1,500 mt to comply with the plan.

The estimate of SSB_{MSY} for the high recruitment scenario is critical to inferences regarding the probability of achieving rebuilding under different future levels of catch, and also less well determined by the data than SSB_{MSY} for the low recruitment scenario. In particular, the estimates of SSB_{MSY} based on the high recruitment scenario are substantially larger than the largest spawning stock size included in the assessment. This extrapolation considerably increases the uncertainty associated with these estimates of SSB_{MSY}. Previous meetings have used SSB_{1975} as a rebuilding target in the context of interpreting projections. Arguably SSB_{1975} is appropriate as a target level for interpreting the implications of projections based on the high recruitment scenario. Under such a target level for the high recruitment scenario, a TAC of 2,700 mt has an estimated probability of reaching the rebuilding level of about 50 percent.

The SCRS cautioned that these conclusions do not capture the full degree of uncertainty in the assessments and projections. An important factor contributing to uncertainty is mixing between fish of eastern and western origin. Furthermore, the projected increases in stock size are strongly dependent on estimates of recent recruitment, which are a particularly uncertain part of the assessment. A sensitivity test in which the estimates of the below average 1996 and the strong 1997 year classes were excluded from the analysis gave somewhat less optimistic results in terms of the estimated probabilities of recovery by 2018. However, these projections still predicted increases in spawning biomass for both recruitment scenarios, except for extreme increases in catch.

Table 3.7 Probability of western Atlantic bluefin tuna achieving rebuilding target by 2018. Source: ICCAT, 2004.

Catch	Low Recruitment Scenario		High Recruitment Scenario	
(MT)	SSB_{1975}	SSB_{MSY}	SSB_{1975}	SSB_{MSY}
500	95 %	100 %	98 %	73 %
1,000	89 %	100 %	96 %	62 %
1,500	77 %	100 %	87 %	47 %
2,000	60 %	99 %	75 %	30 %
2,300	45 %	98 %	66 %	24 %
2,500	35 %	97 %	60 %	20 %
2,700	26 %	95 %	52 %	17 %
3,000	14 %	83 %	38 %	11 %
5,000	0 %	1 %	2 %	0 %

3.2.2.3 Effects of Regulations

The SCRS' management recommendation for the western Atlantic bluefin tuna management area is directed at the Rebuilding Program adopted by ICCAT in 1998. According to the Program, the MSY rebuilding target can be adjusted according to advice from SCRS. In 2002, ICCAT set the annual Total Allowable Catch (TAC), inclusive of dead discards, for the western Atlantic management area at 2,700 mt, effective beginning in 2003. The Program states that the TAC for the west would only be adjusted from the 2,500 mt level adopted for 2003 – 2004 if SCRS advises that (a) a catch of 2,700 mt or more has a 50 percent or greater probability of rebuilding or (b) a catch of 2,300 mt or less is necessary to have a 50 percent or greater probability of rebuilding.

The Program is designed with the intent to rebuild with 50 percent probability by 2018 to the spawning biomass level associated with MSY. In light of the uncertainty in the assessment, the choice between recruitment scenarios and rebuilding targets, and assumptions about mixing, the weight of scientific opinion within the SCRS favored no change from the current TAC of 2,500 mt per year. Projections based on the low recruitment scenario indicate that the TAC could be increased without violating the Rebuilding Program, assuming that relatively large recruitment estimates for some recent year classes are realistic. The high levels of recruitment estimated for some recent year classes are consistent with a higher biomass level as a rebuilding target. In previous assessment sessions, the spawning biomass level in 1975 was considered a useful rebuilding target. The 1975 biomass is more than twice the MSY spawning biomass level associated with the low recruitment scenario. The projections indicate a 35 – 60 percent probability of rebuilding to the 1975 spawning biomass level for a catch of 2,500 mt per year, depending on the recruitment scenario assumed. It seems likely that a recruitment scenario corresponding to a SSB_{MSY} equal to the level in 1975 would indicate a probability of rebuilding by 2018 for a catch of 2,500 mt per year within the range of 35 – 60 percent.

The MSY spawning biomass associated with the high recruitment scenario, which is nearly twice the 1975 level, is unlikely to be reached by 2018 if the recent level of catch (and TAC) is maintained. However, the SCRS does not recommend the sharp reduction in TAC that would be necessary to comply with the rebuilding Program based on the high recruitment scenario because of:

- Uncertainty about the most appropriate recruitment scenario;
- Recognition that for the high recruitment scenario, the spawning biomass associated with MSY is not well determined (because estimation leads to extrapolation beyond biomass levels included within the current assessment); and
- The generally positive outlook for the resource according to the current assessment regardless of the recruitment scenario assumed.

As emphasized in previous assessments, mixing across management unit boundaries of fish of western and eastern origin could be important for management of the resource in both areas. In particular, the condition of the eastern Atlantic stock and fishery could adversely affect recovery in the West Atlantic, which was also noted in the SCRS's 1998, 2000, and 2001 reports. Therefore, the SCRS stressed the importance of continuing efforts to manage the fisheries in both the east and West Atlantic according to ICCAT's objectives.

The first regulatory measure for a scientific monitoring level was adopted for western Atlantic bluefin catches in 1981. Since then, monitoring levels have been changed in various years. Until 1987, both estimated catches and landings were below or equal to the level of the catch limits. However, from 1988 to 1997, estimated landings were very close to the level of the limits and, for some years, exceeded the limit by a maximum of 100 mt. Estimated catches (including discards) were higher than the limits every year during this period (by about 200 to 300 mt) with the exceptions of 1992 and 1997. The estimated catches exceeded the 2,500 mt limit in 2000 by 165 mt, by 218 mt in 2001, and by 715 mt in 2002. It should be pointed out that for compliance purposes, some countries (including the United States) are using fishing years that do not correspond to calendar years. Also, according to the ICCAT regulatory measure, the amount of catch that exceeded quota or was left over from the quota can be carried over to succeeding years. Hence, the catch limit set for each year could have been adjusted accordingly. The SCRS notes that the excess of the catch limits in most recent years is due to some new fisheries that operated without a quota.

For the West Atlantic, a size limit of 6.4 kg with 15 percent allowance, in number of fish, has been in effect since 1975. In addition, a prohibition on the taking and landing bluefin tuna less than 30 kg (or 115 cm) with an eight percent tolerance, by weight on a national basis, became effective in 1992. The SCRS notes that, since 1992, the proportion of undersized fish for all catches combined has been below the allowance level (*e.g.*, one percent and three percent <115cm in 2000 and 2001, respectively). Updated estimates will be available at the upcoming 2006 SCRS stock assessment.

The U.S. bluefin fishery continues to be regulated by quotas, seasons, gear restrictions, limits on catches per trip, and size limits. To varying degrees, these regulations are designed to restrict total U.S. landings and to conform to ICCAT recommendations. U.S. 2004 provisional estimated landings and discards from the northwest Atlantic (including the Gulf of Mexico), as reported by the United States to ICCAT in its annual National Report (NMFS 2005), were 899 mt and 71 mt, respectively. Those estimated landings and discards represent a decrease of 509 mt from the 2003 estimates. (Out of a total western Atlantic management area TAC of 2,700 mt, total reported catches were 2,191 mt in 2003 and about 2,000 mt in 2004). The 2004 United States landings by gear were: 32 mt by purse seine, 41 mt by harpoon, 1 mt by handline, 180 mt by longline (including discards) of which 103 mt were from the Gulf of Mexico, and 716 mt by rod and reel.

In response to 1992 regulations limiting the allowable catch of small fish by U.S. fishermen, in conformity with ICCAT agreements, enhanced monitoring of the rod and reel fishery was implemented in 1993 for the purpose of providing near real-time advice on catch levels by this fishery. This monitoring activity has continued and has included estimation of catches by finer scale size categories than reported above. The preliminary estimates for the 2004 rod and reel fishery off the northeastern United States (including the North Carolina winter fishery) for landings in several size categories were 264 fish < 66 cm, 10,193 fish 66-114 cm, 3,414 fish 115-144 cm, and 634 fish 145-177 cm (an estimated 1.5, 198, 142, and 49 mt, respectively), (NMFS 2005).

3.2.2.4 Recent and Ongoing Research

As part of its commitment to the Bluefin Program, research supported by the United States has concentrated on ichthyoplankton sampling, reproductive biology, and methods to evaluate hypotheses about movement patterns, spawning area fidelity, stock structure investigations and population modeling analyses.

Ichthyoplankton surveys in the Gulf of Mexico during the bluefin spawning season were continued in 2004 and 2005. Data resulting from these surveys, which began in 1977, are used to develop a fishery-independent abundance index of spawning West Atlantic bluefin tuna. This index has continued to provide one measure of bluefin abundance that is used in SCRS assessments of the status of the resource. During the 2004 U.S. ichthyoplankton survey, a plankton net of a type used in the Spanish surveys was fished in addition to the nets normally used to determine the impact of using a wider net mouth and larger mesh on the size and catch rates of bluefin in the Gulf of Mexico. The results of this work will be reported as they become available. U.S. scientists also collaborated in development of the larval working group agenda for the Climate Impacts on Oceanic Top Predators (CLIOTOP) program managed by GLOBEC (Global Ocean Ecosystem Dynamics) initiated by SCOR and the IOC of UNESCO in 1991.

Since 1998, researchers from Texas A & M University and the University of Maryland with assistance of researchers from Canada, Europe, and Japan have studied the feasibility of using otolith chemical composition (microconstituents and isotopes) to distinguish bluefin stocks. Recent research has investigated the value of using additional microconstituent elements (transitional metals) to enhance classification success. By themselves the transitional metals provided little discriminatory power, but when combined with the other trace elements (for 13 elements in all), the classification success for several year-classes has been moderate ranging from 60 – 90 percent, and classification functions show strong year-to-year variability. In SCRS/2005/083 the utility of an alternative chemical marker in otoliths, carbon and oxygen stable isotopes, to discriminate bluefin tuna from natal regions were reported upon. The discriminatory power of stable isotopes ($\delta_{13}C$, $\delta_{18}O$) in otoliths of yearlings (age-1) was high, with 91 percent of individuals classified correctly to eastern and western nurseries. These stable isotopes and in particular $\delta_{18}O$ can be used to reliably predict nursery origin of Atlantic bluefin tuna. An initial application compared otolith core material (corresponding to the first year of life) of large school, medium, and giant category bluefin tuna to reference samples of yearling signatures to determine their origin. A large fraction (~43 – 64 percent) of the Atlantic bluefin tuna collected in the western Atlantic fishery (comprised primarily of large school and medium category fish) originated from nurseries in the east. Alternatively, medium and giant category bluefin tuna from the Mediterranean were largely (~82 – 86 percent) of eastern origin. Thus, initial evidence suggests that the western fishery received high input from the Mediterranean population. (See generally SCRS/2003/105, and Rooker et al 2001a, 2001b and 2003).

Scientists from the University of Maryland, Virginia Institute of Marine Science, and Texas A&M University have continued to sample specimens for genetic and otolith chemistry studies of stock structure. Roughly 10 – 20 young of the year were collected in 2004. In addition, limited sampling of ages 1 and older continues. Efforts are also continuing to obtain samples from juveniles and mature bluefin from the Mediterranean Sea and adjacent waters.

In response to the ICCAT Commission's request for options for alternative approaches for managing mixed populations of Atlantic bluefin tuna, SCRS/2005/108 further examined some implications of incorporating electronic tagging information on transfer rates into virtual population analyses. SCRS/2005/084 examined yield and spawner per recruit consequences of different assumed levels of mixing between eastern and western bluefin stocks to provide guidance to the Commission as requested at the 3rd Meeting of Working Group to Develop Coordinated and Integrated Bluefin Tuna Management Strategies. Researchers at the Imperial College, London, continue work with the University of Miami, the University of New Hampshire and the National Marine Fisheries Service to develop methods to estimate bluefin movement and fishing mortality rate patterns (SCRS/2005/048). Operating models are being developed which will use conventional and electronic tagging data and fishing effort by management area. These models will be used to examine possible harvest control rules and the evaluation of possible management procedures.

U.S. scientists from Stanford and Duke University along with the Monterey Bay Aquarium and NMFS have placed over 700 electronic tags in bluefin tuna in the region along the U.S. coast of North Carolina. The data from implantable archival tags has been critical for establishing the basic biology of Atlantic bluefin and the patterns of movements to feeding and breeding grounds. Results from a large number of these tags were interpreted in a paper in the journal Nature in 2005 (Block *et al.* 2005). Tagging off the Carolinas, in the Gulf of Maine, and elsewhere continued in 2004 and 2005 and more than 90 tags were placed in fish off the Carolinas in 2005. The tags are due to report 7 – 9 months from the deployment dates and will be further reported upon as results become available.

U.S. scientists from the University of New Hampshire have placed over 200 pop-up satellite archival tags on New England bluefin tuna. Ongoing efforts include examining short and long-term dispersals of bluefin in the Gulf of Maine, the identification of spawning grounds, the spatial correlation between bluefin locations and oceanographic features and continuing to determine Atlantic-wide migratory paths. Results from much of this tagging effort were recently published in the journal Marine Biology (Wilson, *et.al.* 2005).

A new research initiative in 2005 involving scientists from the University of New Hampshire, the Virginia Institute of Marine Science, and Virginia SeaGrant will place electronic tags on juvenile bluefin from off the U.S. coast of Virginia. As results become available, they will be reported upon.

A recent publication by Fromentin and Powers (2005), titled “Atlantic bluefin tuna: population dynamics, ecology, fisheries and management” provides an extensive summary of old and new information on the biology and ecology of Atlantic bluefin tuna and associated fishery management implications. The abstract reads as follows:

> “Both old and new information on the biology and ecology of Atlantic bluefin tuna have confronted scientists with research challenges: research needs to be connected to current stock-assessment and management issues. We review recent studies on habitat, migrations and population structure, stressing the importance of electronic tagging results in the modification of our perception of bluefin tuna population dynamics and behavior. Additionally, we question, from both scientific and management perspectives, the usefulness of the classical stock concept and suggest other approaches, such as Clark’s contingent and metapopulation theories. Current biological information confirms that a substantial amount of uncertainty still exists in the understanding of reproduction and growth. In particular, we focus on intriguing issues such as the difference in age-at-maturity between West Atlantic and Mediterranean bluefin tuna. Our description of Atlantic bluefin tuna fisheries places today’s fishing patterns within the two millennium history of exploitation of this species: we discuss trap fisheries that existed between the 17th and the early 20th centuries; Atlantic fisheries during the 1950s and 1960s; and the consequences of the recent development of the sushi–sashimi market. Finally, we evaluate stock status and management issues since the early 1970s. While important

uncertainties remain, when the fisheries history is confronted with evidence from biological and stock-assessment studies, results indicate that Atlantic bluefin tuna has been undergoing heavy overfishing for a decade. We conclude that the current exploitation of bluefin tuna has many biological and economic traits that have led several fish stocks to extreme depletion in the past."

In 1982, ICCAT established a line separating the eastern and western Atlantic management units based on discontinuities in the distribution of catches at that time in the Atlantic and supported by limited biological knowledge. The United States is allocated quota from the western Atlantic management unit where the U.S. fisheries primarily occur. However, the overall distribution of the catch in the 1990s is much more continuous across the North Atlantic than was seen in previous decades. Tagging evidence indicates that movement of bluefin across the current east/west management boundary in the Atlantic does occur, that movements can be extensive (including trans-atlantic) and complex, that there are areas of concentration of electronically tagged fish (released in the west) in the central North Atlantic just east of the management boundary, and that fisheries for bluefin tuna have developed in this area in the last decade. At least some of these fish have moved from west of the current boundary.

Complementary studies, which might show east to west movement, are less advanced. The composition and natal origin of these fish in the central North Atlantic area are not known. The SCRS emphasizes that "it is clear that the current boundary does not depict our present understanding of the biological distribution and biological stock structure of Atlantic bluefin tuna." The SCRS also notes that "the current boundary is a *management* boundary and its effectiveness for management is a different issue."

There has been an accumulation of evidence on bluefin tuna mixing in the last few years through the collection of tagging data and its examination through the modeling of mixing scenarios for evaluating their effect on management. However, the origin of fish older than one year still remains unknown. Mixing results were reviewed in 2001 by the Workshop on Bluefin Tuna Mixing. This research led to a long-term plan for modeling finer scale spatial mixing and to short-term strategies for assessment to assist the advice for management. The data and research were reviewed again in 2002.

ICCAT, at its 2002 Meeting in Bilbao, called for a *Working Group to Develop Integrated and Coordinated Atlantic Bluefin Tuna Management Strategies,* which met in 2003 and again in 2004. In response to the recommendations from these meetings, the SCRS is developing a revised proposal for initiating a coordinated Bluefin Tuna Research Program to address priority research and data needs for providing scientific advice to ICCAT related to revised management procedures for bluefin tuna. Uncertainty exists regarding the importance and impacts of mixing on western stocks. The most important uncertainty regarding management advice by the SCRS for the eastern stock is the uncertainty in the catch data that are being taken.

More than 20 scientific documents related to bluefin tuna biology were presented to the 2005 SCRS. Many of the contributions dealt with the important issue of stock structure and mixing, and new information is available for both stocks. In particular, studies of otolith microchemistry and genetics have resulted in advances in our understanding of this component of the biology of bluefin tuna. These results continue to advance our knowledge about the overlapping distribution of fish originating from the east and the west. Therefore, the SCRS continues to question present hypotheses on stock identification. While these results are promising, more complete sampling and development of appropriate analytical approaches are required. The SCRS also received contributions relating to age and growth, sampling, parasitology and condition of bluefin tuna.

3.2.3 Atlantic BAYS Tuna

All text, figures and tables for this Section are from the SCRS 2004 and 2005 Reports and the U.S. National Report to ICCAT, 2005. All weights are reported as whole weights unless indicated as otherwise.

3.2.3.1 Atlantic Bigeye Tuna

Life History and Species Biology

The geographical distribution of bigeye tuna is very wide and covers almost the entire Atlantic Ocean between 50°N and 45°S. This species is able to dive deeper than other tuna species and exhibits extensive vertical movements. Similar to the results obtained in other oceans, pop-up tagging and sonic tracking studies conducted on adult fish in the Atlantic has revealed that they exhibit clear diurnal patterns being much deeper in the daytime than at night. Spawning takes place in tropical waters when the environment is favorable. From the nursery areas in tropical waters, juvenile fish tend to diffuse into temperate waters as they grow larger. Catch information from the surface gears indicate that the Gulf of Guinea is a major nursery ground for this species.

Dietary habits of bigeye tuna are varied such that prey organisms like fish, mollusks, and crustaceans are found in stomach contents. A growth study based on otolith and tagging data resulted in the adoption by the SCRS of a new growth curve (Report of the SCRS, 2004). The curve shows bigeye tuna exhibit relatively fast growth: about 105 cm in fork length at age three, 140 cm at age five, and 163 cm at age seven. Bigeye tuna become mature at about age three and a half. Young fish form schools mostly mixed with other tunas such as yellowfin and skipjack. These schools are often associated with drifting objects, whale sharks, and sea mounts. This association appears to weaken as bigeye tuna grow larger. An estimate of natural mortality (M) for juvenile fish was provided based on the results of a tagging program. According to this study, mortality for juvenile fish only is at a similar level of M as that currently used for the entire Atlantic stock as well as the level of M used for all other oceans. Various evidence including a genetic study, the time-area distribution of fish, and movements of tagged fish suggest an Atlantic-wide single stock for this species, which is currently accepted by the SCRS. However, the possibility of other scenarios, such as north and south stocks, should not be disregarded.

Stock Status and Outlook

ICCAT's SCRS conducted a new stock assessment for bigeye tuna in July 2004 using various types of models. However, there were considerable sources of uncertainty arising from the lack of information regarding (a) reliable indices of abundance for small bigeye from surface fisheries, (b) the species composition of Ghanaian fisheries that target tropical tunas, and (c) details on the historical catch and fishing activities of Illegal, Unregulated, Unreported (IUU) fleets (*e.g*., size, location and total catch).

Three indices of relative abundance were available to assess the status of the stock (Figure 3.6). All were from longline fisheries conducted by Japan, Chinese Taipei, and United States. While the Japanese indices have the longest duration since 1961 and represent roughly 20 – 40 percent of the total catch, the other two indices are shorter and generally account for a smaller fraction of the catch than the Japanese fishery. These three indices primarily relate to medium and large-size fish.

Various types of production models were applied to the available data and the SCRS notes that the current year's model fits to the data were better than in past assessments, although they required similar assumptions regarding stock productivity. The point estimates of MSY obtained from different production models ranged from 93,000 mt to 113,000 mt. The lower limit of this range is higher than the one estimated in the 2002 assessment, probably due to the revised indices and the addition of a new index. An estimate obtained from another age-aggregated model was 114,000 mt. The inclusion of estimation uncertainty would broaden this range considerably.

These analyses estimate that the total catch was larger than the upper limit of MSY estimates for most years between 1993 and 1999, causing the stock to decline considerably, and leveling off thereafter as total catches decreased. These results also indicate that the current biomass is slightly below or above (85 – 107 percent) the biomass at MSY (Figure 3.7), and that current fishing mortality is also in the range of 73 percent to 101 percent of the level that would allow production of MSY (Table 3.8). However, indications from the most targeted and wide-ranging fishery are of a more pessimistic status than implied by these model results. Several types of age-structured analyses were conducted using the above-mentioned longline indices from the central fishing grounds and catch-at-age data converted from the available catch-at-size data. In general, the trajectories of biomass and fishing mortality rates are in accordance with the production model analyses. Model fits appeared improved over those of past assessments, apparently as a result of using a new growth curve for the calculation of catch at age.

The most noteworthy trend in fisheries observed is the general declining trend in catches for all gears after a high peak (121,000 mt) in 1999. After that, the total annual catch has steadily declined to a current low of 72,000 mt for 2004. The decline of longline catch is mostly attributable to the decrease of Japanese and estimated IUU catches while the other country/entity's catches are generally maintained. Other gears (purse seine and baitboat) also indicated a similar but more variable decline. The decline of the Japanese catch is related to the reduced fishing effort as well as the declined CPUE in the major fishing grounds in tropical waters.

Among the fisheries catching bigeye, two changes are noted. One is an increase in catch from the northern Islands (Azores and Madeira) area due to baitboat fisheries after four years of low catch for 2000 – 2003. Another change is also observed for the fishing area of Japanese longline fishery. Since around 2001, some of the fleet had operated in central north Atlantic between 25°N – 35°N and 40°W – 75°W. In addition to the above changes in fisheries, several countries increased their individual catch levels in 2004, although the overall catch total did not significantly increase. Such increases are reported for Philippines (1,850 mt), Venezuela (1,060 mt) and Korea (630 mt). The current reported catch of Chinese Taipei for 2003 is considered under-estimated. Chinese Taipei will re-estimate the bigeye catch for 2003 in near future. The new estimate is expected to be higher than the current reported catch.

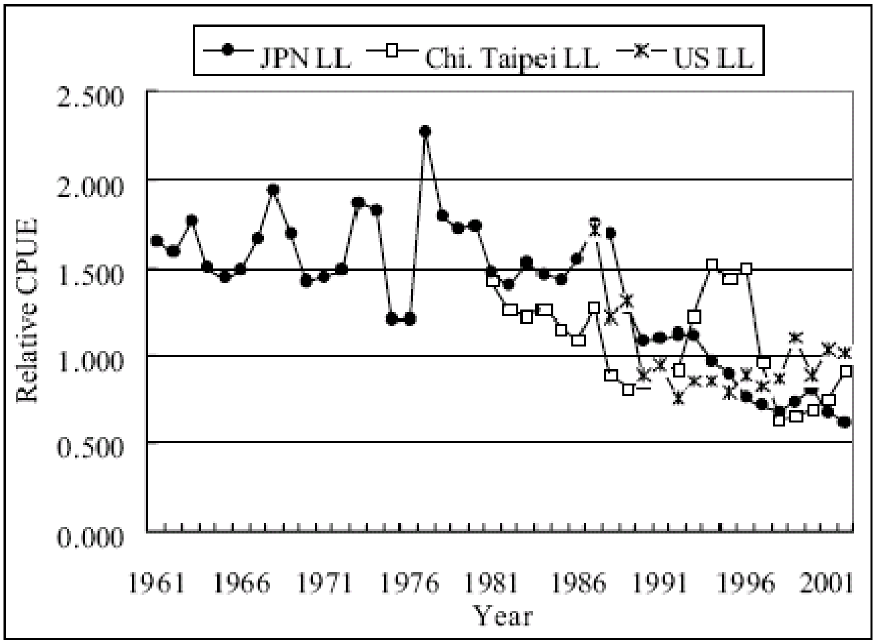

Figure 3.6 Abundance indices in numbers of BET. All ages are aggregated. Source: ICCAT, 2004.

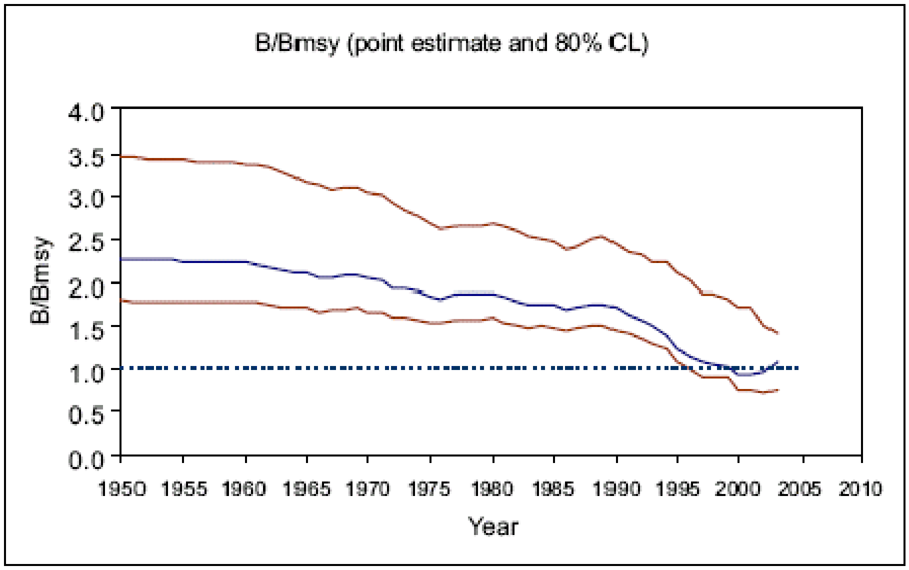

Figure 3.7 **Trajectory of the BET biomass modeled in production model analysis (middle line) bounded by upper and lower lines denoting 80 percent confidence intervals.** Source: ICCAT, 2004.

Table 3.8 **Summary Table for the Status of Atlantic Bigeye Tuna.** Source: ICCAT, 2005.

Age/size at Maturity	Age 3/~100 cm curved fork length
Spawning Sites	Tropical waters
Current Relative Biomass Level *Minimum Stock Size Threshold*	B_{03}/B_{MSY} = 0.85 - 1.07 $0.6B_{MSY}$ (age 2+)
Current Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{02}/F_{MSY} = 0.73-1.01 F_{year}/F_{MSY} = 1.00
Maximum Sustainable Yield	93,000 - 114,000 mt
Current (2004) Yield	72,000 mt
Current (2003) Replacement Yield	89,000 - 103,000 mt
Outlook	Overfished; overfishing is occurring

This assessment indicated that the stock has declined due to the large catches made since the mid-1990s to around or below the level that produces the MSY, and that fishing mortality exceeded F_{MSY} for several years during that time period. Projections indicate that catches of more than 100,000 mt will result in continued stock decline. ICCAT should be aware that if major countries were to take the entire catch limit set under the ICCAT Recommendations and other countries were to maintain recent catch levels, then the total catch could exceed 100,000 mt. The SCRS highly recommended that catch levels of around 90,000 mt or lower be maintained at least for the near future for ICCAT to rebuild the stock.

Effects of Regulations

The bigeye minimum size regulation of 3.2 kg (Recommendation 79-01) was adopted in 1980 to reinforce the same regulation for yellowfin, and was in effect until 2004. The Committee did not evaluate this regulation at this time. However, the recommendation regarding the minimum size regulation was dropped as it was not feasible to sort the undersized bigeye and yellowfin tuna from purse seine and bait-boat catch mixed with regulation sized small skipjack without large quantities of dead discards of small bigeye and yellowfin tuna. Conversely strict enforcement of the regulation would have likely meant the closure of one of the largest tuna fisheries in the Atlantic. While the measure was in effect, it is believed that a large quantity (around 50 percent in total number of fish) of juvenile bigeye tuna smaller than 3.2 kg was caught in 2004 as well, because there are no substantial changes in the fisheries (the equatorial surface fleets) that account for most of the juvenile catch.

ICCAT asked the SCRS to examine the impact on stocks of the current minimum size regulation (bigeye tuna Recommendation 04-01). At the same time, ICCAT also asked the SCRS to recommend the necessary modifications that would improve its effectiveness as well as to review possible modifications to be applied to the closure. Although the new regulation has not been implemented yet, the SCRS met to provide a response to the Commission.

Previous yield-per-recruit and spawner-per-recruit analyses highlighted the potential importance of reducing fishing mortality on small fish. However, the percentage of fish caught less than this minimum size (3.2 kg) is very high (46 – 62 percent of the total fish caught) since 1989. The SCRS, therefore, recommends the full implementation of the moratorium on Fish Aggregation Device (FAD) fishing by all surface fisheries in the Gulf of Guinea. The moratorium on FAD fishing by surface gears in the Gulf of Guinea were observed by all fishing sectors, including Ghanaian surface fleet during 2004/2005 season. However, available purse seine catch and effort data indicated significant fishing on FADs in the moratorium area.

Limiting the annual catch to the average catch in two years of 1991 and 1992 entered into force for the major fishing countries whose 1999 catch reported to the 2000 SCRS was larger than 2,100 mt (Recommendation 01-01). The 2003 and 2004 total reported catch for the major countries and fishing entities to which the catch limit applies (EC-Spain, EC-France, EC-Portugal, Japan, Ghana, China and Chinese Taipei) were 67,000 mt and 59,500 mt, respectively. These were much lower than the total catch limit (84,200 mt) for these counties/entities. As a whole, the total catch in 2003 and 2004 for all countries is about 12,000 mt and 24,000 mt lower than the average total catch of 1991 and 1992 (96,000 mt).

Total reported U.S. bigeye tuna catches and landings (preliminary) for 2004 decreased by 69 mt from 483 mt in 2003 to 414 mt. Note that like yellowfin tuna, the estimates of rod and reel catch are considered provisional and may be revised based on results of a future review of recreational harvest estimates.

The SCRS noted its appreciation for the effort made by ICCAT in establishing the Statistical Document Program for bigeye tuna and expressed hope that the data to be submitted to the Secretariat will be useful to improve estimates of unreported catches. The SCRS also stated its appreciation regarding the initiatives to reduce the IUU activities taken by several fishing authorities. These efforts are helpful in identifying and reducing the unreported catches in the Atlantic and will make the catch limit regulation more effective, and thus will contribute to reduce uncertainties in the bigeye stock assessment. As far as the IUU catches of bigeye tuna are concerned, they are almost disappearing according to the available estimates. Nevertheless, the SCRS expressed concern that unreported catches may have been underestimated.

Recent and Ongoing Research

In addition to monitoring catch and effort statistics for tropical tunas that include bigeye tuna, United States scientists participated in the 2005 ICCAT Workshop on Methods to Reduce Mortality of Juvenile Tropical Tunas, held in Madrid from 4 – 8 July, 2005. Document SCRS/2005/063 used the ICCAT Task 2 catch and effort data to estimate expected changes in the catches of tropical tunas attributable to replacing the current moratorium with a time-area closure (Recommendation 04-01). The results indicate that catches of tropical tunas are expected to increase substantially if the time-area closure replaces the current moratorium. Considering that the current ICCAT hypothesis is that purse-seine fleet efficiency gains three percent per year, the net change could in fact be a large overall increase to levels above the pre-moratoria fishing mortality rate levels. SCRS/2005/079 explored the expectations for catches of undersized bigeye tuna considering the agreement reached in Recommendation 04-01. In all cases examined, total catches can be expected to increase from 5.5 to 6.7 percent as a result of Recommendation 04-01, and catches of bigeye tuna can be expected to increase from 16 to 22.1 percent. In all cases, catch of juvenile bigeye tuna increases.

U.S. scientists from the University of Miami's Rosenstiel School of Marine and Atmospheric Science continue to collaborate with EC scientists on the EU-funded assessment and management modeling project titled Framework for the Evaluation of Management Strategies (FEMS) project, on management strategy evaluations related to tropical tuna fisheries.

3.2.3.2 Atlantic Yellowfin Tuna

Life History and Species Biology

Yellowfin tuna is a cosmopolitan species distributed mainly in the tropical and subtropical oceanic waters of the three oceans, where they form large schools. The sizes exploited range from 30 cm to 170 cm fork length (FL). Smaller fish (juveniles) form mixed schools with skipjack and juvenile bigeye tuna, and are mainly limited to surface waters, while larger fish are found in surface and sub-surface waters. The majority of the long-term recoveries of tagged fish have been tagged in the western Atlantic and recovered in the eastern Atlantic, where several recaptures are recorded each year.

Sexual maturity occurs at about 100 cm FL. Reproductive output among females has been shown to be highly variable, although the extent of this is unknown. The main spawning ground is the equatorial zone of the Gulf of Guinea, with spawning occurring from January to April. Juveniles are generally found in coastal waters off Africa. In addition, spawning occurs in the Gulf of Mexico, in the southeastern Caribbean Sea, and off Cape Verde, although the relative importance of these spawning grounds is unknown.

Although such separate spawning areas might imply separate stocks or substantial heterogeneity in the distribution of yellowfin tuna, a single stock for the entire Atlantic is assumed as a working hypothesis (Atlantic Yellowfin Working Group, Tenerife, 1993). This hypothesis indicates yellowfin are distributed continuously throughout the entire tropical Atlantic Ocean by taking into account tagging data showing transatlantic migration (from west to east), a 40-year time series of longline catch data, and other information such as time-area size frequency distributions and locations of fishing grounds).

Growth patterns are variable with size, being relatively slow initially, and increasing by the time the fish leave the nursery grounds. Males are predominant in the catches of larger sized fish. Natural mortality is assumed to be higher for juveniles than for adults. Tagging studies for Pacific yellowfin supports this assumption.

Stock Status and Outlook

A full assessment was conducted by the SCRS/ICCAT for yellowfin tuna in 2003 applying various age-structured and production models to the available catch data through 2001.

The variability in overall catch-at-age is primarily due to variability in catches of ages zero and one (note that the catches in numbers of age zero and especially age one were particularly high during the period 1998 – 2001). Both equilibrium and non-equilibrium production models were examined in 2003 and the results are summarized in Table 3.9. The estimate of MSY based upon the equilibrium models ranged from 151,300 to 161,300 mt; the estimates of F_{2001}/F_{MSY} ranged from 0.87 to 1.29. The point estimates of MSY, based upon the non-equilibrium models, ranged from 147,200 – 148,300 mt. The point estimates for F_{2001}/F_{MSY} ranged from 1.02 to 1.46. The main differences in the results were related to the assumptions of each model. The SCRS was unable to estimate the level of uncertainty associated with these point estimates. An age-structured virtual population analysis (VPA) was made using eight indices of abundance. The results from this model were more comparable to production model results than in previous assessments, owing in part to a greater consistency between several of the indices used. The VPA results compare well to the trends in fishing mortality and biomass estimated from production models. The VPA estimates that the spawning biomass (Table 3.7) and the levels of fishing mortality (Table 3.8) in recent years have been very close to MSY levels. The estimate of MSY derived from these analyses was 148,200 mt.

In summary, the age-structured and production model analyses implied that although the 2001 catches of 159,000 mt were slightly higher than MSY levels, effective effort may have been either slightly below or above (up to 46 percent) the MSY level, depending on the assumptions. Consistent with these model results, yield-per-recruit analyses also indicated that 2001 fishing mortality rates could have been either above or about the level which could produce MSY. Yield-per-recruit analyses further indicated that an increase in effort is likely to decrease the yield-per-recruit, while reductions in fishing mortality on fish less than 3.2 kg could result in substantial gains in yield-per-recruit and modest gains in spawning biomass-per-recruit.

Table 3.9 Summary Table for the Status of Atlantic Yellowfin Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 3/~110 cm curved fork length
Spawning Sites	Tropical waters
Relative Biomass Level *Minimum Stock Size Threshold*	B_{01}/B_{MSY} = 0.73 - 1.10 $0.5B_{MSY}$ (age 2+)
Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{01}/F_{MSY} = 0.87 - 1.46 F_{year}/F_{MSY} = 1.00
Maximum Sustainable Yield	~ 148,000 mt
Current (2004) Yield	116,000 mt
Replacement Yield (2001)	May be somewhat below the 2001 yield (159,000 mt)
Outlook	Approaching an overfished condition

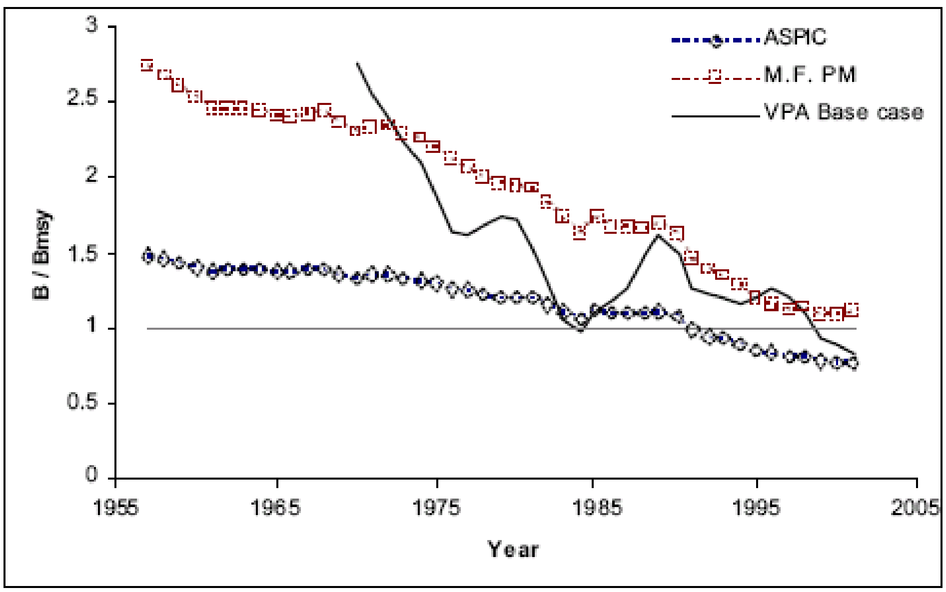

Figure 3.8 Comparison of relative biomass trends calculated using VPA and non-equilibrium production models. Source: ICCAT, 2004.

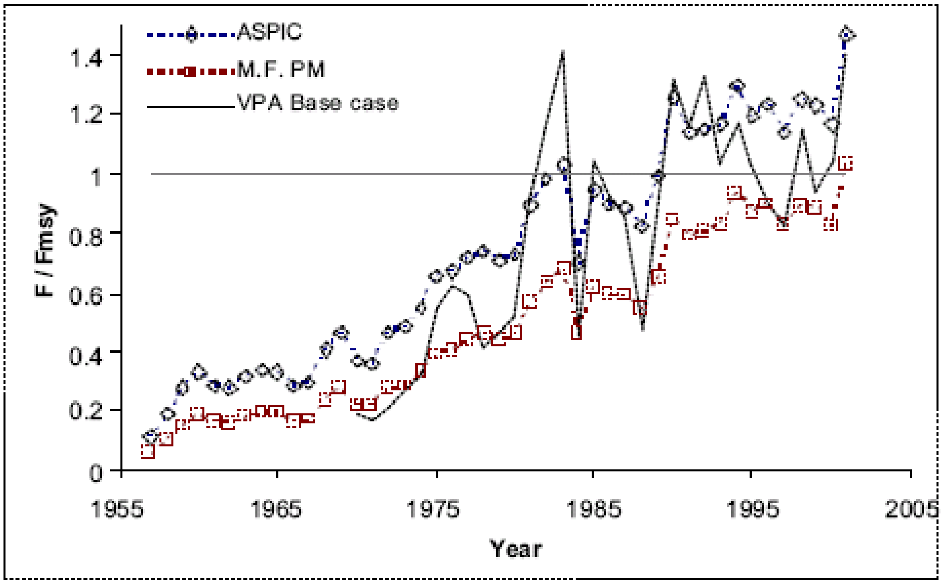

Figure 3.9 Comparison of relative fishing mortality trends calculated using VPA and non-equilibrium production models. Source: ICCAT, 2004.

In contrast to the increasing catches of yellowfin tuna in other oceans worldwide, there has been a steady decline in overall Atlantic catches since 2001. Atlantic surface fishery catches have shown a declining trend from 2001 to 2004, whereas longline catches have increased. In the eastern Atlantic, purse seine catches declined from 89,569 mt in 2001 to 58,632 mt in 2004, a 35 percent reduction. Baitboat catches declined by 23 percent, from 19,886 mt to 15,277 mt. This decrease is almost entirely due to reduced catches by Ghana baitboats, which resulted from a combination of reduced days fishing, a lower number of operational vessels, and the observance of the moratorium on fishing using floating objects. Catches by other baitboat fleets were generally increasing. In the western Atlantic, with the majority of the landings reported by the United States, Mexico, Venezuela, Brazil and St. Vincent and Grenadines, purse seine catches declined from 13,072 mt to 3,217 mt, a 75 percent reduction. In addition, baitboat catches also declined by eight percent from 7,027 mt to 6,735 mt. However, for the same time period, longline catches were increasing. In the eastern Atlantic, longline catches increased from 5,311 mt to 10,851 mt, a 104 percent increase. In the western Atlantic, longline catches increased from 12,740 mt to 15,008 mt, an 18 percent increase.

At the same time, the nominal effort in the purse seine fishery was declining. As an indicator, the number of purse seiners from the European and associated fleet operating in the Atlantic declined from 46 vessels in 2001 to 34 vessels in 2004. On the other hand, the European and associated baitboat fleet increased from 16 to 22 vessels during the same period. Of the relevant scientific documents presented to the 2005 SCRS, most were descriptive of the catches by country fleets. Three papers discussed observer programs in Ghana, Uruguay, and Spain, and three papers analyzed catches in the context of the moratorium. No new standardized catch rate information has been presented since the last assessment. However, examination of nominal catch rate trends from purse seine data suggest that catch-per-unit effort was stable or possibly declining since 2001 in the East Atlantic, and was clearly declining in the West Atlantic.

Since effort efficiency was estimated to have continued to increase, adjustments for such efficiency change would be expected to result in a steeper decline. Also, the average weights in European purse seine catches have been declining since 1994, which is at least in part due to changes in selectivity associated with fishing on floating objects.

Recent signals in the fishery data could result in a substantially different evaluation of stock status than that which is summarized above. It is important that the next assessment take these and other indicators (such as age of vessels and any loss of regional yellowfin fisheries) into account.

Effects of Regulations

Estimated catches of yellowfin tuna have averaged 141,000 mt over the past three years. This average falls near the lower estimate of the range of MSY from the age-structured and production model analyses conducted during the 2003 assessment. The SCRS considers that the yield of 159,000 mt in 2001 is likely somewhat above the replacement yield and those levels of fishing effort and fishing mortality may have been near MSY. Total catches since 2001 have been declining, but without a new assessment the SCRS in 2005 reaffirms its support for ICCAT's 1993 recommendation "that there be no increase in the level of effective fishing effort exerted on Atlantic yellowfin tuna, over the level observed in 1992." (During the 2003 assessment, the SCRS' estimates of effective fishing effort for recent years fell near the estimate for 1992).

In 1973, ICCAT adopted a regulation that imposed a minimum size of 3.2 kg for yellowfin tuna, with a 15 percent tolerance in the number of undersized fish per landing. This regulation has not been adhered to internationally, as the proportion of landings of yellowfin tuna less than 3.2 kg has been far in excess of 15 percent per year for the purse seine and baitboat fisheries. Based on the catch species composition and catch-at-size data available during the 2003 assessment, yearly catches in number ranged between 54 percent and 72 percent undersized yellowfin tuna by purse seiners and from 63 percent to 82 percent undersized fish for baitboats over the period 1997 – 2001. Landings of undersized fish occur primarily in the equatorial fisheries. Unfortunately, it is difficult to realize substantial reductions in catches of undersized fish in these fisheries because small yellowfin tuna are mostly associated with skipjack tuna, especially when fishing occurs on floating objects; thus it is difficult to avoid catching small yellowfin when catching skipjack, the latter being an important component of eastern Atlantic (equatorial) purse seine fleet catches.

Unfortunately, the use of minimum size limits as a means of reducing the mortality of juvenile tuna remains extremely problematic in this fishery for several reasons which are described in detail in "Report of the 2005 ICCAT Workshop on Methods to Reduce Mortality of Juvenile Tropical Tunas (Madrid, July 4 – 8, 2005)." In accordance with the Committee's current recommendation, any minimum size limit (or lack thereof) should be consistent for all species in a multi-species fishery. It follows that, since the minimum size limit for bigeye tuna has been eliminated, the minimum size limit for yellowfin tuna should likewise be eliminated. Notwithstanding this, the protection of juvenile tunas may be important and alternative approaches to accomplish this should be studied.

In 1993, ICCAT recommended "that there be no increase in the level of effective fishing effort exerted on Atlantic yellowfin tuna, over the level observed in 1992." As measured by fishing mortality estimates from the 2003 assessment, effective effort in 2001 appeared to be approaching or exceeding the 1992 levels. Since the relatively high catch levels of 2001 (159,000 t), catches have declined each year to a current level of 116,000 mt, a reduction of 27 percent. (Estimates of total yellowfin landings in 2002 and 2003, which were not available at the time of the assessment, are 139,000 mt and 124,000 mt, respectively). A potential explanation for this decline is the reduction in purse seine effort, but until a full assessment is conducted it is not possible to confirm this, since declines in nominal catch rates could suggest decreases in abundance or availability. Although the catches have been declining since 2001, as has the nominal effort of the purse seiners, the trend in effective effort is not clear.

Yellowfin tuna is listed as approaching an overfished condition by the United States. Several management measures have been implemented in the United States, consistent with ICCAT advice to limit fishing effort and to prevent overfishing. In 1999, NMFS implemented limited access in the pelagic longline fishery for Atlantic tunas, as well as a recreational retention limit for yellowfin tuna. The United States has also maintained its minimum size limit for YFT of 27" which was greater than that recommended by ICCAT before the organization repealed the recommendation.

Yellowfin tuna is the principal species of tropical tuna landed by U.S. fisheries in the western North Atlantic. Total estimated landings decreased to 6,500 mt in 2004, from the 2003 landings estimate of 7,702 mt. The 2004 estimate is considered provisional and may change owing to incorporation of late reports of commercial catches as they become available and to possible revisions in estimates of rod and reel catches made by recreational anglers. A high proportion of the estimated landings were due to rod and reel catches of recreational anglers in the NW Atlantic (3,434 mt). Estimates of U.S. recreational harvests for tuna and tuna-like species continue to be reviewed and this may result in the need to report additional revisions to the available estimates in the future.

Recent and Ongoing Research

In addition to the United States research findings for tropical tunas discussed above under bigeye tuna, one document was presented to the SCRS in 2005 that gave an overview of fishery trends and stock status for yellowfin tuna worldwide. It was noted that the natural mortality vector used by ICCAT in the Atlantic, while the same as that used by the IOTC for the Indian Ocean, is lower than is used by other scientific bodies for other oceans, particularly for the youngest ages. It was further noted that more recent information and methodologies may be available to potentially improve the estimates of natural mortality. Another document considered the estimation of natural mortality from multi-species tagging data. Due to limitations in the data (such as unbalanced design and different size distributions of released fish) and potential fishing differences between fleets, conclusions were limited to ratios of total mortality between fishing periods rather than any direct statement about natural mortality. Considering the importance of natural mortality estimates in the assessment of the stock, the improvement of natural mortality estimates remains a high research priority. It was noted that future stock assessments should include an evaluation of the sensitivity of results to the uncertainty in natural mortality estimates. Differences were also noted for other biological parameters used by the various scientific bodies, such as growth and maturity vectors, the extent to which these differences reflect estimation methodology, data quality, or real differences between stocks warrants investigation.

3.2.3.3 Atlantic Albacore Tuna

Life History and Species Biology

Albacore is a temperate tuna widely distributed throughout the Atlantic Ocean and Mediterranean Sea. For assessment purposes, the existence of three stocks is assumed based on available biological information: northern and southern Atlantic stocks (separated at 5ºN), and a Mediterranean stock. Albacore spawning areas in the Atlantic are found in subtropical western areas of both hemispheres and throughout the Mediterranean Sea. Spawning takes place during austral and boreal spring-summer. Sexual maturity is considered to occur at about 90 cm FL (age five) in the Atlantic, and at smaller size (62 cm, age two) in the Mediterranean. Until this age, they are mainly found in surface waters, where they are targeted by surface gears. Some adult albacore are also caught using surface gears but, as a result of their deeper distribution, they are mainly caught using longlines. Young albacore tuna are also caught by longlines in temperate waters.

Stock Status and Outlook

The last assessment of the northern stock by ICCAT/SCRS was conducted in 2000, using data from 1975 to 1999, and that of the southern stock in 2003; no assessment of the Mediterranean stock has ever been carried out. To coordinate the timing of the assessments of northern and southern albacore tuna, the stock assessment for northern albacore was postponed at the 2004 ICCAT meeting from 2006 to 2007 (note the management measures for northern albacore expire at the end of 2006). The SCRS noted the considerable uncertainty that continues to remain in the catch-at-size data for the northern and southern stocks, and the profound impact this has had on attempts to complete a satisfactory assessment of northern albacore tuna.

<u>North Atlantic</u>

In 2003, the SCRS concluded that it was inappropriate to proceed with a VPA assessment based on the catch-at-age until the catch-at-size to catch-at-age transformation is reviewed and validated. In 2005, a document was presented on the analyses of catch-at-size and identifying the source of bias in the catch-at-age of the North Atlantic albacore stock. The SCRS recommends holding a data preparatory working group meeting to allow for a thorough revision of the North Atlantic stock prior to the next assessment in 2007. Consequently, the current state of the northern albacore stock is based primarily on the last assessment conducted in 2000 together with observations of CPUE and catch data provided to the SCRS in 2003. The results, obtained in 2000, showed consistency with those from previous assessments (Table 3.10).

The SCRS noted that CPUE trends have varied since the last assessment in 2000, and in particular differed between those representatives of the surface fleets (Spain Troll age two and Spain Troll age three) and those of the longline fleets of Japan, Chinese Taipei, and the United States. The Spanish age two troll series, while displaying an upward trend since the last assessment, nonetheless declined over the last ten years. For the Spanish age three troll series, the trend in the years since the last assessment is down; however, the trend for the remainder of the last decade is generally unchanged. For the longline fleets, the trend in CPUE indices is either upwards (Chinese Taipei and United States) or unchanged (Japan) in the period since the last assessment. However, variability associated with all of these catch rate estimates prevented definitive conclusions about recent trends of albacore catch rates.

Equilibrium yield analyses, carried out in 2000 and made on the basis of an estimated relationship between stock size and recruitment, indicate that spawning stock biomass was about 30 percent below that associated with MSY. However, the SCRS noted considerable uncertainties in these estimates of current biomass relative to the biomass associated with MSY (B_{MSY}), owing to the difficulty of estimating how recruitment might decline below historical levels of stock biomass. Thus, the SCRS concluded that the northern stock is probably below B_{MSY}, but the possibility that it is above it should not be dismissed (Figure 3.10). However, equilibrium yield-per-recruit analyses made by the SCRS in 2000 indicate that the northern stock is not being growth overfished ($F < Fmax$).

In terms of yield per recruit, the assessment carried out in 2000 indicates that the fishing intensity is at, or below, the fully exploited level. Concerning MSY-related quantities, the SCRS recalls that they are highly dependent on the specific choice of stock-recruitment relationship. The SCRS believed that using a particular form of stock-recruitment relationship that allows recruitment to increase with spawning stock size provided a reasonable view of reality. This hypothesis together with the results of the assessment conducted in 2000 indicate that the spawning stock biomass (B_{1999}) for the northern stock (29,000 mt) was about 30 percent below the biomass associated with MSY (42,300 mt) and that current F (2000) was about 10 percent above F_{MSY}. However, an alternative model allowing for more stable recruitment values in the range of observed SSB values would provide a lower estimate of SSB at MSY, below the current value.

South Atlantic

In 2003, an age-structured production model, using the same specifications as in 2000, was used to provide a base case assessment for southern Atlantic albacore. Results were similar to those obtained in 2000, but the confidence intervals were substantially narrower in 2003 than in 2000 (Table 3.11). In part, this may be a consequence of additional data now available, but the underlying causes need to be investigated further. The estimated MSY and replacement yield from the 2003 base case (30,915 mt and 29,256 mt, respectively) were similar to those estimated in 2000 (30,274 mt and 29,165 mt). In both 2000 and 2003, the fishing mortality rate was estimated to be about 60 percent of F_{MSY}. Spawning stock biomass has declined substantially relative to the late 1980s, but the decline appears to have leveled off in recent years and the estimate for 2002 remains well above the spawning stock biomass corresponding to MSY.

Catches of albacore in the South Atlantic in 2001 and 2002 were above replacement yield, and were below estimates of MSY in 2003. Nevertheless, both the 2000 and 2003 albacore assessments estimated that the stock is above B_{MSY}. There is now greater confidence in these estimates of MSY and therefore there is justification to base a TAC recommendation on MSY instead of replacement yield estimates from the model as in 2000. This results from the SCRS' view that current stock status is somewhat above B_{MSY} and catch of this level, on average, would be expected to reduce the stock further towards B_{MSY}. Recent estimates of high recruitment could allow for some temporary increase in adult stock abundance under a 31,000 mt catch, but this result is uncertain.

Mediterranean

Given the lack of an assessment, the implications of the rapid increase in landings are unknown.

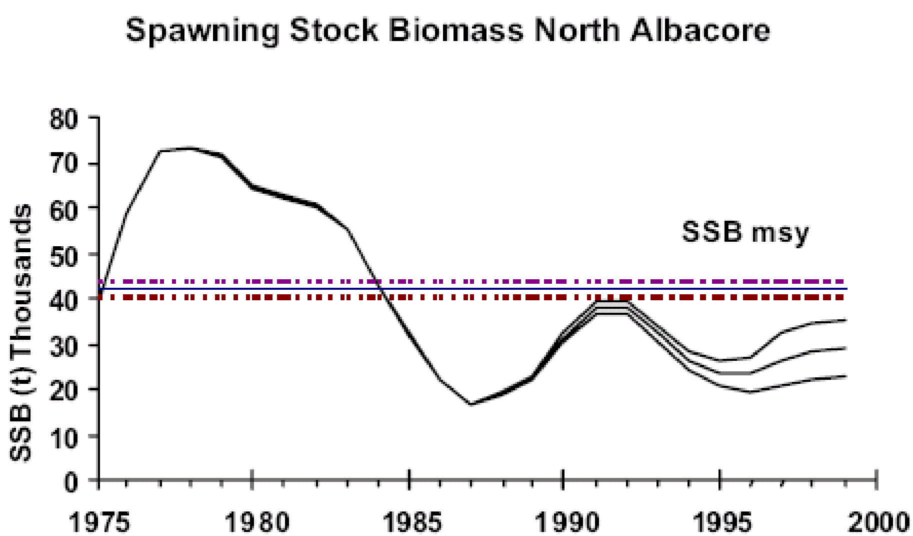

Figure 3.10 North Atlantic albacore spawning stock biomass and recruits with 80 percent confidence limits. Source: ICCAT, 2004.

Table 3.10 Summary Table for the Status of North Atlantic Albacore Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 5/~90 cm curved fork length
Spawning Sites	Subtropical western waters of the northern Hemisphere
Current Relative Biomass Level *Minimum Stock Size Threshold*	B_{99}/B_{MSY} = 0.68 (0.52 - 0.86) *0.7B_{MSY}*
Current Relative Fishing Mortality Rate *Maximum Fishing Mortality Threshold*	F_{99}/F_{MSY} = 1.10 (0.99 - 1.30) F_{year}/F_{MSY} = 1.00
Maximum Sustainable Yield	32,600 mt [32,400 - 33,100 mt]
Current (2004) Yield	25,460 mt
Current (2004) Replacement Yield	not estimated
Outlook	Overfished; overfishing is occurring

Table 3.11 Summary Table for the Status of South Atlantic Albacore Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 5/~90 cm curved fork length
Spawning Sites	Subtropical western waters of the southern Hemisphere
Current Relative Biomass Level	B_{02}/B_{MSY} = 1.66 (0.74 - 1.81)
Current Relative Fishing Mortality Rate	F_{02}/F_{MSY} = 0.62 (0.46 - 1.48)
Maximum Sustainable Yield	30,915 mt (26,333 - 30,915)
Current (2004) Yield	22,468 mt
Current (2004) Replacement Yield	29,256 mt (24,530 - 32,277)
Outlook	Not overfished; overfishing is not occurring

Effects of Regulations

North Atlantic

In 2000, the SCRS recommended that in order to maintain a stable Spawning Stock Biomass in the near future the catch should not exceed 34,500 mt (the 1999 catch level) in the period 2001 – 2002. The SCRS further noted that should ICCAT wish the spawning stock biomass to begin increasing towards the level estimated to support MSY, and then catches in 2001 and 2002 should not exceed 31,000 mt. In 2004, the SCRS reiterated its previous advice and extended it until the next assessment in 2007. There is no ICCAT rebuilding plan for this species.

Since 2001, ICCAT established a TAC of 34,500 mt for this stock. In 2003, ICCAT extended this TAC through 2006. The SCRS noted that reported catches for 2001, 2002, 2003, and 2004 have been below the TAC. A 1998 recommendation that limits fishing capacity to the average of 1993 – 1995 also remains in force. The SCRS is unable to assess whether or not these recommendations have had a direct effect on the stock.

U.S. harvest of albacore tuna, based on 1997 through 2004 data, is landed primarily by rod and reel and pelagic longline fisheries in the Northwest Atlantic. Approximately 98 percent of total U.S. landings are harvested in the Northwest Atlantic. U.S. landings from the Caribbean increased in 1995 to make up over 14 percent of the total U.S. harvest of Albacore, but have since remained below four percent of the total.

Historically, albacore has not been a main focus of the U.S. commercial tuna fisheries operating in the North Atlantic. The commercial pelagic longline fishery harvests northern albacore tuna as incidental catch in the swordfish and other tuna pelagic fisheries. Reported commercial catches were relatively low prior to 1986; however, these catches increased substantially and have remained at higher levels throughout the 1990s. Commercial longline landings from the Northwest Atlantic over the past five years have ranged from a high of 172 mt in 2001 to a low of approximately 96 mt in 2003. In contrast, recreational estimates show a growing targeted albacore fishery off the United States Atlantic coast with landings increasing from approximately 122 mt in 2001 to over 500 mt in 2004. Calendar year landings vary between years by up to 30 percent for the longline fleet and by as high as a factor of four for the rod and reel fishery.

Since the ICCAT recommendation of a 607 mt TAC was implemented, total U.S. landings have been 453 mt (74 percent), 488 mt (80 percent), and 446 mt (73 percent) in 2001, 2002, and 2003 respectively. Calendar year landings for 2004 were 646 mt. These landings have been well below the annual TAC of 607 mt until 2004. The United States has annually taken less than two percent of the recorded total annual international landings (Table 3.6). In 2004, U.S. calendar year landings remained below the adjusted annual quotas. ICCAT recommendation provides for an adjusted TAC by adding the remaining balance from the previous year as carryover. The U.S. caught only 84 percent of the adjusted quota in 2004 and has a domestic adjusted quota in 2005 of 729 metric tons.

South Atlantic

Recent catches of albacore tuna in the South Atlantic are in the vicinity of the current and recent estimates of MSY (30,915 mt). Both the 2000 and the 2003 albacore assessments estimated that the stock is above B_{MSY} (2003 estimates $B_{current}/B_{MSY} = 1.66$, $F_{current}/F_{MSY} = 0.62$). The SCRS recommends that in order to maintain SSB in the near future the catch should not exceed 31,000 mt until the next assessment in 2007.

Since 1999, ICCAT established the TAC for this stock (in 2001 – 2003, the TAC had been set at 29,200 mt). In 2003, ICCAT extended this TAC through 2004. The SCRS noted that reported catches have not exceeded the TAC in 2004. Also, the total catch by Chinese Taipei, South Africa, Brazil, and Namibia (26,620 mt) did not exceed the 27,500 mt catch limit of parties actively fishing for southern albacore, as stipulated by resolution 02-06. It should be noted that sufficient capacity exists within the fisheries to exceed the TAC as was done in 2000, 2001, and 2002. U.S. landings of South Atlantic Albacore over the past five years have been minimal (two or less mt / year). Japan adhered to its bycatch limit of four percent of the total catch of bigeye tuna in the Atlantic Ocean. However, the SCRS is unable to assess whether or not these catch limits have had a direct effect on the stock.

Mediterranean

There are no ICCAT management recommendations for the Mediterranean stock. However, the SCRS recommended to ICCAT that reliable data be provided on catch, effort and size for Mediterranean albacore tuna. The SCRS also recommended that an effort be made to recover historical data. Improvements to these basic inputs are essential before a stock assessment of Mediterranean albacore tuna can be attempted.

Recent and Ongoing Research

U.S. scientists prepared document SCRS/2005/081 which described population models for North Pacific albacore (*Thunnus alalunga*) that have been developed and reviewed within the North Pacific Albacore Workshop (NPALBW) forum since 2000. Currently, the NPALBW relies on a Virtual Population Analysis (VPA) model for the purposes of formulating an international-based consensus regarding the "status" of this fish stock. Recently, an equally important research directive from the NPALBW has been to develop alternative, more detailed statistical-based models, in efforts to evaluate more fully the relationship between this species' population dynamics and associated fishery operations (*i.e.*, areas of uncertainty in an overall stock assessment). Participants on the NPALBW developed one candidate model based on the Age-structured Assessment Program (ASAP), which generally represents a maximum likelihood-based numerical approach for conducting relatively straightforward, forward-simulation catch-at-age analyses. In addition, the document presents a brief discussion concerning development of other alternative stock assessment models, particularly length-based/age-structured platforms (*e.g.*, MULTIFAN-CL and Stock Synthesis 2).

3.2.3.4 Atlantic Skipjack Tuna

Life History and Species Biology

Skipjack tuna is a gregarious species forming schools in the tropical and subtropical waters of the three oceans. Skipjack spawn opportunistically throughout the year in vast areas of the Atlantic Ocean. The size at first maturity is about 45 cm for males and about 42 cm for females in the East Atlantic, while in the West Atlantic sexual maturity is reached at around 51 cm for females and 52 cm for males. Skipjack growth is seasonal, with substantial differences according to the latitude. There remains considerable uncertainty about the variability of the growth parameters between areas. It is, therefore, a priority to gain more knowledge on the growth schemes of this species.

Skipjack is a species that is often associated with floating objects, both natural objects or fish aggregating devices (FADs) that have been used extensively since the early 1990s by purse seiners and baitboats (during the 1991 to 2003 period, about 55 percent of skipjack were caught with FADs). The concept of viscosity (low interchange between areas) could be appropriate for the skipjack stocks. A stock qualified as "viscous" can have the following characteristics:

- It may be possible to observe a decline in abundance for a local segment of the stock;
- Overfishing of that component may have little, if any, repercussion on the abundance of the stock in other areas; and,
- Only a minor proportion of fish may make large-scale migrations.

The increasing use of FADs could have changed the behavior of the schools and the migrations of this species. It is noted that, in effect, the free schools of mixed species were much more common prior to the introduction of FADs than now. These possible behavioral changes ("ecological trap" concept) may lead to changes in the biological parameters of this species as a result of the changes in the availability of food, predation, and fishing mortality. Skipjack caught with FADs are usually found associated with other species. The typical catch with floating objects is comprised of about 63 percent skipjack, 20 percent small yellowfin, and 17 percent juvenile bigeye and other small tunas. A comparison of size distributions of skipjack between periods prior to and after the introduction of FADs show that, in the eastern Atlantic, there has been an increase in the proportion of small fish in the catches, as well as a decline in the total catch in recent years in some areas.

The SCRS reviewed the current stock structure hypothesis that consists of two separate management units, one in the east Atlantic and another in the West Atlantic, separated at 30°W. The boundary of 30°W was established when the fisheries were coastal, whereas in recent years the East Atlantic fisheries have extended towards the west, surpassing this longitude, and showing the presence of juvenile skipjack tuna along the Equator, west of 30°W, following the drift of the FADs. This implies the potential existence of a certain degree of mixing. Nevertheless, taking into account the large distances between the east and west areas of the ocean, various environmental constraints, the existence of a spawning area in the east Atlantic as well as in the northern zone of the Brazilian fishery, and the lack of additional evidence (*e.g.*, transatlantic migrations in the tagging data), the hypothesis of separate east and west Atlantic stock is maintained as the most plausible alternative. On the other hand, in taking into account the biological characteristics of the species and the different fishing areas, smaller management units could be considered.

Stock Status and Outlook

The last ICCAT/SCRS assessment on Atlantic skipjack tuna was carried out in 1999 (Table 3.12). The state of the Atlantic skipjack stock(s), as well as the stocks of this species in other oceans, show a series of characteristics that make it extremely difficult to conduct an assessment using current models. Among these characteristics, the most noteworthy are:

- The continuous recruitment throughout the year, but heterogeneous in time and area, making it impossible to identify and monitor the individual cohorts;
- Apparent variable growth between areas, which makes it difficult to interpret the size distributions and their conversion to ages; and,
- Exploitation by many and diverse fishing fleets (baitboat and purse seine), having distinct and changing catchabilities, which makes it difficult to estimate the effective effort exerted on the stock in the East Atlantic.

For these reasons, no standardized assessments have been able to be carried out on the Atlantic skipjack stocks. Notwithstanding, some estimates were made by means of different indices of the fishery and some exploratory runs were conducted using a new development of the generalized production model.

<u>Western stock</u>

Standardized abundance indices up to 1998 were available from the Brazilian baitboat fishery and the Venezuelan purse seine fishery, and in both cases the indices seem to show a stable stock status. Uncertainties in the underlying assumptions for the analyses prevent the extracting of definitive conclusions regarding the state of the stock. However, the results suggest that there may be over-exploitation within the FAD fisheries, although it was not clear to what extent this applies to the entire stock. The SCRS could not determine if the effect of the FADs on the resource is only at the local level or if it had a broader impact, affecting the biology and behavior of the species. Under this supposition, maintaining high concentrations of FADs would reduce the productivity of the overall stock. However, since 1997, and due to the implementation of a voluntary Protection Plan for Atlantic tunas, agreed upon by the Spanish and French boat owners in the usual areas of fishing with objects, which later resulted in an ICCAT regulation on the surface fleets that practice this type of fishing, there has been a reduction in the skipjack tuna catches associated with FADs. Maintaining this closure would continue to have a positive effect on the resource. The development of nominal abundance indices of Brazilian baitboat fisheries and Venezuelan purse seiners, obtained up to 2004, seemed to show a stable stock status.

Eastern stock

Standardized catch rates are not available. However, an analysis was made, for the 1969 – 2002 period, of the different indices of the purse seine fishery that could provide valuable information on the state of the stock. For the majority of the indices, the trends were divergent, depending on the area, which may indicate the viscosity of the skipjack stock, with limited mixing rates between areas. Because of the difficulties in assigning ages to the skipjack catches, the estimates of the values of natural mortality by age and obtaining indices of abundance (especially for the eastern stock), no catch-by-age matrices were developed and, consequently, no analytical assessment methods were applied.

There is no quantified information available on the effective fishing effort exerted on skipjack tuna in the East Atlantic. It is supposed, however, that the increase in fishing power linked to the introduction to improved technologies on board the vessels as well as to the development of fishing under floating objects have resulted in an increase in the efficiency of the various fleets. An estimate of the increase in the coefficient of total mortality (Z) between the early 1980s and the end of the 1990s was carried out with a model using tagging data (Workshop on the mortality of juveniles in July 2005). For the range of sizes considered (about 40 – 60 cm FL), the increase in Z on the order of a factor 3 would reflect this increase in efficiency. This interpretation is supported by a comparison of skipjack size distributions in the East Atlantic between the periods prior to, and following, the use of FADs as an increase is observed in the proportion of small fish in the catches.

A document on the Spanish observer program on board purse seiners, presented during the 2005 SCRS, shows that for the 2001-2005 period the average rate of discards of skipjack tunas under FADs in the East Atlantic is estimated at 42 kg per ton of skipjack landed. In the West Atlantic, fishing effort of the Brazilian baitboats (which comprises the major skipjack fishery) decreased by half between 1985 and 1996, but seems to be stabilized since, after a slight increase.

Table 3.12 Summary Table for the Status of West Atlantic Skipjack Tuna. Source: ICCAT, 2005.

Age/size at Maturity	Age 1 to 2/~50 cm curved fork length
Spawning Sites	Opportunistically in tropical and subtropical waters
Current Relative Biomass Level *Minimum Stock Size Threshold*	*Unknown* *Unknown*
Current Relative Fishing Mortality Rate F_{2003}/F_{MSY} *Maximum Fishing Mortality Threshold*	*Unknown* $F_{year}/F_{MSY} = 1.00$
Maximum Sustainable Yield	*Not Estimated*
Current (2004) Yield	26,910 mt
Current Replacement Yield	*Not Estimated*
Outlook	*Unknown*

Effects of Regulations

There is currently no specific ICCAT regulation in effect for skipjack tuna. However, the French and Spanish boat owners voluntarily applied a moratorium on fishing under FADs for the period of November 1997 through January 1998, and November 1998 through January 1999. The moratorium, which was implemented in order to protect juvenile bigeye tuna, has had an influence on the skipjack catches made with FADs. Since 1999, a similar moratorium was applied, recommended by ICCAT, and is still in force. The average purse seine skipjack catches during the months from November to January by the fleets that applied the moratoria were reduced by 64 percent compared to the average catches between the 1993 – 1996 period (before the moratoria) and those corresponding to the 1998 – 2002 period. For the entire period in which the moratoria have been in effect (1998 – 2002), the average annual skipjack catches by the purse seine fleets that applied the moratoria decreased by 41 percent, which is equivalent to 42,000 mt per year. However, this decrease is likely a combined result of the decrease in effort and the moratorium impact; this is supported by the observation that the mean annual catch by boats has decreased only 18 percent between the two periods.

Total catches in 2004 in the Atlantic Ocean amounted to almost 161,000 mt which represents an increase of approximately 12.9 percent compared to the average of the last five years. Since the early 1990s, numerous changes in the fishery (such as the use the FADs and the expansion of the fishing area to the west) have increased skipjack catchability as well as the proportion of the skipjack stock which is exploited. At present, the major fisheries are the purse seine fisheries, particularly those of EC-Spain, EC-France, NEI, Ghana and Netherlands Antilles, followed by the baitboat fisheries of Ghana, EC-Spain and EC-France. The catches made in 2004 in the East Atlantic reached 134,000 mt, representing a 15.8 percent increase as compared to the average of 1999 – 2003. In the West Atlantic, the major fishery is the Brazilian baitboat fishery, followed by the Venezuelan purse seine fleet. The 2004 caches in the West Atlantic amounted to 26,900 mt, which is a level close to the average of the historical period in recent years.

Skipjack tuna are caught by U.S. vessels in the western North Atlantic. Total reported skipjack landings (preliminary) increased from 78 mt in 2003 to 102 mt in 2004. Almost 70 percent of U.S. landings are from recreational rod and reel catches and landings from the NW Atlantic and Caribbean areas, based on LPS statistical surveys of the U.S. recreational harvesting sector. Estimates of recreational harvests of skipjack continue to be reviewed and could be revised again in the future.

Recent and Ongoing Research

U.S. small tuna research is directed mainly on king and Spanish mackerel stocks, as the amount landed of other small tunas such by U.S. fishermen is generally low. The focus of research on skipjack research by the international scientific community is on basic stock structure and abundance and the influence of FADs on increase in efficiency of the various fleets. During the ICCAT Workshop on Methods to Reduce Mortality of Juvenile Tropical Tunas in July 2005 (Document SCI-032), a re-analysis on the tagging data in the Senegalese area showed however that the parameters of the skipjack growth curve obtained in this region were in fact closer to the growth estimates made in the Gulf of Guinea or in other oceans than those done previously in Senegal. In 2004 and 2005, U.S. scientists collaborated with Caribbean nations under the banner of the Caribbean Regional Fisheries Mechanism in initiating stock assessment analyses for small tuna (and other) stocks of mutual concern.

3.2.4 Atlantic Billfish

3.2.4.1 Blue Marlin

Life History/Species Biology

Blue marlin (*Makaira nigricans*) range from Canada to Argentina in the western Atlantic, and from the Azores to South Africa in the eastern Atlantic. Blue marlin are large apex predators with an average weight of 100 – 175 kg (220 – 385 lb). Female blue marlin grow faster and reach a larger maximum size than males. Young blue marlin are one of the fastest growing teleosts, reaching 30 – 45 kg (66 – 99 lb) after the first year. The maximum growth rate of these fish is 1.66 cm/day (0.65 inches/day) which occurs at 39 cm LJFL (15.3 inches) (NMFS, 1999). Life expectancy for blue marlin is between 20 – 30 years based on age and growth analyses of dorsal spines.

Estimates of natural mortality rates for juvenile and adult billfish would be expected to be relatively low, generally in the range of 0.15 to 0.30, based on body size, behavior and physiology (NMFS, 1999). Sagitta otolith weight is suggested to be proportional to age, indicating that both sexes are equally long-lived, based on the maximum otolith weight observed for each sex. Predicting age from length or weight is imprecise due to many age classes in the fishery, and otoliths may provide a more accurate measure of age.

Blue marlin have an extensive geographical range, migratory patterns that include trans-Atlantic as well as trans-equatorial movements, and are generally considered to be a rare and solitary species relative to the schooling Scombrids (tunas). Graves et al. (2002) captured eight blue marlin with recreational fishing gear and then implanted fish with satellite pop-up tags. These fish moved 74 – 248 km (40–134 nautical miles (nm)) over five days, with a mean displacement of 166 km (90 nm). Fish spent the vast majority of their time in waters with temperatures between 22 and 26°C (71–78°F) and at depths less than 10 m. Prince et al. (2005) tagged one blue marlin with a PSAT tag off the coast of Punta Cana, Dominican Republic and found that this fish moved 406.2 km (219.3 nm) during a 40-d deployment (10.15 km/day (5.48 nm/day)). The maximum time at liberty recorded of a tagged individual was 4,024 days (about 11 years) for a blue marlin that was estimated to weigh 29.5 kg (65 lb) at the time of release. Junior et al. (2004) found the depth of capture for blue marlin with pelagic longline gear ranged from 50 – 190 m (164 – 623 feet), with most individuals captured at 90 m (295 feet).

The Cooperative Tagging Center (CTC) program has tagged 24,108 and recaptured over 220 blue marlin and found that these fish moved an average of 903 km (488 nm) (Ortiz et al., 2003). Some individuals have exhibited extended movement patterns, and strong seasonal patterns of movement of individuals between the United States and Venezuela are evident. A blue marlin released off Delaware and recovered off the island of Mauritius in the Indian Ocean represents the only documented inter-ocean movement of a highly migratory species in the history of the CTC. The minimum straight-line distance traveled for a blue marlin was 14,893 km (8,041 nm) and the maximum number of days at large was 4,024 d.

Adults are found primarily in the tropics within the 24°C (75°F) isotherm, and make seasonal movements related to changes in sea surface temperatures. In the northern Gulf of Mexico they are associated with the Loop Current, and are found in blue waters of low productivity rather than in more productive green waters. Off of Puerto Rico, the largest numbers of blue marlin are caught during August, September, and October. Equal numbers of both sexes occur off northwest Puerto Rico in July and August, with larger males found there in May and smaller males in September. Very large individuals, probably females, are found off the southern coast of Jamaica in the summer and off the northern coast in winter, where males are caught in December and January.

There has not been an Atlantic wide survey of spawning activity for blue marlin, however, these fish generally reproduce between the ages of two and four, at 220 – 230 cm (86 – 90 inches) in length, and weigh approximately 120 kg (264 lb). Female blue marlin begin to mature at approximately 47 – 60 kg (104 – 134 lb), while males mature at smaller weights, generally from 35 – 44 kg (77 – 97 lb). There are likely two separate spawning events that occur at different times in the North and South Atlantic. South Atlantic spawning takes place between February and March (NMFS, 1999). Peak spawning activity in the North Atlantic Ocean occurs between July and October, with females capable of spawning up to four times per reproductive season (de Sylva and Breder, 1997). Prince et al. (2005) conducted 23 neuston tows in the vicinity of Punta Cana, Dominican Republic between 23 April and 17 May and successfully identified four larval blue marlin; the size of the larvae indicated that spawning activity was taking place in the same general area where these samples were conducted. Serafy et al. (2003) identified 90 blue marlin larvae in the vicinity of Exuma Sound, Bahamas in the month of July, indicating that spawning activity had taken place 18 days prior to sampling.

During the spawning season, blue marlin release between one and eleven million small (1 – 2 mm), transparent pelagic planktonic eggs. The number of eggs has been correlated to interspecific sizes among billfish and the size of individuals within the same species. Ovaries from a 147 kg (324 lb) female blue marlin from the northwest Atlantic Ocean were estimated to contain 10.9 million eggs, while ovaries of a 125 kg (275 lb) female were estimated to contain seven million eggs. Males are capable of spawning at any time.

Blue marlin are generalist predators feeding primarily on epipelagic fish and cephalopods in coastal and oceanic waters, however, mesopelagic fish and crustaceans associated with rocky, sandy, and reef bottoms are also important components of the diet. Feeding in mesopelagic areas probably takes place at night (Rosas-Alayola et al., 2002). Diet studies of blue marlin off the northeastern coast of Brazil indicate that oceanic pomfret (*Brama brama*) and squid (*Ornithoteuthis antillarum*) were the main prey items and present in at least 50 percent of stomachs. Other important prey species vary by location and include dolphin fishes, bullet tuna (*Auxis. spp*) around the Bahamas, Puerto Rico, and Jamaica, and dolphin fishes and scombrids in the Gulf of Mexico. Stomach contents have also included deep-sea fishes such as chiasmodontids.

Constant ingestion of small quantities of food is necessary. Blue marlin have relatively small stomachs, reducing the proportion of the body allocated for visceral mass, and allocating more volume to musculature for swimming speed and endurance (Junior *et al*., 2004). In the Pacific Ocean, changes in the diet observed are related more with abundance and distribution of prey than preferences in food items, with *Auxis* spp. (bullet and frigate tunas) well represented in all locations. Predators of blue marlin are relatively unknown. Sharks will attack hooked blue marlin, but it is not known if they attack free-swimming, healthy individuals.

Stock Status and Outlook

Since 1995, blue marlin have been managed under a single stock hypothesis because of tagging data and mitochondrial DNA evidence that are consistent with one Atlantic-wide stock. The last stock assessment for blue marlin was in 2000 using similar methods to the previous assessment (1996), however, data was revised in response to concerns raised since the 1996 assessment. The assessment reflects a retrospective pattern wherein improvement in estimated biomass ratios result in estimated lower productivity. The 2000 assessment was slightly more optimistic than the 1996 assessment. Atlantic blue marlin are at approximately 40 percent of B_{MSY} and overfishing has taken place for the last 10 – 15 years. B_{MSY} is estimated at 2,000 mt (4,409,245 lb) and current fishing mortality is approximately four times higher than F_{MSY} (Table 3.13) (SCRS, 2005). There is uncertainty in the assessment because the historical data is not well quantified. The 2000 assessment estimated that overfishing was still occurring and that productivity (MSY and a stock's capacity to replenish) was lower than previously estimated. Therefore, it is expected that landings in excess of estimated replacement yield would result in further stock decline (SCRS, 2005).

No additional assessment information became available in 2005 to modify recommendations currently in force. The current assessment indicates that the stock is unlikely to recover if the landings contemplated by the 1996 ICCAT recommendation continue into the future. While there is additional uncertainty in stock status and replacement yield, estimates are not reflected in bootstrap results, these uncertainties can only be addressed through substantial investment in research into habitat requirements of blue marlin and further verification of historical data. The SCRS recommended that the ICCAT take steps to reduce the catch of blue marlin as much as possible, including: reductions in fleet-wide effort, a better estimation of dead discards, establishment of time area closures, and scientific observer sampling for verification of logbook data. The SCRS noted that future evaluation of management measures relative to the recovery of the blue marlin stock are unlikely to be productive unless new quantitative information on the biology and catch statistics of blue marlin, and additional years of data are available (SCRS, 2004 and 2005).

A summary of Atlantic blue marlin stock assessment data can be found in Table 3.13. Estimated catches of Atlantic blue marlin by region for the period 1956 – 2001 can be found in Figure 3.11. A composite CPUE series for blue marlin for the period 1955 – 2000 can be found in Figure 3.12. The estimated median relative fishing mortality trajectory for Atlantic blue marlin can be found in Figure 3.13. A stock assessment for blue marlin is scheduled for 2006.

Table 3.13 Summary of Atlantic Blue Marlin Stock Assessment data. Weights are in metric tons, whole weight. Source: SCRS, 2005.

ATLANTIC BLUE MARLIN SUMMARY[1]	
	Total Atlantic
Maximum Sustainable Yield (MSY)	~ 2,000 t (~ 1,000 ~ 2,400 t)[2]
2002 Yield	2,626 t
2003 Yield	2,713 t
2004 Yield[4]	2,076 t
1999 Replacement Yield	~ 1,200 t (~ 840 - 1,600 t)[2]
Relative Biomass (B_{2000}/B_{MSY})	~ 0.4 (~ 0.25 - 0.6)[2]
Relative Fishing Mortality (F_{1999}/F_{MSY})	4.0 (~ 2.5 - 6.0)[2]
Management Measures in Effect	- Reduced pelagic longline and purse seine landings to 50% of 1996 or 1999 levels, whichever is greater [Recs. 00-13[3], 01-10[3] and 02-13].

[1] Assessment results are uncertain. Uncertainty in these estimates is not fully quantified by bootstrapping.
[2] Approximate 80% CI from bootstrap for ASPIC model.
[3] These measures did not take effect until mid-2001.
[4] Reported Task I value, which is likely to be a substantial underestimate of the total catch.

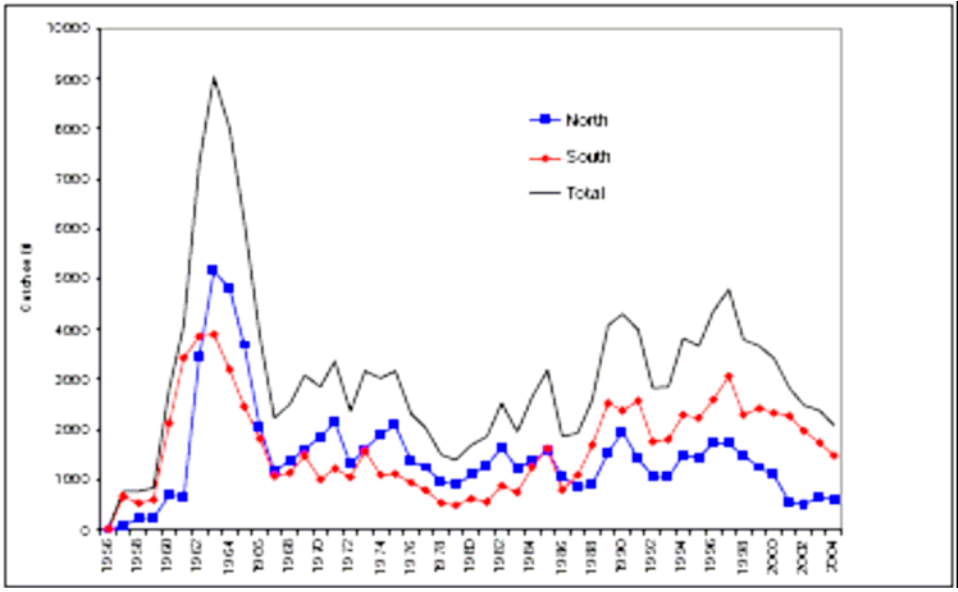

Figure 3.11 Estimated catches (including landings and dead discards in mt) of blue marlin in the Atlantic by region. The 2003 catch reported to ICCAT is preliminary and is not included in this figure. Weights are in metric tones, whole weight. Source: SCRS, 2005.

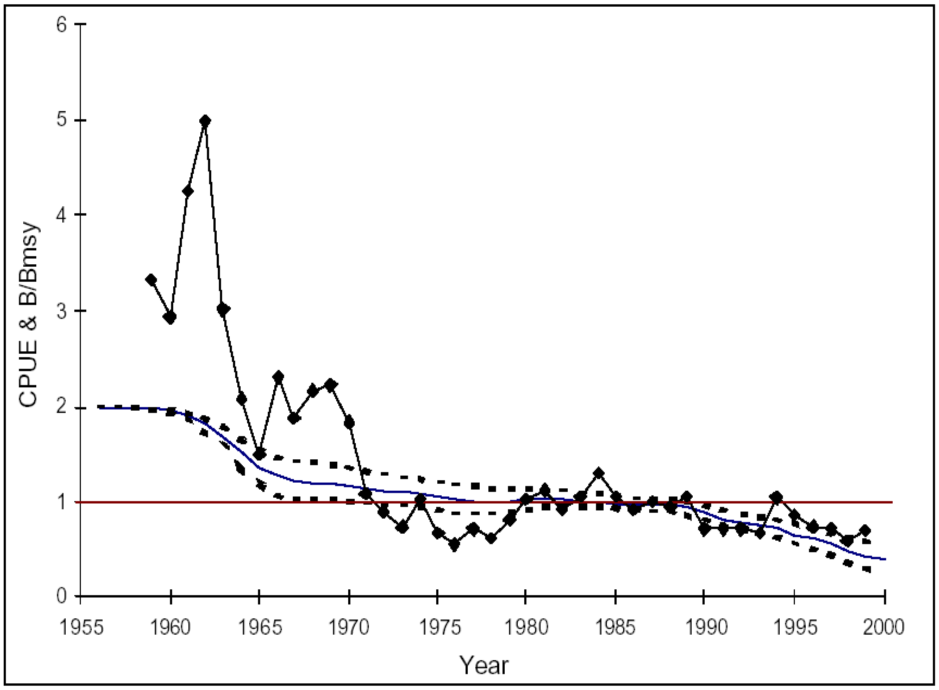

Figure 3.12 Composite CPUE series (symbols) used in the blue marlin assessment compared to model estimated median relative biomass (solid lines) from bootstrap results (80 percent confidence bounds shown by dotted lines). Source: SCRS, 2005.

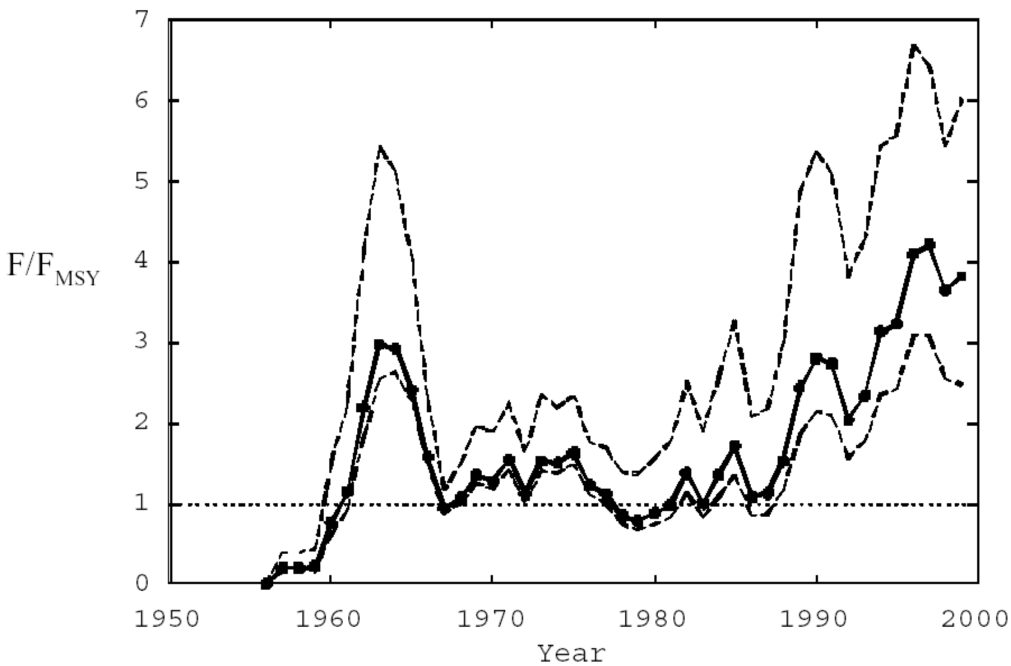

Figure 3.13 Estimated median relative fishing mortality trajectory for Atlantic blue marlin (center, dark line) with approximate 80 percent confidence range (light lines) obtained from bootstrapping. Source: SCRS, 2005.

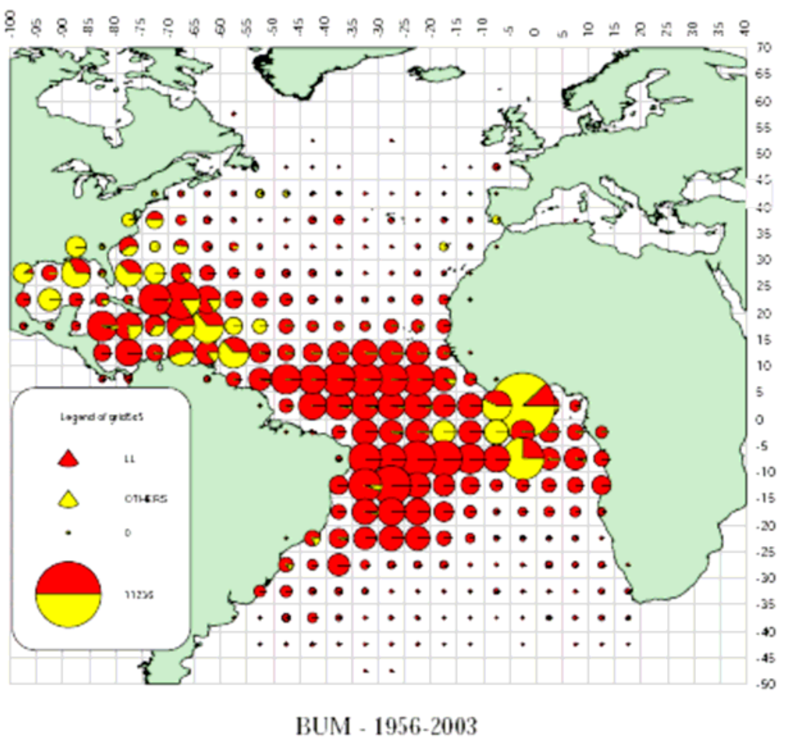

Figure 3.14 Geographical distribution of reported catches of blue marlin for the period 1956-2003. Source: SCRS, 2005.

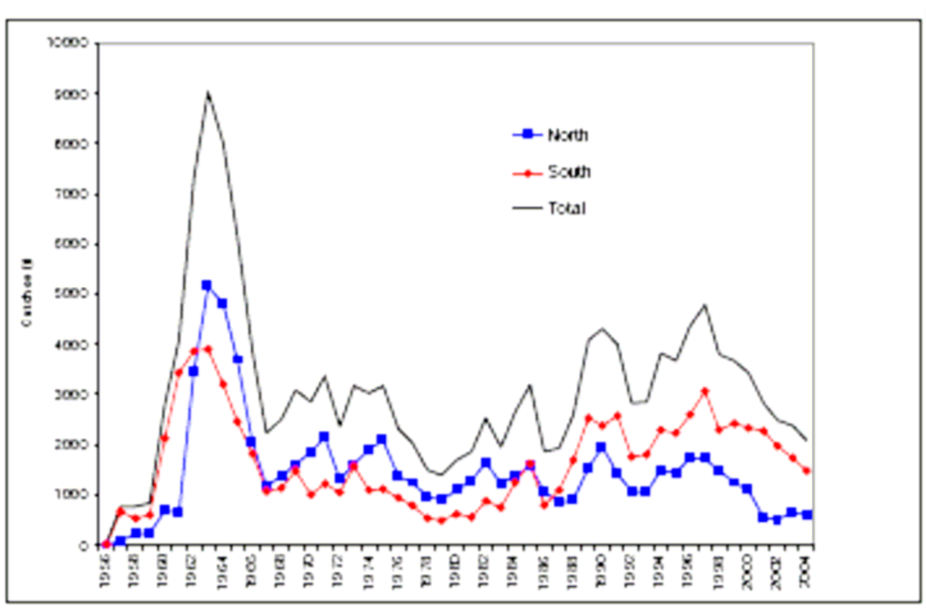

Figure 3.15 Estimated catches (including landings and dead discards in t) of blue marlin in the Atlantic by region (1950-2004). Source: SCRS, 2005.

Effect of Regulations

ICCAT Management Recommendations

ICCAT Recommendation 97-09 required Contracting Parties to reduce, starting in 1998, blue marlin and white marlin landings by at least 25 percent for each species from 1996 landings, by the end of 1999. Recommendations 00-13, 01-10, 02-13, and 04-09 imposed or extended additional catch restrictions for blue marlin. These included limiting the annual amount of blue marlin that can be harvested by pelagic longline and purse seine vessels and retained for landing to no more than 50 percent of the 1996 or 1999 landing levels, whichever is greater, as well as requiring that all blue marlin and white marlin brought to pelagic longline and purse seine vessels alive be released in a manner that maximizes their survival. The live release provision does not apply to marlins that are dead when brought along the side of the vessel or that are not sold or entered into commerce (SCRS, 2004). Globally, catches of blue marlin appear to have been reduced as a result of ICCAT recommendations, which tied reductions in blue marlin landings to 1996 or 1999 levels, whichever was greater. Total Atlantic-wide catches of blue marlin, as reported to ICCAT, decreased by approximately 46 percent from 3,836 mt in 1999 to 2,076 mt in 2004. Total Atlantic-wide longline landings of blue marlin, as reported to ICCAT, decreased by approximately 41 percent from 2,276 mt in 1999 to 1,343 in 2004.

In addition, these recommendations limited recreational landings in the United States to 250 blue and white marlin combined, on an annual basis. Also in 2000, ICCAT recommended that a blue marlin minimum size be established for recreational fisheries (251 cm (98.8 inches) LJFL). Most recently, ICCAT recommendation 04-09, extended phase one of the ICCAT mortality reduction plan, as established and modified by recommendations 00-13, 01-10, 02-13, through 2006 and postponed the next scheduled assessment of Atlantic blue marlin until 2006. The SCRS noted that it does not expect to have enough new information to provide an assessment of these recent regulations until 2006.

Domestic Regulations

The U.S. Atlantic billfish fishery, including blue marlin, white marlin, sailfish, and spearfish, has been reserved as a recreational fishery through domestic regulation since 1988. Possession of Atlantic billfish is prohibited by U.S. pelagic longline vessels and no sales of Atlantic billfish are allowed. Data on bycatch of Atlantic billfish in the domestic Atlantic pelagic longline fishery can be found in Section 3.4.1 and Appendix C. The recreational fishery is an open access fishery. Anglers must possess either a HMS Angling category permit or a CHB category permit to possess a billfish. General category tuna permit holders may possess Atlantic billfish only when participating in a registered HMS tournament. Details of the permitting program, including the number of permit holders can be found in Section 3.9. Data on domestic recreational catches of Atlantic billfish are obtained from a combination of sources, including: the Recreational Billfish Survey; the HMS swordfish and billfish non-tournament reporting line; MRFSS, and LPS. U.S. recreational billfish landings can be seen in section 4.2.3 of this document. The U.S. implemented a minimum legal size of 251 cm (99 inches), 167 cm (66 inches), 160 cm (63 inches) for blue marlin, white marlin, and sailfish respectively, in 1999.

Possession of Atlantic longbill spearfish have been prohibited since 1988. Rod and reel is the only type of gear authorized in the domestic billfish fishery.

Recent and Ongoing Research

The NMFS SEFSC played a substantial role in the ICCAT Enhanced Research Program for Billfish in 2004, with SEFSC scientists acting as the coordinator for the western Atlantic Ocean. Major accomplishments in the western Atlantic in 2004 were documented in SCRS/04/028. Highlights include 11 at-sea sampling trips with observers on Venezuelan industrial longline vessels in September 2004. Of the trips accomplished to date, 4 observer trips were on Korean type vessels fishing under the Venezuelan flag. Most of these vessels are based out of Cumana targeting tuna, swordfish, or both at the same time. Biological sampling of swordfish, Istiophorids, and yellowfin tuna for reproductive and age determination studies, as well as genetics research were continued during the 2004 sampling season. Shore-based sampling of billfish landings for size frequency data, as well as tournament sampling was obtained from Venezuela, Grenada, U.S. Virgin Islands, Bermuda, Barbados, and Turks and Caicos Islands. Program participants in Venezuela, Grenada, and Barbados continued to assist in obtaining information on tag-recaptured billfish, as well as numerous sharks, in the western Atlantic Ocean during 2004; a total of 44 tag recovered billfish and sharks were submitted to the Program Coordinator in 2004. Age, growth, and reproductive samples from several very large billfish were also obtained during 2004.

A study conducted by the Virginia Institute of Marine Science (VIMS) to evaluate post release survival and habitat use from the recreational fishery for Atlantic white marlin using pop-up satellite archival tags (PSATs) was finalized in 2004 and published in the peer review literature. A separate study conducted by VIMS on U.S. longline vessels to evaluate post release survival of marlin, as well as evaluating hook performance and related mortality was also finalized in 2004. These data have been submitted to a peer reviewed journal and are currently under review. The SEFSC has conducted several studies in the Northwest Atlantic and the Pacific coast of Central America to evaluate habitat use and reproductive biology of billfish using PSAT technology. About 200 PSATs have been deployed in this effort over the last 4 years with deployments ranging from a month to 5.5 months. Several peer reviewed papers summarizing these results are in press at this time, while other papers are currently in preparation. In addition, SEFSC is also currently conducting pelagic longline research to evaluate gear behavior, and the effects of gear modification on catch rate and survival of target and non-target species. Three cruises have been completed to date. This work in ongoing and should be finished sometime in 2006. Cooperative billfish research between US and Brazilian scientists was initiated in 2005.

The Fishery Management Group of the University of Miami is carrying out research on Atlantic billfish on three areas, population parameter estimation, population modeling and development of socio-economic indicators. Others at the University of Miami's Rosenstiel School and elsewhere are conducting research on early life history, reproductive biology and ecology of billfishes, as well as age and growth estimation.

Updates of standardized CPUE for blue and white marlin from the United States pelagic longline fishery in the NW Atlantic and Gulf of Mexico and the U.S. recreational tournament fishery in the NW Atlantic and Gulf of Mexico were developed and presented to ICCAT in 2005 (Document SCRS/2005/30 and SCRS/2005/31). Numerous additional papers were presented regarding standardization of CPUEs. Please see http//:www.iccat.es for additional information.

Multiple papers on habitat use were submitted to the ICCAT SCRS in 2005. These included papers on: vertical habitat use of white marlin in numerous locations of the western North Atlantic using PSAT tags (SCRS/2005/034); the depth distributions of 52 blue marlin in relation to exposure to longline gear using PSAT tags (SCRS/2005/035); and, a quantitative framework and numerical method for characterizing vertical habitat use by large pelagic animals using pop-up satellite tag data (SCRS/2005/). Additional information on spawning area research and other topics can be found at http//:www.iccat.es.

3.2.4.2 White Marlin

Life History/Species Biology

White marlin (*Tetrapturus albidus*) are found exclusively in tropical and temperate waters of the Atlantic Ocean and adjacent seas, unlike sailfish and blue marlin, which are also found in the Pacific Ocean. White marlin are found at the higher latitudes of their range only in the warmer months. Junior et al. (2004) captured white marlin with pelagic longline gear off northeastern Brazil in depths ranging from 50 – 230 m (164 – 754 feet), with no obvious depth layer preference. White marlin generally prefer water temperatures above 22°C (71° F) with salinities between 35 – 37 ppt (NMFS, 1999). They may occur in small, same-age schools, however, are generally solitary compared to the Scombrids (tunas). Catches in some areas may include a rare species (*Tetrapturus georgei*) which is superficially similar to white marlin. The so-called “hatchet marlin” may also represent (*T. georgei)*, and has been caught occasionally in the Gulf of Mexico and South Atlantic (NMFS, 1999).

White marlin are generally 20 – 30 kg (44 – 66 lb) at harvest. These fish grow quickly, with females attaining a larger maximum size than males, and have a life span of 18 years (SCRS 2004). Adult white marlin grow to over 280 cm (110 inches) TL and 82 kg (184 lb). White marlin exhibit sexually dimorphic growth patterns; females grow larger than males, but the dimorphic growth differences are not as extreme as noted for blue marlin. This species undergoes extensive movements, although not as extreme as those of the bluefin tuna and albacore. Trans-equatorial movements have not been documented for the species. There have been 31,483 white marlin tagged and released by the CTC program, with 577 reported recaptures (1.83 percent of all releases) (Ortiz et al., 2003). The majority of releases took place in the months of July through September, in the western Atlantic off the east coast of the United States. Releases of tagged white marlin also occurred off Venezuela, in the Gulf of Mexico, and in the central west Atlantic. The longest distance traveled is 6,517 km (4,049 miles) and the maximum days at large is 5,488 days (approx. 15 years). A substantial number of individuals moved between the Mid-Atlantic coast of the United States and the northeast coast of South America. Overall, 1.1 percent of documented white marlin recaptures have made trans-Atlantic movements. The longest movement was for a white marlin tagged during July 1995 off the east coast near Cape May, NJ and recaptured off Sierra Leone, West Africa, in November, 1996. The fish traveled a distance of at least 6,517 km (3,519 nm) over 476 days (NMFS, 1999). Prince et al. (2005) tagged six white marlin off the coast of Punta Cana, Dominican Republic and found their displacement to be between 58.7 and 495.8 km (31.7 – 267.7 nm), ranging from 2.1 – 13.3 km/day (mean = 6.3 km/day).

White marlin spawn in the spring (March through June) in the northwestern Atlantic Ocean and females are generally 20 kg (44 lb) in mass and 130 cm (51.2 inches) in length at sexual maturity. White marlin spawn in tropical and sub-tropical waters with relatively high surface temperatures and salinities (20 – 29°C (68 – 84°F) and over 35 ppt) and move to higher latitudes during the summer. There has not been an Atlantic-wide study of the spawning behavior of white marlin. Spawning seems to take place in more offshore areas than for sailfish, although larvae are not found as far offshore as blue marlin. Females may spawn up to four times per spawning season (de Sylva and Breder, 1997). It is believed there are at least three spawning areas in the western north Atlantic: northeast of Little Bahama Bank off the Abaco Islands; northwest of Grand Bahama Island; and southwest of Bermuda. Prince et al. (2005) found eight white marlin larvae in neuston tows in April/May off the coast of Punta Cana, Dominican Republic indicating that there had been recent spawning activity in this general area. Larvae have also been collected from November to April, but these may have been sailfish larvae (*Istiophorus platypterus*), as the two can not readily be distinguished (NMFS, 1999). Spawning concentrations occur off the Bahamas, Cuba, and the Greater Antilles, probably beyond the U.S. EEZ, although the locations are unconfirmed. Concentrations of white marlin in the northern Gulf of Mexico and from Cape Hatteras, NC to Cape Cod, MA are probably related to feeding rather than spawning (NMFS, 1999).

White marlin are primarily piscivorous. Oceanic pomfret and squid were the most important food items in a study that sampled stomachs collected off the coast of Brazil in the southwestern Atlantic Ocean (Junior et al., 2004). The number of food items per stomach ranged from 1 – 12 individuals. The largest prey observed in white marlin stomachs were snake mackerel (*Gempylus serpens*), that were 40 – 73 cm (15.7 – 28.7 inches) in length (Junior et al., 2004). Squid, dolphin, hardtail jack, flying fish, bonitos, mackerels, barracuda, and puffer fish are the most important prey items in the Gulf of Mexico.

Data from a large sport fishery for white marlin that occurs during the summer between Cape Hatteras, NC and Cape Cod, MA indicates that white marlin inhabit offshore (148 km (80 nm)) submarine canyons, extending from Norfolk Canyon in the Mid-Atlantic to Block Canyon off eastern Long Island. Concentrations of white marlin are associated with rip currents and weed lines (fronts), and with bottom features such as steep drop-offs, submarine canyons, and shoals. Sport fishing for white marlin also occurs in the Straits of Florida, southeast Florida, the Bahamas, and off the north coasts of Puerto Rico and the Virgin Islands. Summer concentrations in the Gulf of Mexico are found off the Mississippi River Delta and at DeSoto Canyon, with a peak off the delta in July, and in the vicinity of DeSoto Canyon in August. In the Gulf of Mexico, adults appear to be associated with blue waters of low productivity, being found with less frequency in more productive green waters. While this is also true of the blue marlin, there appears to be a contrast between the factors controlling blue and white marlin abundance, as higher numbers of blue marlin are generally caught when catches of white marlin are low, and vice versa. It is believed that white marlin prefer slightly cooler temperatures than blue marlin.

Stock Status and Outlook

White marlin have been managed under a single stock hypothesis by ICCAT since 2000. The most recent stock assessments for white marlin (1996, 2000, and 2002) all indicated that biomass of white marlin has been below B_{MSY} for more than two decades and the stock is overfished. In 2004, the SCRS indicated that in spite of significant improvements in the relative abundance estimates made available during the last three assessments, they are still not informative enough to provide an accurate estimate of stock status (SCRS, 2004). The 2002 assessment indicated that the relative fishing mortality is 8.28 times that permissible at F_{MSY} (Table 3.14). Given that the stock is severely depressed, the SCRS concluded that ICCAT should take steps to reduce the catch of white marlin as much as possible, first by increasing observer coverage to improve estimates of catch and dead discards of white marlin. Furthermore, SCRS recommended that Contracting Parties conduct research into habitat requirements and post-release survival of white marlin and take steps to verify historical fishery data.

The SCRS suggested that ICCAT take steps to make sure that the intended reductions in catch are complied with, and monitored, so that proper evaluation can be carried out in the future. The SCRS recommended improving observer programs so that better estimates of catch and dead discards of white marlin are obtained. The SCRS further recommended that, in the absence of observing a change in population status resulting from the most recent management measures, the potential for increasing stock size of white marlin may require future catches to be reduced beyond the level apparently intended by its most recent recommendations. However, the SCRS also stated that more definitive advice should be available after several years of data become available. The SCRS also noted that future evaluation of management measures relative to the recovery of the white marlin stock is unlikely to be productive unless new quantitative information on the biology and catch statistics of white marlin, and additional years of data, are available (SCRS, 2004). As such, ICCAT postponed the next white marlin assessment until 2006. A summary of Atlantic white marlin stock assessment data can be found in Table 3.14.

New standardized catch rate information was presented in 2005, updating catch rates from U.S. recreational fisheries in the northwest Atlantic and Gulf of Mexico and the Venezuelan longline and artesinal fisheries. In spite of the progress made, the SCRS can not interpret the historic CPUE trends for white marlin (SCRS, 2005). In 2002, an ESA listing review was completed by NMFS. NMFS determined that listing Atlantic white marlin under the Endangered Species Act was not warranted at that time. NMFS has committed to conducting another ESA listing review in 2007.

Table 3.14 Summary of Atlantic White Marlin Stock Assessment data. Weights are in metric tons, whole weight. Source: SCRS, 2005.

ATLANTIC WHITE MARLIN SUMMARY[1]				
	Likely value	*Continuity case[2] estimate (80% conf. limit)*	*Retrospective adjusted estimate[3]*	*Range of sensitivity[4] estimates*
Maximum Sustainable Yield	Below 2000 Yield	964 t (849-1070)		323-1,320 t
2002 Yield	822 t	--		--
2003 Yield	615 t	--		--
2004 Yield[5]	532 t			
2001 Replacement Yield	Below 2000 Yield	222 t (101-416)	371 t	102-602 t
Relative Biomass (B_{2001}/B_{MSY})	<1 (Over-fished)	0.12 (0.06-0.25)	0.22	0.12-1.76
Relative Fishing Mortality (F_{2000}/F_{MSY})	>1 (Over-fishing)	8.28 (4.5-15.8)	5.05	0.80-10.30
Management Measures in Effect:	- In 2001 and 2002, PS and LL fisheries limit landings to 33% of max (1996, 1999) level. [Rec. 00-13], [Rec. 01-10] and [Rec. 02-13].			

[1] Assessment results are highly uncertain.
[2] The data used are not sufficiently informative to choose a "best case". For consistency, the continuity case presented here is based on data and assumptions that closely resemble the analyses made in 2000. Confidence limits from bootstrapping are conditional on this model-data set and thus may underestimate the real uncertainty.
[3] These results are for the continuity case except that they were adjusted for retrospective biases.
[4] The sensitivity analyses made were not chosen in a systematic way; the range is presented only for qualitative guidance.
[5] Reported Task I value for 2004, which is likely an underestimate of total catch.

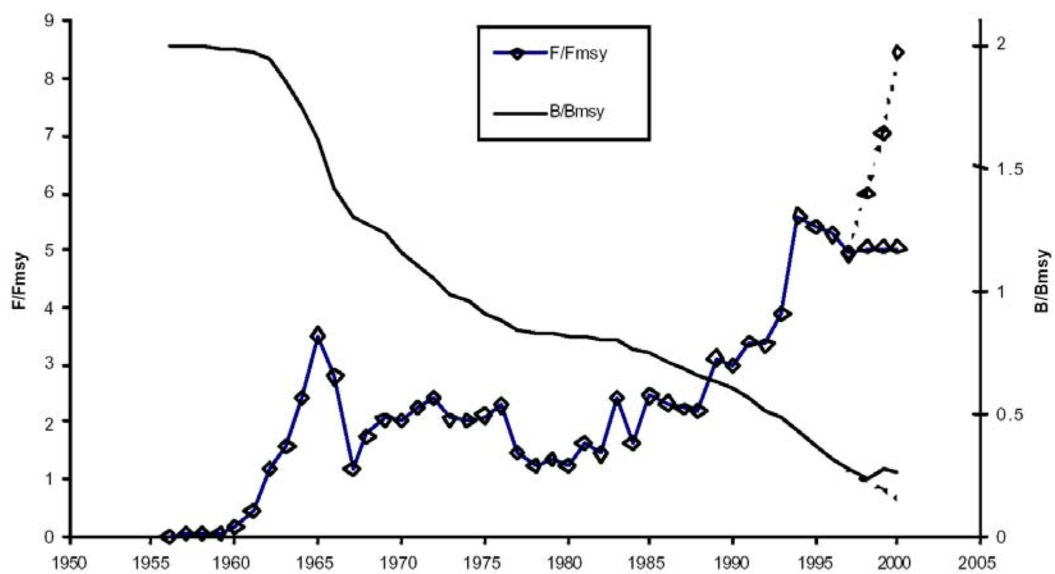

Figure 3.16 Estimated biomass ratio B_{2000}/B_{MSY} (solid line, no symbols) and fishing mortality ratio F2000/FMSY (solid line with symbols) from the production model fitted to the continuity case for white marlin. Ratios of last three years have been adjusted for retrospective pattern. Broken lines show unadjusted ratios. Note that scales are different for each ratio. Source: SCRS, 2004.

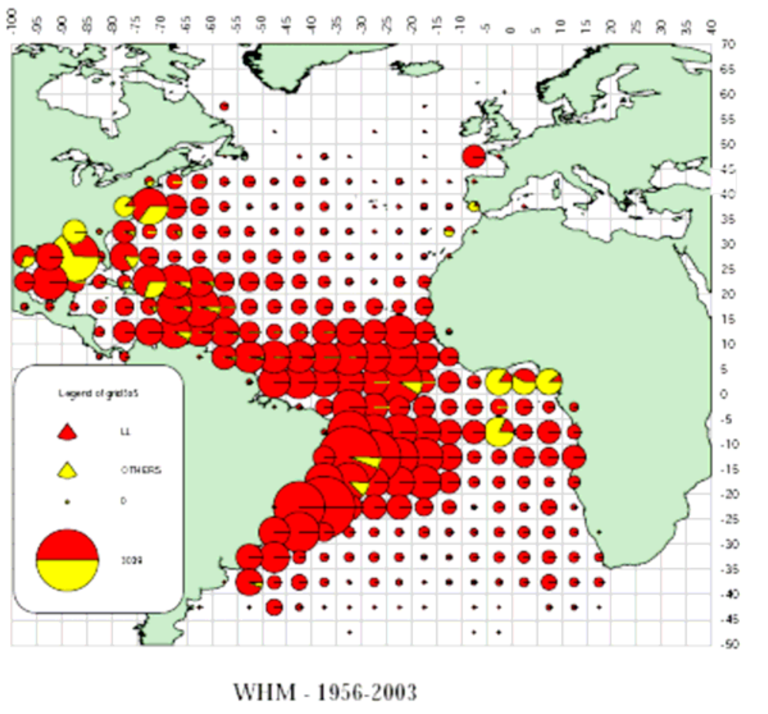

Figure 3.17 Geographical distribution of white marlin catches for the period 1956-2003. Source: SCRS, 2005.

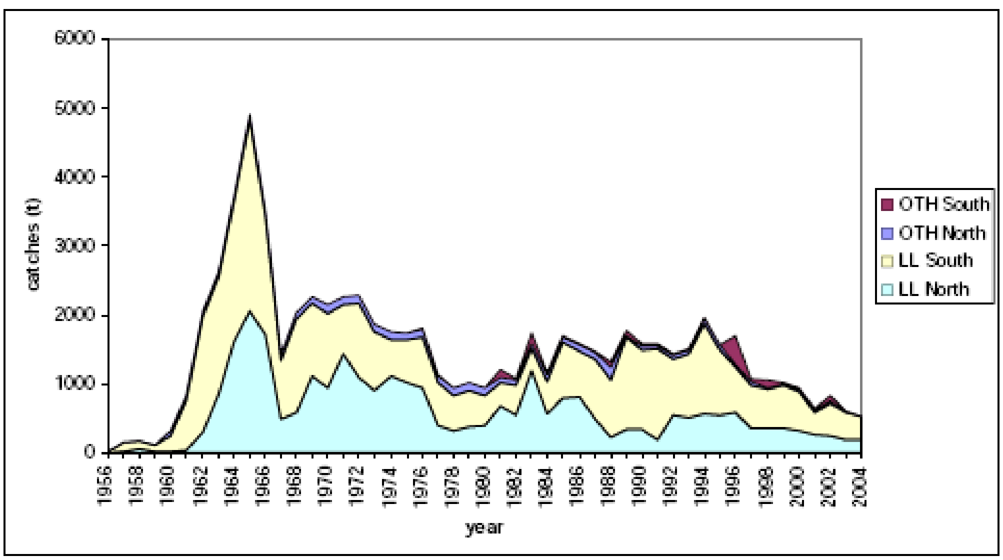

Figure 3.18 Reported catch of white marlin (Task I) in the North and South Atlantic for longline (LL) gear and other (OTH) gears. Source: SCRS, 2005.

Effect of Regulations

ICCAT Management Recommendations

Recommendation 97-09 required ICCAT Contracting Parties to reduce, starting in 1998, blue marlin and white marlin landings by at least 25 percent for each species from 1996 landings, such reduction to be accomplished by the end of 1999. ICCAT Recommendations 00-13, 01-10, and 02-13 imposed or extended additional catch restrictions for white marlin. These included reductions to no more than 33 percent of the 1996 or 1999 landing levels, whichever is greater, in the annual amount of white marlin that can be harvested and retained for landing by pelagic longline and purse seine vessels. Further, all blue marlin and white marlin brought to pelagic longline and purse seine vessels alive are required to be released in a manner that maximizes their survival (SCRS, 2004). Post-release survival studies concluded that white marlin can generally survive the trauma of being captured on pelagic longline gear (SCRS, 2005) and suggest that current management practices requiring the release of live white marlin (Rec. 00-13) will reduce fishing mortality on the stock. The live release provision does not apply to marlins that are dead when brought along the side of the vessel or that are not sold or entered into commerce. While the stock status evaluations are uncertain, projections indicated that the apparent intent of the ICCAT Billfish recommendations has, in the short term, some potential for stabilizing the stock biomass near current levels. Since 2000 is the last year of data used for the last stock assessment, it is too early to evaluate the effect of these recommendations on the stock. A stock assessment for white marlin is scheduled for 2006.

Globally, catches of white marlin appear to have been reduced as a result of ICCAT recommendations to less than 1,000 mt since 2000. Preliminary catches for 2004 were 532 mt, a slight decrease from 2003. Reported catches in 2004 by Brazil are lower than in previous years as a result of the implementation of the ICCAT recommendation to release live marlins, increased observer coverage, and a reduction in longline fishing effort (SCRS, 2005). Total Atlantic-wide catches of white marlin, as reported to ICCAT, decreased by approximately 48 percent from 1,028 mt in 1999 to 532 mt in 2004. Total Atlantic-wide longline landings of white marlin, as reported to ICCAT, decreased by approximately 46 percent from 924 mt in 1999 to 501 mt in 2004. Purse seine fisheries have incidental catches of white marlin, especially those that set on FADs. A temporary ban on FADs implemented by the EU resulted in a 300 – 400 mt (661,386 – 881,849 lb) decrease in incidental purse seine catches of all marlins (Gaertner et al., 2002). In the United States, white marlin are managed exclusively for recreational fisheries. This fishery is subject to an ICCAT imposed, 250-fish limit, annually for both blue and white marlin combined. In 2005, 31 recreationally landed white marlin were reported to ICCAT by the United States. In 2001, time area closures were established in the United States to reduce interactions between longline fisheries and white marlin and other billfish.

Domestic Regulations

Please see the discussion of domestic regulations contained in section 3.2.4.1, above.

Recent and Ongoing Research

Please see the discussion of recent and ongoing research contained in section 3.2.4.1, above.

3.2.4.3 Sailfish

Life History/Species Biology

Sailfish have a pan-tropical distribution and prefer water temperatures between 21 and 28°C (69 – 82°F). Although sailfish are the least oceanic of the Atlantic billfish and have higher concentrations in coastal waters (more than any other Istiophorid), they are also found in offshore waters. They range from 40°N to 40°S in the western Atlantic and 50°N to 32°S in the eastern Atlantic. No trans-Atlantic movements have been recorded, suggesting a lack of mixing between east and west. Although sailfish are generally considered to be rare and solitary species relative to the schooling Scombrids, sailfish are known to occur along tropical coastal waters in small groups consisting of at least a dozen individuals. Junior et al. (2004) captured sailfish in the southwestern Atlantic Ocean with pelagic longline gear at depths between 50 – 210 m (164 – 688 feet), with most individuals captured at 50 m. Sailfish are the most common representative of the Atlantic Istiophorids in U.S. waters (SCRS, 2005). Female sailfish grow faster, and attain a larger maximum size, than males while both sexes have a life expectancy of 15 years (NMFS, 1999).

In the winter, sailfish are found in schools around the Florida Keys and eastern Florida, in the Caribbean, and in offshore waters throughout the Gulf of Mexico. In the summer, they appear to migrate northward along the U.S. coast as far north as the coast of Maine, although there is a population off the east coast of Florida year-round. During the summer, some of these fish move north along the inside edge of the Gulf Stream. In the winter, they regroup off the east coast of Florida. Sailfish appear to spend most of their time above the thermocline, which occurs at depths of 10 – 20 m (32.8 – 65.6 feet) and 200 – 250 m (656 – 820 feet), depending on location. The 28°C (82°F) isotherm appears to be the optimal temperature for this species. Sailfish are mainly oceanic but migrate into shallow coastal waters. Larvae are associated with the warm waters of the Gulf Stream (NMFS, 1999).

A total of 65,868 sailfish have been tagged and released through the efforts of the CTC program, with reported recapture of 1,204 sailfish (1.83 percent of all releases). Most releases occurred off southeast Florida, from north Florida to the Carolinas, the Gulf of Mexico, Venezuela, Mexico, the northern Bahamas and the U.S. Virgin Islands. One tagged and recaptured specimen traveled from Juno, FL to the Mid-Atlantic, a distance of 2,972 km (1,745 miles). The longest movement tracked by tagging was 3,861 km (2,084 miles) and the longest time at large was 6,658 days (18.2 years) (Ortiz et al., 2003). During the winter, sailfish are restricted to the warmer parts of their range and move farther from the tropics during the summer. The summer distribution of sailfish does not extend as far north as for marlins, especially white marlin. Tag-and-recapture efforts have recovered specimens only as far north as Cape Hatteras, NC. Few trans-Atlantic or trans-equatorial movements have been documented using tag-recapture methods (NMFS, 1999).

Most sailfish examined that have been caught off Florida are under three years of age. Mortality is estimated to be high in this area, as most of the population consists of only two year classes. The longest period a recaptured-tagged animal was found to be at-large was 16.1 years. Unfortunately, the size at release is not available for this fish. Growth rate in older individuals is very slow (0.59 kg/yr (1.3 lb/year). Sailfish are probably the slowest growing of the Atlantic istiophorids. Sexual dimorphic growth is found in sailfish, but it is not as extreme as with blue marlin (NMFS, 1999).

Female sailfish spawn at age three and are generally 13 – 18 kg and 157 cm (28.6 – 39.6 lb and 61.8 inches), whereas males generally mature earlier at 10 kg and 140 cm (22 lb and 55.1 inches). Spawning takes place between April and October (de Sylva and Breder, 1997). Spawning has been reported to occur in shallow waters 9 – 12 m (30 – 40 ft) around Florida, from the Florida Keys to the region off Palm Beach on the east coast. Spawning is also assumed to occur, based on presence of larvae, offshore beyond the 100 m (328 feet) isobath from Cuba to the Carolinas, from April to September. However, these spawning activities have not been observed. Sailfish can spawn multiple times in one year, with spawning activity-moving northward in the western Atlantic as the summer progresses. Larvae are found in Gulf Stream waters in the western Atlantic, and in offshore waters throughout the Gulf of Mexico from March to October (NMFS, 1999). Serafy et al. (2003) found three larval sailfish in Exuma Sound, Bahamas, in the month of July indicating that there had been recent spawning activity in this vicinity. In the Pacific Ocean, sailfish spawn in waters between 27 – 30°C (Hernandez-H and Ramirez-H, 1998).

Sailfish are generally piscivorous, but also consume squid. Larvae eat copepods early in life then switch to fish at 6.0 mm (0.2 inches) in length (NMFS, 1999). The diet of adult sailfish caught around Florida consists mainly of pelagic fishes such as little tunny (*Euthynnus alletteratus*), halfbeaks (*Hemiramphus* spp.), cutlassfish (*Trichiurus lepturus*), rudderfish (*Strongylura notatus*), jacks (*Caranx* spp.), pinfish (*Lagodon rhomboides*), and squids (*Argonauta argo* and *Ommastrephes bartrami)*. Sailfish are opportunistic feeders and there is evidence that they may feed on demersal species such as sea robin (*Triglidae*), cephalopods and gastropods found in deep water.

Sailfish collected in the western Gulf of Mexico contained a large proportion of shrimp in their stomachs in addition to little tunny, bullet tuna (*Auxis* spp.), squid, and Atlantic moonfish (*Vomer setapinnis*). Junior et al. (2004) determined that squid were actually the second most important food item in the southwestern Atlantic off the coast of Brazil. Number of food items per stomach ranged from 1-14, and 6 percent of the stomachs were empty upon collection (Junior *et al*., 2004). Adult sailfish are probably not preyed upon often, but predators include killer whales (*Orcinus orca*), bottlenose dolphin (*Tursiops turncatus*), and sharks.

Participants from many nations target sailfish in both the western and eastern Atlantic Ocean. Sailfish are found predominantly in the upper reaches of the water column and are caught in directed sport fisheries (recreational) and as bycatch in the offshore longline fisheries for swordfish and tunas and as a directed catch in coastal fisheries. In coastal waters, artisanal fisheries use many types of shallow water gear to target sailfish (NMFS, 2003).

Stock Status and Outlook

Sailfish and longbill spearfish landings have historically been reported together in annual ICCAT landing statistics. An assessment was conducted in 2001 for the western Atlantic sailfish stock based on sailfish/spearfish composite catches and sailfish "only" catches. The assessment tried to address shortcomings of previous assessments by improving abundance indices and separating the catch of sailfish from that of spearfish in the offshore longline fleets. The 2001 assessment looked at catches reported between 1956 and 2000 and all the quantitative assessment models used produced unsatisfactory fits, therefore the SCRS recommended applying population models that better accounted for these dynamics in order to provide improved assessment advice. For the western Atlantic stock, annual sailfish catches have averaged about 700 mt (1,543,235 lb) over the past two decades and the abundance indices have remained relatively stable. The 2000 yield was 506 mt (1,115,539 lb) (Table 3.15). The reported catches of sailfish/spearfish (Task I) for 2004 were 1,017 and 1,088 mt for the west and east Atlantic, respectively. Recent analyses did not provide any information on the MSY or other stock benchmarks for the 'sailfish only' stock. In the eastern Atlantic, abundance indices based on coastal/inshore fisheries for sailfish have decreased in recent years, while those attained from the Japanese longline fishery indicate constant estimates of abundance since the mid-1970s (SCRS, 2004).

Based on the 2001 assessment, it is unknown if the western or eastern sailfish stocks are undergoing overfishing or if the stocks are currently overfished. Therefore, SCRS recommended that Contracting Parties consider methods to reduce fishing mortality rates, overall, and that western Atlantic catches should not be increased above current levels. Furthermore, the SCRS expressed concern about the incomplete reporting of catches, particularly in recent years.

A summary of Atlantic sailfish stock assessment data is given in Table 3.15. The evolution of estimated sailfish/spearfish catches in the Atlantic during the period 1956 – 2002 for both east and west stocks is given in Figure 3.19. Available CPUE for western Atlantic sailfish/spearfish for the period 1967 – 2000 is shown in Figure 3.20. Estimated sailfish only catches from 1956 – 2000 are shown in Figure 3.21.

Table 3.15 Summary of Atlantic Sailfish Stock Assessment data. Weights are in metric tons, whole weight. Source: SCRS, 2004.

ATLANTIC SAILFISH "ONLY" SUMMARY		
	West Atlantic	**East Atlantic**
Maximum Sustainable Yield (MSY)	Not estimated	Not estimated
Recent Yield (2000)[1]	506 t[2]	969 t[2]
2000 Replacement Yield	~ 600 t	Not estimated
Management Measures in Effect	None	None

[1] Estimated yield includes that carried over from previous years.
[2] Recent yield (2000) was estimated during the 2001 sailfish assessment. To estimate the 2001, 2002 and 2003 yield, catches of sailfish and spearfish would have to be separated. A separation similar to the one conducted in the 2001 assessment has not yet been conducted.

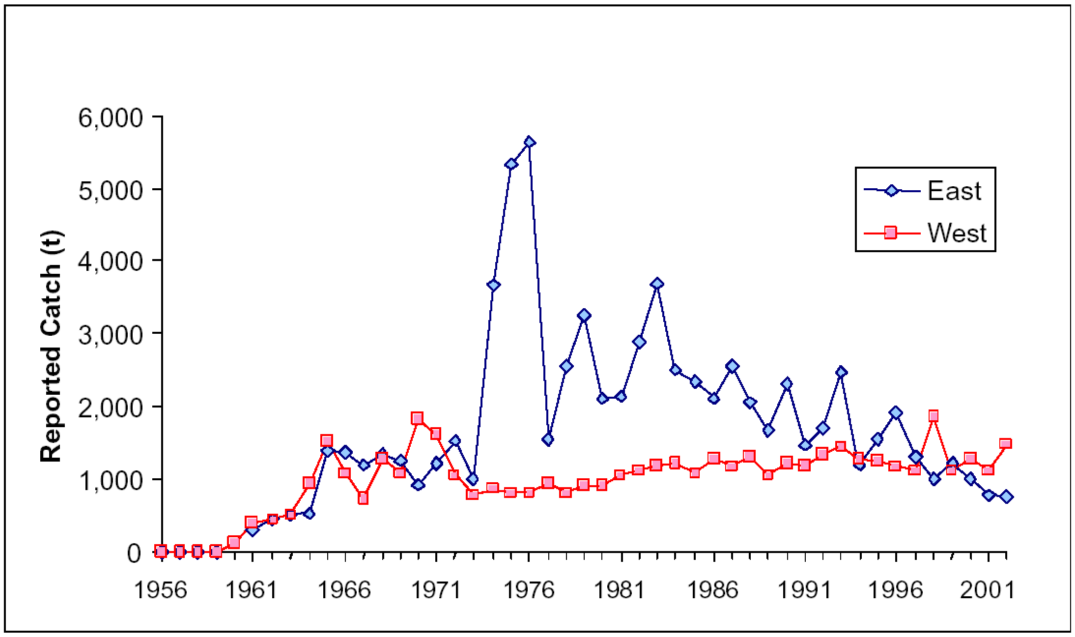

Figure 3.19 Evolution of estimated sailfish/spearfish catches in the Atlantic (landings and dead discards, reported and carried over) in the ICCAT Task I database during 1956-2002 for the east and west stocks. The 2003 catch reported to ICCAT is preliminary and is not included in this figure. Weights are in metric tons, whole weight. Source: SCRS, 2005.

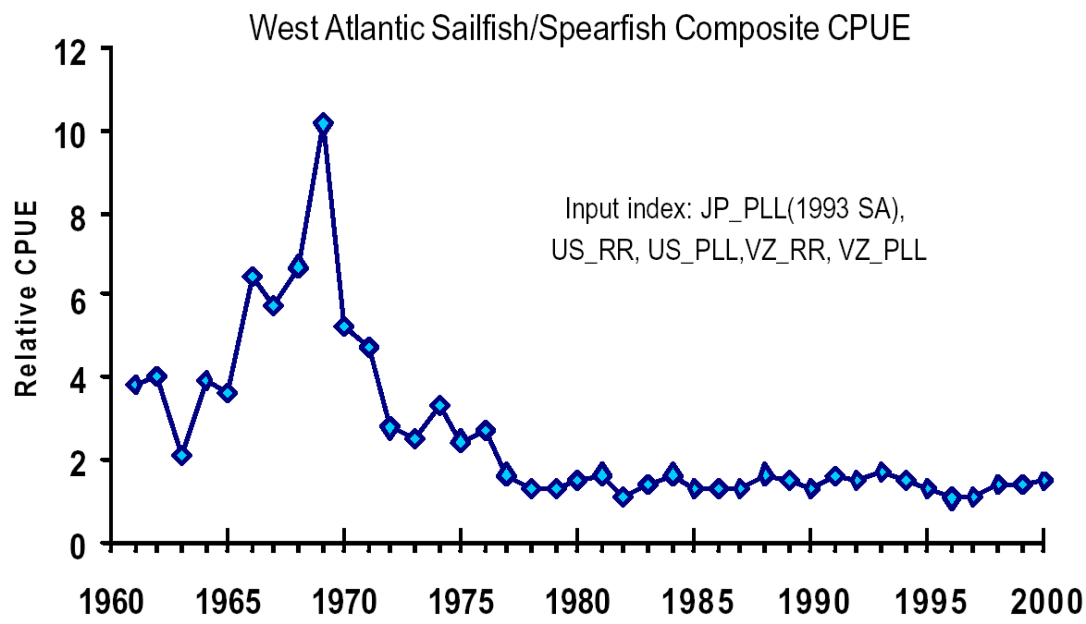

Figure 3.20 Available standardized CPUE for western Atlantic sailfish/spearfish for the period 1967-2000, including Japanese, U.S., and Venezuelan time series data. Source: SCRS, 2005**.**

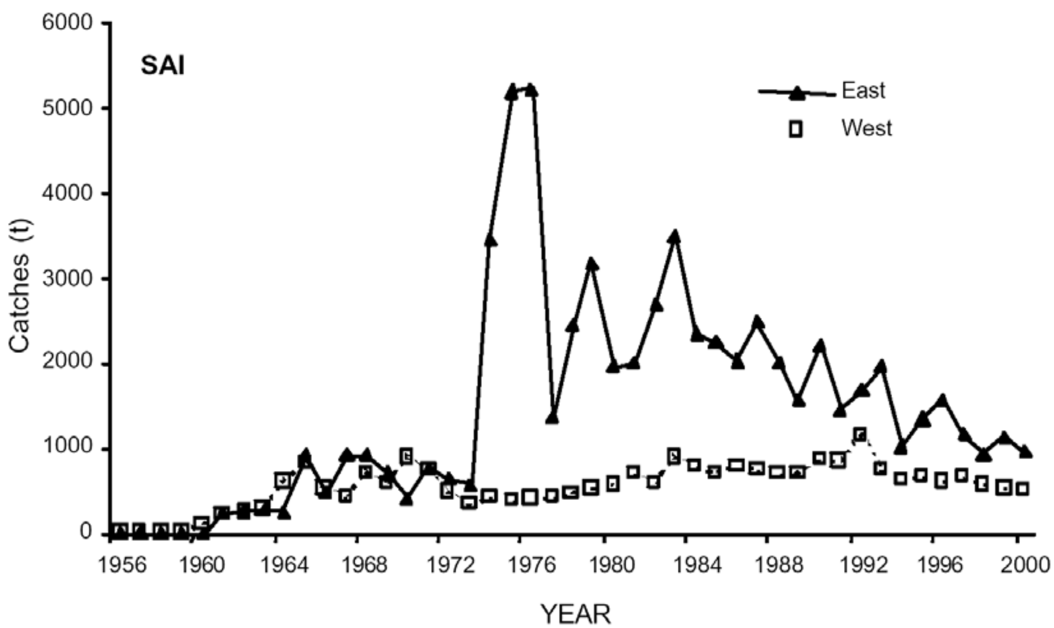

Figure 3.21 Estimated sailfish "only" catches based on the new procedure for splitting combined sailfish and longbill spearfish catches from 1956-2000. Weights are in metric tons, whole weight. Source: SCRS, 2005.

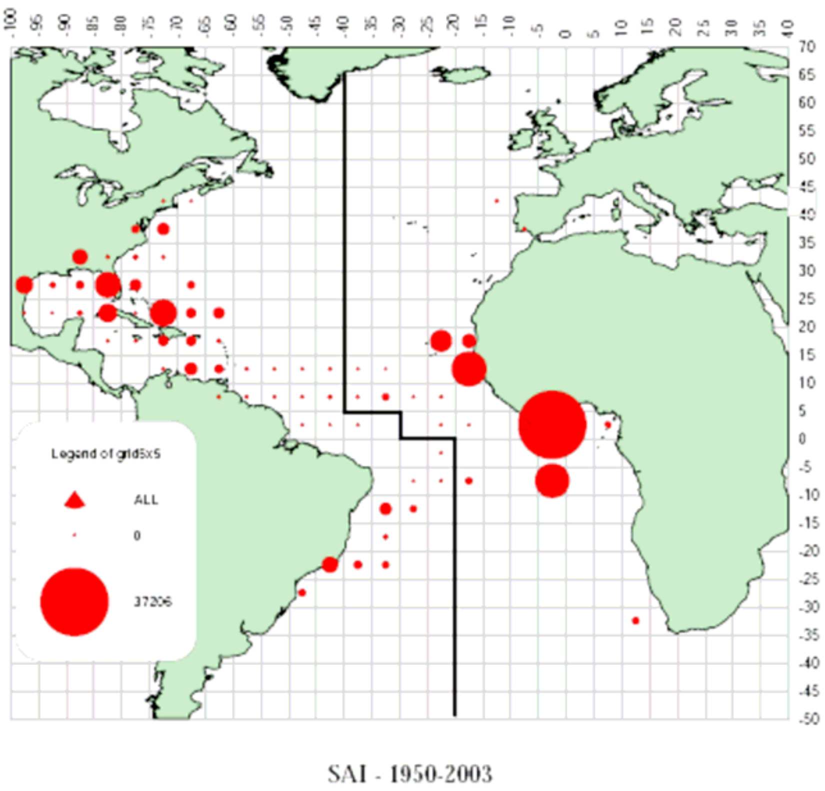

Figure 3.22 Geographical distribution of sailfish/spearfish catches between 1950-2003. Source: SCRS, 2005.

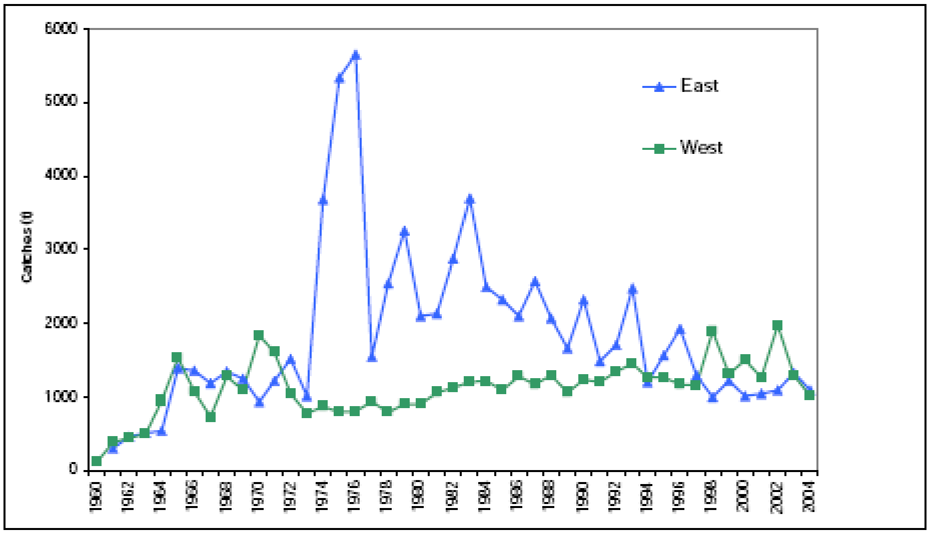

Figure 3.23 Evolution of estimated sailfish/spearfish catches in the Atlantic (landings and dead discards, reported and carried over) in the ICCAT Task I database during 1956-2004 for the east and west stocks. Source: SCRS, 2005.

Effect of Regulations

<u>ICCAT Management Recommendations</u>

No ICCAT management regulations are currently in effect for Atlantic sailfish. Sailfish are managed as distinct eastern and western Atlantic stocks. This separation into two management units is based on life history information. General management recommendations made by the SCRS to ICCAT have remained consistent in recent years. These management recommendations indicated that ICCAT should consider methods for reducing fishing mortality rates. The current western Atlantic assessment led the SCRS to recommend that the West Atlantic sailfish "only" catches should not exceed current levels. For the East Atlantic, the SCRS recommended that sailfish "only" catches should not exceed current levels and that ICCAT should consider practical and alternative methods to reduce fishing mortality and assure data collection systems. SCRS expressed concern about the incomplete reporting of catches, particularly for the most recent years, the lack of sufficient reports by species, and evaluations of the new methods used to split the sailfish and spearfish catch and to index abundance. The SCRS recommended all countries landing sailfish/spearfish or having dead discards, report these data to the ICCAT Secretariat and that the SCRS should consider the possibility of a spearfish "only" assessment in the future (SCRS, 2004).

Domestic Regulations

Please see the discussion of domestic regulations contained in section 3.2.4.1, above.

Recent and Ongoing Research

Please see the discussion of recent and ongoing research contained in section 3.2.4.1, above.

3.2.4.4 Longbill Spearfish

The longbill spearfish (*Tetrapturus pfluegeri*) are the most rare of the Atlantic istiophorids, and were identified as a distinct species in 1963. There is relatively little information available on spearfish life history. A related istiophorid, the Mediterranean spearfish (*Tetrapturus belone*), is the most common representative of this family in the Mediterranean Sea. Longbill spearfish are known to occur in epipelagic waters above the thermocline, off the east-coast of Florida, the Bahamas, the Gulf of Mexico, and from Georges Bank to Puerto Rico. Junior et al. (2004) captured spearfish off the coast of Brazil at depths ranging from 50 – 190 m (164 – 623 feet). The geographic range for this species is from 40°N to 35°S.

Spearfish spawn from November to May and females are generally 17 – 19 kg (37.4 – 41.8 lb) and 160 – 170 cm (63 – 66 inches) at first maturity. These fish are unique among istiophorids in that they are winter spawners. Larval spearfish have been identified from the vicinity of the Mid-Atlantic ridge from December to February, indicating that this species spawns in offshore waters (de Sylva and Breder, 1997).

Common prey items include fish and squid. Specifically, Junior et al. (2004) observed 37 stomachs and found that oceanic pomfret and squid comprised 63 percent of the items identified in stomachs. Most prey items were between 1 – 10 cm (0.39 – 3.9 inches) in length, with a mean length of 6.7 cm (2.63 inches). The maximum number of prey items found in any individual stomach was 33.

Similar to sailfish, spearfish are caught incidentally or as bycatch in offshore longline fisheries by many nations. There are also artisinal fisheries that take place in the Caribbean Sea and in the Gulf of Guinea. Directed recreational fisheries for spearfish are limited due to the fact that the fish are generally located further offshore than other istiophorids. The reported catches of sailfish/spearfish (Task I) for 2003 are 1,310 and 416 mt (2,888,055 and 917,123 lb) for the west and east Atlantic, respectively. The 2001 – 2003 reported catch of unclassified billfish was 12 percent of the reported catch for all billfish and, for some fisheries, this proportion is much greater. This is a problem for species like spearfish for which there is already a paucity of data (SCRS, 2004).

Stock Status and Outlook

Initial stock assessments conducted on spearfish aggregated these landings with sailfish. As mentioned in the Sailfish section, the 2001 assessment included a ‘sailfish only’ in addition to an aggregate sailfish/spearfish assessment. West Atlantic catch levels for sailfish/spearfish combined seem sustainable because, over the past two decades, CPUE and catch levels have remained constant, however, MSY is unknown. As a result, it is unknown whether or not spearfish are experiencing overfishing or are overfished. Spearfish catch levels are shown in Figure 3.24. The SCRS recommends implementing measures to reduce or keep fishing mortality levels constant and evaluating new methods to split sailfish and spearfish indices of abundance (SCRS, 2004).

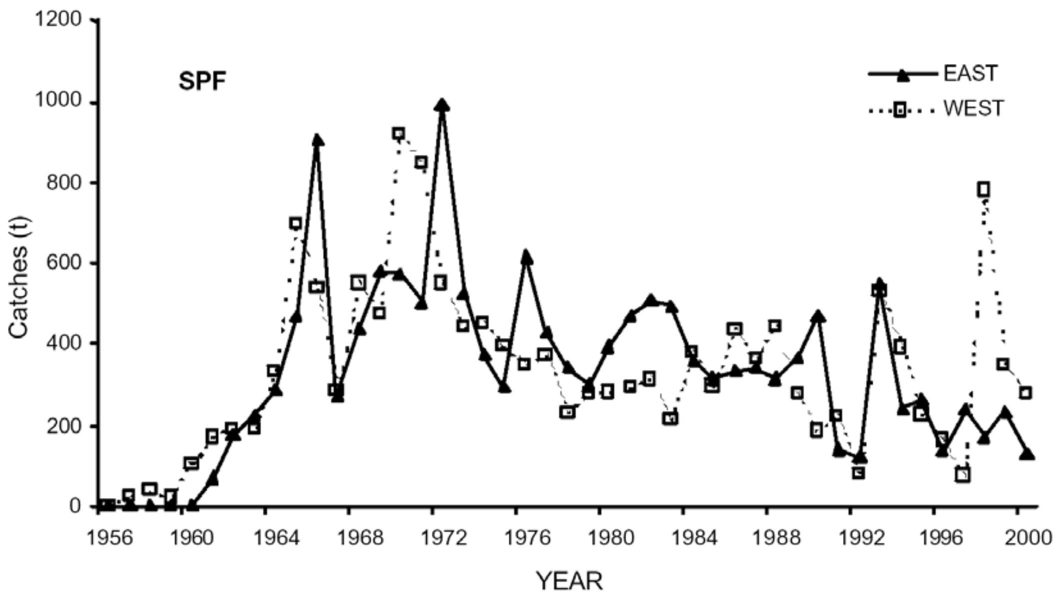

Figure 3.24 Estimated spearfish "only" catches in the Atlantic based on the new procedure for splitting combined sailfish and spearfish catches from 1956-2000. Weights are in metric tons, whole weight. Source: SCRS, 2005.

Effect of Regulations

ICCAT Management Recommendations

No ICCAT management regulations are currently in effect for Atlantic longbill spearfish. Management recommendations are similar to those listed for sailfish, including: consider methods for Contracting Parties to reduce mortality rates, encourage Contracting Parties to provide complete reporting of spearfish catches, evaluate new methods to split the sailfish and spearfish catch/index abundance, and assess sailfish independently of spearfish.

Domestic Regulations

Please see the discussion of domestic regulations contained in section 3.2.4.1, above.

Recent and Ongoing Research

Please see the discussion of recent and ongoing research contained in section 3.2.4.1, above.

3.2.5 Atlantic Sharks

3.2.5.1 Life History/Species Biology

Sharks belong to the class Chondrichthyes (cartilaginous fishes) that also includes rays, skates, and deepwater chimaeras (ratfishes). From an evolutionary perspective, sharks are an old group of fishes characterized by skeletons lacking true bones. The earliest known sharks have been identified from fossils from the Devonian period, over 400 million years ago. These primitive sharks were small creatures, about 60 to 100 cm long, that were preyed upon by larger armored fishes that dominated the seas. The life span of all shark species in the wild is not known, but it is believed that many species may live 30 to 40 years or longer.

Relative to other marine fish, sharks have a very low reproductive potential. Several important commercial species, including large coastal carcharhinids, such as sandbar (*Carcharhinus plumbeus)* (Casey and Hoey, 1985; Sminkey and Musick, 1995; Heist *et al*., 1995), lemon (*Negaprion brevirostris)* (Brown and Gruber, 1988), and bull sharks (Branstetter and Stiles, 1987), do not reach maturity until 12 to 18 years of age. Various factors determine this low reproductive rate: slow growth, late sexual maturity, one to two-year reproductive cycles, a small number of young per brood, and specific requirements for nursery areas. These biological factors leave many species of sharks vulnerable to overfishing.

There is extreme diversity among the approximately 350 species of sharks, ranging from tiny pygmy sharks of only 20 cm (7.8 in) in length to the giant whale sharks, over 12 meters (39 feet) in length. There are fast-moving, streamlined species such as mako (*Isurus* spp.*)* and thresher sharks (*Alopias* spp.), and sharks with flattened, ray-like bodies, such as angel sharks (*Squatina dumerili)*. The most commonly known sharks are large apex predators including the white (*Carcharadon carcharias*), mako, tiger (*Galeocerdo cuvier*), bull (*Carcharhinus leucas)*, and great hammerhead (*Sphyrna mokarran*). Some shark species reproduce by laying eggs, others nourish their embryos through a placenta. Despite their diversity in size, feeding habits, behavior and reproduction, many of these adaptations have contributed greatly to the evolutionary success of sharks.

The most significant reproductive adaptations of sharks are internal fertilization and the production of fully developed young or "pups." These pups are large at birth, effectively reducing the number of potential predators and enhancing their chances of survival. During mating, the male shark inseminates the female with copulatory organs, known as claspers that develop on the pelvic fins. In most species, the embryos spend their entire developmental period protected within their mother's body, although some species lay eggs. The number of young produced by most shark species in each litter is small, usually ranging from two to 25, although large females of some species can produce litters of 100 or more pups. The production of fully-developed pups requires great amounts of nutrients to nourish the developing embryo.

Traditionally, these adaptations have been grouped into three modes of reproduction: oviparity (eggs hatch outside body), ovoviviparity (eggs hatch inside body), and viviparity (live birth).

Adults usually congregate in specific areas to mate and females travel to specific nursery areas to pup. These nurseries are discrete geographic areas, usually in waters shallower than those inhabited by the adults. Frequently, the nursery areas are in highly productive coastal or estuarine waters where abundant small fishes and crustaceans provide food for the growing pups. These areas also may have fewer large predators, thus enhancing the chances of survival of the young sharks. In temperate zones, the young leave the nursery with the onset of winter; in tropical areas, young sharks may stay in the nursery area for a few years.

Shark habitat can be described in four broad categories: (1) coastal, (2) pelagic, (3) coastal-pelagic, and (4) deep-dwelling. Coastal species inhabit estuaries, the nearshore and waters of the continental shelves, *e.g.*, blacktip (*Carcharhinus limbatus*), finetooth, bull, lemon, and sharpnose sharks (*Rhizoprionondon terraenovae*). Pelagic species, on the other hand, range widely in the upper zones of the oceans, often traveling over entire ocean basins. Examples include shortfin mako (*Isurus oxyrinchus*), blue (*Prionace glauca*), and oceanic whitetip (*Carcharhinus longimanus*) sharks. Coastal-pelagic species are intermediate in that they occur both inshore and beyond the continental shelves, but have not demonstrated mid-ocean or transoceanic movements. Sandbar sharks are examples of a coastal-pelagic species. Deep-dwelling species, *e.g.*, most cat sharks (*Apristurus* spp.) and gulper sharks (*Centrophorus* spp.) inhabit the dark, cold waters of the continental slopes and deeper waters of the ocean basins.

Seventy-three species of sharks are known to inhabit the waters along the U.S. Atlantic coast, including the Gulf of Mexico and the waters around Puerto Rico and the U.S. Virgin Islands. Thirty-nine species are managed by HMS; spiny dogfish also occur along the U.S. coast, however management for this species is under the authority of the Atlantic States Marine Fisheries Commission as well as the New England and Mid-Atlantic Fishery Management Councils. Deep-water sharks were removed from the management unit in 2003. Based on the ecology and fishery dynamics, the sharks have been divided into four species groups for management: (1) large coastal sharks, (2) small coastal sharks, (3) pelagic sharks, and (4) prohibited species (Table 3.16).

Table 3.16 Common names of shark species included within the four species management units under the purview of the HMS management division.

Management Unit	Shark Species Included
Large Coastal Sharks (11)	Sandbar, silky, tiger, blacktip, bull, spinner, lemon, nurse, smooth hammerhead, scalloped hammerhead, and great hammerhead sharks
Small Coastal Sharks (4)	Atlantic sharpnose, blacknose, finetooth, and bonnethead sharks
Pelagic Sharks (5)	Shortfin mako, thresher, oceanic whitetip, porbeagle, and blue sharks
Prohibited Species (19)	Whale, basking, sandtiger, bigeye sandtiger, white, dusky, night, bignose, Galapagos, Caribbean reef, narrowtooth, longfin mako, bigeye thresher, sevengill, sixgill, bigeye sixgill, Caribbean sharpnose, smalltail, and Atlantic angel sharks

3.2.5.2 Stock Status and Outlook

NMFS is responsible for conducting stock assessments for the Large and Small Coastal Shark complexes (LCS and SCS) (Cortes, 2002; Cortes *et al*., 2002). ICCAT and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) have recently conducted assessments of three pelagic shark species. Stock assessments were conducted for the LCS and SCS in 2002. NMFS is conducting stock assessments for LCS and SCS in 2006 and 2007, respectively. NMFS also recently released a stock assessment for dusky sharks (May 25, 2006, 71 FR 30123). Species-specific assessments for blacktip and sandbar sharks within the LCS complex and finetooth sharks, Atlantic sharpnose sharks, blacknose sharks (*Carcharhinus acronotus*), and bonnethead sharks (*Sphyrna tiburo*) within the SCS complex, were also conducted in 2002. The conclusions of these assessments are summarized in Table 3.18 and Table 3.17 and are fully described in Amendment 1 to the 1999 Atlantic Tunas, Swordfish, and Sharks FMP. Summaries of recent stock assessments and reports on several species of pelagic sharks (blue sharks, shortfin mako sharks, and porbeagle sharks (*Lamna nasus*) by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and ICCAT are also included in this section. More detailed information on life history and distribution of sharks can be found in Appendix B (EFH).

3.2.5.3 Large Coastal Sharks

The last LCS stock assessment was held in June 2002, however, results from a new stock assessment should be released in 2006. Discussions of the 2002 stock assessment focused on the availability of four additional years worth of catch estimates, biological data, catch rate series, and the types of models that should be used. The modeling itself was performed after the Shark Evaluation Workshop and incorporated new catch and effort estimates for the years 1998 – 2001 as well as over 20 catch-per-unit-effort (CPUE) series for the LCS complex, sandbar, and blacktip sharks (

Table 3.17).

A variety of stock assessment models were used to investigate the population dynamics of LCS including: (1) a non-equilibrium Schaefer biomass dynamic model using the sampling/importance re-sampling (SIR) algorithm (Bayesian SPM) and several weighting schemes; (2) a non-equilibrium Schaefer state-space surplus production model (SSSPM) using a Markov Chain Monte Carlo (MCMC) method for numerical integration; (3) a lagged recruitment, survival, and growth (SSLRSG) state-space model; (4) the maximum likelihood estimation model (MLE); and (5) a fully age-structured, state-space population dynamic model (ASPM). General descriptions of these models can be found in the stock assessment. The use of multiple approaches in evaluating stock status can reduce uncertainty in the best available data and can balance individual model strengths and weaknesses.

Due to concerns that catch series may underestimate mortality from the commercial fishery, four separate catch scenarios were considered to evaluate catch histories: updated, baseline, and the alternative scenarios. The updated catch scenario was comprised of catches used in the 1998 SEW, including data through 1997, and additional catches for 1998 – 2001. The baseline catch scenario included similar information and discards from the menhaden fishery, and Mexican catches, bottom longline discards back to 1981, and commercial and recreational catches back to 1981. The alternative scenario reconstructed historical catches back in time (calendar years 1960 – 2001) and applied to the LCS complex only. The age-structured models for sandbar and blacktip shark included both updated and baseline scenarios in which specific catch series were linked to specific catchability and selectivity parameters. The alternative scenarios were used for sandbar and blacktip shark catch history evaluation.

Catch rates were also analyzed for other species included in the LCS complex such as tiger, hammerhead, dusky, and silky shark. Generally, commercial data indicate increasing catch rates for tiger shark (Brown and Cramer, 2002; Cortes *et al.*, 2002) as well as decreasing trends for dusky shark, sand tiger shark, and hammerhead shark (Brown, 2002; Cortes *et al.*, 2002; Brown and Cramer, 2002). Recreational catch data for hammerhead and bull shark point towards declining trends for both species (Cortes *et al.*, 2002).

Considering the outputs of all model analyses combined, the assessment results were considerably more pessimistic for the LCS aggregate as compared to those for individual species within the complex (*i.e.*, sandbar and blacktip sharks). While results illustrate improvements in the LCS complex since 1998, all of the models and catch scenarios described above, with the exception of the Bayesian SPM scenario which used only fishery-independent CPUE series, indicate that overfishing may be occurring and that the LCS complex may be overfished. Tables 3.4 and 3.5 provide biomass and fishing mortality estimates used to make these determinations. As such, the stock assessment finds that at least a 50-percent reduction in 2000 catch levels for the complex could be required for the biomass to reach maximum sustainable yield (MSY) in 10, 20 or 30 years. Furthermore, a 20-percent reduction in 2000 catch levels for the complex would result in less than a 50-percent probability of achieving MSY even after 30 years of implementation under those catch levels. Overall, the stock assessment found that the LCS complex as a whole is overfished and overfishing is occurring (Cortes *et al.*, 2002).

The assessment acknowledges that the results between the complex and sandbar and blacktip sharks may be considered conflicting, given that sandbar and blacktip sharks comprise the majority of LCS commercial harvests. Specifically, sandbar and blacktip sharks make up approximately 44 percent of the total commercial catch (Burgess and Morgan, 2003) and over 70 percent of the landings (Cortes and Neer, 2002). The remainder of the catch is comprised mostly of tiger, scalloped hammerhead, silky, and sand tiger, with catch composition varying by region (Burgess and Morgan, 2003). These species are less marketable and are often released, so they are reflected in the overall catch but not the landings. Nonetheless, the complex represents a variety of species beyond sandbar and blacktip shark, some of which are in apparent decline.

In December 2002, the peer review process of the 2002 LCS stock assessment was completed as required by a court settlement agreement. The peer reviews were conducted by three separate non-NMFS reviewers who were asked to respond to five questions regarding the appropriateness of specific modeling approaches and the selection there of, consideration of available data and the quality of data sets, application of available data in selected models, reliability of projections, and the effects of various catch scenarios on stock trajectories. Peer review findings were generally positive in that reviewers agreed that a state-of-the-art assessment was performed and that the best available science was employed. Reviewers noted assessment strengths including (1) compilation of several indices of abundance, (2) consideration of multiple stock assessment models, including Bayesian analyses, (3) discussion of myriad alternative harvest policies, and (4) analytical changes to address concerns raised by previous reviewers. Further investigation of catch series indices, assessment of individual species within the LCS complex, investigation of age and age-sex-area assessment models, consideration of alternative harvest policies in contrast to the current constant-catch policy, and NMFS support for observer programs to obtain fishery independent estimates of abundance were among the recommendations offered for improvements to future stock assessment for LCS.

The 2005/2006 stock assessment for LCS follows the Southeast Data, Assessment, and Review (SEDAR) process. This process is a cooperative program designed to improve the quality and reliability of the stock assessments. The SEDAR process emphasizes constituent and stakeholder participation in the assessment development, transparency in the assessment process, and a rigorous and independent scientific review of the completed stock assessment. The Data Workshop for the stock assessment, which documented, analyzed, reviewed, and compiled the data for conducting the assessment, was held from October 31 to November 4, 2005, in Panama City, FL (September 15, 2005, 70 FR 54537; correction October 5, 2005, 70 FR 58190). The Assessment Workshop, which developed and refined the population analyses and parameter estimates, was held from February 6 to February 10, 2006, in Miami, FL (December 22, 2005, 70 FR 76031). At the time of writing this Final HMS FMP, the last workshop, the Review Workshop, had not yet occurred. At the Review Workshop, independent scientists should review the assessment and data. This Workshop should be held on June 5 to June 9, 2006, in Panama City, FL (March 9, 2006, 71 FR 12185). The final results should be released after the review workshop. All reports are posted on SEDAR webpage when complete (http://www.sefsc.noaa.gov/sedar/).

Recently, the SEFSC released the first dusky shark stock assessment (May 25, 2006, 71 FR 30123). Results from all of the models used were similar with all models indicating that the stock is heavily exploited. The stock assessment summarizes relevant biological data, discusses the fisheries affecting the species, and details the data and methods used to assess the stock. At the time of writing this Final HMS FMP, NMFS is reviewing the stock assessment and considering implications for management.

3.2.5.4 Small Coastal Sharks

A stock assessment for small coastal sharks (SCS) was also conducted in 2002. This was the first assessment since 1992 and as such the assessment included new information regarding SCS age and growth, reproduction, and population dynamics. Additional information relative to commercial and recreational catches as well as extended bycatch estimates for the shrimp trawl fishery were also considered.

Trends in catch were analyzed for the SCS complex as well as the four species comprising this aggregate grouping (Table 3.18). Overall, SCS commercial landings exceeded recreational harvest in all years since 1996, with the exception of 2000. Of the four species of SCS analyzed, bonnetheads contributed to over 50 percent of all SCS commercial landings in 1995, but Atlantic sharpnose and finetooth sharks each accounted for over 30 percent of the commercial landings in years 1996 – 1999 and 1998 – 2000 respectively. Atlantic sharpnose dominated recreational catch in all years between 1995 and 2000.

Also, in 2002, researchers at the Mote Marine Laboratory and the University of Florida, conducted a stock assessment for SCS using similar data but different models. The results were similar to the NMFS assessment in that current biomass levels for Atlantic sharpnose, bonnethead, and blacknose were at least 69 percent of the biomass in 1972 while the current biomass level for finetooth sharks was only nine percent the level in 1972 (Simpfendorfer and Burgess, 2002). Both stock assessments note that the data used for finetooth sharks is not as high a quality as the data used for Atlantic sharpnose due to shorter catch-per-unit-effort (CPUE) and catch series, lack of bycatch estimates, and no catches reported in some years.

NMFS intends to conduct a new stock assessment for SCS starting in 2007. The new stock assessment would follow the SEDAR process.

Finetooth Sharks

Additional information on finetooth sharks and the results specific to this species from the 2002 SCS stock assessment are provided in this section because finetooth sharks were the only exception to the results of the assessment, in that fishing mortality in the final five years of data considered was above the mortality level associated with producing MSY. As such, finetooth sharks are not overfished, however, overfishing is occurring (Table 3.17 and Table 3.20). Sections 2.2.2 and 4.2.2 provide more detail on the alternatives that were considered to prevent overfishing of finetooth sharks.

Finetooth sharks inhabit shallow coastal waters to depths of 10 m (32.8 feet) near river mouths in the Gulf of Mexico and South Atlantic Ocean between Texas and North Carolina. These fish often form large schools and migrate to warmer waters when water temperatures drop below 20°C (68°F). Finetooth sharks are relatively productive compared to other sharks as fish are sexually mature at 3.9 (TL = 118 cm (46 inches)) and 4.3 (TL = 123 cm (48 inches)) years for males and females, respectively (Carlson *et al*., 2003). Reproduction in finetooth sharks is viviparous with yolk sac placenta and embryos nourished through a placental connection. Females move into the nursery areas in late May and gestation is approximately 12 months. Each litter can have 1 – 6 pups with individuals measuring 51 – 64 cm (20 – 25 inches) in length. The finetooth shark feeds primarily on mullet, Spanish mackerel, spot, Atlantic menhaden, cephalopods, and crustacean (Bester and Burgess, 2004).

In 2002, NMFS conducted a stock assessment for all SCS, including finetooth sharks. Five catch rate series were used, including fishery-independent and -dependent data. The fishery-independent data sources included the NMFS Pascagoula and Panama City Laboratory longline surveys (NMFS SE LL and NMFS LL PC), and the NMFS Panama City Laboratory Gillnet Survey (NMFS GN). Fishery-dependent catch series data were included from the combined recreational series and the Directed Shark Gillnet Fishery Observer Program (DSGFOP). This catch rate series data were combined with life history information for finetooth sharks and evaluated with several stock assessment models. There were four models utilized for the assessment and numerous scenarios within each model, producing a range of point estimates for fishing mortality, relative fishing mortality, biomass, relative stock biomass, maximum fishing mortality threshold, minimum stock size threshold, and other parameters.

Of the catch series data used in the analysis, three of the five showed a positive trend (*i.e.*, had positive slopes) in catch over time, suggesting an increase in finetooth shark abundance. The catch series data showing positive trends were DSGFOP (0.03), NMFS SE LL (0.34), and NMFS LL PC (0.04); however only the slope for the DSGFOP catch series data was statistically significant different from zero ($P = 0.03$). However, it should be noted that data were missing from some years in the NMFS SE LL and the DSGFOP catch series data; therefore, one cannot necessarily assume that finetooth sharks are increasing in abundance. The other two datasets, NMFS LL PC and NMFS GN PC, had negative trends in catch over time as indicated by their negative slopes (-0.24 and -0.11, respectively) but neither trend was statistically significant from zero. Overall, the slopes for the small coastal shark (SCS) complex as a whole and other individual species were relatively flat, indicating that the relative abundance of the stocks remained fairly stable during the exploitation phase (Cortés, 2002).

Four different stock assessment models were used to evaluate the status of SCS using Bayesian statistical techniques. Results of both surplus production models and the Lagged Recruitment Survival and Growth State Space model (LRSG) (using several different scenarios) indicate that the current level of removals is sustainable for the SCS aggregate and the individual species within the complex. Relative stock biomass and fishing mortality trajectories obtained with the Bayesian state-space Schaefer surplus production model (SPM) for the small coastal aggregate and the Atlantic sharpnose sharks followed similar trends, since the catches were dominated by these species. The model predicted that the stock biomass for the small coastal shark complex in any given year from 1972 – 2000 exceeded the biomass producing MSY. Relative fishing mortality (F/F_{MSY}) was generally below one for the SCS complex, but for finetooth sharks, the final five values of F in the series (1996 – 2002) estimated by the model were above the level of F corresponding to MSY.

Results for finetooth sharks were directly influenced by the catch series used, which did not include any bycatch estimates, and this, in turn, influenced certain parameters of the Bayesian models (specifically, the priors chosen for K, which describes uncertainty in assessment models) (Cortés, 2002). The lack of bycatch data in the catch series data lead to low values of MSY predicted for finetooth sharks in the SCS stock assessment (especially those obtained through the SPM models). This lack of bycatch data and shorter catch and catch per unit effort (CPUE) series, coupled with no catches reported in some years, led to some uncertainty in the stock assessment for finetooth sharks. In the case of finetooth sharks, model estimates of recent F levels are above F_{MSY}, indicating that recent levels of effort directed at this species, if continued, could result in an overfished status in the relatively near future. The various stock assessments models used and sensitivity analyses run support these general conclusions (Cortés, 2002). Future work should continue to monitor the status of this individual species (Cortés, 2002).

Landings of finetooth sharks in other fisheries are extensive; however, catch series data from these fisheries are currently unavailable. The inclusion of such data in future stock assessments will provide better information on both fishing effort and estimates of MSY. Thus, it may be prudent to develop a plan to prevent overfishing that first investigates other sources of fishing mortality before initiating a particular set of management actions. In order to capture additional catch series data on fisheries contributing to finetooth fishing mortality, NMFS is expanding observer programs to include DSGFOP observers on all boats that have directed or incidental shark permits to determine if these gillnet vessels in the South Atlantic are contributing to the majority of fishing mortality. A continuation of a pilot program initiated in the spring of 2005 that placed observers on board additional gillnet vessels targeting other fish species will improve data collection efforts. Furthermore, contacting Regional Fishery Management Councils and Interstate Marine Fisheries Commissions to determine sources of mortality occurring under other fishery management plans, and having finetooth sharks included as a select species for sub-sampling of bycatch in the Gulf of Mexico Shrimp Trawl Observer Program will provide additional landings data necessary for appropriate management and conservation actions in the future.

Table 3.17 Summary Table of Biomass and Fishing Mortality for Large Coastal Sharks (LCS). Source: Cortes *et al*., 2002.

Species/Complex	2001 Biomass (N_{2001})	2001 Relative Biomass (N_{2001}/N_{MSY})	Fishing Mortality Rate (F_{2001})	Maximum Fishing Mortality Threshold (F_{MSY})	Outlook
Large Coastal Complex	2,940-10,156	0.46-1.18	0.07-0.21	0.05-0.10	Overfished; Overfishing is occurring
Sandbar Sharks	1,027-4.86 E-8	3.25E4-2.22	0.0001-0.70	0.05-0.46	Not overfished; Overfishing is occurring
Blacktip Sharks	5,587-3.16 E7	0.79-1.66	0.01-0.21	0.06-0.18	Not overfished; No overfishing occurring

Table 3.18 Summary Table of Biomass and Fishing Mortality for Small Coastal Sharks (SCS) Source: Cortes, 2002.

Species/Complex	**MSY mill lb dw**	**2001 Relative Biomass Level (B_{2001}/B_{MSY})**	**Minimum Stock Size Threshold MSST = $(0.5)B_{MSY}$ if M>=0.5 MSST = (1-M)Bmsy if M<0.5**	**Fishing Mortality Rate (F_{2000})**	**Maximum Fishing Mortality Threshold (F_{MSY})**	**Outlook**
Small Coastal Sharks (SCS)	7.0-2.2	1.38-2.39	16.2-50.2	0.03-0.24	0.04-0.28	Not overfished; No overfishing occuring
Bonnethead Sharks	1.8-0.5	1.46-2.78	2.3-7.3	0.03-0.18	0.05-0.53	Not overfished; No overfishing occuring
Atlantic Sharpnose Sharks	7.8-1.9	1.69-3.16	11.5-33.4	0.02-0.06	0.04-0.42	Not overfished; No overfishing Occurring
Blacknose Sharks	0.8-0.2	1.92-3.15	1.6-4.5	0.02-0.19	0.03-0.32	Not overfished; No overfishing Occurring

Table 3.19 **Summary table of the status of the biomass of finetooth sharks.** Sources: 2002 SCS stock assessment; E. Cortes, personal communication. **LRSG=lagged recruitment, survival, and growth model; SPM=surplus production model**

Species	Model	Current Biomass B_{2001}	B_{MSY}	Current Relative Biomass Level B_{2001}/B_{MSY}	Over-fished?	Minimum Stock Size Threshold MSST = (1-M)B_{MSY} if M<0.5 MSST = 0.5 B_{MSY} if M>=0.5	Minimum Biomass Flag Bflag = (1-M)B_{OY}	Biomass Target B_{OY} = 125%B_{MSY}	MSY (million lb dw)	Outlook
Finetooth Sharks	Bayesian LRSG using Gibbs sampler	1.9	0.8	2.37	No	0.4 to 0.7	0.5 to 0.8	1.00	0.26 (118)	Stock not overfished $B_{2001} > B_{OY}$
	Bayesian SPM using Gibbs sampler	2.3	1.65	1.39	No	0.8 to 1.4	1.0 to 1.7	2.06	0.05 (23)	

Table 3.20 **Summary table of the status of the biomass of finetooth sharks.** Sources: 2002 SCS stock assessment; E. Cortes, personal communication. **LRSG=lagged recruitment, survival, and growth; SPM=surplus production model.**

Species	Model	Current F F_{2000}	Maximum Fishing Mortality Threshold MFFT = F_{MSY}	Current Relative fishing Mortality Rate F_{2000}/F_{MSY}	Over-fishing?	Fishing Mortality Target $F_{OY} = 0.75F_{MSY}$	Management Measures to Reduce Fishing Mortality Required? $F_{2000} > F_{OY}$	Outlook
Finetooth Sharks	Bayesian LRSG using Gibbs sampler	1.50	0.44	3.42	YES	0.33	YES	OVERFISHING
	Bayesian SPM using Gibbs sampler	0.13	0.03	4.13	YES	0.02	YES	

3.2.5.5 Pelagic Sharks

Pelagic sharks are subject to exploitation by many different nations and exhibit trans-oceanic migration patterns. As a result, ICCAT's Standing Committee on Research and Statistics (SCRS) Subcommittee on Bycatch has recommended that ICCAT take the lead in conducting stock assessments for pelagic sharks.

An ICCAT meeting was held in September 2001 to review available statistics for Atlantic and Mediterranean pelagic sharks. Newly available biological and fishery information presented for review included age and growth, length/weight relationships, species identification, species composition of catch, catch per unit effort, mortality (both natural and fishing estimates for blue sharks), bycatch, and tagging and migration studies. Landings estimates, which incorporated data for both the Atlantic and Mediterranean populations of blue shark, suggested that landings declined in 2000 (3,652 mt) following a peak of 32,654 mt in 1999. Landings of porbeagles peaked in 1997, with an estimated total of 1,450 mt, and have slowly declined each year since that time period (1998 – 2000). Similarly, landing estimates for Shortfin mako also peaked in 1997 (5,057 mt) and have declined by 83 percent (863 mt in 2000) since that time. Meeting participants expressed concern regarding the lack of information pertaining to the number of fleets catching sharks, landing statistics, and dead discards for sharks.

The SCRS decided to conduct an assessment of Atlantic pelagic sharks beginning in 2004. Emphasis was placed on blue sharks and shortfin mako sharks. Several models such as non-equilibrium production and statistical age/length-structured models will be considered to analyze the population dynamics of pelagic shark species.

ICCAT Stock Assessment on Blue and Shortfin Mako Sharks

At the 2004 Inter-Sessional Meeting of the ICCAT Subcommittee on bycatch, stock assessments for Atlantic blue shark (*Prionace glauca*) and shortfin mako (*Isurus oxyrinchus*) were conducted. This work included a review of their biology, a description of the fisheries, analyses of the state of the stocks and outlook, analyses of the effects of current regulations, and recommendations for statistics and research. The assessment indicated that the current biomass of North and South Atlantic blue shark seems to be above MSY ($B>B_{MSY}$), however, these results are conditional and based on assumptions that were made by the committee. These assumptions indicate that blue sharks are not currently overfished, again, this conclusion is conditional and based on limited landings data. The committee estimates that between 82,000 and 114,000 mt ww (180,779,054 – 251,326,978 lb) of blue shark are harvested from the Atlantic Ocean each year.

The North Atlantic shortfin mako population has experienced some level of stock depletion as suggested by the historical CPUE trend and model outputs. The current stock may be below MSY ($B<B_{MSY}$), suggesting that the species may be overfished. Overfishing may also be occurring as between 13,000 and 18,000 mt ww (28,660,094 – 39,683,207 lb) of shortfin mako are harvested in the Atlantic Ocean annually. South Atlantic stocks of shortfin mako shark are likely fully exploited as well, but depletion rates are less severe than in the North Atlantic.

The results of both of these assessments should be considered preliminary in nature due to limitations on quality and quantity of catch data available (SCRS, 2004). The subcommittee stated that catch data currently being reported to ICCAT does not represent the total catch actually landed, and are very limited with regard to size, age, and sex of shark harvested or caught incidentally. In order to attain a more accurate estimate of total landings, and improve future stock assessments, the committee made several recommendations, including: increase the infrastructure investment for monitoring the overall catch composition of sharks, standardize catch per unit effort (CPUE) from major fishing fleets, expand use of trade statitistics (fins) to extend historical time series, and include scientists from all Contracting Parties with significant blue and shortfin mako catches in future assessments (SCRS, 2004).

COSEWIC Stock Assessment on Porbeagle

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) conducted a species report and assessment for porbeagle in 2004. They suggest that significant declines in porbeagle abundance have occurred as a result of overexploitation in fisheries. In 2001, porbeagle biomass was estimated at 4,409 mt ww (9,720,181 lb), a decline of 89 percent from the pre-fishing biomass in 1961 (COSEWIC, 2004). The model employed predicts that populations declined precipitously after the fishery was developed in 1961, recovered slightly in the 1980s, and then declined again to the current level. Porbeagle quotas have been reduced significantly for Canadian fisheries. NMFS is interested in working with the Canadian government to address concerns raised by the COSEWIC report. Currently, NMFS has a species-specific quota of 92 mt dw (202,823 lb) for porbeagle. These fish are generally harvested incidentally in the pelagic longline fisheries. Between 2000 and 2003, landings of porbeagle were approximately 3.4 mt dw for the four fishing years, combined (0.85 mt dw/year). NMFS is currently reviewing the latest Canadian stock assessment in terms of the overfishing and overfished thresholds defined in the FMP. At this time, the status of porbeagle sharks is unknown; however, if the stock is found to meet the thresholds, the status would be redefined.

3.2.5.6 Effects of Regulations

Atlantic sharks have been managed by NMFS since the 1993 FMP for Atlantic Sharks. The 1999 FMP for Atlantic Tunas, Swordfish, and Sharks addressed numerous shark management measures, including: reducing commercial LCS and SCS quotas; establishing a commercial quota for blue sharks and a species-specific quota for porbeagle sharks; expanding the list of prohibited shark species; implementing a limited access permitting system in commercial fisheries; and establishing season-specific over- and under-harvest adjustment procedures. The 1999 FMP also partitioned the LCS complex into ridgeback and non-ridgeback categories but did not include regional quota measures. Due to litigation, many management measures in the 1999 FMP were not implemented.

The final rule implementing Amendment 1 to the 1999 FMP was published in the Federal Register on December 23, 2003. This final rule revised the shark regulations based on the results of the 2002 stock assessments for SCS and LCS. Results of these stock assessments indicate the SCS complex is not overfished (e.g. depleted in abundance) and overfishing is not occurring; the LCS complex continues to be overfished, and overfishing is occurring; sandbar sharks are not overfished, but overfishing is occurring; blacktip shark stocks are rebuilt and healthy; and finetooth sharks are not overfished, but overfishing is occurring. In Amendment 1 to the 1999 FMP, NMFS revised the rebuilding timeframe for LCS to 26 years from 2004, and implemented several new regulatory changes. Management measures enacted in the amendment included: re-aggregating the large coastal shark complex; using maximum sustainable yield (MSY) as a basis for setting commercial quotas; eliminating the commercial minimum size restrictions; implementing a commercial trip limit for LCS and SCS; implementing trimester commercial fishing seasons effective January 1, 2005; imposing gear restrictions to reduce bycatch; implementing a time/area closure off the coast of North Carolina effective January 1, 2005; and establishing three regional commercial quotas (Gulf of Mexico, South Atlantic, and North Atlantic) for LCS and SCS management units. For more detail on the management history surrounding shark regulations see Section 3.1.

As a result of using the MSY as a basis for setting quotas and implementing a new rebuilding plan, the overall quota for LCS in 2004 of 1,017 metric tons (mt) dressed weight (dw) (2.24 million lbs dw) was lower than both the 2002 LCS quota of 1,285 mt dw (2.83 million lbs dw) and the 2003 LCS quota of 1,714 mt dw (3.78 million lbs dw). The annual SCS quota is 454 mt dw per year. The annual quotas for pelagic sharks are 273 mt dw for blue sharks, 92 mt dw for porbeagle sharks, and 488 mt dw for pelagic sharks other than porbeagle and blue sharks.

The regulations governing the recreational and commercial shark fisheries allow opportunities for participants to pursue sharks for leisure, subsistence, and/or commercial gain while maintaining compliance with statutes that include, but are not limited to, the Magnuson Stevens Act, Endangered Species Act, Marine Mammal Protection Act, and the National Environmental Policy Act. These regulations seek to minimize bycatch of non-target, prohibited shark species, and protected resources by a variety of measures, including, but not limited to: mandating the use of corrodible, non-stainless steel hooks; requiring possession of handling and release equipment for protected resources (long handled line cutters and dipnets); conducting gillnet checks every two hours; mandatory observer coverage for commercial fisheries (if selected); limits on the deployment and operation of authorized gears; and, maintaining 19 species of shark on the prohibited species list (possession not authorized). Rebuilding overfished stocks is another objective of shark fishery regulations, and is accomplished through numerous measures, including, but not limited to: regional and trimester fishing quotas based on MSY; regional and trimester fishing seasons; commercial trip limits (4,000 lbs dw for LCS); recreational bag limits (1 shark/vessel/day for all authorized species except Atlantic sharpnose and bonnethead sharks (1 shark/person/day); and, recreational minimum size limits (>54" FL for all authorized species except Atlantic sharpnose and bonnethead sharks). Controlling fishing effort is accomplished by the requirement to possess a limited access permits for commercial shark fisheries and upgrading restrictions for transferred permits. Reducing fishing mortality of prohibited dusky sharks and juvenile sandbar sharks is achieved by the Mid-Atlantic time area closure (January 1 – July 31) and the requirement to use VMS when bottom longline gear is onboard during this time period.

Shark landings are monitored for adherence to regional and trimester quotas by requiring the submission of shark dealer landings reports every two weeks. Fishermen must also submit trip reports describing target and incidental landings within seven days of offloading. These data are used for stock assessments. Regulations are subject to change based on stock assessments, international obligations, litigation, and public sentiment. An updated LCS stock assessment should be available in 2006 and data workshops for an updated SCS stock assessment are scheduled to begin in early 2007. Domestic management measures affecting the U.S. shark fishery are constantly being evaluated for their effectiveness; furthermore, the United States is taking steps to improve the conservation and management of pelagic sharks within international fora, including ICCAT.

At the 2004 ICCAT annual meeting in New Orleans, ICCAT adopted a recommendation concerning the conservation of sharks caught in association with fisheries managed by ICCAT. This was the first binding measure passed by ICCAT dealing specifically with sharks. This recommendation includes, among other measures: reporting of shark catch data by Contracting Parties, a ban on shark finning, a request for Contracting Parties to live-release sharks that are caught incidentally, a review of management alternatives from the 2004 assessment on blue and shortfin mako sharks, and a commitment to conduct another stock assessment of selected pelagic shark species no later than 2007. In 2005, additional measures pertaining to pelagic sharks were added to the 2004 ICCAT recommendation. Measures included a requirement for contracting parties that have not yet implemented the 2004 recommendation, to reduce shortfin mako mortality, and annually report on their efforts to the commission.

3.2.5.7 Recent and Ongoing Research

Northeast Fisheries Science Center

Fishery Independent Survey for Coastal Sharks

The biannual fishery independent survey of Atlantic large and small coastal sharks in US waters from Florida to Delaware was conducted from April 19 to June 1, 2004. The goals of this survey are to: (1) monitor the species composition, distribution, and abundance of sharks in the coastal Atlantic; (2) tag sharks for migration and age validation studies; (3) collect biological samples for age and growth, feeding ecology, and reproductive studies; and (4) collect morphometric data for other studies. Results from this 2004 survey included 557 sharks representing eight species caught on 69 longline sets. The time series of abundance indices from this survey are critical to the evaluation of coastal Atlantic shark species.

Age and Growth of Coastal and Pelagic Sharks

A comprehensive aging and validation study for the shortfin mako (*Isurus oxyrinchus)*, continued in conjunction with scientists at Moss Landing Marine Laboratories, California using bomb carbon techniques. Additional validation studies have begun on the sandbar shark, (*Carcharhinus plumbeus),* dusky shark, (*Carcharhinus obscurus),* tiger shark, (*Galeocerdo cuvieri)*, and white shark, (*Carcharodon carcharias)*. Age and growth studies on the tiger shark (with scientists at the University of New Hampshire), thresher shark, (*Alopias vulpinus)* (with scientists at the University of Rhode Island), night shark, (*Carcharhinus signatus)* (with NMFS scientists at the SEFSC Panama City Laboratory), and the bull shark, (*Carcharhinus leucas)* (with scientists with the Florida Division of Natural Resources) are underway. Collection, processing, photographing, and reading of samples are in various stages for these species including intercalibration of techniques, criteria, and band readings. This intercalibration process involves sharing samples and comparing counts between researchers including a researcher from the Natal Sharks Board, South Africa for joint work on shortfin mako, blue, and basking shark band periodicity. Collections of vertebra took place at tournaments and on the biannual research cruise with 285 sharks injected with OTC for validation. Night and dusky sharks were prepared with gross sectioning to determine the best method for reading and all processing was initiated using histology. Readings were completed on the thresher and tiger sharks towards intercalibration to generate bias graphs. Vertebrae, length-frequency data, and tag/recapture data collected from 1962 to present are being analyzed on each of these species to obtain growth parameters.

Biology of the Thresher Shark

Life history studies of the thresher shark continued. Data collection was augmented to include reproductive and food habits, in addition to age and growth information.

Biology of the Porbeagle Shark

A cooperative U.S./Canada research program continued on the life history of the porbeagle shark, (*Lamna nasus)* with preliminary analysis of porbeagle tagging and recaptures data using information from U.S., Canadian, and Norwegian sources.

Collection of Recreational Shark Fishing Data and Samples

Biological samples for age and growth, feeding ecology, and reproductive studies and catch data for pelagic sharks were collected at recreational fishing tournaments in the Northeast. Analysis of these tournament landings data was initiated by creating a database of historic information (1961 – 2004) and producing preliminary summaries of one long term tournament. The collection and analysis of these data are critical for input into species and age specific population and demographic models for shark management.

Cooperative Shark Tagging Program (CSTP)

The Cooperative Shark Tagging Program, operated by the Northeast Fisheries Science Center, has involved over 6,500 volunteer recreational and commercial fishermen, scientists, and fisheries observers conducted since 1962, continued to tag large coastal and pelagic sharks and provide information to define essential fish habitat for shark species in U.S. Atlantic and Gulf of Mexico waters. Since its inception, the CSTP has tagged over 128,000 sharks representing 40 species.

Atlantic Blue Shark Life History and Assessment Studies

A collaborative program to examine the biology and population dynamics of the blue shark, *Prionace glauca,* in the North Atlantic is ongoing. Research on the food and feeding ecology of the blue shark is being conducted cooperatively with University of Rhode Island staff with additional samples collected and a manuscript under revision. A detailed reexamination of the reproductive parameters of the blue shark continued with collection of additional biological samples to determine if any changes have occurred since the 1970s. A manuscript on blue shark stock structure based on tagging data was completed detailing size composition and movements between Atlantic regions. Additionally, a research focus on the population dynamics in the North Atlantic with the objectives of constructing a time series of blue shark catch rates (CPUE) from research surveys, estimation of blue shark migration and survival rates, and the development of an integrated tagging and population dynamics model for the North Atlantic for use in stock assessment continued in collaboration between NEFSC scientists and scientists at the School of Aquatic and Fishery Sciences, University of Washington. Progress to date includes the preliminary recovery of historical research survey catch data, size composition, and biological sampling data on pelagic sharks and preliminary analysis of survival and movement rates for blue sharks based on tag and release data from the NMFS CSTP. Preparation of standardized catch rate and size composition data compatible with pelagic longline observer data continued with a resulting ICCAT submission. As part of this comprehensive program, cooperative research continued with the Irish Marine Institute and Central Fisheries Board on mark-recapture databases including coordination of formats and programs with the NMFS CSTP for joint data analyses.

Atlantic Shortfin Mako Life History and Assessment Studies

A collaborative program with students and scientists at the University of Rhode Island to examine the biology and population dynamics of the shortfin mako in the North Atlantic was continued. Ongoing research included an update on age and growth and reproductive parameters and an examination of the predator-prey relationships between the shortfin mako and its primary prey, bluefish (*Pomatomus saltatrix)*. A manuscript was completed comparing contemporary and historic levels of bluefish predation. Future research includes the estimation of shortfin mako migration rates and patterns and survival rates using CSTP mark/recapture data and satellite tags with movements correlated with Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature data. Toward these goals, two shortfin mako sharks were tagged with pop-up archival transmitting tags.

Blacktip Shark Migrations

Analysis of movements of the blacktip shark (*Carcharhinus limbatus)* in the western North Atlantic and Gulf of Mexico based on release and recapture data is ongoing with the examination of general migration patterns and exchange between and within regions of U.S. and Mexican waters. Release and recapture data were analyzed for evidence of Atlantic and Gulf primary and secondary blacktip nursery grounds.

Cooperative Atlantic States Shark Pupping and Nursery Survey (COASTSPAN)

NEFSC Apex Predators Program staff manages and coordinates this project that uses researchers in major coastal Atlantic states from Florida to Delaware to conduct a cooperative, comprehensive, and standardized investigation of valuable shark nursery areas. This research identifies which shark species utilize coastal zones as pupping and nursery grounds, gauges the relative importance of these areas, and determines migration and distribution patterns of neonate and juvenile sharks. This program is described in further detail in Section 3.3 of this document.

Juvenile Shark Survey for Monitoring and Assessing Delaware Bay Sandbar Sharks

NEFSC staff conduct this part of the COASTSPAN monitoring and assessment project for the juvenile sandbar shark population in the Delaware Bay nursery grounds using monthly longline surveys from June to September each year. A random stratified sampling plan based on depth and geographic location is ongoing to assess and monitor the juvenile sandbar shark population during the nursery season. In addition, the tagging and recapture data from this project are being used to examine the temporal and spatial relative abundance and distribution of sandbar sharks in Delaware Bay.

Habitat Utilization, Food Habits, and Essential Fish Habitat of Delaware Bay Sandbar and Smooth Dogfish Sharks

The food habits portion of the study characterizes the diet, feeding periodicity, and foraging habits of the sandbar shark as well as examines the overlap in diet and distribution with the smooth dogfish shark (*Mustelus canis)*. Stomach contents from over 800 sandbar sharks and over 200 smooth dogfish sharks have been sampled through a non-lethal lavage method. Acquired data will be coupled with environmental data, providing information on preferred habitat. This information is an important contribution towards understanding essential fish habitat and provides information necessary for nursery ground management and rebuilding of depleted shark populations.

Ecosystems Modeling

Ecosystem modeling, focusing on the role of sharks as top predators, will be conducted using ECOPATH - ECOSIM models, using the sandbar shark as a model species and examining the ecological interactions between sandbar and smooth dogfish sharks in Delaware Bay.

Overview of Gulf and Atlantic Shark Nurseries

Due to the requirement for a better understanding of shark nursery habitat in U.S. coastal waters, NEFSC staff serves as editors for an American Fisheries Society symposium proceedings volume on U.S. Atlantic and Gulf of Mexico coastal shark nursery ground and habitat studies.

Post-Release Recovery and Survivorship Studies in Sharks – Physiological Effects of Capture Stress

This ongoing research is directed towards the sandbar shark (*Carcharhinus plumbeus)*, and is being conducted cooperatively with Massachusetts Division of Marine Fisheries biologists. The study utilizes blood and muscle sampling methods in addition to acoustic tracking to obtain physiological profiles of individual sharks to characterize stamina and to determine ultimate post release survival. These analyses are requisite in view of the extensive current and proposed catch-and-release management strategies for coastal and pelagic shark species.

Southeast Fisheries Science Center

Stock Assessments of Pelagic, Large Coastal, and Prohibited Sharks

The ICCAT Subcommittee on Bycatch conducted a stock assessment of blue sharks and shortfin makos in Tokyo, Japan, in June 2004. All information available on biology, fisheries, stock identity, catch, CPUE, and size of these species was reviewed and an evaluation of the status of stocks conducted using surplus production, age-structured, and catch-free stock assessment models. U.S. scientists contributed eight working documents for this meeting on various aspects of shark biology and methods to assess stock status; SEFSC scientists participated in the assessment process and authored or co-authored six of those documents. A stock assessment of dusky shark, a prohibited species under the shark FMP and candidate for listing under the ESA, is under way with expected completion in summer of 2006. Biological and fishery information available for this species is being synthesized and stock status will be evaluated using multiple stock assessment methodologies. The next assessment of large coastal sharks is planned for FY06, but data collection, synthesis, analysis, and preliminary stock evaluations will begin in late FY05.

Update on Catches of Atlantic Sharks

An update on catches of large and small coastal and pelagic sharks in U.S. Atlantic, Gulf of Mexico, and Caribbean waters was generated in FY 05 for inclusion in the 2005 SAFE Annual Report and future shark stock assessments. Time series of commercial and recreational landings and discard estimates from several sources were compiled for the large coastal shark complex and sandbar and blacktip sharks. In addition, recent species-specific commercial and recreational landings were provided for sharks in the large coastal, small coastal, and pelagic groups. Species-specific information on the geographical distribution of commercial landings by gear type and geographical distribution of the recreational catches was also provided. Trends in length-frequency distributions and average weights and lengths of selected species reported from three separate recreational surveys and in the directed shark bottom-longline observer program were also included. Another update on catches of Atlantic sharks will be generated in FY 06.

Ecosystem Modeling

A dynamic mass-balance ecosystem model was used to investigate how relative changes in fishing mortality on sharks can affect the structure and function of Apalachicola Bay, Florida, a coastal marine ecosystem. Simulations were run for 25 years wherein fishing mortality rates from recreational and trawl fisheries were doubled for ten years and then decreased to initial levels. Effect of time/area closures on ecosystem components were also tested by eliminating recreational fishing mortality on juvenile blacktip sharks. Simulations indicated biomass of sharks declined up to 57 percent when recreational fishing mortality was doubled. Simulating a time/area closure for juvenile blacktip sharks caused increases in their biomass but decreases in juvenile coastal shark biomass, a competing multispecies assemblage that is the apparent competitor. In general, reduction of targeted sharks did not cause strong top-down cascades. Another update on catches of Atlantic sharks was generated in FY05

Elasmobranch Feeding Ecology and Shark Diet Database

The current Fishery Management Plan for Atlantic Tunas, Swordfish, and Sharks gives little consideration to ecosystem function because there is little quantitative species-specific data on diet, competition, predator-prey interactions, and habitat requirements of sharks. Given this, several studies are currently underway describing the diet and foraging ecology, habitat use, and predator-prey interactions of elasmobranchs in various communities. In 2005, a study on latitudinal variation in diet and daily ration of the bonnethead shark from the eastern Gulf of Mexico was completed and a manuscript is being prepared for publication. A database containing information on quantitative food and feeding studies of sharks conducted around the world has been in development for several years and presently includes over 200 studies. This fully searchable database will continue to be updated and fine-tuned in FY 06. The goal is to make this tool available to researchers in the relatively near future.

Cooperative Gulf of Mexico States Shark Pupping and Nursery Survey (GULFSPAN)

The SEFSC Panama City Shark Population Assessment Group manages and coordinates a survey of coastal bays and estuaries between the Panhandle of Florida and Texas. Surveys identify the presence/absence of neonate and juvenile sharks and attempt to quantify the relative importance of each area as it pertains to essential fish habitat requirements for sharks. The SEFSC Panama City Shark Population Assessment Group also initiated a juvenile shark abundance index survey in 1996. The index is based on random, depth-stratified gillnet sets conducted throughout coastal bays and estuaries in northwest Florida monthly from April to October. The species targeted for the index of abundance are juvenile sharks in the large and small coastal management groups. More information on this program can be found in Section 3.3 of this document.

Angel Shark Life History

The Atlantic Angel Shark is a benthic species inhabiting deep waters of the Gulf of Mexico and the Atlantic Ocean. This species is listed as prohibited by the 1999 Fisheries Management Plan for Atlantic Tunas, Swordfish, and Sharks due to the lack of biological data and a precautionary approach for species thought to be highly susceptible to exploitation. Life history studies began in 2003. Samples are obtained from commercial fishers and fishery-independent surveys. Preliminary reproductive parameters were determined in 2004 and results presented at the annual American Elasmobranch Society meeting held in Norman, Oklahoma, in May 2004.

Life History Studies of Elasmobranchs

Biological samples are obtained through research surveys and cruises, recreational fishers, and through collection by onboard observers on commercial fishing vessels. Age and growth rates and other life history aspects of selected species are processed and data analyzed following standard methodology. This information is vital as input to population models incorporating variation and uncertainty in estimates of life-history traits to predict the productivity of the stocks and ensure that they are harvested at sustainable levels. The age and growth parameters of bull shark (*Carcharhinus leucas*) and spinner shark (*C. brevipinna*) were completed and submitted for publication in 2004.

Cooperative Research – Definition of Winter Habitats for Blacktip Sharks in the Eastern Gulf of Mexico

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory is underway to define essential winter habitats for blacktip sharks (*Carcharhinus limbatus*). Deployment of archival Pop-Up Archival Transmitting (PAT) tags on sharks during January and February of FY05 in the Florida Keys and north Florida will be executed with the cooperation of the charterboat industry. PAT tags will be programmed to detach from individuals during late spring and early summer when sharks have recruited to coastal areas.

Cooperative Research – Habitat Utilization among Coastal Sharks

Through a collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory, the utilization of coastal habitats by neonate and young-of-the-year blacktip and Atlantic sharpnose sharks will be monitored through an array of underwater acoustic receivers (VR2, Vemco Ltd.) placed throughout each study site. Movement patterns, home ranges, activity space, survival, and length of residence of individuals will be compared by species and area to provide information to better manage critical species and essential fish habitats.

Cooperative Research – Characterization of Bycatch in the Gulf Butterfish, (*Peprilus burti*), Trawl Fishery, with an Emphasis on Identification of Life History Parameters for several Potentially High-Risk Species

A proposal with the SEFSC Panama City Shark Population Assessment Group and the University of Florida was submitted to MARFIN to quantify and qualify the elasmobranch bycatch in the butterfish, (*Peprilus triacanthus)*, trawl fishery in the Gulf of Mexico. Determination of life history parameters for the roundel skate, (*R. texana)*, the clearnose skate, (*R. eglanteria)*, the spreadfin skate (*Dipturus olseni)*, and the Atlantic angel shark, (*Squatina dumerili)* will be developed ultimately for the estimation of vital rates. Vital rate information will be used to determine the productivity of the stocks and ensure that they are harvested at sustainable levels.

Using elemental chemistry of shark vertebrae to reconstruct large-scale movement patterns of sharks

A project examining ontogenetic shifts in habitat utilization of bull sharks using Sr:Ca ratios of vertebrae will begin in FY06, funds permitting. Laser ablation ICPMS will be used to assay transects across the entire vertebral section along the corpus calcareum. Given the relationship of Sr:Ca to habitat developed from the reference samples, habitat type (freshwater, estuarine, or marine) will be assigned to each growth band, thereby reconstructing the migration history of the shark on a year-by-year basis over its lifetime.

Coastal Shark Assessment Research Surveys

The SEFSC Mississippi Laboratories in Pascagoula have been operating annual research cruises aboard NOAA vessels since 1995. The objectives of this program are to conduct bottom longline surveys to assess the distribution and relative abundance of coastal sharks along U.S. and Mexican waters of the Gulf of Mexico and the U.S. eastern seaboard. This is the only long-term, nearly stock-wide, fishery-independent survey of Atlantic sharks conducted in U.S. and neighboring waters. Ancillary objectives are to collect biological and environmental data, and to tag-and-release sharks. Starting in 2001 and under the auspices of the Mex-US-Gulf Program, the Pascagoula Laboratories have provided logistical and technical support to Mexico's Instituto Nacional de la Pesca to conduct a cooperative research cruise aboard the Mexican research vessel Onjuku in Mexican waters of the Gulf of Mexico. The cruise also took place in 2002, but was suspended in 2003 and 2004 because of mechanical problems with the research vessel and other issues.

A proposal was submitted in 2005 to gather data to help clarify the uncertainty on the current status of oceanic whitetip sharks in the western North Atlantic Ocean. Data on behavior and movement patterns will be collected using on-board observers on pelagic longline vessels. Archival satellite pop-up tags will be utilized to monitor the movement patterns, depth, and temperature preferences of this species. In addition, time-depth recorders, and hook-timers will be used to determine the depth and times at which sharks take baits. These data will be incorporated with sea surface temperature data from satellites and incorporated into new habitat-based analyses of the data to provide a better understanding of the status of oceanic whitetip sharks.

Cooperative Research – The capture depth, time, and hooked survival rate for bottom longline-caught large coastal sharks

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and the University of Florida to examine alternative measures in the shark bottom longline fishery to reduce mortality on prohibited sharks such as reduced soak time, restrictions on the length of gear, and fishing depth restrictions will be tested using hook timers. Funding is being sought through the NMFS Cooperative Research Program.

Utilizing Bioenergetics and Matrix Projection Modeling to Quantify Population Fluctuations in Long-lived Elasmobranchs: Tools for Fisheries Conservation and Management

Under the supervision of SEFSC scientists at the Panama City Laboratory, the NMFS-Sea Grant Fellow in Population Dynamics and Resource Economics conducted research that sought to use a bioenergetics and matrix approach to examine the population dynamics of the cownose ray (*Rhinoptera bonasus*). Laboratory experiments and field data were used to obtain basic life history information, and that information configured the individual-based bioenergetics model. The bioenergetics model was coupled to a matrix projection model, and the coupled models were used to predict how warmer and cooler water temperatures would affect the growth and population dynamics of the cownose rays. Changes in growth rates under the warmer and cooler conditions lead to changes in age-specific survivorship, maturity, and pup production, which were used as inputs to a matrix projection model. Faster growth of individuals under the cooler scenarios translated into an increased population growth rate (4.4 – 4.7 percent/year versus 2.7 percent/year under baseline), shorter generation time, and higher net reproductive rates, while slower growth under the warmer scenarios translated into slower population growth rate (0.05 – 1.2 percent/year), longer generation times, and lower net reproductive rates. Elasticity analysis indicated that population growth rate was most sensitive to adult survival. Reproductive values by age were highest for intermediate ages.

Cooperative Research – Definition of Winter Habitats for Blacktip Sharks in the Eastern Gulf of Mexico

A collaborative effort between SEFSC Panama City Shark Population Assessment Group and Mote Marine Laboratory is underway to define essential winter habitats for blacktip sharks (*Carcharhinus limbatus*). Deployment of two pop-off satellite archival tags (PAT) on sharks during January and February of 2005 in the Florida Keys was accomplished with the cooperation of the charter boat industry. Preliminary results from these two sharks indicate one shark remained in the Keys while the other moved to an area southwest of the coast of Cuba. Additional PAT tags will be placed on sharks during the summer of 2005.

Cooperative Research – Definition of Summer Habitats and Migration Patterns for Bull Sharks in the Eastern Gulf of Mexico

A collaborative effort between SEFSC Panama City Shark Population Assessment Group, University of Florida, and Mote Marine Laboratory is underway to determine summer habitat use and short-term migration patterns of bull sharks (*Carcharhinus leucas*). Sharks are being outfitted with Pop-Up Satellite Archival Tags (PSAT) during July and August of 2005 and scheduled to deploy in autumn. This project is driven by the lack of data for this species and its current prominence within the Florida coastal community. A better understanding of this species is required to effectively manage this species for both commercial and recreational fishers as well as the general public. Concerns regarding this species will continue to be an issue as fishers and the public demand that state and federal governments provide better information concerning the presence and movements of these sharks.

3.3 Habitat

3.3.1 Regulatory Requirements

Section 303(a)(7) of the Magnuson-Stevens Act, 16 U.S.C. §§ 1801 *et seq*., as amended by the Sustainable Fisheries Act in 1996, requires FMPs to describe and identify essential fish habitat (EFH), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat. The Magnuson-Stevens Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." (16 U.S.C. § 1802 (10)). The EFH regulations (at 50 C.F.R. 600 Subpart J) provide additional interpretation of the definition of essential fish habitat:

> "Waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic