STATUS REVIEW REPORT OF ATLANTIC BLUEFIN TUNA (*Thunnus thynnus*)

Prepared by the

Atlantic Bluefin Tuna Status Review Team

for the

National Marine Fisheries Service
National Oceanic and Atmospheric Administration

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ACOE	Army Corps of Engineers
ATCA	Atlantic Tunas Convention Act
BCD	bluefin catch documents
BFT	bluefin tuna
Bmsy	biomass that will support maximum sustainable yield
C	centigrade
CAA	catch-at-age
CAS	catch-at-size
CBA	capture based aquaculture
CBD	Center for Biological Diversity
CDS	catch documentation scheme
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna
CFL	curved fork length
CFR	Code of Federal Regulations
cm	centimeters
COC	Compliance Comittee
COST	Continental Offshore Stratigraphic Test
CPC	Contracting Party, Cooperating non-Contracting Party Entity, or Fishing Entity
CPUE	catch-per-unit-of-effort
CV	coefficient of variation
DDT	dichlorodiphenyl trichloroethane
DEIS	draft environmental impact statement
DFO	Department of Fisheries and Oceans (Canada)
DO	dissolved oxygen
DPS	Distinct Population Segment
DWH	Deepwater Horizon
EEZ	Economic Exclusive Zone
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
ESA	Endangered Species Act
EU	European Union
FAO	Food and Agriculture Organization
FL	fork length
FMP	Fishery Management Plan
FR	Federal Register
GBYP	Grande Bluefin Tuna Year Program
GIS	Geographic Information System
GMFMC	Gulf of Mexico Fishery Management Council
HAPC	habitat area of particular concern
HMS	highly migratory species
ICCAT	International Commission for the Conservation of Atlantic Tunas
in	inches
IPCC	Intergovernmental Panel on Climate Change

IUCN	International Union for Conservation of Nature
IUU	illegal, unreported and unregulated fishing
kg	kilogram
km	kilometer
LNG	liquefied natural gas
LPS	Large Pelagics Survey
MGD	million gallons of seawater per day
mi	miles
mm	millimeters
MMS	Minerals Management Service
MOC	Meridional Overturning Circulation
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSRA	Magnuson-Stevens Fishery Conservation and Management Reauthorization Act
MSY	maximum sustainable yield
mt	metric ton
mtDNA	mitochondrial DNA
NAO	North Atlantic Oscillation
nDNA	nuclear DNA
NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OCS	outer continental shelf
PCBs	polychlorinated biphenyls
PECE	Policy for the Evaluation of Conservation Efforts
PEIS	programmatic environmental impact statement
pers. comm.	personal communication
PFCFL	pectoral fin curved fork length
PS	purse seine
PSAT	pop-up satellite archival tag
SAFE	Stock Assessment and Fishery Evaluation
SPA	Shore Protection Act
SPOIR	significant portion of its range
SRR	Status Review Report
SRT	Status Review Team
SCRS	Standing Committee on Research and Statistics
SSB	spawning stock biomass
SSBmsy	spawning stock biomass that will support maximum sustainable yield
TAC	Total Allowable Catch
TL	total length
VMS	vessel monitoring system
VPA	Virtual Population Analysis
WBFT	western Atlantic bluefin tuna
YOY	young-of-the-year

1. INTRODUCTION AND BACKGROUND

1.1. Petition Background

This document provides a summary of the information gathered for an Endangered Species Act (ESA) status review for Atlantic bluefin tuna (*Thunnus thynnus*). On May 24, 2010, the National Marine Fisheries Service (NMFS) received a petition from the Center for Biological Diversity (CBD), requesting that we list Atlantic bluefin tuna, an Atlantic bluefin tuna distinct population segment (DPS) consisting of one or more subpopulations in United States waters, or the entire species of Atlantic bluefin tuna as endangered or threatened under the ESA and designate critical habitat for the species. The petition contains information on the species, including the taxonomy; historical and current distribution; physical and biological characteristics of its habitat and ecosystem relationships; population status and trends; and factors contributing to the species' decline. The Petitioners also included information regarding possible DPSs of Atlantic bluefin tuna. The petition addresses the five factors identified in section 4(a)(1) of the ESA as they pertain to Atlantic bluefin tuna: (A) current or threatened habitat destruction or modification or curtailment of habitat or range; (B) overutilization for commercial purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; and (E) other natural or man-made factors affecting the species' continued existence.

On September 21, 2010, NMFS determined that the petitioned action may be warranted and published a positive 90-day finding in the *Federal Register* (FR) (75 FR 57431). Following NMFS' positive 90-day finding, NMFS convened an Atlantic bluefin tuna status review team (SRT) to review the status of the species.

In order to conduct a comprehensive review, the SRT was asked by NMFS to assess the species' status and degree of threat to the species with regard to the factors provided in section 4 of the ESA without making a recommendation regarding listing. The SRT was provided a copy of the petition and all information submitted in response to the data request that was specified in the FR notice announcing the 90-day finding. In order to provide the SRT with all available information, NMFS invited several Atlantic bluefin tuna experts to present information on the life history, genetics, and habitat used by Atlantic bluefin tuna to the SRT. NMFS also hosted five listening sessions with bluefin tuna fishermen. These sessions were held in Maine, Massachusetts, New Jersey, North Carolina, and Mississippi. Those with information relevant to the discussion topics for the sessions were also encouraged to submit information via mail or electronic mail. The SRT reviewed all this information during its consideration and analysis of potential threats to the species. This status review report (SRR) is a summary of the information assembled by the SRT and incorporates the best scientific and commercial data available (e.g., fisheries data that are available to assist in assessing the status of the species). In addition, the SRT summarized current conservation and research efforts that may yield protection, and drew scientific conclusions about the status of Atlantic bluefin tuna throughout its range.

1.2. ESA Background

The purposes of the ESA are to provide a means to conserve the ecosystems upon which endangered species and threatened species depend, to provide a program for the conservation of endangered and threatened species, and to take appropriate steps to recover a species. The U.S. Fish and Wildlife Service (FWS) and NMFS share responsibility for administering the ESA; NMFS is responsible for determining whether most marine, estuarine or anadromous species, subspecies, or DPSs are threatened or endangered pursuant to the ESA. To be considered for listing under the ESA, a group of organisms must constitute a "species."

The ESA provides the following definitions:

> *"the term **species** includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature."*
>
> *"**endangered species**" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range."*
>
> "***threatened species***" *is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."*

Additional criteria regarding entities appropriate for listing under the ESA have been set forth. First, there is the ability to identify and list DPSs (61 FR 4722) when a population satisfies the criteria of being discrete and significant.

The process for determining whether a species (as defined above) should be listed is based upon the best available scientific and commercial information. The status is determined from an assessment of factors specified in section 4(a)(1) of the ESA including:

- (A) The present or threatened destruction, modification, or curtailment of its habitat or range;
- (B) Overutilization for commercial, recreational, scientific, or educational purposes;
- (C) Disease or predation;
- (D) Inadequacy of existing regulatory mechanisms;
- (E) Other natural or manmade factors affecting the continued existence of the species.

The available information related to these five factors is described in depth below. Within this SRR, the SRT also summarizes any ongoing or future protective efforts that might possibly abate any risks to Atlantic bluefin tuna. Finally, the SRT considers all of the available information and any protective efforts afforded to the species to determine the risk of Atlantic bluefin tuna becoming extinct.

2. LIFE HISTORY AND BIOLOGY OF BLUEFIN TUNA

Atlantic bluefin tuna (hereafter, in the report referred to as bluefin tuna) are managed domestically by NMFS' Highly Migratory Species (HMS) Management Division and internationally by the International Commission for the Conservation of Atlantic Tunas (ICCAT). ICCAT manages the bluefin tuna population as two separate stocks (eastern and western), separated by the 45°W meridian. In recent years, stock assessments for bluefin tuna have been conducted approximately every two years by the Standing Committee on Research and Statistics (SCRS). The most recent stock assessment was conducted from September 6 to 12, 2010. The SRT has used information from this stock assessment as well as the previous assessment in 2008 to summarize much of the life history information presented below.

2.1. Taxonomy

Class: Actinopterygii
Order: Perciformes
Family: Scombridae
Species: *Thunnus thynnus*, Linnaeus 1758

North Atlantic bluefin tuna (*Thunnus thynnus thynnus*) and North Pacific bluefin tuna (*T. t. orientalis*) were originally considered subspecies; however, morphological and genetic differentiation have led to recognizing both as separate species (Collette and Klein-MacPhee, 2002).

2.2. Species Description

The body of bluefin tuna is spindle shaped, fusiform, and robust with a pointed snout and a thin caudal peduncle. There are two dorsal fins. The body is countershaded with darker colors dorsally and lighter colors ventrally. Coloring on the dorsal surface ranges from black to dark blue with an iridescence of gray or green shimmer. The ventral and lateral surface and cheeks are silvery, and can have gray spots and bands as markings. The pectoral fins originate before the first dorsal fin, are short with a silvery and blackish coloring, and do not reach the origin of the second dorsal fin. The first dorsal fin is triangular, tapers backward from the first spine, and is blackish in color. The second dorsal fin begins close behind the last spine of the first dorsal fin, and is reddish-brown in color. The height of the second dorsal fin is greater than that of the first dorsal fin. The anal fin originates below the last spine of the second dorsal fin, and is dusky with some yellow coloring. The caudal fin is evenly lunate with sharply pointed lobes and is dusky or silvery in color. The caudal keel is colored black as an adult, but semi-transparent when immature. Finlets are yellow, edged in black. There are 34-43 gill rakers on the first gill arch, the liver is striated on the ventral surface, and a large swim bladder is present (Collette and Klein-MacPhee, 2002; NMFS, 2009).

2.3. Life history

Bluefin tuna are highly migratory pelagic fish that range across most of the North Atlantic and its adjacent seas, particularly the Mediterranean Sea. They are the only large pelagic fish living permanently in temperate Atlantic waters (Bard *et al.*, 1998 as cited in Fromentin and Fonteneau, 2001). Archival tagging and tracking information have confirmed that bluefin tuna are endothermic (i.e., able to endure cold as well as warm temperatures while maintaining a stable internal body temperature). It was once thought that bluefin tuna preferentially occupy surface and subsurface waters of the coastal and open-sea areas; however, data from archival tagging and ultrasonic telemetry indicate that they frequently dive to depths of 500 m to 1,000 m (Lutcavage *et al*., 2000). While they do dive frequently to deeper depths, they generally spend most of their time in waters less than 500 m, and often much shallower.

Similar to other large predators, juvenile and adult bluefin tuna are opportunistic feeders (Fromentin and Powers, 2005). Their diet may consist of a variety of species including fish, crabs, octopus, jellyfish, salps, and sponges (Collette and Klein-MacPhee, 2002; Chase, 2002; ICCAT, 2008). Juveniles typically feed on crustaceans, fish and cephalopods while adults are generally piscivorous, primarily eating available baitfish such as herring, anchovy, sand lance, sardine, sprat, bluefish, and mackerel (Chase, 2002; Collette and Klein-MacPhee, 2002; ICCAT, 2008). Zooplankton, primarily copepods, are thought to make up the diet of bluefin tuna larvae (Fromentin and Powers, 2005). While there is limited information regarding feeding migrations both in the Mediterranean and the North Atlantic, electronic tagging results have demonstrated that bluefin tuna movement patterns vary considerably between individuals, years and areas (Lutcavage *et al*., 1999; Block *et al*., 2005).

While bluefin tuna are epipelagic and typically oceanic, they do come close to shore seasonally (Collette and Nauen, 1983). They often occur over the continental shelf and in embayments, especially during the summer months when they feed actively on herring, mackerel, and squids in the North Atlantic. Larger individuals move into higher latitudes than do smaller fish. Changes in important fisheries indicate that apparent variations in the spatial dynamics of bluefin tuna may be the result of interactions between biological factors (e.g., prey distribution), environmental variations and fishing practices.

Bluefin tuna are highly migratory. However, they do display homing behavior and spawning site fidelity in both the Mediterranean Sea and Gulf of Mexico, and these two areas constitute the two primary spawning areas that have been identified to date. However, larvae have been documented outside of the Gulf of Mexico, and the possibility of additional spawning areas cannot be discounted (McGowan and Richards, 1989).

Bluefin tuna are oviparous (i.e., lay eggs) and iteroparous (i.e., spawn regularly), and are multiple batch spawners (Schaefer, 2001). The number of eggs produced is dependent on the size of the fish. Fromentin (2006) determined that fertilization takes place directly in the water column, and hatching occurs without parental care after 2 days. Larvae are pelagic and re-absorb the yolk sac within a few days (Fromentin and Powers, 2005). Atlantic bluefin tuna have not been observed spawning (Richards, 1991); however recent work has identified putative breeding behaviors by bluefin tuna while in the Gulf of Mexico (Teo *et al*., 2007). Presumed Atlantic bluefin tuna breeding behaviors were associated with bathymetry (continental slope waters), sea surface temperature (moderate), eddy kinetic energy (moderate), surface chlorophyll (low concentrations), and surface wind speed (moderate) (Teo *et al*., 2007). Although individuals may spawn more than once a year, it had been assumed that there is a single annual spawning period. However, some authors have suggested that bluefin tuna do not spawn on an annual cycle (Lutcavage *et al*., 1999; Block *et al*., 2005; Fromentin and Powers, 2005; Goldstein *et al*., 2007), or a component of the western stock is spawning somewhere other than the Gulf of Mexico (*e.g.*, in the central North Atlantic or Gulf Stream edge) (Mather *et al*., 1995; Lutcavage *et al*., 1999; Goldstein *et al*., 2007).

There is some debate over the age of maturity of bluefin tuna and very different maturity schedules have been assumed for the putative eastern and western stocks. The apparent differences likely arise in part because the data and methods used to determine maturity differ between the two stocks (Schirripa, 2010). Histological studies conducted in the Mediterranean Sea suggest that some bluefin are capable of reaching maturity as early as age 3 and that 50% of the age 4 (25 kg) fish caught on the spawning grounds are mature; however, the relative fraction of age 3 and 4 fish that actually move to the spawning grounds has not been accounted for. In contrast, size frequency data from longline fisheries in the Gulf of Mexico longline suggests that fish younger than age 9 (140 kg) rarely visit the spawning grounds. However, Mather et al. (1995) estimated that western Atlantic bluefin tuna most likely first spawn at age 5, but more research would be required to establish this. The ICCAT SCRS has pointed out this level of disparity between the two stocks seems unlikely given the similarity in growth, but could possibly arise if smaller western fish spawn outside the Gulf of Mexico in an as yet unknown location or if there is a juvenescent subpopulation in the Mediterranean.

Juvenile bluefin tuna grow rapidly for a teleost fish, but slower than many other tuna and billfish species. Fish born in June attain lengths of about 30-40 cm and weights of about 1 kg by October. After one year, they are about 4 kg and 60 cm long. Adult growth in length tends to be slower than for juveniles, but the reverse is true for growth in weight. By age 10, a bluefin tuna is generally about 200 cm long and weighs up to 150 kg and by age 20, size has increased to approximately 300 cm and 400 kg. This species is long lived and recent radiocarbon deposition studies indicated that the maximum life span for bluefin tuna is approximately 40 years.

A mixed-stock analysis, based on the isotopic compositions of a limited number of otoliths, indicated that approximately 60 percent of the adolescent bluefin tuna (less than 5 years of age) collected from foraging areas in the Atlantic Ocean off the United States originated in the Mediterranean Sea, which suggest a substantial trans-Atlantic movement of adolescents from east to west (Rooker *et al*., 2008). In addition, a strong natal homing has been described for this species with about 94 percent of the adult bluefin tuna sampled in the Mediterranean Sea being identified as originating in this basin (Rooker *et al*., 2008). It is unclear if the remaining 6 percent of adult bluefin tuna sampled in the Mediterranean Sea were of western origin inasmuch as the maximum likelihood composition estimator tends to overestimate the lesser contributor when the two stocks differ greatly in local abundance (SCRS 2008).

According to Rooker *et al.* (2008), the chemical signature of bluefin tuna otoliths (fish ear bones) provides strong evidence of very high rates of natal homing to both the Mediterranean and Gulf of Mexico spawning areas. Electronic tagging studies described in Block *et al.* (2005) also support natal homing. Genetic analysis of young-of-the-year bluefin tuna from both stocks was conducted by Carlsson *et al.* (2007). These authors' results provide evidence of significant genetic differentiation between bluefin tuna caught on the spawning grounds in the Gulf of Mexico and those caught in the Mediterranean. Thus, these data provide further support for natal homing and will be explored in further detail in the information presented below pertaining to DPSs.

Santamaria *et al*. (2009) indicated that bluefin tuna in the Mediterranean Sea exhibit a sexually dimorphic length-weight relationship. After reaching sexual maturity, the length at weight of female bluefin tuna in the Mediterranean Sea is greater than that of males, and both sexes exhibit a negatively allometric growth pattern in which they become leaner as they increase in size. Based on this study, theoretical maximum age and lengths were determined to be 50 years and 382 cm fork length (FL) for males, and 43 years and 349 cm FL for females (Santamaria *et al*., 2009). Although Santamaria *et al*. (2009) only estimated age at length up to 15 years for bluefin tuna in the Mediterranean, their findings are comparable to the SCRS estimate where mean FL by age 1 was estimated at 60 cm, by age 10 mean FL was estimated at 201.2cm, and by age 15 mean FL was estimated at 249.4cm.

For the purposes of this status review report, the mean generation time for bluefin tuna was determined to be approximately 17 to 19 years. Mean generation time was computed as the fecundity-weighted average age of the spawning population at equilibrium in the absence of fishing, where the values for the age at maturity and natural mortality rate associated with the eastern and western DPS units were set to those used by the SCRS (and average weight was used as a proxy for fecundity). The mean generation time was similar for the two stocks because the younger age of maturity assumed for the eastern stock (which would imply a younger generation time) is mitigated by the lower natural mortality rate assumed for spawning age fish (which implies and older generation time). Further support for this timeframe is provided by the time period that has been identified by ICCAT for rebuilding which is based on a generation time of 20 years. The mean generation time was determined appropriate for consideration in this report because it would likely take a generation for any management action to be realized. In addition, it would take several years before changes to the spawning stock biomass would be reflected in recruitment.

Western Bluefin Tuna Essential Fish Habitat

Nearly all highly migratory species (HMS) essential fish habitat (EFH) is defined according to the geographic boundaries of a given area and water column characteristics, as opposed to specific benthic habitat types that might be affected by fishing gears, particularly bottom-tending gears such as shrimp trawls or fish traps. Bluefin tuna EFH was defined in Final Amendment 1 to the Consolidated Highly Migratory Species Fishery Management Plan (NMFS Amendment 1, 2009), per the Magnuson-Stevens Act, and is described below and in Figures 2.1-2.3 The following text and figures are summarized from, and all references cited below are provided in, NMFS Amendment 1. Note that bluefin tuna habitat includes areas beyond the jurisdiction of the United States; however, designations of EFH and Habitat Areas of Particular Concern (HAPC) are limited to waters under the jurisdiction of the United States, per the Magnuson-Stevens Act.

Bluefin tuna EFH definition:

- Spawning, eggs, and larvae: In the Gulf of Mexico from the 100 meter depth contour to the EEZ , continuing to the mid-east coast of Florida as shown in Figure 2.1.
- Juveniles (<231 cm FL): In waters off North Carolina, south of Cape Hatteras, to Cape Cod. Please refer to Figure 2.2 for detailed EFH map.
- Adults (≥231 cm FL): In pelagic waters off the central Gulf of Mexico and the Mideast coast of Florida. North Carolina from Cape Lookout to Cape Hatteras, and New England from Connecticut to the mid-coast of Maine. Please refer to Figure 2.3 for detailed EFH map.

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

Additionally, NMFS Amendment 1 designated a Habitat HAPC for bluefin tuna. The bluefin tuna HAPC is located west of 86° W and seaward of the 100 m isobath, extending from the 100 m isobath to the Exclusive Economic Zone (EEZ), the limit of U.S. jurisdiction (Figure 2.4). The area includes a majority of the locations where bluefin tuna larval collections have been documented, overlaps with adult and larval bluefin tuna EFH, and incorporates portions of an area identified as a primary spawning location by Teo *et al.* (2007). The area meets at least one, and possibly more, of the requirements for HAPC designation, including “the importance of the ecological function provided by the habitat,” “whether and to what extent, development activities are, or will be, stressing the habitat,” and the “rarity of the habitat type.” The Gulf of Mexico is believed to be the primary spawning area for western Atlantic bluefin tuna, and the HAPC designation highlights the importance of the area for bluefin tuna spawning. It may also provide added conservation benefits if steps are taken to reduce impacts from development activities through the consultation process.

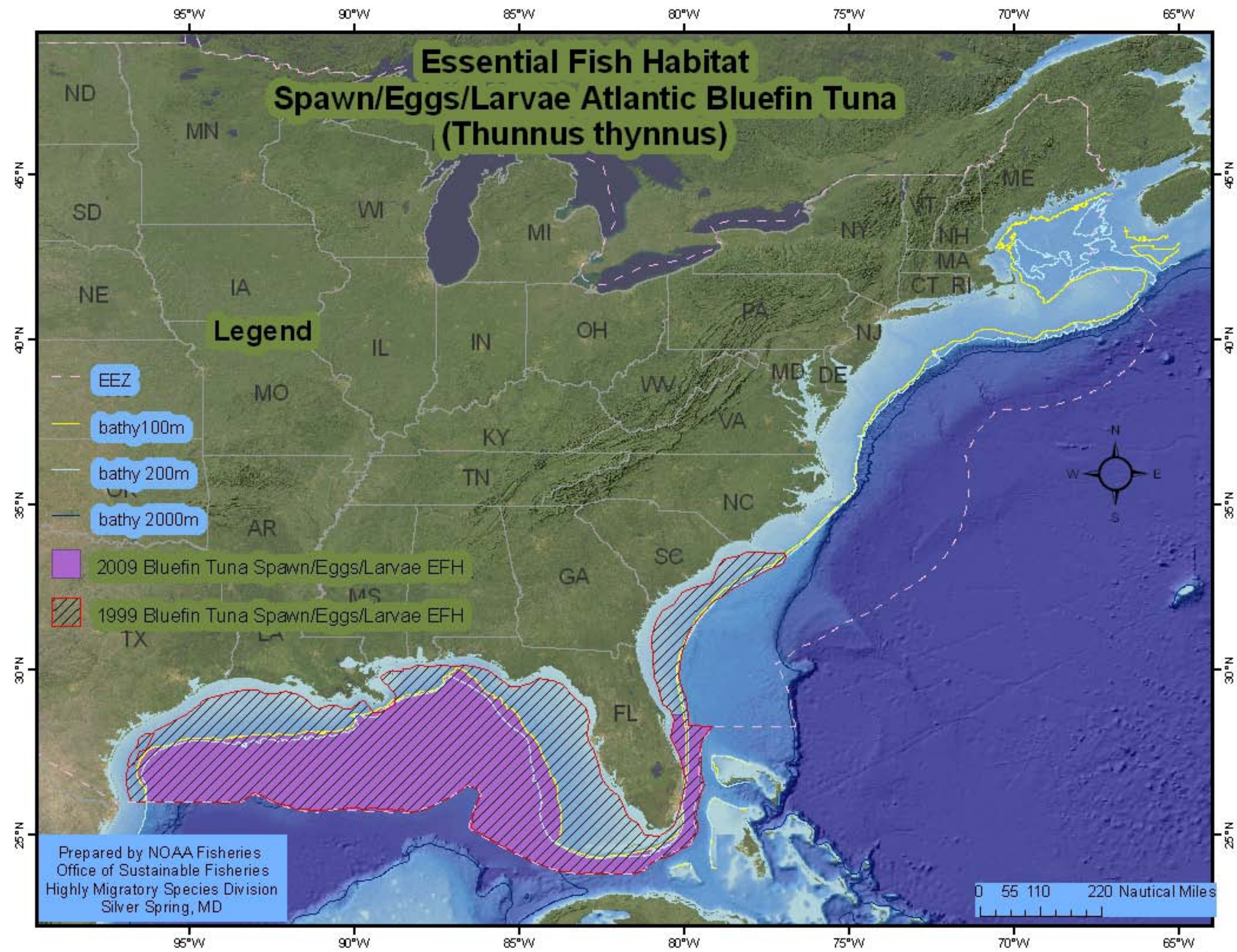


Figure 2.1. Essential Fish Habitat for spawning, eggs, and larval BFT.

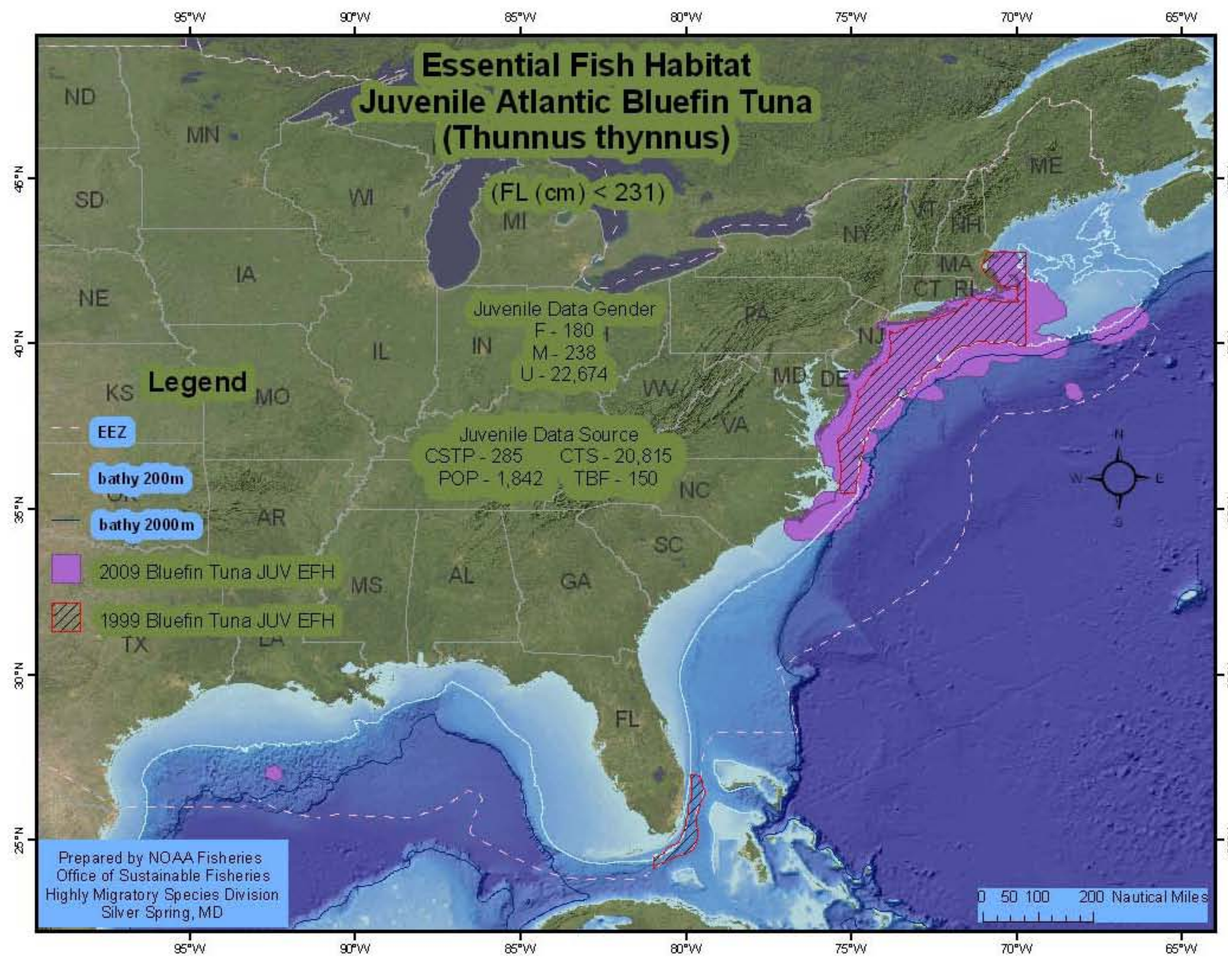


Figure 2.2. Essential Fish Habitat for juvenile BFT.

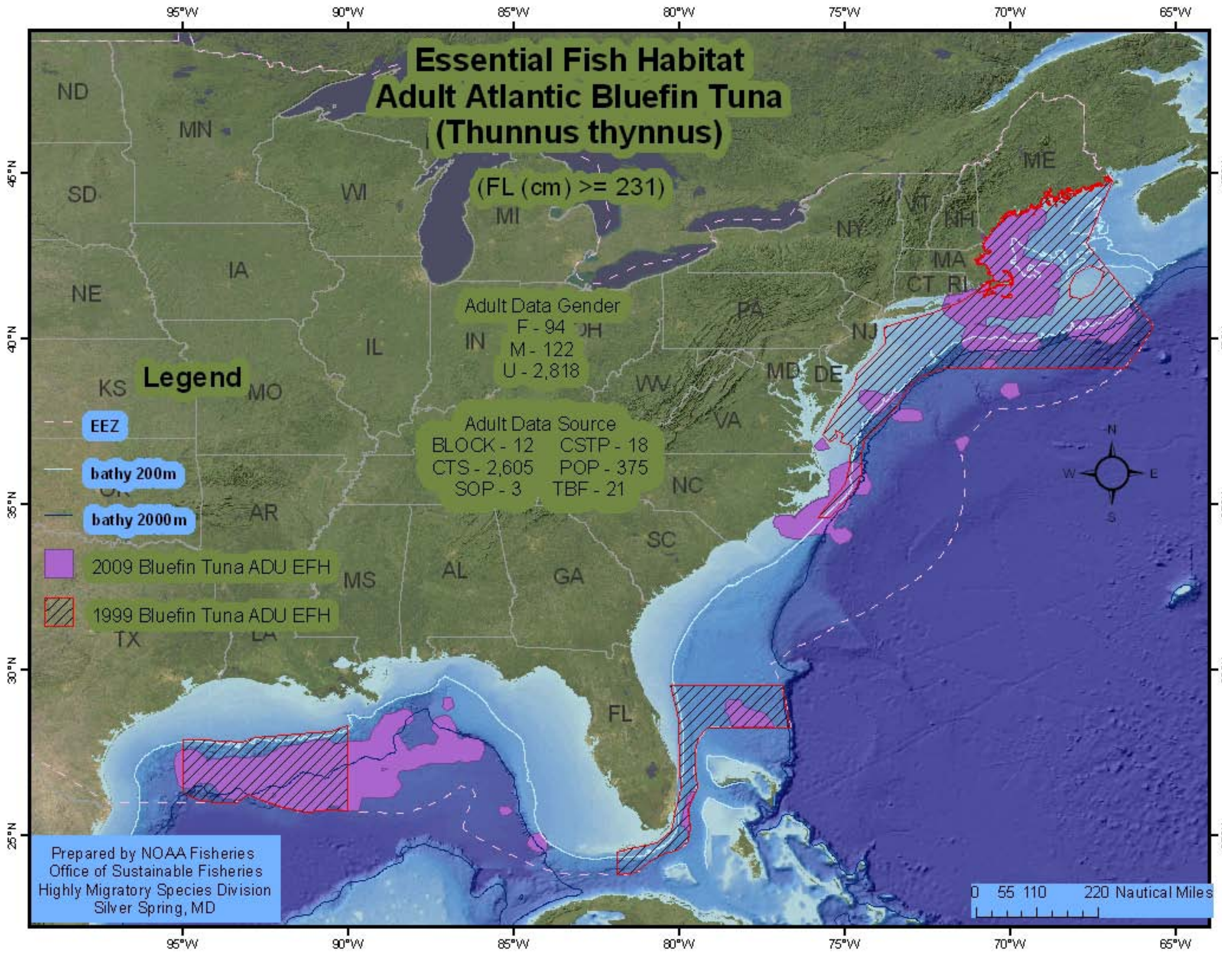


Figure 2.3. Essential Fish Habitat for adult BFT.

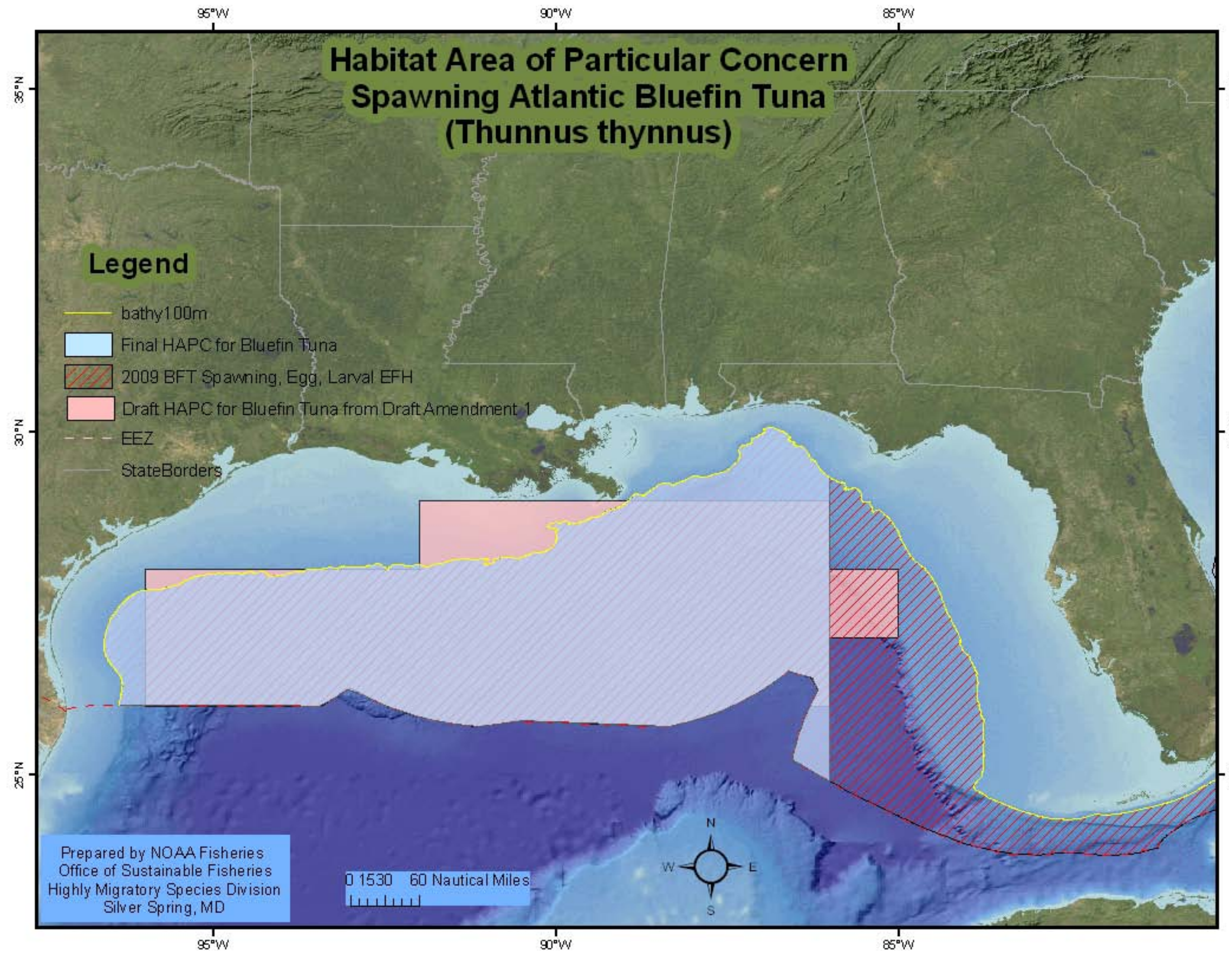


Figure 2.4. Final Habitat Area of Particular Concern (HAPC) for Spawning Bluefin Tuna in the Gulf of Mexico (in light blue). The figure shows the boundary for bluefin tuna spawning, egg, and larval EFH (hatched areas) and the area originally proposed for the HAPC in the Draft Amendment for preferred Alternative 2 (in pink). The hatched area is continuous underneath the HAPC area.

Western Atlantic bluefin tuna are believed to spawn primarily from April to June in the Gulf of Mexico, and it has been suggested that some spawning may occur in the Bahamas and the Florida Straits (Baglin, 1982; McGowan and Richards, 1989; Block *et al*., 2005). Recent results from larval surveys in the northern Yucatan indicate that larvae are found in April in parts of the western Caribbean (Muhling *et al*., 2010). This suggests a southward extension of known spawning sites. Larvae have been confirmed to originate from the Gulf of Mexico and have been found as far north as the Carolinas, although their presence was associated with advection from the Florida Straits and not from offshore spawning (McGowan and Richards, 1989). Most of the larvae found were located in waters near the surface around the 1,000 fathom depth contour in the northern Gulf of Mexico, with some sporadic collections off Texas. In the Florida Straits, they were primarily collected along the western edge of the Florida Current, suggesting active transport from the Gulf of Mexico. This would also explain their occasional collection off the southeast United States.

It appears that larvae are generally retained in the Gulf of Mexico until June, and schools of young-of-the-year begin migrating to juvenile habitats (McGowan and Richards, 1989) thought to be located over the continental shelf around 34°N and 41°W in the summer and further offshore in the winter. Also, they have been identified from the Dry Tortugas area in June and July (McGowan and Richards, 1989; ICCAT, 1997). Juveniles migrate to nursery areas located between Cape Hatteras, North Carolina and Cape Cod, Massachusetts (Mather *et al*., 1995).

Eastern Atlantic Bluefin Tuna Spawning Habitat

Eastern Atlantic bluefin tuna spawning usually takes place from late May to July, with a peak from June to July; however, a time shift in the peak of spawning has been noticed from year to year which seems to depend on climate and oceanographic conditions. The best known spawning areas are southwest of the Balearic Sea, the central and southern Tyrrhenian Sea, the central Mediterranean Sea southwest of Malta, and the eastern Mediterranean Sea in the south Aegean to the area north of Cyprus, particularly the area between Anamur and Mersin in the Levantine Sea (See Figure 2.5). Important spatial changes in some of the most relevant spawning areas have been noticed in the last 10 years, particularly in the south Tyrrhenian and central Mediterranean. Most of the available information reports a major presence of bluefin tuna along the coasts of Croatia, south Adriatic Sea, western Ionian Sea, Tyrrhenian Sea, all the northwestern Mediterranean coast, in some areas of Morocco and Tunisia, in a few Aegean areas and in the Levantine Sea (between Anamur and Mersin).

A remarkable shifting of the areas where juveniles concentrate has been noticed from year to year. Juveniles are mostly present in feeding aggregations or schools during fall, from September to December. Mature specimens have been reported from most of the Mediterranean areas, with the only exceptions being the Gulf of Lions and the northern Adriatic Sea. Larvae have also been found as well in most of the Mediterranean surface waters, with a major concentration in areas where gyres and fronts are present, particularly in the second part of summer. Young-of-the-year (YOY) bluefin tuna have been found mostly in coastal areas over the continental shelf, whenever appropriate prey is present. Tagging data showed that bluefin tuna movement within the Mediterranean Sea is often limited, particularly for individuals tagged in the eastern regions of the basin. Movements of bluefin tuna tagged in the central and western Mediterranean Sea were more pronounced than those tagged in the eastern portion. Seasonal prey abundance (e.g. *E. encrasicolus, S. pilchardus, M. norvegica, S. scombrus, A. rochei*, etc.) drives the concentration of both young and adult specimens in those Mediterranean Sea areas not used for reproduction (e.g. Ligurian sea, north-central Adriatic). Many larger individuals (>150 kg) move out of the Mediterranean and their movement patterns and displacement distance seem to be related to size and the exploitation of feeding grounds outside the Mediterranean Sea (Wurtz, 2010), while some are resident year round. Some juvenile and adolescent bluefin appear to migrate to western foraging grounds.

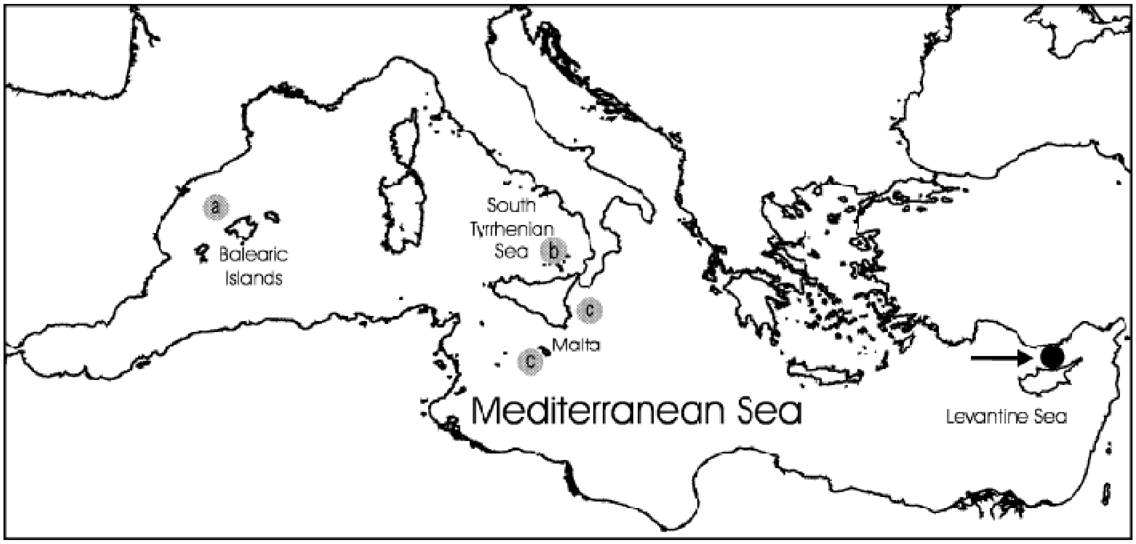


Figure 2.5. Map of spawning areas in the Mediterranean (Karakulak et al., 2004).

3. CONSIDERATION OF A DISTINCT POPULATION SEGMENT UNDER THE ESA

3.1. Distinct Population Segment Background

According to Section 3 of the ESA, the term "species" includes "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature." Congress included the term "distinct population segment" (DPS) in the 1978 amendments to the ESA. One of the purposes of establishing DPSs is to conserve genetic diversity. In February 1996, the U.S. Fish and Wildlife Service and NMFS (jointly, the Services) published a policy to clarify their interpretation of the phrase "distinct population segment" for the purpose of listing, delisting, and reclassifying species (61 FR 4721). The policy identified the following two elements to be considered in determining whether a vertebrate population qualified as a DPS:

1. The discreteness of the population segment in relation to the remainder of the species or subspecies to which it belongs; and
2. The significance of the population segment to the species or subspecies to which it belongs.

Determining if a population is discrete requires either one of the following conditions:

1. It is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
2. It is delimited by international governmental boundaries within which differences in control of exploitation, management of habitat, conservation status, or regulatory mechanisms exist that are significant in light of Section 4(a)(1)(D) of the Act.

If a population is deemed discrete, then the population segment is evaluated in terms of significance, which may include, but is not limited to, the following:

1. Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon.
2. Evidence that loss of the discrete population segment would result in a significant gap in the range of the taxon.
3. Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range.
4. Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

If a population segment is deemed discrete and significant then it qualifies as a DPS. The DPS should be evaluated for endangered and threatened status based on the ESA's definitions of those terms and a review of the factors enumerated in Section 4(a)(1).

3.2. DPS Determination

As noted previously, ICCAT manages Atlantic bluefin tuna as two separate stocks. The boundary between these two stocks is the 45ºW meridian. According to Fromentin and Powers (2005), this delineation was originally established for management convenience, and also on evidence at the time indicating that catches were confined to the coasts, there were limited trans-Atlantic recaptures, and other evidence suggesting that this delineation was appropriate. However, this has been a source of controversy, particularly given the higher rates of trans-Atlantic migrations that have been documented via electronic tagging studies (Lutcavage *et al.*, 1999; Block *et al.,* 2001) and other methods (Rooker *et al*., 2008; Dickhut *et al*., 2009). Block *et al.* (2005) supported the two-population hypothesis, with a distinct spawning area in the Mediterranean Sea and one in the Gulf of Mexico, but also identified an overlapping distribution on North Atlantic feeding grounds. While this hypothesis is supported by the tagging data, the number of fish that have been tagged is limited and thus, it is unclear if all the modes of bluefin tuna behavior are represented in the sample. Additionally, from the conventional tagging data there appears to be significant annual and decadal variability in trans-Atlantic migration rates (Fromentin and Powers, 2005).

Dr. David Secor presented results of his current research on bluefin tuna to the SRT on September 16, 2010. Dr. Secor noted that ICCAT manages bluefin tuna under the premise of two stocks (eastern and western Atlantic). He also noted that spawning occurs in restricted areas: Gulf of Mexico and the Florida Straits in the western Atlantic stock, and the Mediterranean Sea for the eastern Atlantic stock. Finally, he presented results from the Rooker *et al.* (2008) publication, which used stable isotope analysis to examine stock structure in bluefin tuna (as described below). He noted that through stable isotope analysis, the tracers indicate that natal homing or spawning site fidelity do occur in both eastern and western bluefin tuna.

Dr. Barbara Block presented relevant results of her bluefin tuna research to the SRT on September 16, 2010. In her presentation, Dr. Block suggested that there are three independent populations of bluefin tuna: western Atlantic, eastern Mediterranean, and western Mediterranean, citing Reeb (2010). She also presented some new information on the results of her most recent genetic analyses of bluefin tuna samples from the known spawning areas in the Gulf of Mexico and Mediterranean. New information from Reeb and Block (Block pers. comm.) assessed the genetic population structure using 22 microsatellite loci from tagged fish and adult samples. Their preliminary analyses suggested that there are four genetically distinct populations of bluefin tuna – Gulf of St. Lawrence, Gulf of Mexico, western Mediterranean and eastern Mediterranean. She noted that the fish from the Gulf of St. Lawrence appear to spawn in a separate area in the Gulf of Mexico; thus, she theorized that the four populations of bluefin tuna may spawn in four separate locations (e.g., eastern and western Mediterranean, and two separate areas in the Gulf of Mexico). She also noted that not all spawning occurs in the Gulf of Mexico, and that spawning behavior has been recorded outside of the Gulf of Mexico, east of the Bahamian Bank and Puerto Rico. She noted that bluefin tuna are moving across the Atlantic and mixing in foraging areas along the East Coast of North America, and although Mediterranean fish enter the Gulf of Mexico, they return to the Mediterranean to spawn.

Lutcavage *et al.* (1999) also indicated that other possible spawning grounds might exist. According to Lutcavage *et al.* (1999), there are historical accounts of bluefin tuna spawning in the Azores and Canary Islands (Mather *et al*., 1995), but no larvae have been documented from these areas. Lutcavage *et al*. (1999) noted that Japanese longline fisheries documented the presence of bluefin tuna in the middle and northwest Atlantic (Shingu and Hisada, 1977), as well as in exploratory studies by the United States in the 1950s and 1960s (Mather and Bartlett, 1962; and Squire, 1963). In the late spring, medium- and giant-sized fish in spawning or near spawning condition, or recently spawned condition were documented along the northern boundary of the Gulf Stream off New England (Baglin, 1976; Mather *et al*., 1995). McGowan and Richards (1989) and Rooker *et al.* (2007) noted that bluefin tuna larvae have been found east of the Yucatan Peninsula and off the East Coast of the United States and that it appears likely that these larvae originated from spawning areas outside of the Gulf of Mexico.

Despite the abundance of information, the population structure of this species remains poorly understood and needs to be further investigated. Additionally, the criteria used to designate and manage separate stocks under ICCAT differ from those used to identify DPSs under the ESA (as described above). Recent observational, genetic, microchemistry, organochlorine and polychlorinated biphenyl (PCB) tracer data, tagging studies and historical fisheries data suggest that the bluefin tuna population structure is complex. This information is presented and discussed below as it pertains to discreteness and/or significance under the DPS policy.

3.2.1. Discreteness

Ecological Factors

According to Muhling *et al.* (2010), in order to maximize larval survival, adult bluefin tuna likely spawn in specific habitats or oceanographic features. Tagged fish in the Gulf of Mexico appear to select lower continental slope waters in areas where surface temperatures are between 24 and 27° C and that have relatively low chlorophyll concentrations (Muhling *et al.*, 2010). Bluefin tuna in the Mediterranean also exhibit this type of behavior, as do other large pelagic species (Muhling *et al., 2010*). According to Muhling *et al.* (2010), the waters of the open Gulf of Mexico are warm, which results in higher growth rates of larvae (Miyashita *et al.*, 2000), and predominantly oligotrophic (Gilbes *et al.*, 1996; Muller-Karger *et al.*, 1991; Muhling *et al.*, 2010), which possibly reduces the number of planktonic predators. Muhling *et al.* (2010) developed a habitat model for larval bluefin tuna in the northern Gulf of Mexico. According to this model, bluefin tuna larvae are less likely to be present where water temperatures at 200 m depth are high (e.g., greater than 28 ºC). The authors noted that sampling stations with higher water temperature at depth were likely to have been in the loop current or in warm loop current rings (Schroeder *et al.,* 1974), and they hypothesized that, while the warmer temperatures may be more favorable for egg hatching and larval development, the retention conditions in the loop current may be poor (Muhling *et al.*, 2010). Additionally, Muhling *et al.* (*2010*) stated that the physiological processes of adult bluefin tuna in very warm waters (such as those found in the loop current in late spring) may be compromised (Blank *et al.*, 2004), and tagging data indicated that adult bluefin do not tend to spend time in the loop current when migrating into the Gulf of Mexico (Block *et al.,* 2001). Teo *et al.* (2007) noted that adults may show deep diving behavior when crossing the loop current possibly in avoidance of very warm waters within the current. Thus, Muhling *et al.* (2010) theorized that the combination of poor larval retention and stressful conditions for adults within the loop current make these waters unsuitable as a spawning location for bluefin tuna.

According to Karakulak *et al.* (2004), spawning areas in the Mediterranean have been determined based on the presence of females with hydrated oocytes and post-ovulatory follicles and/or documented larval presence (Nishida *et al.*, 1997; Medina *et al.*, 2002; Corriero *et al.*, 2003). There are three main spawning areas based on the information from these studies – the waters of the Balearic Sea, the waters around Malta and off the eastern coast of Sicily, and the South Tyrrhenian Sea. Carlsson *et al.* (2004) describe the Mediterranean Sea as a semi-enclosed system consisting of two partly isolated basins – eastern and western – which are connected by the Straits of Sicily and Messina (Robinson *et al*., 2001). The two basins differ in their oceanographic characteristics particularly with regard to thermal regime, salinity, and circulation patterns (Millot, 1999; Robinson, 2001; Carlsson *et al*., 2004)). Mature bluefin tuna have also been found in the Ionian Sea in the eastern Mediterranean leading to speculation that additional spawning may occur in this area (Carlsson *et al*., 2004). Oray and Karakulak (2005) investigated larval surveys in the eastern Mediterranean to assess whether there is additional evidence of bluefin tuna spawning in the Levantine Basin. Ichthyoplankton samples were taken at various stations throughout the eastern Mediterranean. Through previous studies, spawning is believed to start in the northern Levantine Basin in mid to late May (Oray and Karakulak, 2005), and De Metrio *et al*. (2004) found that electronically tagged bluefin tuna did not migrate toward the Strait of Gibraltar after reproduction but rather stayed in the eastern Mediterranean. High numbers of bluefin tuna larvae were found in the northern Levantine Sea in the waters between Turkey and Cyprus, particularly in the Bay of Mersin (Oray and Karakulak, 2005). Bluefin larvae were collected at 23 sampling stations in this area and at 2 sampling stations in the Bay of Antalya, ranging in size from 3.1 to 8.9 millimeters (mm), with a mean length of 5.78 ± 1.12. mm (standard deviation) (Oray and Karakulak, 2005).

Garcia *et al*. (2005) characterized the bluefin tuna spawning habitat off the Balearic Archipelago. These authors noted that bluefin tuna larval abundance is associated with surface water temperatures between 24ºC and 25ºC in areas of inflowing Atlantic waters or transitional areas with Atlantic waters mixing with Mediterranean waters, and that generally possess hydrographic features such as fronts and gyres (Garcia *et al*., 2005). According to Garcia *et al*. (2005), significant concentrations of bluefin tuna larvae were found off the Mallorca channel in an area with frontal formations and south of Minorca where an anticyclonic gyre was observed. Garcia *et al*. (2005) note that these frontal structures and gyres may play an important role in providing concentrated prey resources for larval fish which may in turn constitute an important part of the diet of larval bluefin tuna. Low and isolated larval concentrations were observed in Mediterranean water masses north of the islands (Garcia *et al*., 2005). The strong eastward current that flows from Ibiza towards Minorca may act as a transport mechanism for larvae (Garcia *et al*., 2005). The area near Mallorca and the Ibiza channels is generally characterized by low concentrations of chlorophyll a which is primarily due to the major influence of the nutrient poor water masses originating from the Atlantic (Garcia *et al*., 2005).

Physical, Genetic and Behavioral Factors

Evidence to support marked separation of populations based on physical factors includes observed spatial and temporal differences in spawning, genetic data, tagging data, otolith microchemistry, and organochlorine and polychlorinated biphenyl (PCB) tracer data.

As noted previously, western bluefin tuna are assumed to mature at a later age than eastern bluefin tuna (age 9 for the former, age 3 for the latter). Spawning in the west takes place primarily from April through June (Richards, 1976; Rivas, 1954; McGowan and Richards, 1989) while in the east spawning occurs in the Mediterranean during May through July (Rodriguez-Roda, 1967; Susca *et al*., 2001; Medina *et al*., 2002, Corriero *et al*., 2003; Karakulak *et al*., 2004).

Carlsson *et al.* (2006) conducted analyses of 320 young-of-the-year (YOY) bluefin tuna to evaluate the hypothesis that 2 separate spawning grounds exist for the western and eastern stocks – Gulf of Mexico and Mediterranean Sea, respectively. In this study, Carlsson *et al.* (2006) conducted a microsatellite analysis of 8 loci and examined the mitochondrial control region and found significant genetic differentiation among YOY fish captured in the Gulf of Mexico spawning grounds vs. those captured in the Mediterranean spawning area. Their results support a high degree of spawning site fidelity, and thus, they noted that the recognition of genetically distinct populations requires independent management of the stocks of this species (Carlsson *et al.*, 2006).

Carlsson *et al*. (2007) and Rooker *et al.* (2008) indicated that genetic analyses and microchemical signatures from otoliths strongly support that there are two distinct primary spawning areas for bluefin tuna (the Mediterranean and Gulf of Mexico). These authors noted that a significant genetic divergence was found between these two spawning stocks using microsatellite (Carlsson *et al*., 2007) and mitochondrial analyses (Boustany *et al*., 2008), and they also indicated that there are high rates of spawning site fidelity of 95.8 percent and 99.3 percent for the Mediterranean Sea and Gulf of Mexico, respectively (Rooker *et al*., 2008; Block *et al*., 2005).

Given the significant genetic differentiation between the two stocks of bluefin tuna, Riccioni *et al.* (2010) compared microsatellite variation at 8 loci from 256 contemporary samples (collected between 1999 and 2007) and 99 historical samples (collected between 1911 and 1926) from juvenile and adult bluefin tuna collected in the central-western Mediterranean to determine if these complex population dynamics exist also at a finer scale. According to Riccioni *et al.* (2010), size dependent movements and spawning in different areas and at different times have been documented for the Mediterranean stock. The results of their analyses showed that there are statistically significant genetic differences among population samples, and that different samples of bluefin tuna showed genetic differences both spatially and temporally at fine and large scales of variation (Riccioni *et al.,* 2010). They also found that these genetic differences have persisted at least throughout the past century and several generations (Riccioni *et al.*, 2010). According to these authors (Riccioni *et al.*, 2010), it is difficult to define population units unequivocally for highly migratory species; however, based on the heterogeneity of spatial genetic patterns detected in their study and the variation detected in the demographic pattern observed between the historical and contemporary samples and the current genetic variation, they concluded that distinct geographical populations with a unique demographic history may exist in the Mediterranean. These authors noted that this is also supported by the occurrence of multiple environmentally suitable spawning areas in the central-western Mediterranean (Riccioni *et al.,* 2010).

Reeb (2010) discussed the genetic study undertaken by Riccioni *et al*. (2010). She noted that Riccioni *et al.* (2010) found that spatial differences between bluefin tuna sampled in the Adriatic and Tyrrhenian Seas have persisted for nearly a century and that genetic differences have been reported for these two regions in other fish species including red mullet (*Mullus babatus*), anchovies (*Engraulis encrasicolus*), and striped bream (*Lithognathus mormyrus*). According to Reeb (2010), the eastern and western basins of the Mediterranean exhibit differences in temperature, circulation patterns, and salinity, and the basins are considered oceanographically to be separated by the straits of Sicily and Messina. Thus, even though bluefin tuna are highly migratory, the areas that they home to in order to spawn may possess unique characteristics. Reeb (2010) also discussed the challenges of assessing the stock sizes of distinct bluefin tuna populations, given the mixing of fish from various areas (e.g., eastern with western Mediterranean, and Gulf of Mexico with Mediterranean fish). She noted that multi-locus genetic profiles characterizing each bluefin tuna stock would make it possible to assign individuals to their population of origin and thus, enable more accurate accounting of migrating individuals captured in areas of overlap.

Rooker *et al.* (2008) measured the isotopic composition of otoliths from bluefin tuna that were 12 to 18 months of age and that were caught between 1999 and 2004 in both the eastern (Mediterranean Sea/eastern Atlantic Ocean) and western (Gulf of Mexico/eastern coast of the United States) nurseries (Figure 3.1). These authors found that otolith composition was distinct between yearlings from the two different nursery areas, and that otolith $\delta^{18}O$ was significantly higher for yearlings from the eastern nursery in five of the years (all except 2001) (Rooker *et al.,* 2008). With the exception of 2002, they did not find significant differences in otolith $\delta^{13}C$ values between eastern and western bluefin tuna the six years sampled (Rooker *et al.,* 2008).

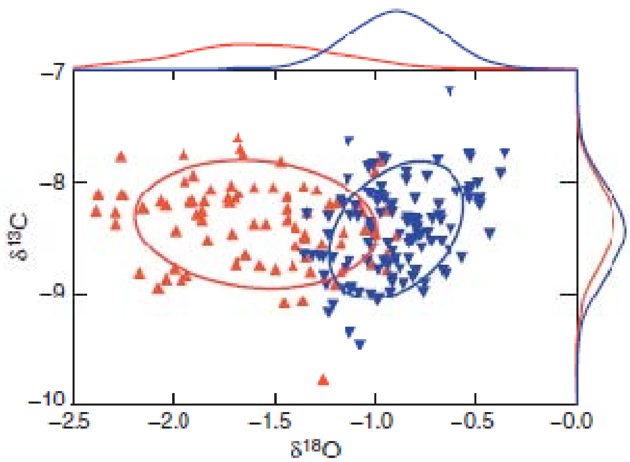


Figure 3.1. Otolith δ^{13}Cand δ ^{18}O values for yearling Atlantic bluefin tuna collected from 1999 to 2004 in the eastern Atlantic Ocean/Mediterranean Sea (blue triangles) and western Atlantic Ocean (red triangles). Gaussian bivariate ellipses (one standard deviation of the mean) and normal distribution curves are shown. Yearlings ranged in age from 12 to 18 months. Two regions of the eastern Atlantic Ocean/Mediterranean Sea were sampled over the 6 years: the eastern Atlantic Ocean (Cantabrian Sea; 2000, 2001, and 2002) and the western/central Mediterranean Sea (Ligurian Sea to Adriatic Sea; 1999, 2000, 2002, 2003, and 2004)(n = 113). In the continental shelf waters of the United States Atlantic Ocean, yearlings were collected from Maryland to Massachusetts over a 6-year period (n = 81)(Rooker et al.,2008).

Otolith microchemistry studies suggest that there is an increasing contribution of fish from the eastern stock to the western fisheries with decreasing average size of the fish in the catch (*i.e.* up to 62 percent for fish in the 69-119 cm size class); while western fisheries supported by the largest size classes (e.g., the Gulf of St. Lawrence and Gulf of Maine fisheries) had little to no eastern component in the catch. However, it is important to note that the samples that were used were collected over multiple years opportunistically and are not necessarily representative of the entire western fishery in any given time and area.

Dickhut *et al*. (2009) used organochlorine and polychlorinated biphenyls (PCBs) tracers from bluefin tuna foraging grounds to determine the rate of mixing of different size classes between the eastern and western stocks. Their results indicated that mixing of juvenile bluefin tuna from the east to the western foraging grounds could be as high as 80 percent for certain age classes and that juveniles from the Mediterranean Sea may migrate to western Atlantic foraging grounds as early as age 1 (Dickhut *et al*., 2009). However, this study also indicated that medium to giant sized bluefin tuna entering the Gulf of Mexico breeding grounds showed PCB ratios similar to that of the western Atlantic young-of-the-year (YOY), which suggests little or no mixing on the spawning grounds in the Gulf of Mexico, as these fish have been foraging in the western Atlantic rather than foraging grounds used by Mediterranean bluefin tuna (Dickhut *et al*., 2009).

It is not yet clear why bluefin tuna migrate long distances to spawn in the Gulf of Mexico (Muhling *et al.*, 2010). As noted previously, several authors including Rooker *et al.* (2008), Cury *et al.* (1998), and Block *et al*. (2005) suggest that natal homing is important, and as discussed in more detail below, others suggest that it is possible that fish return to ancestral spawning grounds as a result of behavior that is learned from older fish in the population. Oligotrophic areas that are similar to the spawning area in the Gulf of Mexico containing warm water temperatures can be found in the Atlantic and Caribbean; however, there is no evidence of large-scale spawning in these areas (Muhling *et al.,* 2010).

Takeuchi *et al*. (2009) described the Japanese longline fishery that occurred for a relatively short period of time in waters off Venezuela and Brazil. According to these authors, a fishery targeting yellowfin and albacore was initiated in the latter half of 1956 and catches of bluefin tuna by this fishery rapidly increased within a few years (Takeuchi *et al*., 2009). Catches of bluefin tuna in this fishery peaked in 1964 at 13,000 mt (Takeuchi *et al*., 2009), but after catches sharply declined in the late 1960s and early 1970s, Japanese fishing effort shifted to the eastern Atlantic and Mediterranean (Mather *et al*., 1995). According to Takeuchi *et al.* (2009), results from tagging giant bluefin tuna in Bahamian waters during roughly the same time as the Japanese longline was operating confirmed the migratory routes that were detailed by Mather *et al*. (1995), which were generally in a north-south direction. Takeuchi *et al*. (2009) noted that additional tagging studies showed a connection between the giant bluefin caught in Bahamian waters and those from Norwegian waters , as at least part of the catch of fish captured by the Japanese longline fishery in the tropical waters overlapped in the length composition of bluefin tuna caught by the Norwegian purse seine fishery. Thus, these authors theorized that they belonged to the same population. There are also tagging data that indicated that these giant bluefin tuna were also associated with the Ibero-Moroccan giant bluefin, which indicates that fish caught in the Japanese longline off Brazil were a mix of eastern and western fish (Takeuchi *et al*., 2009). Because the fish that shifted distribution suddenly were all giants, it is possible that this shift in distribution was associated with spawning (Takeuchi *et al*., 2009).

In April 2008, ICCAT held a "World Symposium for the Study into the Stock Fluctuation of Northern Bluefin Tunas (*Thunnus thynnus* and *Thunnus orientalis*), Including the Historical Periods." The second session of this symposium focused on the collapse of fisheries in the North Sea and off the Norwegian coasts. Written and archaeological evidence demonstrate that bluefin tuna were present and captured in northern European waters for centuries or even millennia before heavy fishing began in the 1950s (Nottestad *et al*., 2008). Because of difficulties in fishing for this species and lack of demand, bluefin tuna was rarely exploited before the 1900s (Nottestad *et al*., 2008). Nottestad *et al*. (2008) noted at the symposium that bluefin virtually disappeared from the Norwegian area after about 1970 (Tangen *et al*., 2008 and Nottestad *et al*., 2008). They also noted that very few adult bluefin migrated to the very productive areas found in the Norwegian Sea and along the coast of Norway. MacKenzie and Myers (2008) also noted that bluefin are no longer commonly found in northern European waters even though they suggested that ecosystem conditions such as temperature, inflow intensities in the North Atlantic, and food abundance in the last 5 to 10 years appeared to be suitable for the species (MacKenzie and Myers, 2008). MacKenzie and Myers (2008) then concluded that the species absence from the area may be a result of decreased abundance associated with fishing pressure and selection pattern or low recruitment potential, or to density-independent changes in migration patterns.

Participants of the symposium discussed the ecosystem with respect to temperature, food abundance and fishing effects before, during and after the disappearance of bluefin from the area. Bluefin tuna were found in the area in both relatively cold and warm periods until the 1960s and have been caught off Iceland and the Faroe Islands in waters as cold as 3°C (Fonteneau and La Person, 2008). Thus, these observations indicate that the disappearance is most likely not related to large-scale changes in temperature. According to the participants, they were also present in the area when food abundance was moderate and high. Herring abundances did decline when the tuna fishery was declining, and thus, it is possible that the bluefin tuna migration changed in relation to the decrease in abundance of forage fish, particularly with regard to the medium-sized tuna (Fromentin, 2008). Large tuna (>200 cm) continued to migrate to the area for a time, but later declined which led participants of the symposium to conclude that the changes may have been the result of changes in migration behavior, production rate (due to few adults remaining in the population), and/or survival (due to increasing exploitation of juveniles). Participants noted that northern European waters have in the last 10 to 15 years increasingly become more suitable for bluefin tuna if warmer waters and higher prey abundance are indicative of suitable conditions. Additionally, southern species (some of which are prey for bluefin tuna) have increased in abundance in the North and Norwegian Seas during the same time period. Participants suggested, therefore, that since bluefin tuna are still rare in the area, overall population abundance has to be low. One theory that was put forward for further study was that young tuna learn the migration patterns from older tuna, which would require that there be an overlap in the distribution of young and old fish. If older fish are extirpated from an area, then there would no longer be a source of information for young fish regarding the migration paths to follow.

Discreteness Conclusion

The best available information indicates that fish from the Mediterranean Sea, while making some trans-Atlantic migrations, return from the western Atlantic to the Mediterranean Sea to spawn, while fish from the west return to the Gulf of Mexico to spawn. This separation between the stocks is supported by observed spatial and temporal differences in spawning, and genetic analyses that indicate significant genetic differentiation between the two stocks as described above. Also, the results of the otolith microchemistry analyses indicate that natal homing or spawning site fidelity does occur, and the study by Dickhut *et al*. (2009) using organochlorine and PCB tracers also indicate that there is little to no mixing on the spawning grounds. According to Rooker *et al.* (2008), the rates of spawning site fidelity are 95.8 percent and 99.3 percent for the Mediterranean Sea and Gulf of Mexico, respectively. Thus, the two populations in the North Atlantic are discrete.

The available data further suggest that the eastern Atlantic stock exhibits genetic differentiation, spatial separation during spawning as a result of spawning site fidelity/natal homing, and differences in behavior (e.g., some resident fish in the eastern Mediterranean versus non-resident/migratory fish in the western Mediterranean), with different spawning areas in the western and eastern Mediterranean. As such, two discrete populations may exist within the larger eastern Mediterranean population. While there is some evidence which indicates that there may be other, discrete spawning areas outside of the Gulf of Mexico, the locations of these areas have not been confirmed or fully described at this time.

Based on the available information, the SRT concludes that the western Atlantic and the eastern Atlantic populations are discrete from each other. Within the eastern Atlantic, the available information suggests that there may be two discrete populations of bluefin tuna; however, the data are inconclusive regarding the Mediterranean at this time.

3.2.2. Support for Significance

The SRT has concluded that the western Atlantic population is discrete from the eastern Atlantic population, and that there could be two discrete populations within the eastern Atlantic population, with separate spawning areas in the Mediterranean. Consequently, it is necessary to assess the biological and ecological significance of each discrete population as described in the Services' DPS policy.

While spawning areas for bluefin tuna may at times be stressful environments, bluefin tuna migrate long distances to reach the particular areas in which they spawn (Block *et al*., 2001) and as presented above, homing fidelity to these sites is high. Muhling *et al*. (2010) concluded that adults are targeting specific areas and oceanographic features in order to maximize larval survival. Consequently, the spawning areas in the Gulf of Mexico and Mediterranean are unique ecologically and possess the features (e.g., appropriate water conditions such as temperatures, depths, salinities, and chorophyll concentrations) and hydrographic features that are necessary for maximizing bluefin tuna spawning success for each population.

As noted above, bluefin tuna exhibit strong natal homing or spawning site fidelity. Therefore, individuals from the Mediterranean are unlikely to spawn in the Gulf of Mexico, or vice versa (individuals from the Gulf of Mexico are unlikely to spawn in the Mediterranean). Thus, if one of the discrete populations was to be extirpated, it would represent a significant gap in the range of the taxon in that either the Gulf of Mexico or the Mediterranean Sea would no longer support bluefin tuna.

There is some evidence suggesting that there may be two discrete populations within the Mediterranean, but the SRT is unable to determine the significance of these populations to the species as a whole. While the two Mediterranean populations may be discrete, the SRT does not have enough information to conclude that they are significant, by themselves, to bluefin tuna.

DPS Conclusion

As discussed above, the available information indicates that the western Atlantic and eastern Atlantic bluefin tuna population segments are discrete and significant. Consequently, the SRT concludes that the two populations qualify as two DPSs of bluefin tuna under the DPS policy.

4. DESCRIPTION OF FISHERIES AND CONSERVATION MECHANISMS

4.1. Description of the Fisheries

Fishing for bluefin tuna has occurred in the Mediterranean since the 7^{th} millennium BC (Desse and Desse-Berset, 1994 in Fromentin and Power, 2005). These ancient fisheries were prosecuted primarily with handlines, beach seines, and other types of seine nets (Fromentin and Powers, 2005). According to Fromentin and Powers (2005), industrial fisheries in this area initially used traps and beach seines. Ravier and Fromentin (2002) analyzed trap catch data beginning in the 16th century and estimated that mean range of annual trap yields was approximately 15,000 metric tons (mt) per year; however, there were large fluctuations in catches. Ravier and Fromentin (2002) estimated annual yields to be between 7,000 and 30,000 mt, which confirms that intense exploitation occurred during this time. According to Fromentin and Powers (2005), few technical modifications were made to the traps until the early 20th century. During the mid-19th century, a handline fishery targeting juvenile bluefin tuna arose in the Bay of Biscay, and this fishery is now mainly composed mainly of bait boats (Fromentin and Powers, 2005).

Fromentin and Powers (2005) note that Nordic fishermen initiated a new fishery for bluefin tuna using purse seines in the 1930s in the North Sea. Production from the purse seine fishery exceeded that of the traditional trap fishery during the 1950s, and catch consisted primarily of large bluefin tuna migrating north to summer feeding areas (Fromentin and Powers, 2005). According to Mather *et al*. (1995), during this same time period, fisheries emerged along the western Atlantic continental shelf, especially between Cape Hatteras and Newfoundland. Purse seine fisheries extending from Cape Cod to Maine targeted juveniles in the 1950s and 1960s (Fromentin and Powers, 2005). Additionally, small fisheries for large fish were conducted by handlines, traps, harpoons, and rod and reel. However, the markets for large fish did not develop fully until many years later (Fromentin and Powers, 2005).

In the 1950s, longlining in oceanic waters of the western Atlantic began primarily by the Japanese fleet, and while these longliners targeted primarily medium sized fish, large fish were landed if they were encountered (Fromentin and Powers, 2005). The total catch of western bluefin tuna peaked at 18,671 mt in 1964, mostly due to the Japanese longline fishery for large fish off Brazil and the U.S. purse seine fishery for juvenile fish. Catches dropped sharply thereafter with the collapse of the bluefin tuna bycatch fishery off Brazil in 1967 and decline in purse seine catches. Fromentin and Powers (2005) indicated that these fisheries moved into the Gulf of Mexico, the primary known spawning area for western bluefin tuna, in the 1970s, where they targeted large fish. Catch then increased again to average over 5,000 mt in the 1970s due to the expansion of the Japanese longline fleet into the northwest Atlantic and Gulf of Mexico and an increase in purse seine effort targeting larger fish for the sashimi market. This represented a transition period for bluefin tuna fisheries as there was a decrease in activity by the Nordic fleet and traps in the East Atlantic and a reduction in purse seine landings of juveniles in the West Atlantic (Fromentin and Powers, 2005). Traditional fisheries in the Mediterranean and East Atlantic were replaced during this time by purse seine and longline fleets (Fromentin and Powers, 2005).

According to Fromentin and Ravier (2005) and Porch (2005), the development of the sushi-sashimi market during the 1980s made bluefin tuna significantly more profitable than it was earlier, and this resulted in a significant increase in the efficiency and capacity of fisheries during this time. Fishing strategies and efficiency were greatly modified when new storage technologies such as carrier vessels with deep-freezing capabilities and systems for holding and fattening fish were introduced (Fromentin and Powers, 2005). The increased profitability associated with these new technologies resulted in the rapid development of new and powerful fleets in the Mediterranean countries, and the expansion of effort which exploited fish in the Mediterranean and North Atlantic Japanese longline fisheries also expanded in the Central North

Atlantic adding pressure on bluefin tuna stocks (Fromentin and Powers, 2005). The development and redistribution of all the fisheries resulted in rapid increases in yields since the 1980s, especially in the Mediterranean Sea. Eastern Atlantic and Mediterranean catches reached an historical peak of over 50,000 mt during the mid-1990s. Catches in the West Atlantic, including discards, have been relatively stable since the imposition of quotas in 1982. However, total western Atlantic catch declined steadily from the high of 2002 until 2007, primarily due to considerable reductions in catches by U.S. fisheries. Two plausible explanations for this situation were considered by SCRS: (1) that availability of fish to the U.S. fishery was abnormally low, and/or (2) that the overall size of the population in the western Atlantic declined substantially from the levels of recent years. SCRS noted in its 2010 stock assessment report that there is no overwhelming evidence to favor one explanation over the other but that the base case assessment implicitly favors the idea of changes in regional availability by virtue of the estimated increase in spawning stock biomass (SSB). The decrease indicated by the United States catch rate of large fish was matched by the increase in several other large fish indices. In 2009, the United States harvested its national base quota.

In U.S. fisheries, bluefin tuna are caught with purse seines, handgear (rod and reel, handline, and harpoon), and pelagic longlines. Pelagic longline gear is not allowed to target bluefin tuna directly, but is allowed to retain a limited amount of bluefin tuna caught incidentally while targeting other species (such as swordfish, yellowfin tuna, and bigeye tuna). Habitat damage by the subject gear types is minor because these gear types rarely comes into contact with the ocean floor. Fishing gears used to target bluefin tuna are generally selective, and also allow for the live release of bycatch species to a great degree.

For more information on U.S. domestic fisheries, see section 6.4.2.

4.2. Fisheries and Biological Data Collection Programs

Consistent with the ICCAT Convention, ICCAT collects and reviews all statistical information on current status and trends of tuna and tuna-like species fisheries in the Convention area to carry out stock assessments aimed at maintaining the populations of these species at levels that allow a maximum sustainable yield (MSY). All Contracting Parties with fisheries of tuna and tuna-like species in the Convention area are requested to submit all basic statistical information on their fleets, nominal effective catches, fishing effort, surveys estimating the size of specimens caught, and the tagging programs carried out. Data collection ranges from the general, including Contracting Party, Cooperating non-Contracting Party Entity, or Fishing Entity (hereafter, referred to as CPCs) annual reports, to species-specific. Bluefin tuna-specific reports include those on CPCs' annual fishing and inspection plans, bluefin caging activities including farming facilities, vessel and farm capacity management reduction plans, list of active vessels, catch reports, joint fishing operations, observer coverage, etc. Annual reports are compiled and published as part of the ICCAT biennial reports, available at: http://www.iccat.int/en/pubs_biennial.htm.

Fisheries dependent data are collected in multiple, nationally-administered programs for fisheries that target or incidentally capture bluefin tuna. All landings of bluefin tuna must be reported to ICCAT, and ICCAT has established a variety of requirements and methods to ensure effective monitoring, control, and reporting of bluefin tuna statistical and other data. Fishery data are recorded through various reports and fish-carcass tagging and tracking programs required for bluefin tuna landings, sales, and trade, vessel-level data collection (such as logbooks and observers), estimation surveys, and angler reporting programs.

Although ICCAT's bluefin tuna fisheries are highly regulated, there is some flexibility in how each ICCAT member meets its obligation to collect and report data. In the United States, for example, the primary mechanism for collecting commercial bluefin tuna landings information is through a mandatory data management program which includes permitting vessels and dealers, tagging each landed bluefin tuna, and daily and biweekly landings reports. Immediately upon offloading a bluefin tuna, a dealer must affix a tag to the carcass. This tag has a unique numerical identifier and is issued exclusively to that dealer by NMFS. The tag number must stay with the fish until it is distributed to its final retail outlet (e.g., it is cut into portions). Within 24 hours of landing a bluefin tuna, the dealer must fax a landings report to NMFS that includes dealer, vessel, and trip related information. Dealers purchasing bluefin tuna must also submit a bi-weekly report for each two-week period, verifying the previously submitted information and including further information such as whether the fish was exported or sold domestically. Bluefin tuna not sold by commercial permit holders must be reported to enforcement agents.

U.S. longline vessels are required, through a mandatory logbook program, to submit detailed information of each longline set deployed that includes gear configuration, total number of hooks deployed, time of day of the fishing operations, location, number of target fish caught by species and bycatch, including the disposition of the bycatch (e.g., released alive or discarded dead). The logbook form must be filled out within 2 days of completing that day's activities and submitted to NMFS within 7 days of offloading. The United States also monitors pelagic longline fishing activity through a national observer program. This program has been in place since 1992 to document finfish bycatch, characterize the behavior of the longline fleet, collect catch and effort data for highly migratory species, and quantify interactions with protected species. Observers record fish species, length, sex, location, and other environmental information associated to each set. The information collected is used to estimate catch rates of target and bycatch species and to estimate discard levels, and this information is presented to ICCAT to be used by the SCRS for stock assessment purposes.

The United States collects data on bluefin tuna recreational fishing effort and catch through a combination of surveys (primarily the Large Pelagics Survey (LPS)) and census programs, including those administered by the States of Maryland and North Carolina, and the NMFS Automated Landings Reporting System. The LPS is specifically designed to collect information on recreational fishing directed at large pelagic species (e.g., tunas, billfishes, swordfish, sharks, wahoo, dolphin, and amberjack). The LPS, which has been conducted by NMFS since 1992, takes place in Northeastern coastal states (Maine through Virginia) from June through October. This spatial and temporal coverage encompasses the major U.S. recreational and sport fisheries for bluefin tuna. The LPS includes two independent, complementary surveys which provide the effort and average catch per trip estimates needed to estimate total catch by species.

ICCAT's bluefin tuna biological data collection programs, including the Atlantic-wide Bluefin Tuna Year Program (GBYP), are discussed in Section 6.2.2. In the United States, NMFS issues permits for research activities involving the collection of biological samples and data from bluefin and other tunas. Researchers are required to submit interim reports regarding collections within five days of the completion of a fishing trip and an annual report within 30 days of the expiration of a permit. Exempted fishing permits and scientific research permits have been issued for a wide range of research involving tagging and biological sampling of bluefin tuna. For instance, as noted above, much research has involved the deployment of archival and pop-up satellite archival tags (PSATs) on bluefin to determine bluefin tuna stock structure as well as the location and timing of spawning. Other tagging studies have investigated migration routes, residency, spawning areas, mixing, and stock structure of bluefin. PSAT work has also been conducted on adult bluefin tuna in the Gulf of Mexico during the spawning season to determine estimates of post-release mortality of live bluefin tuna while on their spawning grounds during 2010 and will be continued in 2011. Biological sampling has been conducted to determine reproduction status, feeding habits, and nutritional condition of fish. In addition, genetic and otolith sampling has been conducted on young-of-year fish to determine the mixture of eastern and western origin yearling fish entering the U.S. mid-Atlantic fishery. In order to improve scientific knowledge about age structure of the bluefin tuna stocks and the extent of mixing between eastern and western bluefin tuna stocks, NMFS has initiated pilot programs to collect hard parts (otoliths, dorsal spines, and caudal vertebrae) and soft tissues from bluefin tuna dealers and recreational anglers. Finally, additional bluefin tuna sampling through the LPS has been conducted to update length-weight conversion tables.

5. BLUEFIN TUNA STOCK ASSESSMENTS

The following information is from the most recent ICCAT stock assessment which was conducted by the ICCAT Standing Committee on Research and Statistics (SCRS) in 2010. This section has been included to provide background information regarding the findings in the most recent ICCAT stock assessment for bluefin tuna to aid in understanding the status of the stocks for fishery management purposes and the methodologies used to assess the status of the stocks. This section refers to the western Atlantic stock and eastern Atlantic/Mediterranean stock (as considered in the stock assessment) rather than DPSs as in the remainder of this status review report.
For the full report (including additional tables and figures), see *Report of the 2010 ICCAT Atlantic Bluefin Stock Assessment Session* (http://www.iccat.int/Documents/Meetings/Docs/2010_BFT_ASSESS_REP_ENG.pdf). All figures and tables included in this section were taken from the aforementioned report.

5.1. Available Data

Nominal catch and fleet characteristics (Task I data), and catch and effort, size frequencies, and catch at size (Task II data) reported to ICCAT through 2009 were reviewed by the SCRS during the 2010 bluefin data preparatory meeting. For those instances where no catches were reported, or where reported catches were lower than those from the catch documentation systems, the SCRS used information from the bluefin tuna catch documents (BCD) and traps and caging declarations to revise the Task I catches. Details on the reported data and revisions can be found in the *Report of the 2010 ICCAT Bluefin Data Preparatory Meeting* (SCRS/2010/014, hereafter referred to as 'Report of Data Preparatory Meeting, 2010'). The revised annual bluefin tuna nominal catches from 1950 to 2009 available for the assessment are summarized in Table 1 *in* the "Report of Data Preparatory Meeting, 2010"; and Figures 5.1-4, and Figure 5.5 shows the spatial distribution of bluefin catches (1950-2009) by gear and decade. Document SCRS/2010/119 (revised) provided estimates of the size composition of the catches (catch-at-size or CAS) for the eastern (1950 to 2009) and western (1960 to 2009) stocks, stratified by quarter and 5x5 (5 by 5 degree) squares.

5.1.1. Eastern Atlantic and Mediterranean

Nominal catches and fishery trends

Reported catches in the East Atlantic and Mediterranean peaked at over 50,000 t in 1996 and then decreased substantially stabilizing around TAC levels established by ICCAT (see Table 1 *in* the "Report of Data Preparatory Meeting, 2010" found on pgs 16-19; and Figure 5.1 and 5.2). Both the increase and the subsequent decrease in declared production occurred mainly for the Mediterranean. Available information showed that catches of bluefin tuna from the eastern Atlantic and Mediterranean were seriously under-reported from 1998 to 2007. In addition, farming activities in the Mediterranean since 1997 significantly changed the fishing strategy of purse seiners and resulted in a deterioration of bluefin tuna CAS data reported to ICCAT. This is because bluefin tuna size sample were obtained only at the time of harvest from the farms and not at the time of capture. The 2008 and 2009 reported catch was reviewed by the SCRS during the bluefin tuna data preparatory meeting. The SCRS indicated that the reporting of catches significantly improved in those two years. However, the SCRS also indicated that some misreporting could still have been taking place because the ICCAT Secretariat did not receive all the information to conduct a full cross-validation of reported landings with vessel-level declarations at the bluefin tuna data preparatory meeting. The SCRS also indicated that the catches estimated by the SCRS using fishing capacity did not exceed reported catches for those two years.

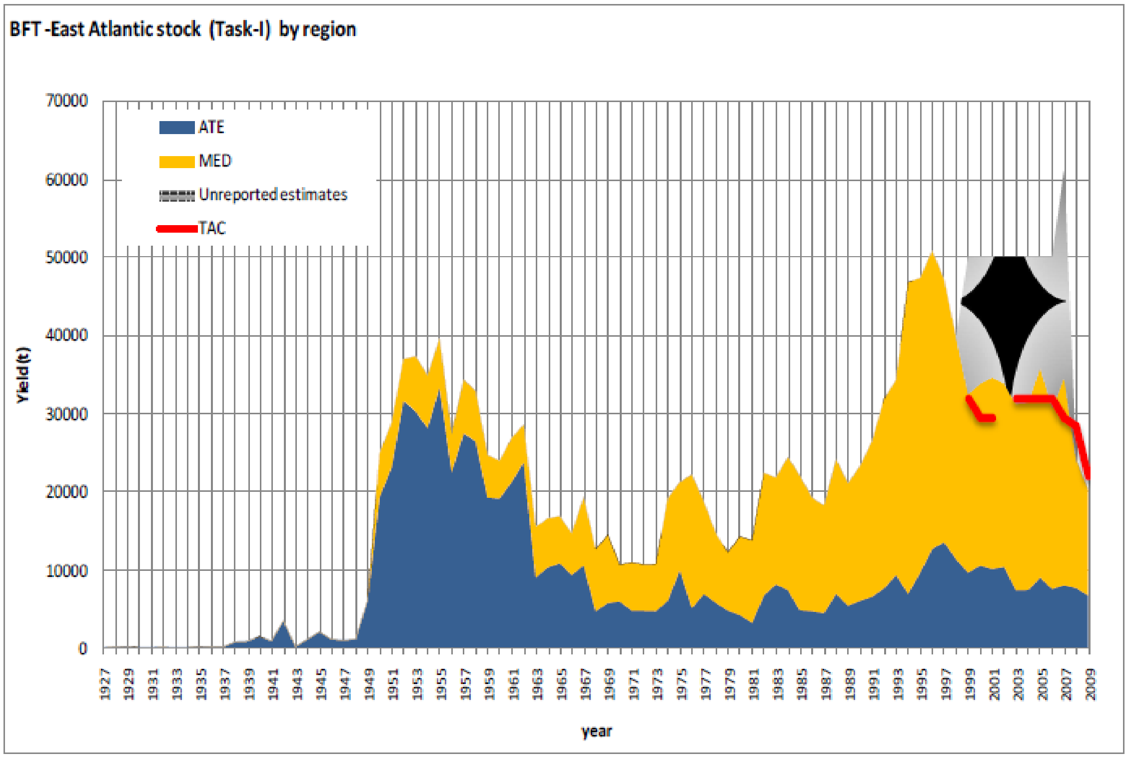


Figure 5.1. Eastern Atlantic and Mediterranean bluefin tuna (BFT) reported and estimated catches by area including eastern Atlantic (ATE), Mediterranean (MED), and the total allowable catch (TAC) (from ICCAT, 2010).

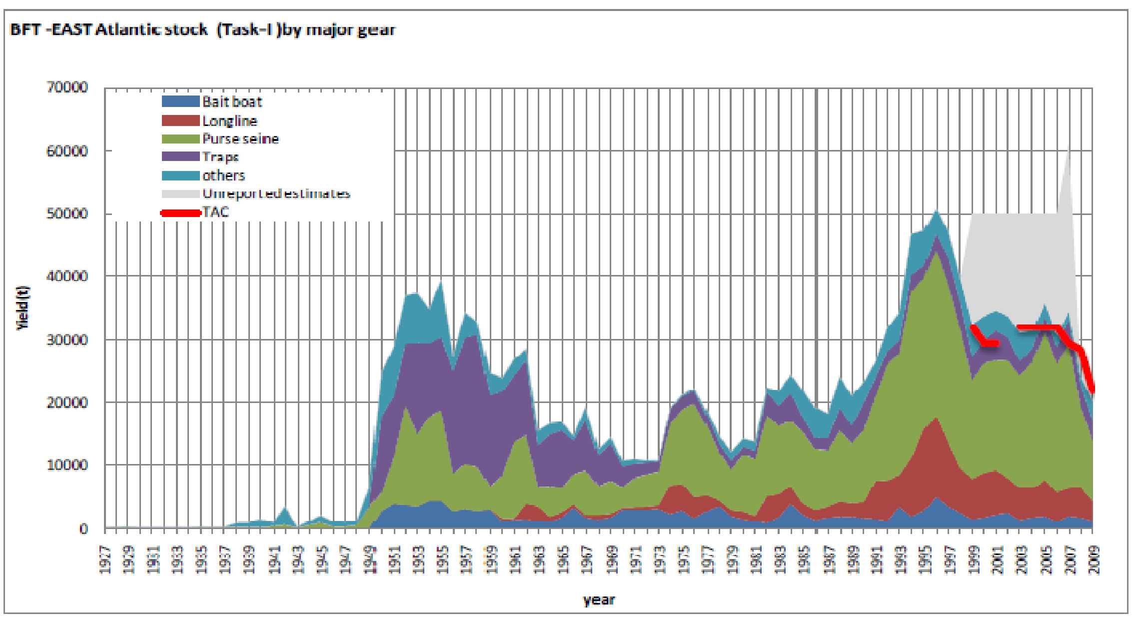


Figure 5.2. Eastern Atlantic and Mediterranean bluefin tuna (BFT) reported and estimated catches by main gears and including the total allowable catch (TAC) (from ICCAT, 2010).

Catch-at-size (CAS) and catch-at-age (CAA)

A revision of the substitution scheme used to estimate catch-at-size (CAS) was conducted by the SCRS during the bluefin tuna data preparatory meeting. The level of substitutions needed to estimate catch-at-age (CAA) for all landings was high across the years, especially for the Mediterranean (with substitution in the last two decades of 30 percent in the East Atlantic unit and 70 percent in the Mediterranean unit, SCRS/2010/119). Analyses presented during the stock assessment session stressed the serious deficiencies in the available data needed to estimate both the CAS and CAA. Most of these problems were related to the low number of size samples which led to high levels of extrapolations and substitutions among years, fleets and areas. For instance, bluefin tuna size samples from the Mediterranean purse seine fishery (PS) are not available after the late 1990s due to the large volume of catches used for farming purposes. As a result, catch at size was estimated using logbook information and back transforming mean weight (see SCRS/2003/128). This methodology was applied to one fleet and then extrapolated to all PS fleets. Consequently, the resulting CAS exhibits a 'skyline' size distribution (sharp and narrow) that slices all cohort information and blurs the age structure in the catches. Large errors in the CAA are known to strongly affect the Virtual Population Analysis (see *Section 5.2* below). The same age slicing procedure was employed to convert CAS to CAA (SCRS/2010/120).

Relative Abundance Indices and fishery indicators

During the BFT data preparatory meeting held in June, the SCRS reviewed available abundance indices series and made recommendations to update and improve some of these indices (see Tables 7, 8 and 9 of 'Report of Data Preparatory Meeting, 2010'). The indices that were available for the 2008 stock assessment meeting were all updated for the 2010 assessment except for the Spanish bait boat fishery in the Bay of Biscay. The updated indices corresponded to the Spanish traps, Moroccan traps, Spanish historical series for baitboat in the Bay of Biscay, and the Japanese longline fishery in the east Atlantic (south of 40˚ N) and Mediterranean, and in the Northeast Atlantic (north of 40˚ N). All available CPUEs with corresponding coefficient of variations (CV)(when calculated) are given in Tables 5.1 and Figure 5.3. Note that the mentioned CPUEs are scaled to their mean value.

Other historical indices available to the SCRS that were used in the 2008 assessment were (1) the historical nominal CPUEs French baitboat index based on the ICCAT Task II data for 1952-1977; and (2) the Norwegian purse seine CPUE for the period1955-86 (SCRS/2008/093, Figure 1c). A historical index for bluefin tuna caught by the bait boat fishery in the Bay of Biscay for the period 1952- 1972 (SCRS/2010/rev079) was submitted for the 2010 assessment.

Table 5.1. Recent CPUE indices used in the tuning of the VPA in the 2010 assessment of the East Atlantic and Mediterranean BFT stock.

series	SP BB historic	CV	*series*	Norway PS from Task II		
age	1 to 5		*age*	10 +		
indexing	Weight		*indexing*	Weight		
area	East Atlantic		*area*	East Atlantic		
method	Lognormal RE		*method*	Nominal		
time of the year	Mid-year		*time of the year*	?		
source	SCRS/2010/075		*source*	Task I	Effort	CPUE
1950						
1951						
1952	501.78	17.82				
1953	457.50	24.50				
1954	428.84	17.30	1955	13394	370	36.20
1955	490.75	17.35	1956	5313	250	21.25
1956	537.53	17.38	1957	6437	225	28.61
1957	468.33	17.97	1958	3860	160	24.13
1958	356.49	17.32	1959	3241	100	32.41
1959	365.99	18.07	1960	4215	90	46.83
1960	299.89	17.56	1961	8553	165	51.84
1961	269.75	17.33	1962	8730	135	64.67
1962	236.13	17.59	1963	167	100	1.67
1963	309.28	18.91	1964	1461	43	33.98
1964	266.71	17.80	1965	2506	36	69.60
1965	291.83	19.10	1966	1000	28	35.70
1966	306.86	18.21	1967	2015	33	61.06
1967	289.25	20.18	1968	753	32	23.53
1960	383.57	19.70	1909	042	30	20.00
1969	325.86	10.77	1970	170	11	12.76
1970	519.46	21.67	1971	653	15	43.52
1971	373.73	19.78	1972	430	10	43.05
1972	385.24	20.37	1973	421	10	42.15
1973			1974	869	19	45.72
1974			1975	988	26	38.00
1975			1976	529	25	21.16
1976			1977	764	18	42.44
1977			1978	221	18	12.28
1978			1979	60	16	3.75
1979			1980	282	14	20.14
1980			1981			
1901			1902			
1982			1983			
1983			1984			
1984			1985			

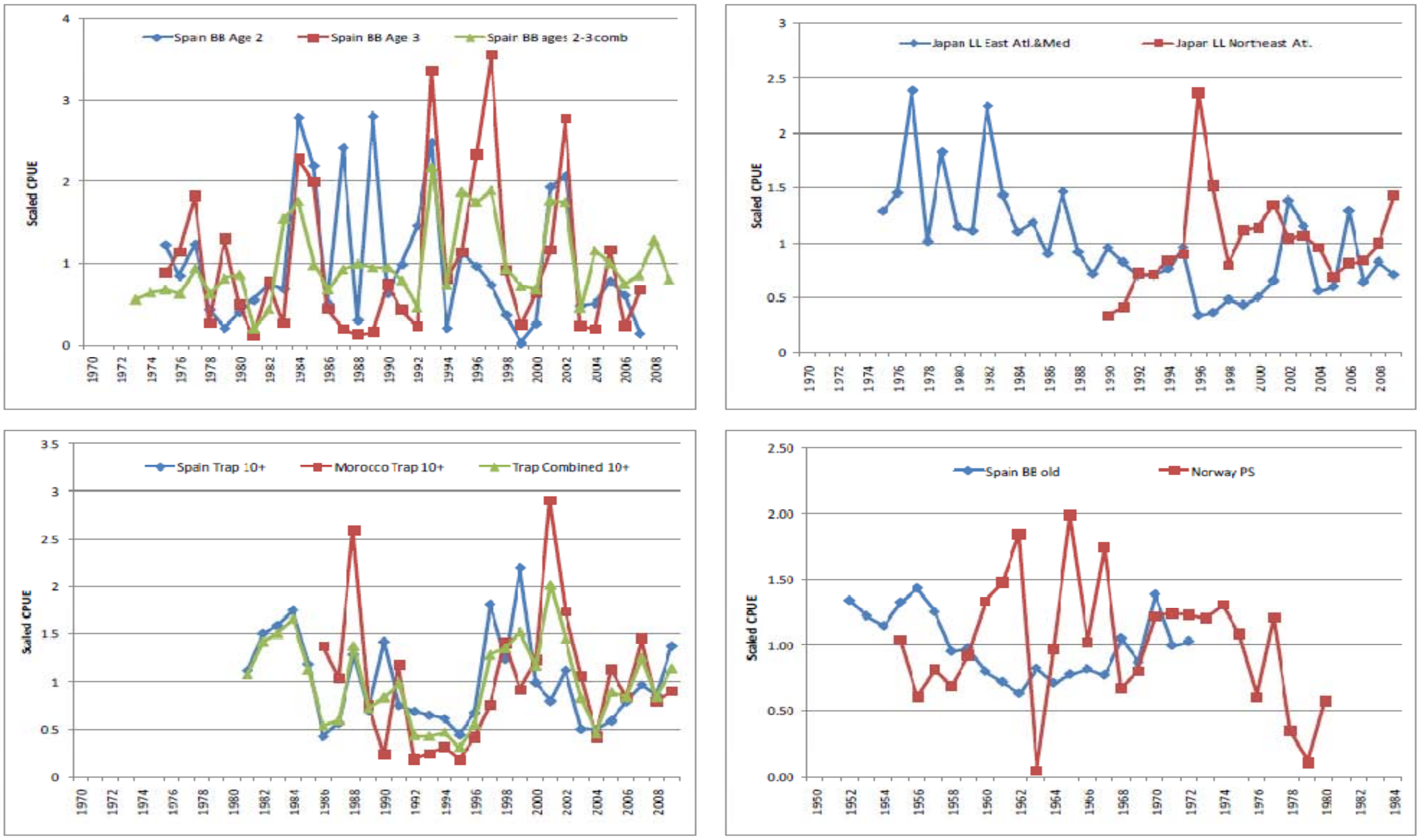


Figure 5.3. Plots of the CPUE time series used as tuning indices in the different runs of the VPA to assess the East Atlantic and Mediterranean stock. All the CPUE series are standardized series except the nominal Norway PS index.

5.1.2. Western Atlantic

Nominal catches and fishery trends

The total catch for the western Atlantic stock peaked at 18,671 t in 1964, mostly due to the Japanese longline fishery for large fish off Brazil and the U.S. purse seine fishery for juvenile fish (Table 5.1., Figures 5.4. and 5.5.). Catches dropped sharply thereafter with the collapse of the bluefin tuna longline fishery off Brazil in 1967 and the decline in purse seine catches. However, they increased again to average over 5,000 t in the 1970s due to the expansion of the Japanese longline fleet into the northwest Atlantic and Gulf of Mexico, and an increase in purse seine effort targeting larger fish for the sashimi market.

Since 1982, the total catch for the western Atlantic including discards has generally been relatively stable due to the imposition of quotas by ICCAT. However, following a total catch level of 3,319 t in 2002 (the highest since 1981), total catch in the West Atlantic declined steadily to a level of 1,638 t in 2007 (Figure 5.3.), the lowest level since 1982, before rising to 1,935 t in 2009, which fell near the TAC. The decline prior to 2007 was primarily due to considerable reductions in catch levels for U.S. fisheries. The major harvesters of western Atlantic bluefin tuna are Canada, Japan, and the United States.

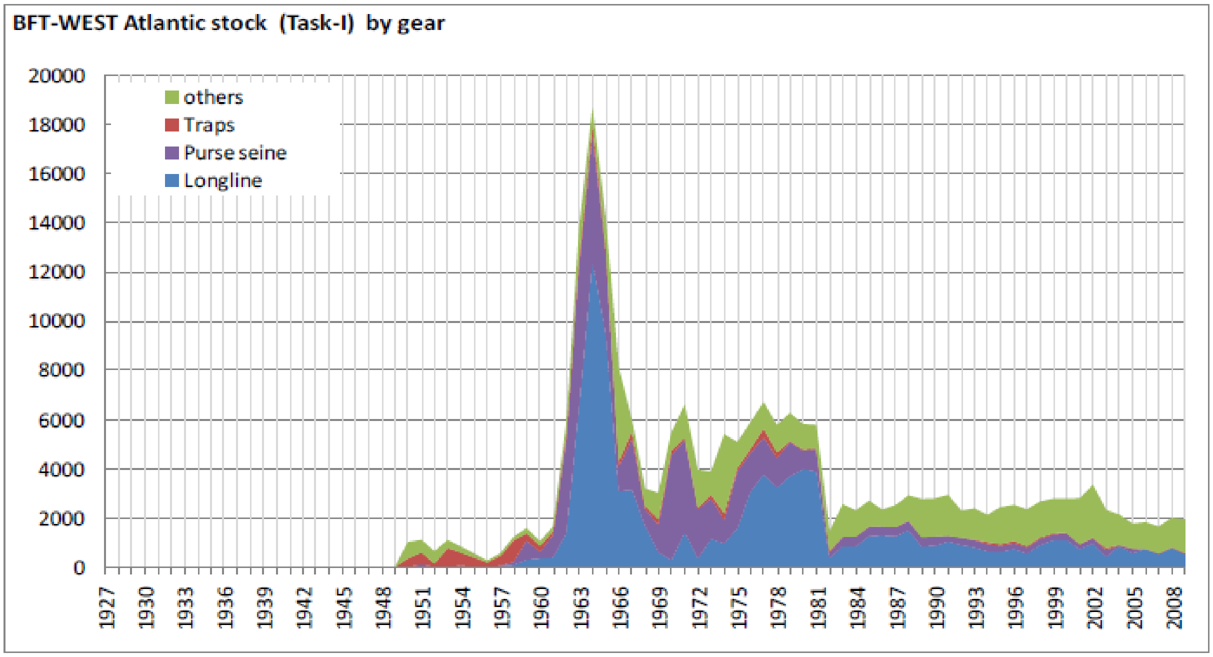


Figure 5.4. Western Atlantic bluefin tuna reported catch by year and main gears.

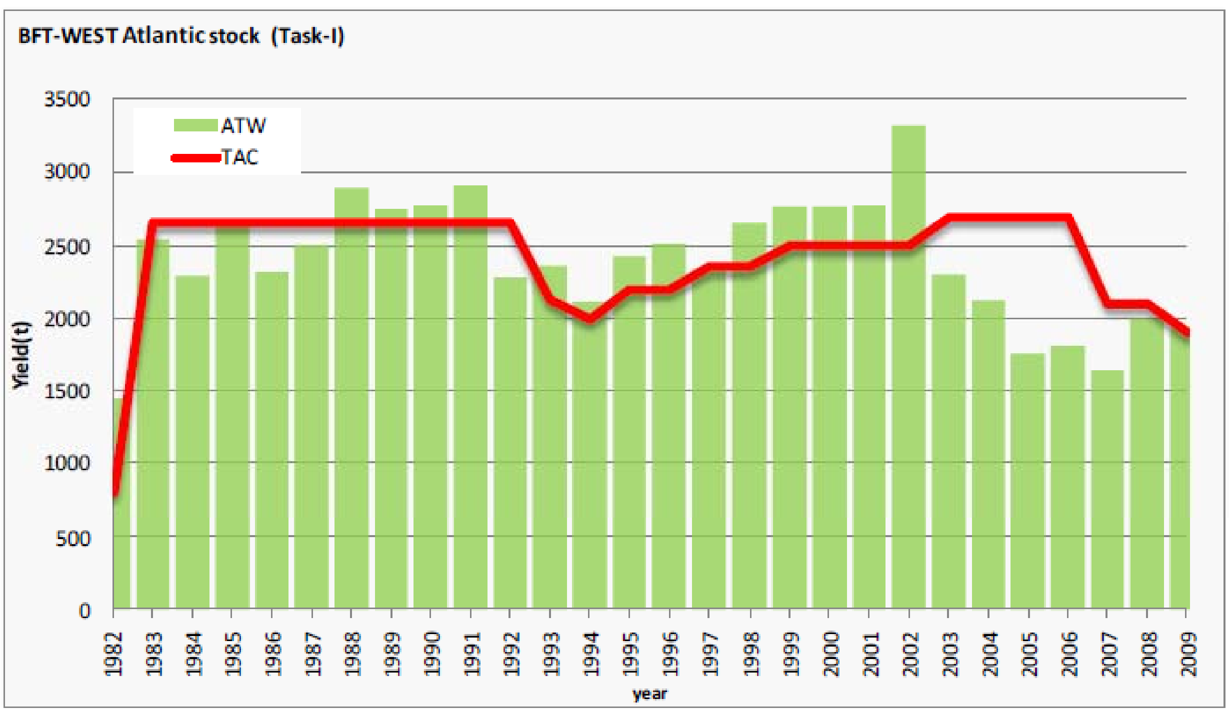


Figure 5.5. Western Atlantic bluefin tuna (BFT) reported annual catch (bars) and the corresponding annual total allowable catch (TAC)(red line).

CANADA: Canadian bluefin tuna fisheries currently operate in several geographic areas off the Atlantic coast from July to November, when bluefin tuna have migrated into Canadian waters. The spatial distribution of the Canadian fisheries has not changed significantly, but there were anecdotal reports of tuna occurring in areas where they have not been observed in many years (for example, the Baie des Chaleurs in the western Gulf of St. Lawrence). Catches for 2005-2009 totaled 600, 733, 491, 575 and 530 t, respectively. The 2006 catch was the highest recorded since 1977. The 2009 landings were taken by rod and reel, tended line, longline, harpoon and trap gear.

JAPAN: Japan uses longline gear to catch bluefin tuna in the Atlantic Ocean. The number of boats engaged in bluefin fishing in the West Atlantic declined to fewer than 10 boats in 2010. Recent catches in the west (about 250-400 t in Japanese fishing year) have fluctuated possibly due to management regulations. The operational pattern also changed in the last few years in the West Atlantic. Fishing in the West Atlantic starts in early December. However, fishing effort in the northwestern area has been reduced in recent years to avoid the catch of small fish (< 100 cm). As a result, during the period January-March some longline vessels operate in an area north and east of Florida/Bahamian Bank (southern ICCAT area BF55/northern ICCAT area BF61). The Japanese longline fleet caught 162 t of bluefin tuna in the western Atlantic in calendar year 2009.

UNITED STATES: The catches (landings and discards) of U.S. vessels fishing in the northwest Atlantic (including the Gulf of Mexico) in 2002 reached 2,014 t, the highest level since 1979. However, catches in 2003-2008 declined precipitously and the United States did not catch its base quota in 2004-2008 with catches of 1,066, 848, 615, 858 and 922 t, respectively. In 2009, the United States fully realized its base quota with total catches (landings including dead discards) of 1,229 t. The 2009 catches, including dead discards, by gear were: 11 t by purse seine, 66 t by harpoon, 291 t by longline, and 860 t by rod and reel.

Catch-at-size (CAS) and catch-at-age (CAA)

The CAS and CAA for the western Atlantic were generated as described in documents SCRS/2010/119 (revised) and SCRS/2010/120. The output from the R-Script AgeIT was also used to generate partial CAA corresponding to some indices with restrictions on sizes and month, a process which was facilitated by the new software.

Relative Abundance Indices and fishery indicators

Indices of abundance for western bluefin tuna available to the Group are presented in Table 5.3. For detailed descriptions of the indices included in the mentioned table the reader should refer to the 'Report of the Data Preparatory Meeting 2010'. The indices used in the base assessment model are presented with their 95 percent confidence limits in Figure 5.9 and are contrasted by area fished in Figure 5.10.

Table 5.2. Description of available indices of abundance for the 2010 western bluefin tuna assessment.

	CAN GLS		CAN SWNS		US RR<145		US RR66-114	
Age Min (Base Treatment)	13		8		1		2	
Age Max(Base Treatment)	16+		14		5		3	
Catch Unit	Numbers		Numbers		Numbers		Numbers	
Effort Unit	Hour		Hour		Offset = log(Hours Fished)		Offset = log(Hours Fished)	
Method	Delta-Lognormal		Delta-Lognormal		Delta-Poisson		Delta-Poisson	
Months Covered	Aug 1 - Oct 31		Aug 1 - Oct 31		June-Sept		June-Sept	
Area Covered	Canada - Gulf of St. Lawrence		Canada - SW Nova Scotia		NE UNITED STATES		NE UNITED STATES	
Updated Since Last Assessment	YES		YES		NO		YES	
USED FOR IN ASSESSMENT	CONTINUITY		CONTINUITY		CONTINUITY		CONTINUITY	
	BASE		BASE		BASE		BASE	
	1960 SENSITIVITY		1960 SENSITIVITY		1960 SENSITIVITY		1960 SENSITIVITY	
	CAN GLS		CAN SWNS		US RR<146		US RR66 114	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1960	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-
1980	-	-	-	-	0.799	0.430	-	-
1981	1.750	0.088	-	-	0.399	0.520	-	-
1982	1.012	0.082	-	-	2.102	0.330	-	-
1983	1.541	0.108	-	-	1.114	0.260	-	-
1984	1.319	0.148	-	-	-	-	-	-
1985	0.443	0.211	-	-	0.630	0.640	-	-
1986	0.383	0.353	-	-	0.778	0.430	-	-
1987	0.337	0.231	-	-	1.219	0.400	-	-
1988	0.576	0.268	2.005	0.222	0.988	0.380	-	-
1989	0.530	0.223	3.122	0.123	0.988	0.430	-	-
1990	0.276	0.268	2.250	0.124	0.904	0.340	-	-
1991	0.540	0.213	1.270	0.139	1.261	0.350	-	-
1992	0.550	0.139	1.208	0.115	0.820	0.420	-	-
1993	0.732	0.168	0.468	0.114	-	-	1.272	0.308
1994	0.259	0.092	1.198	0.104	-	-	0.245	0.650
1995	0.845	0.075	0.907	0.103	-	-	0.821	0.297
1996	0.272	0.078	0.289	0.115	-	-	1.707	0.259
1997	0.259	0.074	0.203	0.122	-	-	2.559	0.225
1998	0.483	0.062	0.425	0.114	-	-	1.537	0.255
1999	0.815	0.060	0.832	0.120	-	-	1.098	0.352
2000	0.641	0.066	0.203	0.130	-	-	0.975	0.533
2001	0.571	0.060	0.573	0.109	-	-	0.421	0.364
2002	0.750	0.066	0.485	0.126	-	-	0.947	0.330
2003	0.753	0.065	1.561	0.213	-	-	0.434	0.281
2004	1.757	0.047	0.558	0.130	-	-	1.731	0.228
2005	1.402	0.040	0.678	0.146	-	-	1.534	0.234
2006	1.281	0.060	0.780	0.120	-	-	0.576	0.340
2007	2.418	0.066	0.765	0.127	-	-	0.580	0.259
2008	1.826	0.141	0.976	0.132			0.228	0.367
2009	4.680	0.098	1.243	0.147			0.335	0.344

Table 5.2. (Continued)

	US RR115-144		US RR145-177		US RR>195		US RR>195 COMB	
Age Min	4		6		10		10	
Age Max	5		8		16+		16+	
Catch Unit	Numbers		Numbers		Numbers		Numbers	
Effort Unit	Offset = log(Hours Fished)		Offset = log(Hours Fished)		Offset = log(Hours Fished)		Offset = log(Hours Fished)	
Method	Delta-Poisson		Delta-Poisson		Delta-Poisson		Delta-Poisson	
Months Covered	June-Sept		June-Sept		June-Sept		June-Sept	
Area Covered	NE UNITED STATES		NE UNITED STATES		NE UNITED STATES		NE UNITED STATES	
Updated Since Last Assessment	YES		NO		NO		NO	
USED FOR IN ASSESSMENT	CONTINUITY BASE 1960 SENSITIVITY		NOT USED		CONTINUITY BASE 1960 SENSITIVITY		NOT USED	
	US RR115-144		US RR145-177		US RR>195		US RR>195 COMB	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1960	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-
1983	-	-	-	-	2.805	0.100	2.544	0.248
1984	-	-	-	-	1.246	0.188	0.961	0.426
1985	-	-	-	-	0.857	0.300	0.736	0.559
1986	-	-	-	-	0.503	1.097	0.433	1.300
1987	-	-	-	-	0.529	0.476	0.617	0.590
1988	-	-	-	-	0.941	0.364	0.796	0.596
1989	-	-	-	-	0.763	0.364	0.583	0.599
1990	-	-	-	-	0.626	0.335	0.482	0.638
1991	-	-	-	-	0.820	0.284	0.612	0.573
1992	-	-	-	-	0.910	0.276	0.741	0.495
1993	2.137	0.446	0.311	3.743	-	-	0.525	0.786
1994	0.502	0.614	0.378	3.118	-	-	0.659	0.669
1995	0.382	0.512	1.334	1.779	-	-	1.104	0.437
1996	0.656	0.491	0.697	2.717	-	-	1.543	0.461
1997	0.244	0.601	0.461	3.046	-	-	1.405	0.572
1998	0.876	0.385	0.362	3.455	-	-	1.347	0.424
1999	0.848	0.471	1.071	2.060	-	-	1.458	0.464
2000	1.894	0.565	0.961	2.064	-	-	0.888	0.553
2001	1.745	0.395	3.424	2.573	-	-	1.564	0.526
2002	2.244	0.419	-	-	-	-	-	-
2003	0.470	0.362	-	-	-	-	-	-
2004	0.502	0.389	-	-	-	-	-	-
2005	0.585	0.391	-	-	-	-	-	-
2006	1.196	0.350	-	-	-	-	-	-
2007	1.356	0.324	-	-	-	-	-	-
2008	0.803	0.361						
2009	0.560	0.422						

Table 5.2. (Continued)

	US RR>177		JLL AREA 2 (WEST)		JLL AREA 3 (31+32)		JLL AREA 17+18		JLL BF61-55	
Age Min	8		2		2		2		2	
Age Max	16+		15+		16+		16+		16+	
Catch Unit	Numbers		Numbers		Numbers		Numbers		Numbers	
Effort Unit	Offset = log(Hours Fished)									
Method	Delta-Poisson		Delta-lognormal		Delta-lognormal		Delta-lognormal		Nominal	
Months Covered	June-Sept									
Area Covered	NE UNITED STATES									
Updated Since Last Assessment	YES		YES		YES		YES		YES	
USED FOR IN ASSESSMENT	CONTINUITY BASE 1960 SENSITIVITY		CONTINUITY BASE 1960 SENSITIVITY		NOT USED		NOT USED		NOT USED	
	US RR>177		JLL AREA 2 (WEST)		JLL AREA 3 (31+32)		JLL AREA 17+18		JLL BF61-55	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1960	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	1.830	0.145	-	-
1976	-	-	0.632	0.417	-	-	2.069	0.121	-	-
1977	-	-	2.329	0.205	-	-	3.463	0.137	-	-
1978	-	-	1.147	0.276	-	-	1.506	0.147	-	-
1979	-	-	0.793	0.242	-	-	2.676	0.135	-	-
1980	-	-	1.445	0.200	-	-	1.688	0.160	-	-
1981	-	-	1.838	0.149	-	-	1.610	0.167	-	-
1982	-	-	0.687	0.239	-	-	3.289	0.128	-	-
1983	-	-	0.300	0.332	-	-	2.116	0.127	-	-
1984	-	-	0.919	0.213	-	-	1.618	0.119	-	-
1985	-	-	1.052	0.207	-	-	1.753	0.146	-	-
1986	-	-	0.079	0.578	-	-	1.325	0.132	-	-
1987	-	-	0.686	0.262	-	-	2.153	0.129	-	-
1988	-	-	1.047	0.202	-	-	1.353	0.134	-	-
1989	-	-	0.872	0.212	-	-	1.044	0.156	-	-
1990	-	-	0.721	0.240	0.377	0.320	1.399	0.133	-	-
1991	-	-	0.723	0.257	0.512	0.294	1.213	0.129	-	-
1992	-	-	1.106	0.210	0.932	0.167	1.030	0.135	-	-
1993	0.900	0.258	1.090	0.225	0.805	0.150	1.039	0.136	-	-
1994	0.994	0.250	1.017	0.218	1.000	0.169	1.110	0.154	-	-
1995	1.426	0.226	0.755	0.285	1.017	0.138	1.391	0.146	-	-
1996	2.492	0.264	2.238	0.198	2.495	0.137	0.484	0.221	-	-
1997	1.086	0.344	1.407	0.247	1.342	0.136	0.521	0.212	-	-
1998	1.451	0.270	0.663	0.281	0.667	0.182	0.700	0.171	-	-
1999	1.589	0.283	0.726	0.300	1.009	0.174	0.628	0.223	-	-
2000	0.762	0.256	0.900	0.264	1.055	0.122	0.711	0.203	-	-
2001	1.610	0.270	0.577	0.389	1.258	0.134	0.942	0.166	-	-
2002	2.116	0.257	0.668	0.298	0.952	0.141	2.018	0.141	-	-
2003	0.435	0.336	0.654	0.385	1.068	0.146	1.682	0.127	-	-
2004	0.527	0.309	0.596	0.373	0.991	0.123	0.814	0.180	-	-
2005	0.441	0.323	0.709	0.219	0.724	0.120	0.871	0.143	0.943	-
2006	0.321	0.444	1.227	0.222	0.939	0.115	1.853	0.143	0.694	-
2007	0.262	0.446	1.883	0.222	0.877	0.118	0.712	0.195	0.821	-
2008	0.372	0.437	0.730	0.353	1.021	0.119	1.206	0.164	1.541	-
2009	0.216	0.515	1.785	0.328	1.490	0.119	1.030	0.236	0.943	-

Table 5.2. (Continued)

	JLL GOM		LARVAL ZERO INFLATED		US PLL GOM 1 - 6		TAGGING		JLL Florida Historic		JLL Brazil Historic	
Age Min	8		9		8		1		9		9	
Age Max	16+		16+		16+		3		16+		16+	
Catch Unit	Numbers		Index of Spawning Biomass		Numbers		Numbers		Numbers		Numbers	
Effort Unit			CPUE = Larvae/100m^2		1000 Hooks		-		-		-	
Method	Delta-lognormal		Delta-lognormal Zero inflated		Delta-Lgn with Repeated Measures		-		-		-	
Months Covered			Apr 20 - May 31		Jan 1 - May 31		-		-		-	
Area Covered			Gulf of Mexico		Gulf of Mexico				Near FL and GOM		Off Brazil	
Updated Since Last Assessment	NO		YES		YES		NO		NO		NO	
USED FOR IN ASSESSMENT	CONTINUITY		CONTINUITY		CONTINUITY		CONTINUITY					
	BASE		BASE		BASE		BASE					
	1960 SENSITIVITY		1960 SENSITIVITY		1990 SENSITIVITY		1960 SENSITIVITY		1960 SENSITIVITY		1960 SENSITIVITY	
	JLL GOM		LARVAL ZERO INFLATED		US PLL GOM 1 - 6		TAGGING		JLL Florida Historic		JLL Brazil Historic	
YEAR	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV	INDEX	CV
1960	-	-	-	-	-	-	-	-	-	-	0.580	0.314
1961	-	-	-	-	-	-	-	-	-	-	0.700	0.239
1962	-	-	-	-	-	-	-	-	-	-	2.406	0.140
1963	-	-									1.566	0.075
1964	-	-	-	-	-	-	-	-	6.084	0.094	2.119	0.083
1965	-	-	-	-	-	-	-	-	9.762	0.125	0.244	0.150
1966	-	-	-	-	-	-	-	-	7.375	0.141	0.111	0.356
1967	-	-	-	-	-	-	-	-	1.954	0.462	0.064	0.501
1968	-	-	-	-	-	-	-	-	2.481	0.584	0.108	0.511
1969	-	-	-	-	-	-	-	-	0.825	1.043	0.023	2.208
1970	-	-	-	-	-	-	1065132	0.200	0.050	4.670	0.014	2.082
1971	-	-	-	-	-	-	1001624	0.200	1.264	0.463	-	-
1972	-	-	-	-	-	-	431955	0.200	-	-	-	-
1973	-	-	-	-	-	-	185615	0.200	-	-	-	-
1974	0.968	0.266	-	-	-	-	341589	0.200	-	-	-	-
1975	0.534	0.205	-	-	-	-	554596	0.200	-	-	-	-
1976	0.666	0.207	-	-	-	-	253265	0.200	-	-	-	-
1977	0.915	0.216	2.654	0.492	-	-	257585	0.200	-	-	-	-
1978	0.876	0.225	4.918	0.241	-	-	121110	0.200	-	-	-	-
1979	1.287	0.283	-	-	-	-	98815	0.200	-	-	-	-
1980	1.158	0.265	-	-	-	-	192541	0.200	-	-	-	-
1981	0.553	0.239	0.758	0.438	-	-	337995	0.242	-	-	-	-
1982	-	-	1.387	0.300	-	-	-	-	-	-	-	-
1983	-	-	1.200	0.361	-	-	-	-	-	-	-	-
1984	-	-	0.382	0.566	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	0.403	0.437	-	-	-	-	-	-	-	-
1987	-	-	0.354	0.476	2.881	0.212	-	-	-	-	-	-
1988	-	-	1.081	0.324	1.500	0.222	-	-	-	-	-	-
1989	-	-	0.768	0.376	2.329	0.218	-	-	-	-	-	-
1990	-	-	0.331	0.340	2.035	0.223	-	-	-	-	-	-
1991	-	-	0.405	0.600	3.284	0.213	-	-	-	-	-	-
1992	-	-	0.525	0.365	0.945	0.224	-	-	-	-	-	-
1993	-	-	0.516	0.681	0.547	0.237	-	-	-	-	-	-
1994	-	-	0.501	0.358	0.404	0.244	-	-	-	-	-	-
1995	-	-	0.349	0.563	0.305	0.251	-	-	-	-	-	-
1996	-	-	0.979	0.528	0.208	0.256	-	-	-	-	-	-
1997	-	-	0.413	0.420	0.316	0.251	-	-	-	-	-	-
1998	-	-	0.124	0.540	0.369	0.250	-	-	-	-	-	-
1999	-	-	0.524	0.538	0.622	0.226	-	-	-	-	-	-
2000	-	-	0.350	0.549	0.705	0.225	-	-	-	-	-	-
2001	-	-	0.399	0.387	0.500	0.239	-	-	-	-	-	-
2002	-	-	0.308	0.662	0.457	0.236	-	-	-	-	-	-
2003	-	-	0.784	0.416	0.754	0.224	-	-	-	-	-	-
2004	-	-	0.557	0.688	0.843	0.221	-	-	-	-	-	-
2005	-	-	0.233	0.326	0.606	0.226	-	-	-	-	-	-
2006			0.619	0.362	0.439	0.250						
2007	-	-	0.258	0.500	0.743	0.231	-	-	-	-	-	-
2008			0.436	0.413	1.274	0.226						
2009			0.667	0.335	0.934	0.232						

5.2. Modeling

5.2.1. Eastern Atlantic and Mediterranean

Virtual Population Analysis (VPA)

Besides using the ADAPT VPA (as implemented in VPA-2box) assessment model, as in the last assessment, the SCRS also explored the use of other models such as Statistical Catch Analysis (ASAP), Year-class curve analysis, Biomass Dynamic Model, and Catch Survey Analysis (CSA). However, as in previous assessments, the scientific advice was based on the results of the VPA. The assessment for the eastern stock used data for the period 1950-2009. The natural mortality vector was the same used for the eastern stock since 1998, i.e., an age specific but time invariant vector. A total of 18 different model runs were performed for the eastern stock. The differences in the runs were based on the indexes of abundance included in the analysis, the selection of the age plus group, and other technical specifications such as the specifications for Terminal F, F-ratios, constraints on recruitment and vulnerability. Details on the technical specifications of the 18 runs are presented in Table 5.3**.** After thorough discussion, the SCRS choose Runs 13 and 15 as base cases. The base cases were then run using the 'inflated' CAA matrix (as defined in the 2008 stock assessment session).

Table 5.3. Technical specifications of the 18 ADAPT-VPA runs investigated for the East Atlantic and Mediterranean BFT stock (for acronyms of CPUE series, see Table BFTE 3.1.1 in 'Report of the Data Preparatory Meeting 2010').

	CPUE series	Terminal F specifications	Constraint on vunnerabilty	Constraint on Recruitment	F-ratios	Plus Group
Run 1	SpBB old & NwPS; SpBB ages 2 & 3; SpMo TP combined; JpLL East&Med	All estimated except Age 1 = 0.75 age 2	2 yr (sig = 0.5)	None	U shape (i.e. 2008)	10+
Run 2	same as Run 1	same as Run 1	2 yr (sig = 0.5)	None	All = 1	10+
Run 3	same as Run 1	All estimated	2 yr (sig = 0.5)	None	U shape (i.e. 2008)	10+
Run 4	same as Run 1	same as Run 3	2 yr (sig = 0.5)	None	All = 1	10+
Run 5	SpBB old & NwPS; SpMo TP combined; JpLL East&Med	Age 4+ estimated, Age 3= 0.8 Age 4; Age 2 = Age 4; Age 1-0.05 Age 4	2 yr (sig = 0.5)	None	U shape (i.e. 2008)	10+
Run 6	same as Run 5	same as Run 5	2 yr (sig = 0.5)	None	All = 1	10+
Run 7	same as Run 5	same as Run 5	2 yr (sig = 0.5)	2 yr (sig = 0.5)	U shape (i.e. 2008)	10+
Run 8	same as Run 5	same as Run 5	2 yr (sig = 0.5)	2 yr (sig = 0.5)	All = 1	10+
Run 9	same as Run 5	same as Run 5	None	2 yr (sig = 0.5)	U shape (i.e. 2008)	10+
Run 10	same as Run 5	same as Run 5	None	2 yr (sig = 0.5)	All = 1	10+
Run 11	SpBB old & NwPS; SpMo TP combined; JpLL East&Med; JpLL Neast	same as Run 5	2 yr (sig - 0.5)	2 yr (sig - 0.5)	U shape (i.e. 2008)	10+
Run 12	same as Run 11	same as Run 5	2 yr (sig = 0.5)	2 yr (sig = 0.5)	All = 1	10+
Run 13	SpBB old & NwPS; SpMo TP combined; JpLL East&Med; JpLL Neast; SpBB ages 2 & 3	All estimated	3 yr (sig = 0.5)	2 yr (sig = 0.5)	U shape (i.e. 2008)	10+
Run 14	same as Run 13	same as Run 13	3 yr (sig = 0.5)	2 yr (sig = 0.5)	All = 1	10+
Run 15	SpBB old & NwPS; SpMo TP combined; JpLL East&Med; JpLL Neast; SpBB ages comb	same as Run 13	3 yr (sig = 0.5)	2 yr (sig = 0.5)	U shape (i.e. 2008)	10+
Run 16	same as Run 15	same as Run 13	3 yr (sig = 0.5)	2 yr (sig = 0.5)	All = 1	10+
Run 17	same as Run 14	same as Run 14	same as Run 14	same as Run 14	same as Run 14	16 +
Run 18	same as Run 16	same as Run 16	same as Run 16	same as Run 16	same as Run 16	16 +

5.2.2. Western Atlantic

Virtual Population Analysis (VPA)

Virtual population analyses (VPA) were conducted using the VPA-2BOX software featured in the ICCAT Software Catalog. The parameter and data specifications used in the VPA during the 2010 assessment were generally similar to those used in the 2008 base case assessment, but there were a number of important departures (most notably the use of a new growth curve to convert size to age and increasing the age of the plus group to 16). Table 5.2 provides a summary of the available indices of abundance. Seventeen different model runs were performed, which included different combinations of indices of abundance and age selectivity vectors. For detailed explanation of the parameter specifications of the different model runs the reader should refer to the *Report of the 2010 ICCAT Atlantic Bluefin Stock Assessment Session* (http://www.iccat.int/Documents/Meetings/Docs/2010_BFT_ASSESS_REP_ENG.pdf).

It should be noted at the outset that one of the most influential changes since the 2008 assessment has been the use of a new growth curve (Restrepo *et al*., 2010) to convert the CAS to CAA. This curve assigns fish above 120 cm to older ages than did the previous growth curve (Turner and Restrepo, 1994). Conversely, it assigns fish smaller than 60 cm to somewhat younger ages.

The natural mortality rate was assumed to be age-independent (=0.14 yr-1) as in previous assessments. The maturity vector used in past assessments assumed ages 1-7 were immature and ages 8 and older were fully mature. The SCRS observed that the original specification of age 8 and older was based on the Turner and Restrepo (1994) growth curve and that fish of the same size would be classified at age 9 with the Restrepo *et al*. (2010) growth curve. Accordingly, for runs using CAA estimated with the Restrepo *et al*. (2010), the SCRS used a new maturity vector with 100 percent maturity starting at age 9.

For the western Atlantic stock, 18 different VPA runs were also performed using different technical specifications such as plus group age, natural mortality, age of maturity, constraints on vulnerability, and F-ratio settings.

5.3. Results of the 2010 Assessment

5.3.1. Eastern Atlantic and Mediterranean

In general, the fits to the available CPUE indices continued to be poor, similar to past assessments. Such a poor fit was due to the poor quality of the CAA matrix (see previous section) and uncertainties about total catch in recent years and CPUE indices.

In general, the different runs lead to different perceptions of the stock reflecting high sensitivity to the technical assumptions (i.e. assumptions about the F-ratios, terminal ages, recruitment and vulnerability penalties, Plus-group) and the choice of the CPUE values.

The selected base cases (Runs 13 and 15) displayed comparable outputs and similar general trends in both fishing mortality rates and stock abundance (Figures 5. 6). Recruitment at the start of the time series varied between 2 and 3 million fish, dropped to around 1 million fish during the 1960s, followed by a steady increase towards maximum values in the 1990s and early 2000's while recruits dropped steeply in the last years. However, the recent levels are known to be less reliable because of the lack of data to estimate them. Note also that a potential strong decline in the recruitment in the most recent years is not in agreement with scientific information from aerial surveys carried out in the Mediterranean Sea (see SCRS/2009/142).

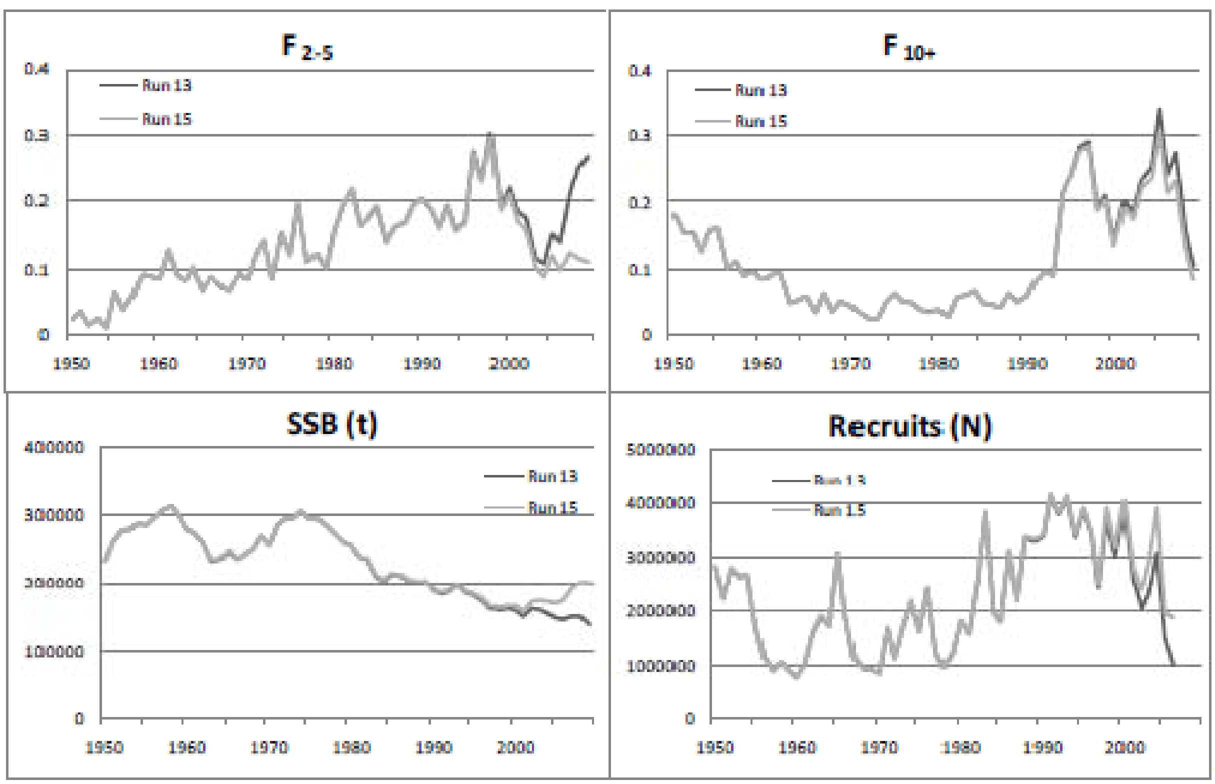


Figure 5.6. Time series of fishing mortality at ages 2-5 (top left), fishing mortality at ages 10+ (top right), SSB (bottom left) and recruits (bottom right) for runs base cases 13 and 15 (reported catch).

Final spawning biomass estimates differed slightly between the two runs. The spawning biomass peaked over 300,000 t in the late 1950s and early 1970s, followed by a decline. Under run 13, the biomass continued to slightly decline to about 150,000 tons, while under Run 15, biomass slightly increased during the late 2000s to about 200,000 tons. Considering both Runs 13 and 15, the analyses indicated that recent (2007-2009) spawning stock biomass (SSB) is about 57 percent of the highest estimated SSB levels (1957-1959).

These two runs were further investigated using an 'inflated' CAA in the same way as it was done in the 2008 assessment (i.e., catch raised to 50,000 tons from 1998 to 2006 and to 61,000 tons in 2007). The results of Runs 13 and 15 were similar to those of the reported catch, except for the SSB (Figure 5.7). In the runs using the reported catches, the SSB over the last 30 years displays mostly a steady decline (except in the last year for Run 15), while the Runs using the 'inflated' catches showed that SSB was approximately for about 20 years followed by a steep decline in the last years (a pattern already noted on the 2008 assessment results).

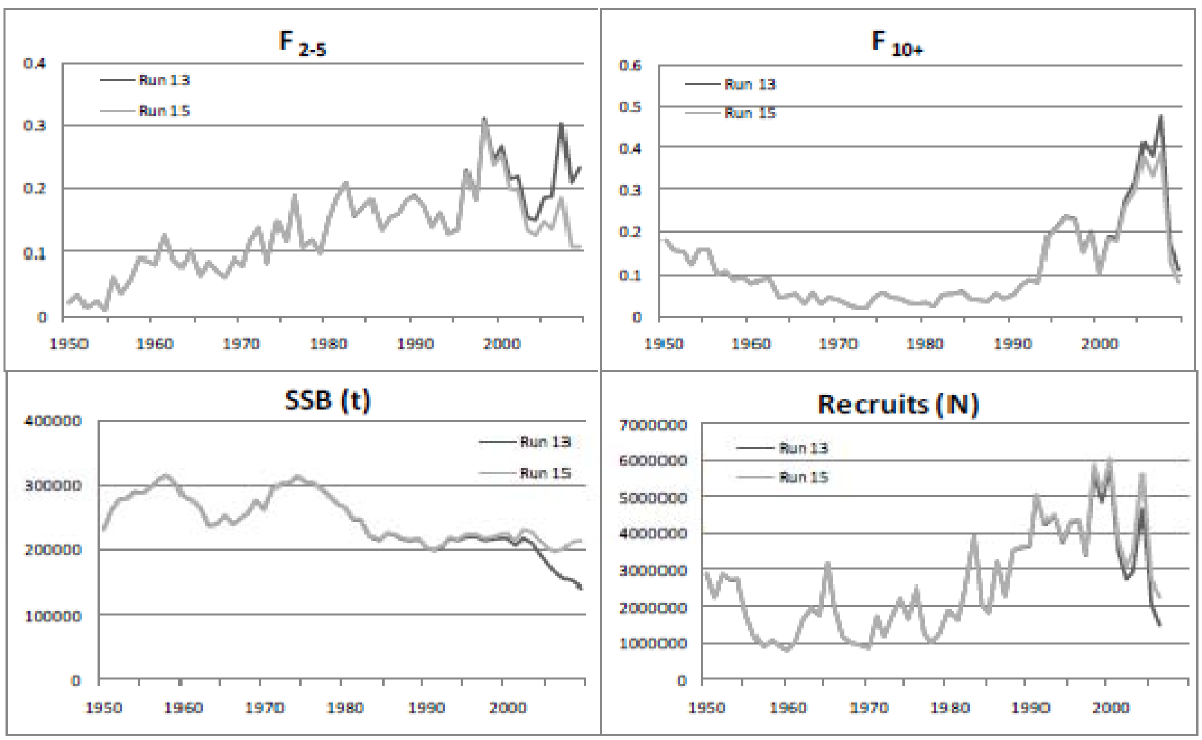


Figure 5.7. Time series of fishing mortality at ages 2-5 (top left), fishing mortality at ages 10+ (top right), SSB (bottom left) and recruits (bottom right) for runs base cases 13 and 15 (inflated catch).

Estimates of the 2009 stock status relative to maximum sustainable yield (MSY) benchmarks lead to the conclusion that F_{2009} remained largely above the reference target $F_{0.1}$, as $F_{2009}/F_{0.1}$ was about 2.9 for both Runs 13 and 15 combined. SSB was about 35 percent (from 19 percent to 51 percent depending on the recruitment levels) of the biomass that is expected under a MSY strategy. The recent declines in Fs led to an improved perception of the stock status relative to the benchmarks in comparison to previous assessment. However, in 2009 the stock remained overfished (e.g., current biomass is less than biomass at MSY), and overfishing (e.g., current fishing mortality is higher than that of the MSY level) was still occurring.

5.3.2. Western Atlantic stock

The basecase assessment is consistent with previous analyses in that SSB declined steadily between the early 1970s and early 1990s. Since then, SSB was estimated to have fluctuated between 21 percent and 28 percent of the 1970 level (Figure 5.8), but with a gradual increase in recent years from the low of 21 percent in 2003 to 29 percent in 2009. The stock has experienced different levels of fishing mortality (F) over time, depending on the size of fish targeted by various fleets. Fishing mortality on spawners (ages 9 and older) declined markedly after 2003. The estimates of recruitment (age 1) are very high for the early 1970s, but are much lower for the years since with the exception of a strong year-class in 2003.

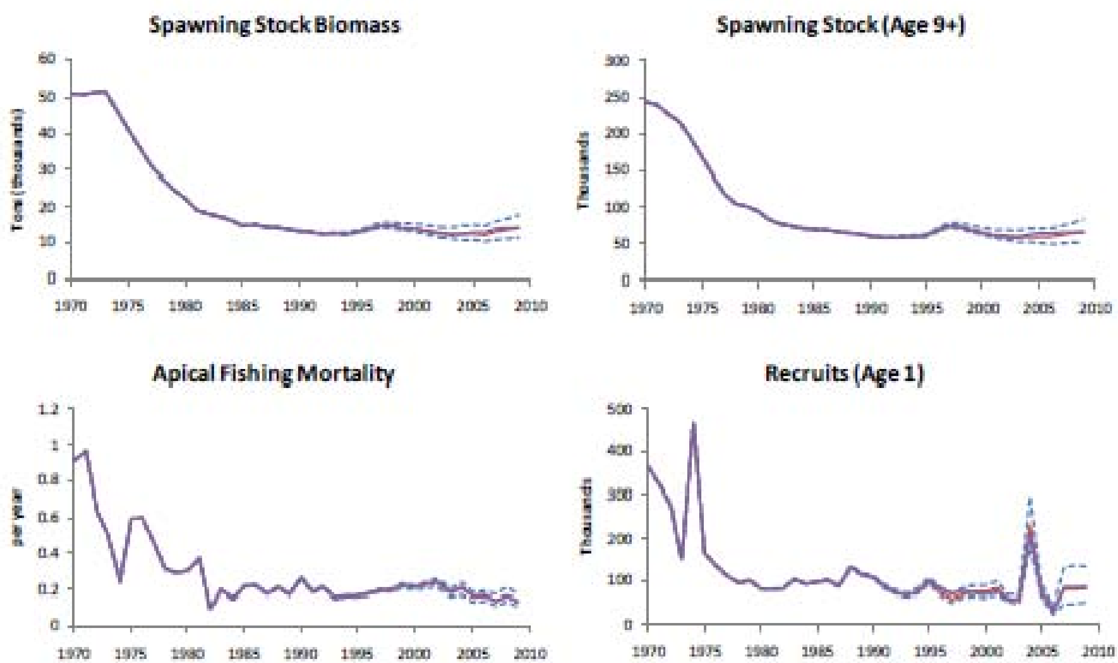


Figure 5.8. Median (solid line) estimates of spawning stock biomass, abundance of spawners (Age 9+), apical fishing mortality and recruitment. The 2007-2009 recruitment estimates were replaced by values from the two-line S-R relationship. Dashed lines indicate the 80 percent confidence interval.

A key factor in determining stock status is the estimation of the MSY-related benchmarks against which the current condition of the stock will be measured. These benchmarks depend to a large extent on the relationship between spawning biomass and recruitment. During the 2010 assessment, the SCRS reexamined the two alternative spawner-recruit hypotheses explored in several prior assessments: the two-line (low recruitment potential scenario) and the Beverton and Holt spawner-recruit formulation (high recruitment potential scenario).

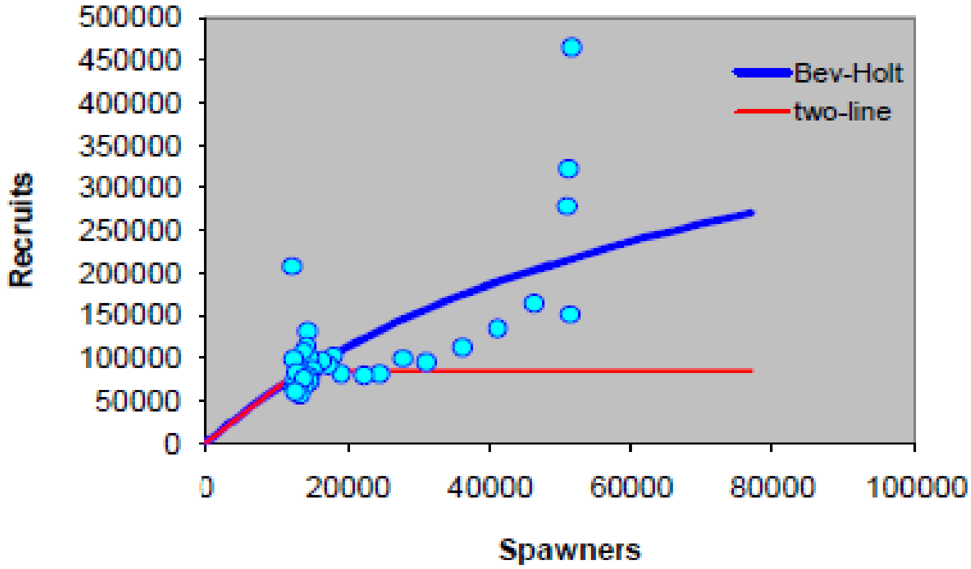


Figure 5.9. The spawner-recruit relationships fit to the 2010 VPA base model. The two-line and Beverton and Holt formulations were used to calculate management reference points and project the population dynamics through 2019. Points represent the estimates from the VPA.

The two-line model assumes recruitment increases linearly with SSB from zero with no spawners to a maximum value (R_{MAX}) when SSB reaches a certain threshold. Here, the SSB threshold (hinge) was set at the average SSB during 1990-1995 (the period with the lowest estimated SSB), and R_{MAX} was calculated as the geometric mean recruitment during 1976-2006 (the recruitment estimates for the last three years were deemed unreliable). The Beverton and Holt function was fit to the SSB and recruitment estimates corresponding to the period 1971-2006. The two curves are shown in Figure 5.9. Due to uncertainty in the estimation of the spawner-recruit relationship, the SCRS also decided to present alternative benchmarks using $F_{0.1}$ as a proxy for F_{MSY}.

Stock status was determined under both the two-line and Beverton-Holt scenarios for the base model from 1970 to 2009 (Figure 5.9). The results under the two-line (low recruitment potential) scenario suggested that the stock has not been overfished since 1970 and that overfishing has not occurred since 1983. The results under the Beverton-Holt (high recruitment potential) scenario suggested that the stock has been overfished since 1970, and the fishing mortality rates have been above F_{MSY}, except for the years 1985, 1986, and 2007 to 2009. It is important to note that under the high recruitment potential scenario the median value of $F_{current}$ (geometric mean F for 2007-2009) is above F_{MSY}.

The estimated ICCAT status of the western Atlantic stock in 2009 and western Atlantic stock status trajectories are shown for the two recruitment levels in Figures 5.10. With the two-line model, recent F (geometric mean from 2007-2009) is 30 percent to 40 percent below F_{MSY}. Spawning stock biomass is 20 percent to 60 percent above SSB_{MSY}. With the Beverton-Holt model, recent F (geometric mean F for 2007-2009) is 40 percent to 90 percent above F_{MSY} and SSB is 60 percent to 80 percent below SSB_{MSY}. In summary, using MSY-related benchmarks, the western Atlantic stock is not overfished and is not undergoing overfishing under the low recruitment potential scenario. However, under the Beverton-Holt recruitment hypothesis (high recruitment potential scenario), the stock remains overfished and overfishing is occurring.

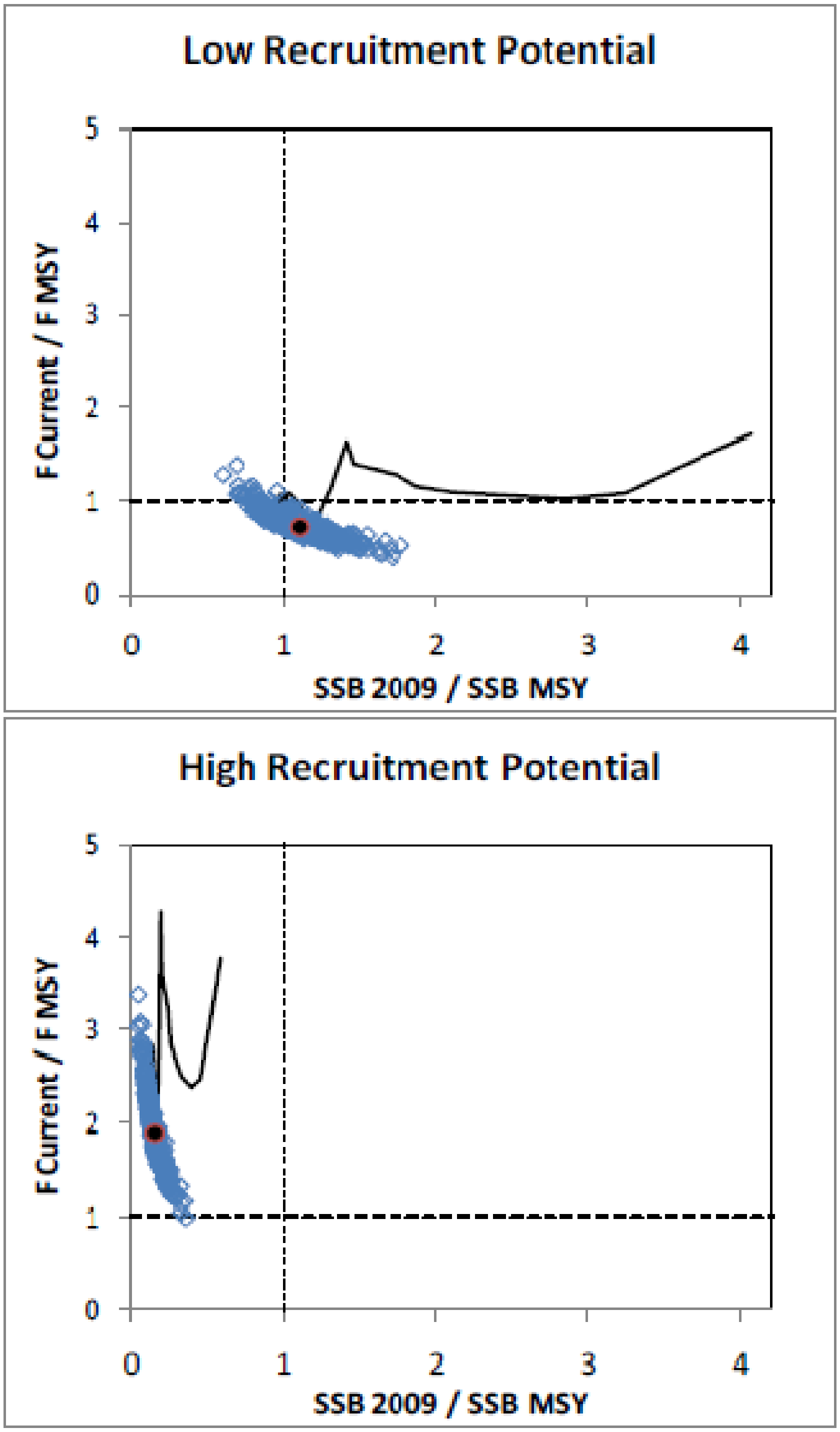


Figure 5.10. Estimated status of stock relative to the Convention objectives (MSY) by year (1970 to 2009). The lines give the time series of point estimates for each recruitment scenario and the cloud of symbols depicts the corresponding bootstrap estimates of uncertainty for the most recent year. The large black circle represents the status estimated for 2009 (the geometric mean fishing mortality during 2006-2008 is the proxy for F in 2009).

The SCRS also concluded that the assessment did 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. Limited analyses were conducted of the two stocks with mixing in 2008, but little new information was available in 2010. Based on earlier work, the estimates of stock status can be expected to vary considerably depending on the type of data used to estimate mixing (conventional tagging or isotope signature samples) and modeling assumptions made. More research needs to be done before mixing models can be used operationally for management advice. Another important source of uncertainty is recruitment, both in terms of recent levels (which are estimated with low precision in the assessment), and potential future levels (the "low" vs. "high" recruitment hypotheses which affect management benchmarks). Improved knowledge of maturity at age will also affect the perception of changes in stock size. Finally, the lack of representative samples of otoliths requires determining the catch at age from length samples, which is imprecise for larger bluefin tuna.

The SCRS reiterated that the conservation and management measures adopted in 2006 and 2008 were expected to result in a rebuilding of the stock towards the Convention objective, but also noted that there has not yet been enough time to detect with confidence the population response to the respective management measures. Some of the available fishery indicators suggest the spawning biomass of western bluefin tuna may be slowly rebuilding.

The results of the 2010 stock assessment for western Atlantic bluefin tuna were strongly influenced by a new growth curve (Restrepo *et al*., 2010). The new growth curve assigns older ages to fish larger than 120 cm. As a result, the age structure of the catch included a higher proportion of older fish, which implied that the stock was subjected to a lower fishing mortality than previously estimated. The SSB trend shows an increase in the last few years of the time series considered. Under the low recruitment potential scenario, SSB was estimated to have greater than a 60 percent chance of being above the level that will support MSY, and overfishing is not occurring. SSB remained low relative to the level at MSY under the high recruitment potential scenario. The fishing mortality rate under the high recruitment potential scenario indicated overfishing was still occurring. The SCRS also noted the strength of the 2003 year class, the largest since 1974, although it also acknowledged that the recruitment estimated by the VPA for subsequent year classes appears to be the lowest on record and, therefore, they are a cause of concern. However, anecdotal information from U.S. recreational and commercial fishermen pointed to a perceived high abundance of small bluefin tuna in U.S. waters in 2010, which seems to contradict the SCRS assertion.

The SCRS also noted the uncertainty in the projections, in particular regarding mixing, age at maturity, recruitment, and, therefore, suggested that a precautionary approach could be needed. Pursuant to an ICCAT resolution (discussed in Section 6.4.1), the SCRS generated 6 strategy matrices that reflected, for various constant catch levels through 2019 and under the low recruitment, high recruitment, and combined scenarios, the probability that: 1) the SSB will exceed the level that will produce MSY in any given year; and 2) the fishing mortality rate will be less than the level that would eventually produce MSY. The SCRS advised that the 2010 TAC (1,800 mt) should allow the SSB to continue to increase under both recruitment scenarios and should offer some protection to the 2003 year class. Under the low recruitment potential scenario, catches of 2,500 mt have a 50 percent probability of preventing overfishing and maintaining the SSB above the level needed to support MSY. However, catches at this level would likely negatively impact the 2003 year class. Under the high recruitment potential scenario, the stock cannot be rebuilt within the rebuilding timeframe even with a zero TAC (i.e., no catches). A TAC of 1,100 mt or less was expected to end overfishing and initiate rebuilding under the high recruitment potential scenario. Once again, the SCRS noted that both the productivity of western Atlantic bluefin tuna and western Atlantic bluefin tuna fisheries is linked to the eastern Atlantic and Mediterranean stock. Therefore, management actions taken in the eastern Atlantic and Mediterranean are likely to influence the recovery in the western Atlantic, because even small rates of mixing from East to West can have significant effects on the West due to the fact that Eastern plus Mediterranean resource is much larger than that of the West (i.e., approximately 10 times the size).

6. ESA SECTION 4(a)(1) FACTORS ANALYSIS

As stated previously, the ESA defines an "endangered" species as any species in danger of extinction throughout all or a significant portion of its range (SPOIR) and a "threatened" species as any species likely to become endangered throughout all or a SPOIR within the foreseeable future. Section 4(b)(1)(a) of the ESA requires that determinations of whether a species is threatened or endangered be based solely on the best scientific and commercial data available and after taking into account those efforts, if any, being made to protect such species. A species may be determined to be endangered or threatened because of one or more of the following five factors described in Section 4(a)(1) of the ESA:

A. The present or threatened destruction, modification, or curtailment of habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

In the following section, each of these five factors is examined for its historic, current, and/or potential impact on bluefin tuna status. It should be noted that current and potential threats, along with current distribution and abundance, determine present vulnerability to extinction. Information about historic threats is included to assist interpretation of historical population trends. The relationship between historic threats and population trends also provides insights that may help to project future population changes in response to current and potential threats.

6.1. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

The Gulf of Mexico is believed to possess certain features for bluefin tuna larval habitat which determine growth and survival rates of bluefin tuna, and can be variable from year to year (McGowan and Richards, 1989). The Gulf Stream can produce upwelling of nutrient rich waters along the shelf edge, which may provide an area favorable to maximum growth and retention of food for the larvae (McGowan and Richards, 1989). Bluefin tuna range along the entire East (For more information on western Atlantic bluefin tuna spawning habitat, see Section 2.3).

The Mediterranean Sea is a basin with unique characteristics, being a semi-enclosed sea connected to the Atlantic Ocean through the narrow Strait of Gibraltar, to the Red Sea by the man-made Suez Canal and to the smaller enclosed Black Sea via the narrow Bosphorus Strait. The Mediterranean Sea exchanges water, salt, heat, and other properties with the North Atlantic Ocean, and is thus, an important factor affecting global water formation processes and variability, and subsequently, the stability of the global thermohaline state of equilibrium (Wurtz, 2010). For more information on eastern Atlantic bluefin tuna spawning habitat, see Section 2.3. Bluefin tuna habitat may be affected by natural and anthropogenic threats which are discussed in detail below.

Offshore Aquaculture

As of 2009, there were no commercial finfish offshore aquaculture operations in U.S. Federal waters although there were several aquaculture operations conducting research and commercial production in state waters, off the coasts of California, New Hampshire, Hawaii, Washington, Maine, and Florida (GMFMC, 2009). In 2009, the Gulf of Mexico Fishery Management Council (GMFMC) developed a Fishery Management Plan (FMP) for offshore aquaculture in the Gulf of Mexico and an estimated 5 to 20 offshore aquaculture operations may be permitted in the Gulf over the next 10 years (GMFMC, 2009) (i.e., 2009 to 2018). Marine aquaculture would be prohibited in Gulf of Mexico EEZ habitat areas of particular concern, marine reserves, marine protected areas, Special Management Zones, permitted artificial reef areas, and coral reef areas as specified in 50 CFR 622, and coral reef areas as defined in 50 CFR 622 (GMFMC, 2009). Additionally, prior to permit review applicants would have to conduct a baseline environmental assessment at the proposed site in accordance with NMFS protocols and procedures (GMFMC, 2009). Potential impacts resulting from offshore aquaculture may include increased nutrient loading, habitat degradation, fish escapement, competition with wild stocks, entanglement of endangered or threatened species and migratory birds, spread of pathogens, user conflicts, economic and social impacts on domestic fisheries, and navigational hazards (GMFMC, 2009).

Areas where marine aquaculture is prohibited in the Gulf of Mexico overlap with the spawning areas of the western Atlantic DPS, and thus, we do not expect any impacts to the spawning habitat of the DPS from offshore aquaculture. The SRT is not aware of specific information that pertains to the effects of offshore aquaculture on the habitat in the eastern Atlantic/Mediterranean; however, impacts to the DPS may be similar to the potential impact resulting from offshore aquaculture as noted above.

Petroleum Exploration and Development

One of the major activities with the potential to impact bluefin tuna habitat is oil and gas development on the outer continental shelf (OCS). As of 2009, there were approximately 4,000 oil and gas platforms in the Gulf of Mexico and fewer than 100 in the Atlantic. Most of the platforms were in waters shallower than 1,000 feet (~300 m); however, there are ongoing efforts to expand oil drilling to deeper areas of the Gulf. Approximately 72 percent of the Gulf of Mexico's oil production comes from wells drilled in 1,000 feet (305 m) of water or greater (MMS, 2008(b)). In 2007, 54 percent of all Gulf of Mexico leases were located in water depths greater than 1,000 ft. In the two 2007 lease sales, Western Gulf Lease Sale 204 and Central Gulf Lease Sale 205, almost 70 percent of the tracts receiving bids were in water depths of 1,312 ft or greater (400 m). Additionally, 94 exploratory wells and 48 development wells were drilled in 2007. Of the 48 development wells drilled, 60 percent were in water depths greater than 5,000 ft. Eight new deepwater discoveries were announced by oil and gas operators in 2007 with the deepest in 7,400 ft of water (MMS, 2008). Many of the shallower sites and most of the deepwater sites fall within habitats used by HMS, particularly by bluefin tuna. Many of the deeper sites are also located within the proposed HAPC for bluefin tuna. The continued expansion of deep water oil exploration is detailed in the MMS report, "Deepwater Gulf of Mexico 2008: America's Offshore Energy Frontier*,*" which chronicles the activities of the oil and gas industry in the deepwater (1,000 ft of water or more) areas of the Gulf of Mexico over the past sixteen years (MMS, 2008(b)).

In the Atlantic, ten oil and gas lease sales were held between 1976 and 1983. Fifty-one wells were drilled in the Atlantic OCS; five Continental Offshore Stratigraphic Test (COST) wells between 1975 and 1979, and 46 industry wells between 1977 and 1984. Five wells off New Jersey had successful drillstem tests of natural gas and/or condensate. These five wells were abandoned as non-commercial. Reports on each of the eight exploratory and two COST wells drilled in the North Atlantic Planning Area are available and reports on 10 of the 34 wells drilled in the Mid-Atlantic Planning Area are available on the MMS webpage at http://www.gomr.mms.gov/homepg/atlantic/georges_bank.html.

For oil platforms, there are direct and indirect impacts to the environment such as disturbance created by the activity of drilling, associated pollution from drilling activities, discharge of wastes associated with offshore exploration and development, operational wastes from drilling muds and cuttings, potential for oil spills, and potential for catastrophic spills caused by accidents, such as the Deepwater Horizon (DWH) oil spill in 2010 (described in detail below), or hurricanes and alteration of food webs created by the submerged portions of the oil platform, which attract various invertebrate and fish communities. Anecdotal information suggests that some recreational fishermen may target various fish species, including HMS, in the vicinity of oil platforms due to increased abundance and availability near platforms. The apparent increase in abundance of several species may be due to increased prey availability resulting from various fish and invertebrate communities that are attracted to or attach directly to the structures and submerged pilings. While the apparent increase in abundance of fish near oil platforms may appear to be beneficial, little is known about the long term environmental impacts of changes caused by these structures to fish communities, including potential changes to migratory patterns, spawning behavior, and development of early life stages. Currently, there is debate about whether the positive effects of the structures in attracting fish communities would be reduced by removal of the platforms when they are decommissioned.

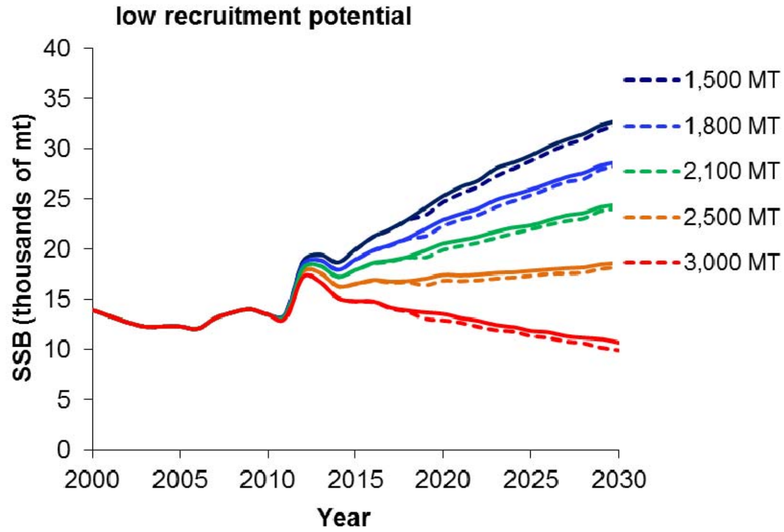
Deepwater Horizon Oil Spill

The potential effect of the DWH spill on the future abundance of western Atlantic bluefin tuna was evaluated by comparing the projections made by the ICCAT Standing Committee on Research and Statistics (SCRS, 2010) with similar projections that assume the number of yearlings (one-year-old-fish) in 2011 will be reduced by 20 percent. The value of 20 percent was based on the recent report by the European Space Agency that suggested that about 20 percent of the spawning habitat was oiled. The SRT noted that another study (SEFSC, 2011, pers. comm.) suggested that considerably less than 20 percent of the spawning habitat for the western DPS was affected by the spill. Moreover, if some larvae survive their encounter with oil and associated toxicants, or if density dependent processes are involved in the mortality of bluefin tuna after the larval phase, then a 20 percent loss of spawning habitat might result in something less than a 20 percent reduction in the expected number of yearlings. On the other hand, factors such as the distribution of oil below the surface and the advection of larvae into the spill area after spawning are not well known. Accordingly, the SRT regarded 20 percent as a reasonable upper bound for the mortality rate of bluefin tuna larvae owing to the spill event.

The results of the projections for the two alternative models used by the SCRS to represent the future recruitment of young fish to the western DPS (i.e., the high and low recruitment potential hypotheses) are presented in Figure 6.1. The 20 percent reduction in the 2010 year-class (2011 yearlings) results in less than a 4 percent reduction in spawning biomass when future catches are within the range historically allowed under ICCAT management (i.e., 2,500 mt or less). This result is not surprising because bluefin tuna are a relatively long-lived species and the 2010 year class is only one of multiple year classes that will contribute to the spawning biomass in any given year. If the TAC remains less than 2,500 mt, as is expected, then the western DPS is expected to continue to increase despite the DWH event. If, on the other hand, catches are allowed to exceed 2,500 mt, then the western DPS is expected to decline and any reduction in the 2010 year class will hasten that decline.

Additional runs were made with the 'MAST' model (Taylor, McAllister and Block, pers. comm.), which uses electronic tagging data in an effort to account for intermixing between the eastern and western DPSs. These runs assumed future catches in the west would be 1,800 mt and future catches in the east would be 13,500 mt (slightly greater than allowed by the current management plans). The results were very similar to those above. In this case, a 20 percent reduction in the 2010 year-class causes only a 3 percent reduction in spawning biomass.

In summary, independent projections with two different types of models show that a 20 percent reduction in the 2010 year-class will likely result in less than a 4 percent reduction in future spawning biomass. However, if a significant fraction of adult bluefin tuna were killed or rendered impotent by the spill, then subsequent year-classes might also be reduced, leading to greater reductions in spawning biomass than estimated above. For example, if 20 percent of the adults were also killed in 2010, then the spawning biomass would be immediately reduced by 20 percent, which might lead to additional reductions in the 2011 and subsequent year-classes (relative to what they would have been in the absence of the spill). The reduction in the 2010, 2011, and subsequent year classes would, in turn, lead to reductions in future spawning biomass levels (9 years later as they begin to mature). To date, however, the SRT has been unable to identify any evidence that any portion of adults were deleteriously affected. The results from several electronic tagging studies confirm that some bluefin tuna have historically spent at least a portion of their time in the waters in the vicinity of the spill area, but the exact fraction is difficult to quantify owing to the uncertainties associated with inferring tracks and the rather low number of samples. All of the electronically-tagged bluefin tuna that were known to have spent time in the Gulf of Mexico during the actual spill event (8 fish) survived long after leaving the Gulf of Mexico.



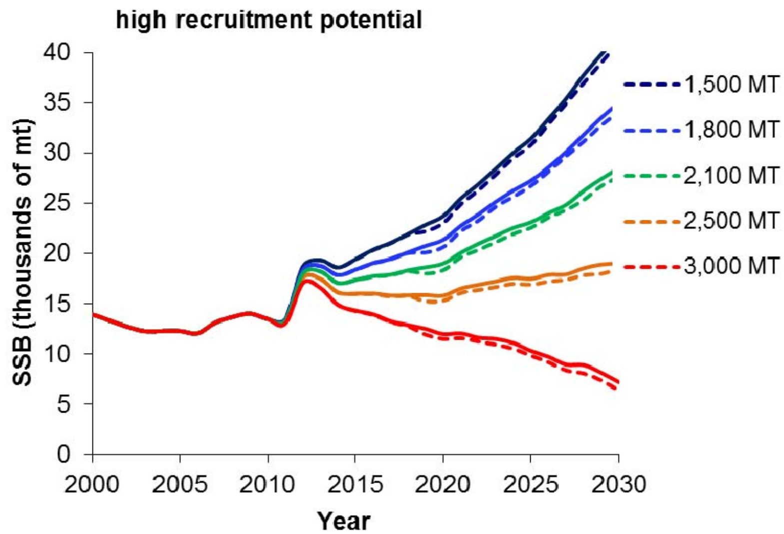


Figure 6.1. Projections of spawning biomass (age 9 and older) relative to the target level (MSY) assuming the 'low' and 'high' recruitment potential models postulated by the ICCAT SCRS. The solid lines represent the trends of the projections under various quotas without regard to the Deepwater Horizon event (as conducted by the SCRS 2010 assessment). The adjacent dashed lines show the corresponding projections when it is assumed that the number of age 1 recruits in 2011 will be reduced by 20 percent (relative to what they would have been had the spill not occurred). The diverging trends in spawning biomass are not marked until 2019 because the age at first maturity is assumed to be nine years old.

Liquefied Natural Gas

Several liquefied natural gas (LNG) facilities have been proposed in the Gulf of Mexico. For LNG facilities, a major environmental concern is the saltwater intake system used to heat LNG and regasify it before piping it to shore. LNG facilities sometimes have open loop, once through heating systems known as open rack vaporizers, which require large amounts of sea water to heat LNG. One such project, Main Pass LNG, which was proposed to be located in the Gulf of

Mexico 37 miles east of Venice, Louisiana, included a water intake system that would require an average of 180 million gallons of sea water per day (MGD) to heat and regasify LNG. Short-term, maximum sea water use for this facility would have been over 200 MGD. As described in the Main Pass LNG draft environmental impact statement (DEIS), the use of the sea water intake system would subject early life stages of marine species to entrainment, impingement, thermal shock, and water chemistry changes, potentially causing the annual mortality of hundreds of billions of zooplankton, including fish and shellfish eggs and larvae. Depending on the location of the facility, this could have an adverse effect on habitat for bluefin tuna or other HMS species. The proposal was amended to include a closed loop system after receiving comments from a number of agencies, including NOAA, that mitigating measures such as a closed loop system should be considered. Closed loop systems are currently being used in the United States to regasify LNG and are proposed for multiple onshore and offshore LNG terminals throughout the nation, with the notable exception of the offshore waters of the Gulf of Mexico. These systems, which do not rely on an external saltwater intake source, and thus, do not require large amounts of seawater, have considerably lower impacts on fish eggs, larvae, and zooplankton than open loop systems.

Cumulative

There are a variety of past, present, and reasonably foreseeable future actions that have the potential to affect bluefin tuna habitat. They range, among other things, from coastal development and associated coastal runoff and non-point source pollution in coastal areas to OCS oil and gas development, and global climate change. Since most bluefin tuna habitat is comprised of open ocean environments occurring over broad geographic ranges, large-scale impacts such as global climate change that affect ocean temperatures, currents, and potentially food chain dynamics, and likely pose the greatest threat to bluefin tuna habitat (Climate Change discussed in section 6.5.1). Anecdotal information suggests that such changes may be occurring and influencing the distribution and habitat usage patterns of bluefin tuna as well as other HMS and non-HMS fish stocks. Ocean temperature changes of a few degrees can disrupt upwelling currents that reduce or eliminate the nutrients necessary for phytoplankton and thereby, could have potential repercussions throughout the food chain. As a result, changes in migratory patterns may be the first indication that large scale shifts in oceanic habitats may be occurring. Some have pointed to the shift in availability of bluefin tuna from fishing grounds off North Carolina to waters off Canada during the winter months as evidence of changes in oceanographic conditions that may be affecting historical distribution patterns. Although the evidence is still lacking, causative factors in the shift include preferences for cooler water temperatures and prey availability. A recent report by the Conservation Law Foundation indicated that low food availability had reduced growth rates in larval cod and haddock and that rising sea surface temperatures had the potential to further reduce productivity for these and other fish stocks off the New England coast (Bandura and Vucson, 2006).

Wetland loss is a cumulative impact that results from activities related to coastal development: residential and industrial construction, dredging and dredge spoil placement, port development, marinas and recreational boating, sewage treatment and disposal, industrial wastewater and solid waste disposal, ocean disposal, marine mining, and aquaculture. In the late 1970s and early 1980s, the United States was losing wetlands at an estimated rate of 300,000 acres per year. The Clean Water Act and state wetland protection programs helped decrease wetland losses to

117,000 acres per year, between 1985 and 1995. Estimates of wetlands loss vary according to the different agencies. The U.S. Department of Agriculture (USDA) attributes 57 percent of wetland loss to development, 20 percent to agriculture, 13 percent to deepwater habitat, and 10 percent to forest land, rangeland, and other uses. Of the wetlands lost to uplands between 1985 and 1995, the FWS estimates that 79 percent of wetlands were lost to upland agriculture. Urban development and other types of land use activities were responsible for six percent and 15 percent of wetland loss, respectively.

Nutrient enrichment has become a major cumulative problem for many coastal waters. Nutrient loading results from the individual activities of coastal development, non-point source pollution, marinas and recreational boating, sewage treatment and disposal, industrial wastewater and solid waste disposal, ocean disposal, agriculture, and aquaculture. Excess nutrients from land based activities accumulate in the soil, pollute the atmosphere, pollute ground water, or move into streams and coastal waters. Nutrient inputs are known to have a direct effect on water quality. For example, in extreme conditions excess nutrients can stimulate excessive algal blooms or dinoflagellate growth that can lead to increased turbidity, decreased dissolved oxygen, and changes in community structure, a condition known as eutrophication.

In addition to the direct cumulative effects incurred by development activities, inshore and coastal habitats are also jeopardized by persistent increases in certain chemical discharges. The combination of incremental losses of wetland habitat, changes in hydrology, and nutrient and chemical inputs produced over time, can be extremely harmful to marine and estuarine biota, resulting in diseases and declines in the abundance and quality of the affected resources.

6.1.1. Summary and Evaluation

Currently, there are numerous potential coastal habitat threats (e.g., dredging, mining, navigation, etc.); however, the ones of most significance for bluefin tuna are offshore (e.g., petroleum, LNG, etc.). While these could represent potential future threats to the species, at this time, these activities are not negatively affecting bluefin tuna, and the SRT concluded that they do not represent a substantial risk to the long term persistence of the species. In the future, should offshore effects such as petroleum and LNG be proposed, the EFH and HAPC process would provide a mechanism by which those impacts could be addressed.

6.2. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

6.2.1. Commercial and Recreational Fisheries

For detailed information and data on commercial and recreational fisheries for bluefin tuna, see Description of Fisheries (Section 5.1), Bluefin Tuna Stock Assessment (Section 6), and Existing Regulatory Authorities, Laws and Policies (Section 7.4).

6.2.2. Scientific and Educational Utilization

Overall, scientific collections or collections for educational purposes do not seem to be significantly affecting the status of bluefin tuna. The SRT found that there are numerous scientific studies of bluefin tuna, the largest of which is being coordinated by ICCAT's SCRS—the Atlantic-wide Bluefin Tuna Year Program (GBYP). The program started in 2010 and is funded by ICCAT members and cooperating parties. It has multiple objectives, including improving the understanding of key biological and ecological processes, basic data collection (including information from farms, observers, and VMS), provision of scientific advice on stock status through improved modeling of key biological processes (including growth and stock-recruitment and mixing between various areas), and developing and using biologically realistic operating models for more rigorous management option testing. Research undertaken to date through the ICCAT program, or in coordination with it by scientists from ICCAT's membership has been either non-lethal (aerial surveys) or has been intended to be non-lethal (tagging programs), although mortalities, while minimal, do sometimes occur after a tagging event. Other types of research (microconstituent analysis, organochlorine tracer analysis, genetic analysis) primarily rely on samples taken from fish harvested in commercial fishing operations or from historical collections. Larval surveys, such as those conducted by the United States, and activities to monitor young-of-the-year do harvest bluefin tuna specifically for research purposes, but the mortality caused by these activities is low. For instance, the young-of-the-year bluefin tuna collected by a U.S. educational institution in 2010 amounted to 6 fish. With respect to collections for education, the SRT noted that this activity is minor and relies largely on products obtained from other activities, such as commercial fishing. Where it does cause bluefin tuna mortalities directly, such as the collection of young-of-the -year, it is minor. Further, the SRT could find no information that a substantial live aquarium trade in Atlantic bluefin tuna exists. In general, bluefin tuna do not survive well in captivity.

6.2.3. Summary and Evaluation

Current impacts from commercial, recreational, scientific or educational purposes do not represent a substantial risk to the long term persistence of the species. Bluefin tuna fisheries are closely managed by various regulatory mechanisms (see Section 6.4), and current TAC levels are projected to result in increased population levels of the DPSs. In addition, scientific collections or collections for educational purposes described above do not seem to be significantly affecting the status of bluefin tuna, and are not likely to significantly affect the long-term persistence of Atlantic bluefin tuna now or into the future.

6.3. Predation and Disease

6.3.1. Predation

As large apex predators, bluefin tuna are not heavily preyed upon. However, predators on adult bluefin tuna may include marine mammals such as killer whales (*Orcinus orca*) and pilot whales (*Globicephala* spp.) and several shark species such as white sharks (*Carcharodon carcharias*), shortfin mako (Isurus oxyrinchus), and longfin mako (*Isurus paucus*) (Nortarbartolo di Sciara, 1987; Collette and Klein-MacPhee, 2002; de Stephanis, 2004; Fromentin and Powers, 2005). According to FishWatch (NMFS, 2010), juvenile bluefin tuna may also be preyed upon by bluefish (*Pomatomus saltatrix*) and seabirds.

Killer whales have been observed to prey upon bluefin tuna in the Strait of Gibraltar during the bluefin tuna spawning migration (Nortarbartolo di Sciara, 1987; de Stephanis, 2004). They were observed to chase tuna for up to 30 minutes at a relatively high sustained speed until they captured them (Guinet *et al.*, 2007). During spring, bluefin tuna between 200 and 400 kg migrate to the Mediterranean Sea to spawn, staying close to the coast and at low depths. Killer whales can be seen around the Spanish *almadrabas*, which are fishing traps placed perpendicularly to the coast set along the Atlantic coasts of Morocco and Spain to catch bluefin tuna. Bluefin tuna do not eat during this migration. Using simple models based on previous locomotor performance data, Guinet *et al.* (2007) studied the swimming speed of killer whales and various tuna species. Their results support the hypothesis that killer whales may use an endurance-exhaustion technique to catch small to medium sized (up to 0.8 to 1.5 m) bluefin tuna. Killer whales may not be able to catch larger tuna without using cooperative hunting techniques or taking advantage of fish caught on long lines, drop lines or trap nets.

In July and August, fishermen target bluefin as they return to the Atlantic through the Strait of Gibraltar (de Stephanis, 2004). These tunas, which weigh between 150 and 300 kg, feed at the bottom of the Strait, and killer whales can be observed around the central area of the Strait of Gibraltar, often in the vicinity of tuna hook and line fishing vessels. Killer whales prey upon these tuna when the bluefin tuna tire and are at the surface, before being gaffed and hauled aboard (de Stephanis, 2004).

6.3.2. Disease

Little information exists on diseases in North Atlantic bluefin tuna, and most of the available disease information for this species, Pacific bluefin tuna (*Thunnus orientalis*), and southern bluefin tuna (*Thunnus maccoyii*) comes from studies of fish reared in net pens for "fattening" before harvesting them for the market (Munday *et al.*, 2003; Bullard *et al.*, 2004; Oraic and Zrncic, 2005; Mladineo *et al.*, 2006; Hayward *et al.*, 2007). Among wild marine fishes, parasites are usually considered benign, though they can be associated with reduced fecundity of their hosts (Jones, 2005; Hayward *et al.*, 2007). Parasites are often associated with mortalities and reduced production among farmed marine fishes (Hayward *et al.*, 2007). Epizootic levels of parasites with short, direct, one-host life cycles, such as monogeneans, can be reached very quickly in cultured fish because of the confinement and proximity of these fish (Thoney and Hargis, 1991).

Young Pacific bluefin tuna are often infected with red sea bream ividoviral (RSBI) infection, but the disease never appears in Pacific bluefin tuna more than 1 year of age, and occurrence is restricted to periods of higher water temperature (greater than 24°C) (Munday *et al.*, 2003). Sometimes the mortality reaches greater than 10 percent for young fish. The fish either die during the acute phase of the disease, or they become emaciated and die later. Munday *et al.* (2003) hypothesize that wild-caught young tuna for aquaculture become infected when they are caged next to other cultured fish.

Aeromonas sp. infections have been reported in association with *Caligus elongatus* damage to the eyes of cultured southern bluefin tuna (Rough *et al.*, 1999). A variety of *Aeromonas* and *Vibrio* spp. in the kidney and other internal organs of southern bluefin tuna, especially those which have suffered trauma, has been reported (Munday *et al.*, 2003). These infectious organisms are normal environmental inhabitants which can colonize wounds (Munday *et al.*, 2003).

Peric (2002) reported lesions consistent with pasteurellosis (*Photobacterium damsel piscicida)* after examining carcasses of 25 harvested Atlantic bluefin tuna. Lesions were similar to those seen in sparids with chronic pasteurellosis. As the causative organism, pasteurellosis does not survive for long outside the host, and prevalence is reported to be very low in Atlantic bluefin tuna (Munday *et al.*, 2003). However, high mortalities of bluefin tuna reared in Adriatic Sea cages occurred during winter 2003 and spring 2004. Based on the results of bacteriological, serological, and histological analysis, Mladineo *et al.* (2006) concluded that pasteurellosis was the causative agent of the mortalities; this was the first such outbreak in reared tuna. Putative tuberculosis was reported in a single specimen of Atlantic bluefin tuna (Biavati and Manera, 1991, as reported by Munday *et al.*, 2003), but the cause is unknown.

Protozoan diseases have been detected in other tunas, though not in Atlantic bluefin tuna. Coccidiosis (*Goussia auxidis*) has been reported in albacore (*Thunnus alalunga)*, and an individual yellowfin tuna (*Thunnus albacores)* from the South Pacific. Munday *et al.* (1997) reported an encephalitis (scuticociliate infection) in young adult southern bluefin tuna caused by *Uronema nigricans*.

Munday *et al.* (2003) provided a summary of metazoan infections (myxosporeans, *Kudoa* sp., monogeneans, blood flukes, larval cestodes, nematodes, copepods) in tuna species. Many metazoans infect *Thunnus* spp., but not many are known to cause mortalities; most studies to date have focused on the health and/or economic importance of these diseases. For example, postmortem liquefaction of muscle due to myxosporean infections occurs in albacore, yellowfin tuna, and bigeye tuna (*Thunnus obesus*), and in poorly identified *Thunnus* spp. Lesions caused by *Kudoa* sp. have been found in yellowfin tuna and southern bluefin tuna (Langdon, 1990; Kent *et al.*, 2001). Munday *et al.* (2003) report that southern bluefin tuna have been found to be infected with an unidentified, capsalid monogenean that causes respiratory stress but does not lead to mortality.

The blood fluke, *Cardicola ahi*, has been reported from yellowfin and bigeye tunas (Smith, 1997). *Cardicola forsteri* occurs in southern bluefin tuna (Cribb *et al.*, 2000). These infections of cultured southern bluefin tuna lead to increased mucus on the gills and have been associated with signs of respiratory distress, lethargy, and slightly increased mortality (Munday *et al.*, 2003). Bullard *et al.* (2004) reported a specimen of *Cardicola forsteri* Cribb, Daintith, and Munday, 2000 (Digenea: Sanguinicolidae) from the lumen of the heart of a 218-cm Atlantic bluefin tuna captured 12 km south of Cape Lookout, North Carolina. The hearts of 12 Atlantic bluefin tuna of similar size (127-262 cm TL) captured on Georges Bank were not infected. This is the first report of this blood fluke from a wild host and of a sanguinicolid from any scombrid in the northwest Atlantic Ocean (this fluke had been reported previously from the heart of caged southern bluefin tuna from south Australia). This is significant because some blood flukes are serious pathogens of cage-cultured fish such as the bluefin tuna (Bullard *et al.*, 2004). Bullard *et al.* (2004) noted the seemingly disjunct distribution of this blood fluke. If its life cycle is like that of all studied sanguinicolids, then it would include a single snail, bivalve, or polychaete intermediate host species (Koie, 1982; Smith, 1997; Bullard *et al.*, 2004). This would mean that the unidentified intermediate host may be widespread, occurring within the range of both the Atlantic bluefin tuna and the southern bluefin tuna. Or, it is possible that the infected individual bluefin tuna could have migrated from southern oceans (Bullard *et al.*, 2004).

Larval cestodes (plerocercoids) up to 9.5 mm in length have been reported in albacore, (*Thunnus alalunga)*, blackfin tuna (*Thunnus atlanticus)*, Atlantic bluefin tuna, bigeye tuna, and yellowfin tuna, but they do not usually cause disease in tunas (Munday *et al.*, 2003). The nematode parasite compatible with *Hysterothylaceum* sp. and Anisakis spp. has been observed in Croatia in cage fattening of Atlantic bluefin tuna (Oraic and Zrncic, 2005). Anisakid nematode infection is of importance because these nematodes can potentially infect humans (Munday *et al.*, 2003). A number of copepods parasitize *Thunnus* spp., but only *C. elongatus*, *Euryphros brachypterus*, and *Penella filosa* are potentially pathogenic (Munday *et al.*, 2003). Very heavy infections of *Euryphorus brachypterus* have been reported in Atlantic bluefin tuna, in which the first gill arch is covered with the parasite, leading to ulceration and bleeding. Similar, but less severe, lesions may be present on the gills and skin (Munday *et al.*, 2003).

There are no unequivocal reports of mortalities in tuna because of toxic microalgae, but Munday and Hallegraeff (1998) considered various causes of the mass mortality episode in southern bluefin tuna at Boston Bay, South Australia, in 1996, and concluded that the weight of the evidence pointed to a microalgal toxicosis due to *Chattonella marina*. Ishimatsu *et al.* (1996) speculated that oxygen radicals produced by *Chattonella* could be responsible for excess mucus secretion from gill mucus cells in fish, leading to respiratory distress. These signs were reported in southern bluefin tuna dying in the 1996 incident. Many variables affect the toxicity of toxic algae, including the stage of growth, temperature, availability of iron, and level of irradiation (Kawano *et al.,* 1996; Bates *et al.*, 2001, Druvietis and Rodinov, 2001; Munday *et al.*, 2003).

To summarize, relatively few bacterial diseases occur in cultured bluefin tuna because the methodology involves using wild-caught fish for aquaculture/farming purposes (Munday *et al.*, 2003) instead of rearing them from larval stages. This low prevalence could also be due to the observation that tunas' immune responses may be independent of ambient temperatures (Watts *et al.*, 2002). Most tunas used for aquaculture are southern, Atlantic, or Pacific bluefin tuna, but more studies have been undertaken on skipjack, *Katsuwonas pelamis* (L.), and yellowfin tuna. While these studies can provide useful information, it may not be possible necessarily to extrapolate from one species to another because there can be significant differences in physiology among species (Bushnell *et al.*, 1990). While it is possible that disease prevalence or magnitude could increase under various climate change scenarios, the SRT is unaware of any data to support this hypothesis at this time.

6.3.3. Summary and Evaluation

Adult bluefin tuna are not likely affected to any large degree by predation by large whales and other large predators. Nor are they likely to be affected to any large degree by diseases caused by viruses, bacteria, protozoans, metazoans, or microalgae. Most of the information on diseases in tunas comes from studies on cultured tuna, and the culture environment introduces stresses to the fish. Therefore, even if studies indicated that cultured bluefin tuna were highly susceptible to diseases and suffered high mortality rates, it is not possible to infer from these data that wild bluefin tuna experience the same diseases and mortality rates. The best available scientific and commercial information indicates that threats to bluefin tuna from predation and disease do not significantly affect the long-term persistence of bluefin tuna now or into the future.

6.4. Existing Regulatory Authorities, Laws and Policies

As stated previously, the bluefin tuna fishery is managed under the dual authority of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) and the Atlantic Tunas Convention Act (ATCA). ATCA authorizes the Secretary of Commerce to implement the binding recommendations of ICCAT. As the United States implements legislation for ICCAT, ATCA also requires that the United States implement binding recommendations adopted by that organization, as necessary and appropriate; stipulates that the United States may not promulgate a regulation that has the effect of increasing or decreasing any allocation or quota of fish or fishing mortality allocated by ICCAT; and establishes a number of procedural requirements.

6.4.1. International Authorities

Since 1982, bluefin tuna have been separated into the two management units described previously, which coincide with the two DPSs we have identified for this status review. ICCAT has established various conservation and management measures for both stocks over the years--most often in those years where new stock assessments have been completed by SCRS as these inform management decisions. ICCAT, however, is free to adopt or alter conservation and management measures even in years where no new stock assessment has been conducted, and it has occasionally done so.

In addition, mixing between the two stocks is known to occur but the nature and extent of mixing is still not well understood despite several years of research using various methods. Because the eastern Atlantic/Mediterranean bluefin tuna stock and fishery is about ten times larger than the western Atlantic stock and fishery, management actions in the East can affect stock recovery in the West since western fish migrate and may become vulnerable to the eastern fishery. In addition, scientific information has indicated that eastern fish compose a portion of the western fishery. Everything else being equal, if overharvest in the eastern Atlantic/Mediterranean reduces availability of eastern fish in the western fishery, then more western origin fish would be needed to meet the western TAC, and mortality on the western stock would necessarily increase. Given how small the western stock and fishery is compared to the east, the opposite is less true. In light of the connection between the two stocks and fisheries, SCRS has advised that robust management is needed for both stocks to ensure effective conservation. Recognizing that management could potentially benefit from an improved understanding of Atlantic bluefin tuna stock structure and mixing, ICCAT and its members have taken a number of steps to improve information in this area. The GBYP discussed in section 6.2.2 is the most recent and important research related initiative to help get at these questions but it was preceded by research recommendations and resolutions on the matter going back to the early 2000s. Pending the outcome of ongoing research on stock structure and mixing, ICCAT has actively looked at management strategies that can take better account of mixing. In that regard, ICCAT has had a measure in place intended to limit catches in the central North Atlantic, an area with high mixing rates, since 2003. Catches from this area are now significantly reduced from previous levels. In addition, ICCAT has adopted the requirement that parties cannot shift effort across the 45 degree management boundary separating the two stocks of Atlantic bluefin tuna.

Western Atlantic Bluefin Tuna

ICCAT adopted its first binding recommendation on bluefin tuna at its 1974 meeting in the form of a 6.4 kg minimum size as well as a limitation on fishing mortality. At that time, the species was managed as one stock. No new management measures were adopted for bluefin tuna until the 1981 ICCAT annual meeting. The SCRS stock assessment conducted prior to this meeting indicated that there was a significant decrease in the abundance of the species in the western Atlantic. In response, the capture of bluefin tuna in the western Atlantic was prohibited by ICCAT for the 1982 fishing season except for a scientific monitoring quota of 1,160 t. The Commission allocated this catch to ICCAT members who had actively participated in the fishery (United States, Canada, and Japan). Brazil and Cuba, whose catches were less than 50 t annually, were exempt from these measures, and ICCAT also prohibited the transfer of effort from the western Atlantic to the eastern Atlantic and Mediterranean.

At the 1982 ICCAT meeting, in light of additional scientific information—notably, changes in historical data associated with the stock-recruitment relationship used in the 1981 assessment, a new recommendation was adopted that continued the measures agreed in 1981 but raised the scientific monitoring quota for the western Atlantic to 2,660 t for 1983. For the first time, ICCAT also included a provision to close the Gulf of Mexico to directed bluefin tuna fishing to protect spawning fish. Given scientific advice, the adopted catch levels and other measures were expected to arrest the decline of the stock as well as permit gradual increases in the long term, proportional to stock recovery. ICCAT extended these measures through 1991 without change.

By the 1991 ICCAT annual meeting, the western stock, while stable, was not recovering as anticipated. In an effort to address this, ICCAT adopted a measure that reduced the TAC to 4,788 t for the combined two year period 1992-1993, where no more than 2,660 t could be taken in the first year, and the remainder of the unused portion would be available in the second year. The recommendation contemplated the establishment of more severe quota reductions in future years if supported by scientific advice. Other measures were also adopted, including an increase in the minimum size to 30 kg with a strict limit on the proportion of fish by weight under this size that could be retained and a specification that fish taken under the minimum size could not be sold, a requirement that, if a party exceeds its quota in any year, it repays 100 percent of the overharvested amount, and a provision to encourage the tag and release of fish less than 30 kg.

At its 1993 annual meeting, ICCAT further reduced the western bluefin tuna scientific monitoring quota for 1994 to 1,995 mt due to continuing concerns about the status of the resource. Another reduction was set to occur in 1995 depending on the outcome of the SCRS stock assessment. That stock assessment, however, was more optimistic than the previous one and a small increase in the 1995 and 1996 quota level (to 2,200 t) was established. The stock was assessed again in 1996. The results indicated that a scientific monitoring quota of 2,500 t was sustainable and that the SSB would have a 50 percent chance of showing a net increase over about 20 years to about twice the size in 1995. ICCAT established a scientific monitoring quota of 2,354 t for both 1997 and 1998, exclusive of dead discards (estimated to be 146 t). As part of this measure, a small allocation (4 t) was provided to the United Kingdom (in respect of Bermuda) for the first time. Previous allocation arrangements only included the United States, Canada, and Japan.

In 1998, western bluefin tuna remained overfished, and ICCAT adopted a rebuilding program for the stock with the goal of reaching the biomass that will support MSY in 20 years. This represented the first time that ICCAT articulated a rebuilding goal to guide its management actions in the context of the recommendation and developed a plan for achieving that goal. SCRS was providing advice based on the results of the stock assessment conducted using both a high and low recruitment potential hypothesis, both of which are viewed by SCRS as equally plausible. The annual TAC established under the program was 2,500 t, inclusive of dead discards. To enhance stability, specific rules were established to guide when a change in the TAC could be considered. The 1998 measure provided ICCAT with the flexibility to alter the TAC, the MSY target, and/or the rebuilding period based upon subsequent scientific advice, but in no case could a change in the TAC or rebuilding period be considered unless the MSY target could be achieved within the rebuilding time frame with a 50 percent or greater probability. The allocation arrangement was again expanded in this recommendation to include a small quota (4 t) for France (in respect of St. Pierre and Miquelon). Further, ICCAT expanded the effort transfer prohibition to specify that eastern harvesters could not transfer effort to the western bluefin tuna fishery. As with the previous management measures, the 1998 rebuilding program maintained critical elements from previous binding measures such as the prohibition on directed fishing for bluefin tuna in the Gulf of Mexico and minimum size requirements.

The western bluefin tuna TAC has been adjusted periodically since 1998. In 2002, ICCAT agreed to increase the TAC to 2,700 t in light of the scientific advice that indicated that SSB should increase for all realistic catch levels under both recruitment scenarios. ICCAT also agreed to provide Mexico with a small allocation. In 2006, ICCAT found it necessary, however, to lower the TAC given scientific advice that overfishing had not been halted. The new TAC of 2,100 t was intended to address this situation. In addition, the ability of countries to fish their unused quota from one year to the next was capped at 50 percent of a country’s initial allocation, and the tolerance for recreational catches of bluefin tuna weighing less than 30 kg (or 115 cm straight fork length, which is equivalent to the current minimum size in the west, 47 inches curved fork length) was increased slightly from 8 percent to 10 percent.

In 2008, ICCAT again lowered the TAC for western bluefin tuna. Specifically, the TAC for 2009 was set at 1,900 t, and the TAC for 2010 was set at 1,800 t. These TACs represent a 10 percent and 14 percent reduction, respectively, from the 2006 level. The 2008 measure envisioned at least a 75 percent probability of success in ending overfishing by 2010. These TACs also substantially increased the probability of rebuilding the stock by 2019, consistent with the 1998 rebuilding program. The recommendation also reduced the amount of under harvest a country can carry forward from one year to the next to 10 percent of its initial quota.

Safina and Klinger (2008) summarized ICCAT management regulations and catch history for the western Atlantic stock; however, it was not a quantitative assessment of the stock. Due to the timing of publication, the authors were only able to consider catch data through 2006, and there have been changes to the western Atlantic bluefin tuna fishery since then. MacKenzie et al. (2009) projected a similar collapse; however due to timing of publication, they were also only considering catch data through 2006. The 2006 U.S. catches of Atlantic bluefin tuna were the lowest in recent history; however, since then, the U.S. fishery has seen increasing catches, and the U.S. base quota was fully realized in 2009 and 2010. MacKenzie et al. (2009) projected that by 2011, the adult population of Atlantic bluefin tuna would be 75 percent lower than the population in 2005. Furthermore, Safina and Klinger (2008) stated that "these trends [in U.S. catches] suggest U.S. bluefin may approach widespread commercial unavailability as early as 2008"; however, the results of the ICCAT 2010 bluefin tuna stock assessment (as described in more detail below), and the catch statistics submitted to ICCAT, clearly refute these assertions.

In 2009, ICCAT adopted a resolution that requested that SCRS complete a "strategy matrix" for ICCAT's consideration in 2010, to lay out the probabilities of meeting bluefin and bigeye tuna management targets regarding ending overfishing and rebuilding overfished stocks in a standardized manner. In 2010, ICCAT considered the 6 strategy matrices generated for western BFT, and adopted a measure that, among other things, reduced the TAC from 1,800 t to 1,750 t for both the 2011 and 2012 fishing seasons—a 2.8 percent reduction overall. Under the low recruitment potential scenario, the new TAC has a 99 percent probability of maintaining the fishing mortality of western bluefin tuna below the fishing mortality associated with MSY and a 95 percent probability of maintaining the stock above the biomass that will support MSY through the end of the rebuilding period. Combining the results of the high and low recruitment potential scenarios, the TAC has a 54 percent probability of ending overfishing within two years and a 48 percent probability of rebuilding the stock to the Bmsy level by the end of the rebuilding period. Under the high recruitment potential scenario, the TAC has an 8 percent probability of ending overfishing within two years and a zero chance of rebuilding the stock to the Bmsy level by the end of the rebuilding period. It is important to note that under any scenario, the agreed TAC is expected to support continued stock growth if compliance with agreed rules remains strong. For the western Atlantic bluefin tuna fishery, compliance with ICCAT measures has typically been high.

In addition to a new TAC, the measure includes an emergency clause similar to the one added in 2009 to the eastern Atlantic and Mediterranean bluefin tuna recommendation. It specified that if SCRS detects a serious threat of stock collapse, ICCAT shall suspend all Atlantic bluefin tuna fisheries in the western Atlantic for the following year. The SCRS monitors the stock in several ways. In addition to the stock assessment meetings (which have been held recently about every two years), the SCRS reports on fishery trends each year. These metrics can include catch, effort and size trends, as well as updated abundance indices (such as standardized catch rate trends by age category and larval survey results). These trends can provide information on threats to the stock even during non-assessment years.

The recommendation further calls on ICCAT members to contribute to ICCAT's Atlantic-wide Bluefin Tuna Research Program (see section 6.2.2), including the enhancement of biological sampling. Consistent with past practice, the provisions contained in previous conservation and management recommendations were retained, including the prohibition on directed fishing for bluefin tuna in the Gulf of Mexico and minimum size requirements. Finally, the measure includes a request to SCRS to provide additional information in the future that might be helpful to management—including with respect to spawning grounds and the size selectivity of the fishery. The next western Atlantic bluefin tuna stock assessment is scheduled for 2012, and management measures will be reconsidered at that time taking into consideration the scientific advice provided by SCRS.

Eastern Atlantic and Mediterranean Bluefin Tuna

The SCRS had been warning since the early to mid-1990s that the eastern stock of bluefin tuna was over-exploited and catches needed to be reduced substantially. Following a rapid increase in annual catches from the early 1980s to the mid-1990s, there was a substantial decrease in the reported bluefin tuna catch. SCRS attributed this decrease to chronic under-reporting rather than actual decreases in annual catch. To conduct stock assessments and to develop management advice, the SCRS has considered two alternative catch histories--one based on reported catches alone and another incorporating SCRS total catch estimates based on vessel capacities and catch rates. Available information suggests, however, that the control measures put in place by Mediterranean fisheries contributed to substantially reducing the level of under-reporting in 2008 and 2009.

As noted above, ICCAT's first Atlantic bluefin tuna management measures were adopted in 1974 and included establishment of a 6.4 kg minimum size and a limitation on fishing mortality. No additional management measures were adopted for the eastern Atlantic/Mediterranean stock of bluefin tuna until 1993 when a time and area closure was adopted prohibiting large pelagic longline vessels greater than 24 meters in length from fishing in the Mediterranean from June 1-July 31 each year in order to improve protections for spawning Atlantic bluefin tuna.

In 1994, ICCAT began adopting measures to limit harvests of eastern Atlantic/Mediterranean bluefin tuna through the application of catch limits due to concerns about the status of the stock and the expansion of fishing effort. ICCAT members were to limit catches to the higher of their 1993 or 1994 levels and, starting in 1996, reduce catches from their base level by 25 percent by the end of 1998. The objective was to reduce harvests to about 25,000 mt, consistent with SCRS advice. In 1995, France reported exceptional Atlantic bluefin tuna catch levels for 1994 and special catch limits were established for that country for the years 1996-98. In general, compliance with the requirement in the 1994 recommendation to reduce catches was poor, and the reduction was not achieved by 1998. Catch limit overharvests by France during the period, however, were repaid in accordance with ICCAT's requirements.

In addition, high levels of catches of very small Atlantic bluefin tuna were an ongoing concern to SCRS and ICCAT. The 1994 eastern Atlantic bluefin tuna recommendation required eastern harvesters to take steps to prevent the catch of age 0 fish (i.e., fish less than 1.8 kg). In 1996 and 1997, this requirement was augmented to prohibit the retention, landing, possession, and sale of these fish, including in markets in nations bordering the Convention area. These small fish provisions were strengthened to apply to fish less than 3.2 kg in a 1998 ICCAT recommendation. Additionally, at its 1996 annual meeting, ICCAT adopted a prohibition on the use of purse seine vessels during the month of August and adopted a ban on the use of aircraft to support bluefin tuna fishing operations in the eastern fishery during the month of June in order to enhance protection of both juvenile and spawning Atlantic bluefin tuna. Unfortunately during these years, the harvest of very small bluefin tuna continued at a relatively high rate. The use of spotter aircraft by some countries also continued despite the prohibition.

In 1998, ICCAT adopted for the first time a firm TAC for the eastern Atlantic and Mediterranean fishery with country specific quotas. The 1999 TAC was set at 32,000 t, and the 2000 TAC was set at 29,500 t, both of which exceeded the scientific advice of 25,000 t. Given concerns about the fairness of the country allocations, Morocco and Libya lodged formal objections and established unilateral quotas for the period. At its 2000 annual meeting, ICCAT established a TAC for 2001 of 29,500 t, but the quota requests of Morocco and Libya again could not be accommodated. The measure provided for these countries to fish on unilaterally declared limits, which were specified in the ICCAT measure.

In 2002, ICCAT succeeded in adopting a multi-annual management measure for the eastern Atlantic and Mediterranean fishery that included an allocation arrangement acceptable to Morocco and Libya and also provided quota to some new parties, such as Algeria and Iceland. The TAC was set at 32,000 per year for the 2003-2006 period. Estimates by SCRS of actual catches for each of these years, however, were on the order of 50,000 t or more. The recommended TAC level by SCRS was still 25,000 t. The 2002 measure also adjusted the time/area closure for purse seine fishing in the Mediterranean from the month of August to July16th-through August 15th each year to enhance protection of juvenile bluefin, increased the minimum size limit to 6.4 kg with some exceptions, established an absolute minimum size of 4.8 kg for the Mediterranean, and, for the sake of clarity, incorporated ICCAT's rules requiring payback of quota overharvest, which is a requirement that had been in effect since the 1990s.

Also in 2002, the SCRS expressed significant concerns about the degradation of the quality of data for the eastern fishery. Part of the reason for this was due to the development of farming activities, described further in Section 6.5.2. The issue of bluefin tuna farming in the Mediterranean has been a longstanding one within ICCAT. Information on the size distribution of bluefin tuna caught and transferred to farming operations, mortality due to normal operations, and information on bluefin tuna growth rates in farms has been lacking although information is improving. Since 2002, ICCAT has adopted ever stricter rules governing farming operations, but progress has been slow. Observers on farms, improvement in joint fishing operation monitoring and control and the placement of limits on these operations, an enhanced catch document program, capacity limitations on farms and other measures are helping address some of the difficulties these operations present to bluefin tuna monitoring and conservation.

Lack of effective management action by eastern harvesters led to a more dire situation for the eastern Atlantic and Mediterranean stock by the mid-2000s. SCRS noted for the first time in its 2006 stock assessment that that there was a high risk of fishery and stock collapse for the eastern Atlantic and Mediterranean stock if significant changes in management were not made. SCRS repeated this warning in its 2008 stock assessment and again in its 2009 report to ICCAT. Despite the strong recommendation from SCRS that catch levels for this stock should not exceed about 15,000 t (the level expected to halt overfishing), the recovery plan adopted by ICCAT at its 2006 meeting, while comprehensive, did not include the suite of measures needed to ensure catches would be restricted to this level. The 2006 recommendation established a 15-year management plan, to be reviewed in 2008, that set a 29,500 t catch level for 2007 with gradual reductions to 25,500 t by 2010. The SCRS estimated the actual catch for 2007 to be upwards of 60,000 t. The 2006 plan also expanded the time/area closures for large-scale longline vessels and purse seine vessels and added closures for baitboats and pelagic trawlers, established a new minimum size of 30 kg with various derogations for limited harvests of fish of 8 kg and 6.4 kg, expanded the ban on the use of spotter aircraft to a year round restriction, and eliminated the possibility of carrying forward quota under harvests from one year to another with a time limited exception for a few countries. In addition, it established various monitoring and control measures, including limits on the use of chartering, establishment of vessel and other records, limitations on at sea transshipment, requirements for the use of vessel monitoring system (VMS) and observers, reporting requirements for joint fishing operations, and establishment of a joint at sea inspection program, among other things.

Given the declining state of the eastern stock and evidence that fishery participants were not implementing agreed rules, the United States, supported by Canada, proposed a temporary suspension of the eastern bluefin tuna fishery at the 2007 ICCAT annual meeting until such time as countries could demonstrate control of their fisheries. The proposal was not adopted. Continuing compliance concerns, however, led an independent panel of experts contracted to conduct a performance review of ICCAT, to also call for a temporary suspension of the eastern bluefin tuna fishery in its 2008 report to ICCAT. At the 2007 ICCAT annual meeting, the European Union (EU) reported on investigations into 2007 eastern bluefin tuna overharvests by its Member States. Given the magnitude of the overharvest known at that time (4,440.39 t), the EU requested additional time to repay the overage. The Commission agreed to a delayed payback plan that began during the 2009 fishing season and extended through 2011.

Also in 2007, ICCAT adopted a proposal establishing a catch documentation scheme (CDS) for bluefin tuna to track product from the time of harvest through the point of final import. This measure replaced a trade tracking program in place since the early 1990s and was intended to help improve bluefin tuna catch statistics and reduce instances of illegal, unreported, and unregulated fishing (IUU) by both ICCAT members and non-members by starting the tracking process at the point of capture and following the product through all aspects of the trading process, including farming operations. The CDS program has been revised and strengthened several times since initial adoption. In 2010, ICCAT adopted a proposal to further improve the program by making it electronic. ICCAT is targeting to have full implementation of an electronic CDS program for bluefin tuna in 2012.

In 2008, the eastern Atlantic and Mediterranean bluefin tuna management plan was reviewed in its entirety and revised. The measure adopted in 2008 set declining TACs for a four year period beginning in 2009. The 2009 TAC was 22,000 t which was stepped down to 18,500 t by the end of the measure in 2011. This was a substantial reduction from the TAC levels for 2009 and 2010 agreed in 2006, though the TACs agreed in 2008 still far exceeded the scientific advice of 15,000 t or less. Overall, the agreement represented a 10,000 t reduction from the previously agreed TAC levels, not including payback of quota over harvest by the EU. To achieve agreement on the 2008 recommendation, however, 1,000 mt of the previous EU overharvest from 2007 was forgiven. It was also agreed that repayment of the remaining overharvest (4,020 t) would be apportioned over the 2009-2012 period. A portion of this reduction was offset by the carry forward of 2005 and 2006 quota underharvests by Libya, Morocco, and Tunisia into 2009 and 2010 (674 t total annually).

In addition to TAC levels, the 2008 measure maintained or strengthened the provisions of the 2006 recommendation. Among other things, it extended the purse seine time and area closure to include an additional 15 days (starting June 15 and including a five day bad weather clause), required reductions in fleet and farming capacity, and strengthened monitoring and control elements in the plan. Specifically, the measure froze fleet capacity and required fleet reductions to be completed by 2013 to ensure capacity is commensurate with allocated quotas. As a first step, parties were to reduce their fleets by 2010 to ensure that at least 25 percent of the discrepancy between their capacity and their quota limits was addressed. Reporting on these activities was mandatory. In addition, farming capacity was frozen at the July 2008 levels. Regarding monitoring and control improvements, among other things, the 2008 recommendation improved national observer programs and established a regional observer program (administered by the ICCAT Secretariat) for large-scale purse seine vessels and farms, banned at-sea transshipment, revised the boarding and inspection regime for the fishery to make it more in line with current standards, and enhanced control and reporting measures for caging transfer activities. The measure also required all parties to establish individual vessel quotas for their fleets, the first time ICCAT applied such a management tool. Implementation of the regional observer program was slow in the first year (2009) with only two parties participating after its entry into force. The program was more fully implemented in 2010.

In 2009, eastern bluefin tuna management measures were again revisited. Specifically, the TAC for 2010 was decreased from 19,950 t to 13,500 t, the upper end of the range of SCRS advice, and a rebuilding objective of achieving Bmsy through 2022 with at least 60 percent probability was established. In addition, the purse seine closure was extended by one month to June 15th to May 15th and the bad weather clause was eliminated; thus, the purse seine fishery was limited to a one month season (May 16 –June 14) each year. ICCAT added an emergency clause to the recommendation, stating that if the SCRS stock assessment detects a serious threat of fishery collapse, the Commission shall suspend all the fisheries for eastern Atlantic and Mediterranean bluefin tuna in the following year. Additional capacity reduction efforts were agreed as well for 2011-2013. During the 2010 intersessional meeting of the ICCAT's Compliance Committee, the capacity reduction plans for all eastern bluefin harvesters were reviewed and approved, as required under the 2008 recommendation and taking into account the TAC reduction agreed in 2009 for the 2010 fishing season. The 2009 measure also established a cap on joint fishing operations with reference years of 2007, 2008, or 2009. Eastern harvesters reported their limit during the 2010 Compliance Committee intersessional meeting. Indications over the last three years are that progress has been made to address non-compliance, and catches over that period appear to be in line with agreed limits based on the monthly catch reports and SCRS information.

As noted above, SCRS conducted a stock assessment for the eastern stock of bluefin tuna in 2010 using data through 2009. The fishing mortality rate that maximizes the yield per recruit (Fmax), which had been offered as an alternative proxy in past years, was found to exceed Fmsy in many cases. The SCRS noted that estimates of current stock status relative to MSY benchmarks were uncertain, but lead to the conclusion that, although recent levels of fishing mortality have declined, fishing mortality remained too high through 2009 (the 2009 TAC for the fishery was 22,000 t and was higher in previous years) and recent SSB too low to be consistent with the Convention objective.

The 2010 assessment also indicated that SSB declined rapidly from the 1970s level though recent data indicate an increase/stabilization in some model runs, with declines shown in other runs depending on the data and assumptions used. SCRS noted that fishing mortality for older fish seems to have declined during the last two years. The 2010 assessment evaluated a variety of constant recruitment scenarios (high, low, and medium). The results indicated the stock would increase in all scenarios even with TACs of 20,000 mt, but the probability to achieve $SSB_{F0.1}$ by the end of 2022 depended on the scenario. SCRS advised that maintaining catches at the 2010 TAC level (13,500 t) under the current management scheme for the 2011-2013 period would likely allow the stock to increase during that period and was consistent with the goal of achieving Fmsy and Bmsy through 2022 with at least 60 percent probability, given quantified uncertainties. Further, the SCRS stated that zero catch would achieve the management objective with 60 percent probability by 2019 and catches greater than 14,000 t would not allow rebuilding in the specified timeframe with 60 percent probability. Under the management measures in place in 2010, SCRS indicated that there was no longer a risk of stock collapse. SCRS continued to express concern about possible overcapacity in the fishery if the current controls are not fully implemented. Finally, SCRS noted that ICCAT might consider a probability of rebuilding standard different from that envisioned in the 2009 agreement by ICCAT (which called for at least a 60 percent probability) considering the unquantified uncertainties associated to the results of the assessment.

During its 2010 annual meeting, ICCAT adopted a new recommendation for eastern and Mediterranean bluefin tuna. The TAC for 2011 and beyond (until changed) was set at 12,900 t, a 600 mt or 4.4 percent reduction from the 2010 level of 13,500 t. This reduction is in addition to existing quota paybacks for previous overharvests by the EU and Tunisia. Thus, the adjusted allowable catch for 2011 and 2012 is approximately 11,500 t. Before taking into account these required reductions, the new TAC has at least a 95 percent probability that the condition of the stock will improve in the coming years and a 67 percent probability of rebuilding the stock by 2023, the end of the rebuilding period.

The 2010 eastern bluefin tuna measure also contains a new allocation arrangement that reflects a decrease for Algeria and corresponding increases for Libya, Turkey, and Egypt. For several years both Libya and Turkey, in particular, had expressed strong interest in receiving greater shares of this resource. Turkey had formally objected to the allocation arrangement after it was adopted in 2007 but has voluntarily complied with its quota to date. Turkey indicated that the small increase it received in the 2010 negotiations was still too low and indicated its intention to object once again to the allocation scheme. Algeria also expressed concern about the reallocation of its previous share and indicated its intention to object formally under the Convention. The 2010 eastern bluefin tuna recommendation maintains all other provisions of previous measures, including the 11-month closure of the Mediterranean purse seine fishery, with a one month opening from mid-May through mid-June. It also tightened existing monitoring and control measures for the eastern Atlantic and Mediterranean fishery, including requiring observers on towing vessels that deliver bluefin tuna to farms, further restricting joint fishing operations, and requiring fishing capacity issues to be fully addressed by 2013.

6.4.2. U.S. Interstate/Federal Authorities

Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et. seq.)

The MSA provides Regional Fishery Management Councils with authority to prepare FMPs for the conservation and management of fisheries in the U.S. EEZ, including the establishment of necessary habitat conservation measures. The MSA was reauthorized and amended in 1996 by the Sustainable Fisheries Act (SFA) and again in 2007 by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA). Among other modifications, the SFA added requirements that FMPs include provisions including standardized methods for reporting bycatch, describe and identify EFH for all managed species and minimize adverse impacts of fishing to the extent practicable, and measures to rebuild overfished stocks. The MSRA further modified the MSA by requiring Annual Catch Limits at a level such that overfishing does not occur and measures to ensure accountability.

The authority to manage the U.S. Atlantic tuna fisheries is delegated to the Secretary of Commerce, which further delegated management to NMFS. In October 2006, NMFS adopted the Consolidated HMS FMP. The regulations under the FMP apply in all waters of the Atlantic Ocean within the U.S. EEZ, including the Gulf of Mexico and Caribbean Sea.

As of October 2010, there were over 32,000 permitted vessels that may participate in the Atlantic tuna fisheries (NMFS, 2010). All owners/operators of vessels (commercial, charter/headboat, or recreational) fishing for regulated Atlantic tunas (Atlantic bluefin, bigeye, albacore, yellowfin and skipjack tunas) in the management area must obtain an Atlantic tunas permit or an Atlantic HMS vessel permit. Vessel permits are issued in five directed fishing categories and two incidental fishing categories. Generally, permits are issued for distinct fishery by gear types, and participants are restricted to the use of only those allowed gears. For directed fisheries on BFT, these gears consist of purse seine, rod and reel, harpoon, handline, bandit gear, and greenstick (which is used primarily to harvest yellowfin tuna). Pelagic longline gear is not an allowed gear type for directed fishing on bluefin tuna and it is used to target other HMS species, primarily swordfish, bigeye, and yellowfin tuna. However, NMFS allocates a quota for landings of incidentally-caught bluefin by longline and trap gear. Only one permit category may be assigned to a vessel. Permit holders may not change permit category after 10 days from the date of permit issuance. All fish dealers purchasing regulated Atlantic tunas from vessels holding an Atlantic tunas permit or an Atlantic HMS vessel permit must obtain an Atlantic tunas dealer permit. An International Trade Permit is required for the international trade of fresh or frozen Atlantic or Pacific bluefin tuna, southern bluefin tuna, swordfish, and/or frozen bigeye tuna. Atlantic tunas may be sold only by fishermen permitted in commercial categories and only to permitted dealers. Atlantic tunas taken by persons aboard angling (recreational) category vessels may not be sold.

The majority of bluefin tuna landings are taken by handgear fisheries in the commercial General category and recreational Angling and Charter/Headboat categories. General category fisheries are focused in New England during the summer and fall, and the South Atlantic during the winter.

Commercial fisheries are focused on ‘large medium’ (73 in to less than 81 in curved fork length (CFL)) and ‘giant’ (81 in CFL or greater) bluefin tuna, while recreational fisheries are focused on ‘large school/small medium’ bluefin tuna (47 in to less than 73 in CFL), with allowances for ‘school’ (27 in to less than 47 in CFL), ‘large medium’, and ‘giant’ bluefin tuna. See Table 6.2. for detailed size class categories of bluefin tuna. Commercial categories are monitored by a census of landing cards, whereas the recreational catch is monitored primarily by a survey, although the states of Maryland and North Carolina have implemented recreational census bluefin tuna tagging programs as well.

Table 6.1. Size class categories of bluefin tuna.

Size class	Total curved fork length		Approx. round weight	
	in	*cm*	lb	*kg*
Young school	< 27	< *69*	< 14	< *6.4*
School	27 - < 47	*69* - < *119*	14 - < 66	*6.4* - < *30*
Large school	47 - <59	*119* - < *150*	66 - < 135	*30* - < *62*
Small medium	59 - < 73	*150* - < *185*	135 - < 235	*61* - < *107*
Large medium	73 - < 81	*185* - < *206*	235 - < 310	*107* - < *141*
Giant	81 or >	*206* or >	310 or >	*141* or >

Recreational fisheries are prosecuted by private vessels fishing in the Angling category and vessels for hire fishing under the Charter/Headboat category. The Consolidated HMS FMP notes that charter/headboats have been targeting school size bluefin tuna off New York and New Jersey since the early 1900s. School size bluefin are recreationally targeted off Virginia, Delaware, and Maryland during the summer and off New Jersey and New York as the summer progresses. In recent years, school size bluefin have been increasingly available to southern New England fisheries, i.e., school bluefin have been appearing and caught further north than in the past. Fishery landings and school size bluefin availability generally decline in the fall with colder water temperatures and degrading fishing conditions.

Recreational fishing also takes place for 'large medium' and 'giant' bluefin in the South Atlantic winter fishery, and the Consolidated HMS FMP notes that this fishery includes an active charter/headboat fishery. 'Large school' and 'small medium' size bluefin are landed by private and charter/headboat fisheries in summer and early fall off Virginia, Delaware, Maryland, New Jersey, and Massachusetts, but are overall less accessible to New York, Connecticut and Rhode Island fisheries. Large school and small medium bluefin are also available in the South Atlantic winter fishery. In general, bluefin tuna fisheries vary from year to year since the exact availability of bluefin tuna and the demand for fishing opportunities is not possible to predict.

All fishing for any species must cease and the vessel must immediately return to port to offload when the large medium or giant bluefin tuna daily retention limit is retained or possessed under regulations pertaining to the General, HMS Charter/Headboat, and HMS Angling category fisheries, as applicable. In the case of multi-day trips, the daily limit applies and may not be exceeded at any point during the trip. Directed fishing for bluefin tuna in the Gulf of Mexico is prohibited. Landing large medium or giant bluefin tuna is allowed in the Gulf of Mexico only under the HMS Angling category "trophy" and Longline category retention limits. Authorized gear for Atlantic tunas: Rod and reel (including downriggers), handline, greenstick gear, harpoon, bandit gear, longlines, traps (pound nets and fish weirs), and purse seines. In addition, various gear type restrictions are in place for bluefin tuna.

Landings of all bluefin tuna must be reported. If sold, the landings of large medium and giant bluefin tuna must be reported by a licensed dealer on landing cards faxed to the NMFS Northeast Regional Office. Bluefin tuna not sold by commercial permit holders must be reported to the nearest NMFS Enforcement office upon landing. Recreational landings of large medium and giant ("trophy") bluefin tuna must also be reported.

<u>6.4.3. Summary and Evaluation</u>

Western bluefin tuna are highly regulated with TAC limits generally set within the range recommended by SCRS. Although greater reductions in TAC were discussed to account more fully for the assessment uncertainties and increase the probability and rate of stock growth and recovery for both eastern and western bluefin tuna DPSs, catch levels agreed in 2010 are expected to support continued growth and recovery of the stocks if compliance with agreed rules continues. Compliance can be expected given the strong control measures for the stocks in effect on the water, in port, and at the marketplace (through the implementation of the catch documentation scheme). The significant public attention bluefin tuna is receiving is also not expected to abate and this should also help ensure ICCAT and its members continue their efforts to ensure the effective conservation and management of this important resource. Given the mixing between the stocks, improved stock conservation in the East would be expected to benefit the western stock as well. First, western origin fish that cross the management boundary will be less vulnerable to harvest in a substantially reduced and highly controlled eastern fishery. Second, as the eastern stock of bluefin tuna recovers, more eastern fish will be available to enter the western fishery and be subject to harvest, thereby reducing mortality of the western stock. The SRT also noted that ICCAT has successfully recovered North Atlantic swordfish applying similar principles to those for bluefin tuna and that the organization is beginning the development of overarching decision making principles to be applied to all stocks under management that would increase the probability of reaching ICCAT's Convention objectives in established time frames. Based on the information above, the SRT concluded that the existing regulatory mechanisms described above are sufficiently protective of bluefin tuna now and into the future.

6.5. Other Natural or Manmade Factors Affecting its Continued Existence

<u>6.5.1. Climate Change and Ocean Acidification</u>

Introduction

In its most recent assessment, the Intergovernmental Panel on Climate Change (IPCC) of the United Nations Environment Program concluded that the earth is warming as evidenced by widespread observations of increases in global average air and ocean temperatures, melting of snow and ice, and rising global average sea level (Pachauri and Reisinger, 2007). Further, the International Symposium on the Effects of Climate Change on the World's Oceans (May 19-23, 2009, Gijon, Spain) concluded that the global warming trend and increasing emissions of carbon dioxide and other greenhouse gases are already affecting environmental conditions and biota in the oceans on a global scale (Valdes *et al.*, 2009). The symposium also concluded that the significance of these effects, nor the mechanisms and processes that link individual responses of a given species with shifts in the functioning of marine ecosystems, are not understood (Valdes, 2009). Moreover, differentiating the impacts of climate change from naturally occurring variability, and the complex interactions inherent in large marine ecosystems, is extremely difficult. Although no particular research study unequivocally documents the long-term effects of climate change on bluefin tuna stock status, several studies have considered the impacts of large scale abiotic environmental changes on bluefin distribution and variations in year class strength (Fromentin and Restrepo, 2001; ICCAT, 2002; Ravier and Fromentin, 2004). Such studies exemplify information that is useful in beginning to understand the potential impacts of climate change on bluefin tuna. In a recent FAO review of physical and ecological impacts of climate change on marine fisheries, Barange and Perry (2009) suggest that potential effects of climate change on a species can be discussed (short of projection or forecasting) using the current knowledge available on the species.

Through gradual warming and changes to the frequency, intensity and location of climate patterns and extreme events, climate change is expected to affect a range of abiotic factors that will in turn affect the productivity and distribution of marine fish populations (Rijnsdorp *et al.,* 2009; Cochrane *et al.,* 2009). Generally for marine fish, the most important of these factors are considered to be temperature, atmospheric circulation, water column stratification and vertical circulation, and ocean acidification, though other factors (e.g., salinity, sea level rise) may be more important relative to a species life history (Rijnsdorp *et al.,* 2009). The factors that are affected could be physiological, behavioral, population dynamics, and/or ecosystem level trophic interactions (Rijnsdorp *et al*., 2009). Physiological responses occur on an organism level, and could include mortality or changes in physiological rates based on climate driven changes such as temperature, oxygen availability, or carbon dioxide related increases in pH. Physiological responses would be most likely to occur when behavioral responses (e.g., avoidance) to a stressor cannot occur. An example is the dissolution of planktonic pteropod shells that is expected in response to increased oceanic carbon dioxide concentrations (Orr *et al.,* 2005). An example of a behavorial response is the climate-induced change in the phenology of annual migrations to feeding and/or spawning grounds for capelin (Carscadden *et al.,* 1997). Population dynamics may be affected by a major shift in recruitment affected by climate change. Extreme heat events could add to the already high and variable mortality of early life history stages, which would impact the future distribution and abundance of populations (Rijnsdorp *et al*., 2009). Productivity as measured by growth could also be impacted if growth rates are affected by warming temperatures.

Responses to climate can thus occur at all trophic levels of the ecosystem. In a changing climate, the level and composition of primary production may be affected by changes to stratification from increased water column stability (Barange and Percy, 2009) and the availability of nutrients, changes to salinity, and oxygen availability. These changes could affect lower level trophic coupling and eventually the recruitment success of marine fish (Cushing, 1990). Fish species can shift distribution based on changed environmental conditions and may shift more readily based on faster life cycles and smaller body sizes (Perry *et al.*, 2005).

Climate Change Status and Predictions

Global ocean temperature has risen by 0.10°C from the surface to a depth of 700 m during approximately the last 40 yrs (Bindoff *et al.*, 2007). The long-term trends for depth-integrated heat content of the Atlantic Ocean for the period 1955 to 2003 are broadly consistent with the warming trajectory for global sea surface temperature. In the Atlantic, this warming extended down to below 1,000 m, deeper than anywhere else in the world ocean because of the deep overturning circulation that occurs in the North Atlantic. Warming was particularly pronounced under the Gulf Stream and North Atlantic Current near 40°N, with a weaker pattern of warming in the Gulf Stream. During this period, the subtropical gyre in the Atlantic warmed and the subpolar gyre cooled, which is consistent with the predominantly positive phase of the North Atlantic Oscillation (NAO) during the last several decades. There has been a discernible trend of increased salinity and warmer temperature in key water masses of the Mediterranean Sea over the last 50 years, which is detectable beyond the wide ranging natural variability (Bindoff *et al.,* 2007). Although there have been changes to key oceanic water masses, there is no clear evidence for large scale changes to meridional overturning circulation (MOC) in the Atlantic.

The IPCC predicts that even if all radiative forcing agents were held constant at year 2000 levels, atmospheric warming would continue for the next two decades at a rate of about 0.1˚C per decade because of the tremendous heat stored in the oceans (Meehl *et al.,* 2007). The greatest temperature increases are projected to occur over land and at high northern latitudes, with less warming over the southern oceans and northern North Atlantic. For the next two decades, a warming of, on average, about 0.2°C per decade is projected for a range of IPCC emission scenarios (IPCC, 2007). It is very unlikely that the Atlantic MOC will undergo a large abrupt transition during the course of the 21st century (Meehl *et al.,* 2007).

Increasing atmospheric carbon dioxide concentrations have led directly to increasing acidification of the ocean surface (Meehl *et al.,* 2007). Projected reductions in pH of between 0.14 and 0.35 units in the 21st century would be added to the present decrease of 0.1 units from pre-industrial times. Southern Ocean surface waters are projected to exhibit dissolution of calcium carbonate during the second half of the century (Orr *et al.,* 2005). Low-latitude regions and the deep ocean will be affected as well (Meehl *et al.,* 2007).

Impacts to Bluefin Tuna

As noted previously, bluefin tuna are wide-ranging and pelagic in nature. Their distribution is generally bounded by 12° north and south latitude (Mather *et al.,* 1995). Spatial distribution and movement was previously hypothesized to be controlled by preferential ranges of temperature (ICCAT, 2006-2009); but more recently, scientists hypothesized that juveniles and adults are associated with ocean fronts, likely to forage for prey (Humston *et al.,* 2001; ICCAT, 2006-2009). However, the complexity of bluefin tuna distribution and behavior is unlikely explained by association with these fronts alone (Shick *et al.,* 2004; Royer *et al.*, 2004). Research studies have shown that migration and movement patterns vary considerably between individuals, years, and areas (Lutcavage *et al.,* 1999; Block *et al.,* 2001; De Metrio *et al.*, 2004; ICCAT, 2006-2009). The appearance and disappearance of past fisheries (e.g., Brazil during the 1960s) could be a result of changes in spatial distribution and/or migration (Fromentin and Powers, 2005). Rijnsdorp *et al.* (2009) hypothesized a shift in distribution in response to increased temperature associated with climate change, and similar distribution shifts for other species have also been observed (Nye *et al.,* 2009). However, without a better understanding of the processes that determine bluefin tuna distribution it is difficult to project a response of the species to climate change.

Rijnsdorp *et al.* (2009) further hypothesized that if the habitat for a certain life-history stage is spatially restricted (e.g., spawning), the species may be more sensitive to climate change. As noted in section 7.5.1., NMFS designated a habitat area of particular concern (HAPC) for bluefin tuna spawning in the Gulf of Mexico in Amendment 1 to the U.S. Consolidated HMS FMP (NMFS, 2009). This area is the primary spawning habitat for the western stock of bluefin, although the potential for other spawning locations has also been suggested (Galuardi *et al.,* 2010). Climate induced temperature increases could increase stress for bluefin tuna during spawning in the Gulf of Mexico. Average ambient temperatures measured during bluefin spawning activity ranged from 23.5°C – 27.3°C (Teo *et al.*, 2007). Bluefin tuna have been found to withstand temperatures ranging from 3°C to 30°C (Block *et al.*, 2001). Although bluefin are believed to use deep diving to thermoregulate, spawning behavior may preclude thermoregulation behavior (Teo *et al.*, 2007). Block *et al.* (2005) indicated that thermal stress appeared to be contributing to mortality of pelagic longline-caught bluefin tuna on the Gulf of Mexico spawning grounds. If the SRT assumes that increases in ocean temperature will mirror those forecasted for air temperature by the IPCC (2007, i.e., + 0.20˚C per decade), and add ten decade's worth of temperature increase (i.e., a total of 2.0˚C) to the temperatures reported by Teo *et al.* (2007), then we can estimate that Gulf of Mexico temperatures during bluefin tuna spawning season could reach 25.5˚C – 29.3˚C by the turn of the century. Muhling *et al.* (2011) modeled a variety of climate change simulations in the Gulf of Mexico to quantify potential effects of warming on the suitability of the Gulf of Mexcio as a spawning ground for bluefin tuna. Model results showed that bluefin tuna were indeed vulnerable to climate change impacts with increasing water temperature affecting both spawning times and locations as well as larval growth, feeding and survival (Muhling *et al*., 2011). Furthermore, if ambient values of abiotic factors such as salinity or pH exceed the tolerance limits for planktonic bluefin tuna eggs and larvae, these life stages could be negatively affected physiologically.

Fabry *et al.* (2008) reviewed the potential impacts of ocean acidification on marine fauna and ecosystem processes. The information reviewed indicated that marine fish were physiologically highly tolerant of carbon dioxide. Ishimatsu *et al.* (2004) found that hatchling stages of some species appeared fairly sensitive to pH decreases on the order of 0.5 or more, but high carbon dioxide tolerance developed within a few days of hatching.

Indirect trophic level dynamics may also have some impact to bluefin tuna as a result of climate change and ocean acidification. Acidification would lead to dissolution of shallow-water carbonate sediments and could affect marine calcifying organisms, including pteropods which are an important component of the plankton in many marine ecosystems (Orr *et al.,* 2005). In their review article, Walther *et al.* (2002) stated that indirect impacts on marine systems appear to be the most widespread effects of climate change. For example, the persistence of a positive vector for the North Atlantic Oscillation (NAO) modifies marine primary and secondary production (Fromentin and Planque, 1996), which could in turn affect the availability of planktonic food for fish larvae and recruitment success (Cushing, 1990). However, ICCAT scientists analyzed the association of the NAO with eastern bluefin tuna recruitment and found no relationship (ICCAT, 2002). Availability of nutrients could also be affected by changes in carbon dioxide, which could affect primary production, changes in species composition, and higher trophic levels (Fabry *et al.*, 2008). Kimura *et al.* (2010) modeled a combination of environmental factors when considering the impact to the recruitment of juvenile Pacific bluefin tuna. For example, an increase in ocean temperature would speed the transport of larvae in the Kuroshio current causing the larvae to arrive too quickly to cold coastal waters. When coupled with high temperatures exceeding the optimal range on the spawning grounds, larval mortality was predicted in 2010 to decline to 36 percent of present recruitment levels (Kimura *et al*., 2010).

Chase (2002) identified squid as one of several important food sources for bluefin tuna caught off New England. Epipelagic squid (e.g., *Illex* and *Loligo* sp.) have been found to be highly sensitive to carbon dioxide because of their unique physiology (Portner *et al.*, 2004; Seibel, 2007).   Yamada and Ikeda (1999) found increased mortality for certain arthropod plankton (krill and certain copepods) with increasing exposure time and decreasing pH. Larval *Thunnus* sp. have been found to feed primarily on copepods (Catalan *et al.*, 2007; Llopiz and Cowen, 2009;). As pelagic predators, bluefin tuna are considered opportunistic and loss of one food source may not have negative consequences. However, in the Florida straits, larval *Thunnus* sp. appeared to exhibit selective feeding behavior (Llopiz and Cowen, 2009) and thus, larvae may not be as opportunistic feeders as adult bluefin tuna.

The effects of fishing in combination with climate change could make fish populations more vulnerable to short-term natural variability by reducing their ability to buffer against the effects of poor year classes (Rijnsdorp, 2009; Cochrane *et al.*, 2009). A population structure with fewer ages and smaller sizes reduces "bet-hedging" capabilities. From an evolutionary perspective, a heavily fished population like bluefin tuna could show a reduction in genetic variability (Rijnsdorp, 2009). In addition, a long-lived species such as bluefin tuna could have less evolutionary ability to adapt to climate change than shorter-lived species.

6.5.2. Aquaculture / Farming

Capture-based aquaculture (CBA) of bluefin tuna occurs only in the Mediterranean, where it began in 1997 (SCRS, 2009). Along with good market conditions, CBA resulted in rapid changes in Mediterranean bluefin tuna fisheries (SCRS, 2009). Purse seine catches increased substantially, and serious under-reporting of the Mediterranean catch ensued.   In 2007, ICCAT adopted a catch documentation program to better account for total catch in this fishery.   In addition, in 2008, ICCAT adopted 100% observer coverage on the large scale purse seine fleet operating in the Mediterranean, including during the transfer of fish to farming cages and during harvest from the cages. Also in 2008, ICCAT adopted strict measures to freeze farming capacity and control the amount of bluefin tuna that can be caged. Further, in 2010, ICCAT required the development of improved methods to estimate the number and weight of bluefin tuna caught and destined for farming operations.

Wild bluefin tuna may be caught at different life cycle stages for CBA (Ottolenghi, 2008). Some Croatian facilities "farm" smaller specimens for longer periods of time (greater than 20 months), while other facilities "fatten" larger fish for a shorter period of 1-7 months, to more closely time production with market demand.

Bluefin tuna bound for cages used to be located by spotter planes and then captured by purse seiners (Ottolenghi, 2008), although the use of aircraft to support fishing activities in the eastern bluefin tuna fishery was partially banned in 1996 and fully banned by 2007. However, since 2008, fishing with the assistance of spotter planes is considered a serious violation according to Annex 8 of ICCAT recommendation (08-05). Towing to the farm can take up to several weeks. It has proven difficult to efficiently determine the size and age composition of fish transferred into the towed or farm cages.

In general, aquaculture cages begin to be filled in late spring through July and may extend into the early fall. Mortality rates are estimated at approximately two percent, though high mortality events occur occasionally because of adverse environmental conditions including strong currents or elevated turbidity. In addition, incidence of mortality to both Pacific and Mediterranean aquaculture raised bluefin tuna have been documented due to viral and/or bacterial disease agents (see Section 6.3.2 above).

Feed is mainly comprised of small pelagic species imported from outside the region, although some locally fished stocks are also used. It is plausible that harvest of local small pelagic stocks for food could at some point have an ecosystem level effect in the Mediterranean and affect the availability of forage for wild bluefin tuna. Use of exogenous food fish sources could result in introduction of disease to farmed fish and the wild population. However, to date, neither of these two conditions has been reported.

Frequently, a diver remains in the cage during feeding of caged tuna, and signals for feeding to stop when tuna are sated. There is some concern about the potential deterioration of the environment in the proximity of the farm site since intensive fish farming tends to generate a large amount of organic waste in the form of unconsumed feed and fecal and excretory matter. This could result in negative impacts to farmed fish and indigenous wild stock; however, since the tuna are generally caged for only up to 7 months (except for off Croatia), there is time for the area to recover (i.e., for the remaining five or more months of the year). In addition, it is important for farms to be located in sites with good water circulation, well oxygenated water and sufficient depth because of the biological needs of this pelagic species, which precludes sites that are more susceptible to eutrophication from farms.

Aquaculture activities for species other than bluefin tuna could potentially have negative impacts on this species. Potential adverse aquaculture-related impacts to HMS EFH were identified in Amendment 1 to the Consolidated HMS FMP (NMFS, 2009) were the discharge of excessive waste products, and the release of exotic organisms and toxic substances. Increased nutrient loads and localized eutrophic conditions were identified as the most probable environmental effects of aquaculture activities. Currently, most saltwater aquaculture facilities in the United States are located in intertidal and coastal areas rather than pelagic waters where bluefin tuna are found. For more information on HMS EFH, see section 2.3.

During a 2006 workshop on the feasibility of tuna aquaculture in the United States, Atlantic bluefin tuna were identified as the tuna species with the most potential (Sylvia and MacCracken, 2006). Market timing with seasonal CBA holding facilities was considered the most likely approach in the northeast and mid-Atlantic region. Holding brood stock year-round likely is feasible in the Gulf of Mexico; however, current regulations prohibit directed fishing for bluefin tuna in the Gulf. The lack of bluefin tuna CBA in the United States was generally attributed to a lack of regulatory structure for permitting (Sylvia and MacCracken, 2006). NOAA's draft aquaculture policy (NOAA, 2011) recognizes this issue by including under its priorities for Regulation: "Work with Congress, Federal agencies, Fishery Management Councils, and Federal advisory councils or committees to clarify NOAA's regulatory authority related to aquaculture in Federal waters and to establish a coordinated, comprehensive, transparent, and efficient regulatory program for marine aquaculture in Federal waters based on criteria for sustainable marine aquaculture." (NOAA, 2011).

In 2009, the Gulf of Mexico Fishery Management Council (GMFMC) prepared a programmatic environmental impact statement (PEIS) for offshore aquaculture development in the Gulf of Mexico, and a proposed rule is expected in the near future (GMFMC, 2009). With the advent of a defined regulatory process, aquaculture in regional Federal waters may increase, including the possibility of bluefin tuna CBA. Other offshore aquaculture activities in the Gulf of Mexico could also be relevant to bluefin tuna because of the bluefin tuna HAPC.

Based on projections in the PEIS, an estimated 5 to 20 offshore aquaculture operations would be permitted in the Gulf over the next 10 years (GMFMC, 2009). Potential impacts resulting from offshore aquaculture may include increased nutrient loading, habitat degradation, fish escapement, competition with wild stocks, entanglement of endangered or threatened species and migratory birds, spread of pathogens, user conflicts, economic and social impacts on domestic fisheries, and navigational hazards (GMFMC, 2009). The preferred alternatives selected by the GMFMC in the Aquaculture FMP are intended to prevent or mitigate to the extent practicable these potential adverse environmental impacts (GMFMC, 2009). Objectives of the FMP specifically include avoiding impacts to wild stocks and protecting EFH through proper location of aquaculture facilities.

6.5.3. Pollution

Since most bluefin tuna habitat includes the pelagic zone and open ocean environments over broad geographic ranges, the greatest habitat-related threats to bluefin tuna have been identified as large-scale impacts, such as global climate change, that affect ocean temperatures, currents, and potentially food chain dynamics (NMFS, 2009). Pollution may cause organisms to be more susceptible to disease or impair reproductive success. However, understanding of the individual, cumulative, and synergistic effects of contaminants on marine ecosystems is incomplete (USEPA, 2005). Increasing sources of anthropogenic caused noise may also have large scale ocean area impacts on fish distribution, communication, fitness and predator-prey interactions (Slabbekoorn *et al*., 2010) although specific levels of impacts on bluefin tuna are unknown at this time.

Contaminants enter water bodies via two main vectors – point sources or non-point sources. Point source pollutants are primarily industrial or urban related wastes, introduced via a specific pipe or outfall, and are regulated by the U.S. Environmental Protection Agency (EPA) under the Clean Water Act and the EPA's National Pollution Discharge Elimination System (NPDES) program. Non-point pollution is also called "polluted runoff" and tends to enter aquatic systems in relatively diffuse contaminant streams from atmospheric and terrestrial sources (Johnson *et al.*, 2008). Aside from atmospheric deposition, most water pollution occurs in inland or coastal areas rather than the pelagic environment of bluefin tuna. Thus, bluefin tuna are somewhat geographically isolated from these impacts.

Metals are one of the seven "priority pollutants" of particular concern for aquatic systems (USEPA, 2003), and mercury has been shown to bioaccumulate in top predators, including bluefin tuna. Atmospheric deposition is one of the most important sources of mercury pollution (Wang *et al.*, 2004). However, bioaccumulation depends upon availability at the trophic level. The processes that govern methylation of mercury in the open-ocean, and subsequent uptake in the food web, are not well understood. However, most uptake into the marine food web is thought to begin via bacteria associated with sediments or detritus (Chen *et al.*, 2008). Methyl mercury can cause nerve and developmental damage in humans and animals. Mercury inhibits reproduction and development of aquatic organisms, with the early life-history stages of fish being the most susceptible to the toxic impacts associated with metals (Johnson *et al.*, 2008). Little information is available about the chronic low-level impacts of mercury, leading the New England Fishery Management Council (NEFMC) to conclude that long-term impacts do not appear significant in most marine organisms (NEFMC, 1998). Most available information on the impacts of bioaccumulation of heavy metals by fish relates to the health effects of human consumption of contaminated fish (Johnson *et al.*, 2008). Although the Food and Drug Administration (FDA) has not issued a health warning specifically for mercury in bluefin tuna, recent observations have indicated that mercury levels in some bluefin tuna samples could be above FDA recommended levels (Fox, 2008).

Some chemicals found in plastics, known as "endocrine disruptors," may interfere with the endocrine system of aquatic organisms by acting as environmental hormones that may mimic the function of the sex hormones androgen and estrogen (Johnson *et al.*, 2008). Adverse effects include reduced or altered reproductive functions, particularly among fish and invertebrates, potential disruption of natural biotic processes and possible population-level impacts (Johnson *et al.*, 2008). Examples of estrogenic chemicals include polychlorinated biphenyl (PCB) congeners, dieldrin, dichlorodiphenyl trichloroethane (DDT), phthalates, and alkylphenols which have had, or still have applications in agriculture, and may be present in polluted runoff or sewage outfalls. Although PCBs and DDTs have been found in bluefin tuna, little information is available on the impacts of these contaminants to bluefin tuna. In the National Academy of Sciences review which included the impacts to fish from endocrine disruptors (National Research Council, 1999), the authors found that the evidence supported the hypothesis that toxic chemicals in eggs were at least partly responsible for some of the decline of Great Lakes lake trout populations and were implicated in Baltic Sea salmonid disease. The land-based origination of such contaminants in amounts significant enough to cause similar impacts to bluefin tuna in a pelagic environment would be unlikely.

6.5.4. Summary and Evaluation

The SRT identified several potential natural or manmade threats to bluefin tuna, as described above. While these could represent potential future threats to the species, at this time, current impacts are not likely and do not represent a substantial risk to the long-term persistence to either DPS. While the SRT acknowledges a growing body of literature on the impacts of climate change on marine fish distribution and abundance, it is speculative to attempt to predict the specific impacts or threats on the long-term health of bluefin tuna. Regarding aquaculture, recent enhancements to monitoring, control, and reporting requirements by ICCAT for aquaculture facilities and related activities will improve the ability to better assess removals from the wild stock and ensure compliance with agreed catch limits. Thus, while these issues could represent potential future threats to the species, at this time, the SRT concluded that they do not represent a substantial risk to the long term persistence to either DPS.

7. CURRENT CONSERVATION EFFORTS AND PECE ANALYSIS

Current conservation efforts underway to protect and restore Atlantic bluefin tuna must be evaluated under the Policy for Evaluation of Conservation Efforts (PECE), under the authority of the ESA. This policy is designed to determine whether any conservation efforts that have been recently adopted or implemented, but not yet proven to be successful, will result in recovering the species to the point at which listing is not warranted or contribute to forming a basis for listing a species as threatened rather than endangered (68 FR 15101). The purpose of the PECE is to ensure consistent and adequate evaluation of future or recently implemented conservation efforts identified in conservation agreements, conservation plans, management plans, and similar documents when making listing decisions. The policy is expected to facilitate the development by the states and other entities of conservation efforts that sufficiently improve a species' status so as to make listing the species as threatened or endangered unnecessary.

In 2003, the Services published guidelines for evaluating conservation efforts that have not yet been implemented or have not yet demonstrated effectiveness when making listing decisions under the ESA. The policy established two basic criteria: 1) the certainty that the conservation efforts will be implemented and 2) the certainty that the efforts will be effective. The first criterion, implementation, requires a high level of certainty that the resources necessary to carry out the conservation effort are available, ensures that the implementing agency has the authority to carry it out, determines if the regulatory or procedural mechanisms are in place to carry out the efforts, and that there is a schedule for completing and evaluating the efforts. The second criterion, effectiveness, requires the conservation effort to describe the nature and extent of the threats to the species to be addressed and how these threats are reduced by the conservation effort, determine if the conservation effort has established specific conservation objectives, determine if the conservation effort identifies the appropriate steps to reduce threats to the species, and evaluate whether the conservation effort includes quantifiable performance measures to monitor for both compliance and effectiveness. Overall, the PECE analysis ascertains whether the formalized conservation effort improves the status of the species at the time a listing determination is made.

The SRT determined that the following conservation efforts required further description in order to be evaluated under the PECE: implementation of the bluefin tuna TAC reductions recommended by ICCAT for western Atlantic bluefin tuna (1,750 mt) and eastern Atlantic/Mediterranean bluefin tuna (12,900 mt) and the recently implemented U.S. requirement for weak hook use in the highly migratory species pelagic longline fishery in the Gulf of Mexico.

7.1. Implementation of 2010 ICCAT Recommendations for Western and Eastern Atlantic/Mediterranean bluefin tuna

Eastern Atlantic/Mediterranean Management

As described in Section 5, the 2010 ICCAT recommendation regarding the eastern Atlantic and Mediterranean bluefin tuna recovery plan set the TAC for 2010 at 12,900 t, a 600 t reduction from the previously agreed TAC level of 13,500 t. The measure included provisions for payback of overharvests, which amount to 1667.38 t for both 2011 and 2012. It also allowed carry forward of voluntary quota reductions from 2009 into 2011, which amounted to 270.28 t. Everything else being equal, the adjusted TAC for 2011 is 11502.89 t.

Notably, Algeria, Turkey, and Norway lodged objections to the 2010 eastern bluefin tuna measure in early 2011. Algeria and Turkey felt their quota allocation was unfairly low. Norway objected due to concerns over the decision making process. Objections officially delay the entry into force of a measure. ICCAT recommendations usually become effective 6 months after official transmission to the parties (i.e., early June each year). In the case of the eastern bluefin tuna recommendation, the objections delay the entry into force an additional 60 days (i.e., until August 14, 2011), Despite this, once a recommendation enters into force, its provisions become binding on all except the objecting nations and compliance will be reviewed accordingly by ICCAT.

In February 2011, a special meeting of ICCAT's Compliance Committee (COC) was held. The purpose was to reinforce the commitment of all parties to implement the eastern bluefin tuna recommendation from the start of the 2011 season and, toward that end, to review the implementation plans (which included fishery management, inspection, and capacity reduction aspects) of eastern bluefin tuna harvesters with a view to endorsing those plans in advance of the season. Failure to receive COC endorsement could lead to a mail vote by ICCAT to suspend fishing for one or more members for the season. There was debate about whether the COC could or should endorse any plans presented by objecting parties. As in the past, Turkey noted that its objection was one of principle and that it intended to fully abide by ICCAT's rules for the eastern bluefin tuna fishery, including its allocation. Turkey asked for and received endorsement of its implementation plan. Algeria also noted that it had objected on principle. Like Turkey, Algeria presented an implementation plan that reflected a commitment to abide by ICCAT's rules but did not seek COC endorsement. Algeria noted that it did not have the technical capacity to harvest its quota in 2011. Norway indicated that it would not be prosecuting a fishery in 2011 and, therefore, had presented no implementation plan. Taiwan also indicated it would not be prosecuting a fishery for eastern bluefin tuna in 2011 and presented no plan. Of the remaining eastern bluefin tuna fishery participants, the COC was able to endorse plans for the EU, Tunisia, Japan, Croatia, Korea, and Morocco. Six countries (Albania, Egypt, Iceland, Libya, Syria, and China) will receive a letter from ICCAT requesting further information as their plans were insufficient. Endorsement of the plans of the six participants receiving letters is conditional on their timely and adequate response. Responses are due by mid-March, and a decision on endorsement will be taken shortly thereafter. Any mail vote to suspend fishing for one or more parties is expected to occur by the end of March. In addition to taking action on the implementation plans, the COC adopted an allocation table specifying the allowable harvest limits by ICCAT members, which included all adjustments, and a fleet capacity table reflecting required reductions for 2011. Given input from those present at the COC intersessional, the adjusted TAC of 11,502.89 t should be the upper bound of realized catches. Factoring in that Norway, Taiwan, and Algeria have indicated they will not be fishing and their combined quota level is 364.33 t, actual catches may be more on the order of 11,138.56 t—notwithstanding any action by ICCAT to suspend one or more fisheries in 2011 due to lack of implementation plan endorsement. Any additional reductions in catch will increase the probability of rebuilding the stock by 2023.

In addition, the 2010 eastern Atlantic recommendation also strengthened the monitoring and control scheme, including enhanced monitoring of farming operations, further restrictions on joint fishing operations (e.g., generally prohibiting joint operations between contracting parties and clarifying that each party is responsible and accountable for catches made under such operations), and requiring fishing capacity issues to be fully addressed by 2013.

Western Atlantic Management

Western Atlantic harvesters are expected to fully implement Recommendation 10-03 by mid-June 2011. This will involve reduced quotas for the United States, Canada, and Japan for 2011 and 2012.

NMFS is currently preparing a proposed rule to implement the ICCAT-recommended U.S. base quota, distributing the quota among domestic quota categories consistent with the 2006 Consolidated HMS FMP, and to adjust the 2011 U.S. quota and subquotas to account for bluefin tuna dead discards and unharvested 2010 quota allowed by ICCAT to be carried forward to 2011. NMFS plans to implement the final rule by the June entry into force date.

NMFS monitors the bluefin tuna fishery and has the authority to take in-season actions such as fishery closures and retention limit adjustments to ensure available quotas are not exceeded or to enhance scientific data collection from, and fishing opportunities in, all geographic areas. For example, in June 2010, following consideration of the available U.S. quota and subquotas, fishery performance in recent years, and the availability and size of bluefin tuna on the fishing grounds, NMFS modified the recreational daily retention limit effective for the remainder of the year to prohibit landings of the fish at the larger end of the allowed size range (59 in to <73 in) in order to constrain landings to the available quotas. NMFS also closed the 2010 recreational fishery for the largest size class of bluefin tuna for waters of southern states and northern states, on June 12th, and July 18th, respectively.

7.2. U.S. requirement to use weak hooks on pelagic longline vessels in the Gulf of Mexico

Effective May 5, 2011, NMFS requires the use of “weak hooks” by pelagic longline vessels fishing in the Gulf of Mexico. A weak hook is a circle hook that meets NMFS’ current size and offset restrictions but is constructed of round wire stock that is thinner-gauge (*i.e.*, no larger than 3.65 mm in diameter) than the 16/0 circle hooks currently used in the Gulf of Mexico pelagic longline fishery. The requirement that the pelagic longline fleet use weak hooks is intended to allow for bluefin tuna to escape capture during pelagic longline fishing for swordfish and yellowfin tuna. The action is intended to reduce pelagic longline incidental catch of bluefin tuna in the Gulf of Mexico, which is the known spawning area for the western Atlantic DPS of bluefin tuna (as described above), and to increase bluefin tuna spawning potential and subsequent recruitment into the fishery, and could also potentially reduce negative ecological and fishing impacts on non-target or protected species. This action would be consistent with the advice of the SCRS that ICCAT may wish to protect the strong 2003 year class until it reaches maturity and can contribute to spawning. Implementation of weak hooks in the Gulf of Mexico pelagic longline fishery by spring 2011 is important because the strong 2003 year class is close to entering adulthood, and it is likely that some individuals of this class will begin to spawn in the Gulf of Mexico this spring. The requirement to use weak hooks is also intended to allow directed fishing for other species to continue year-round while constraining bluefin tuna incidental landings to allocated bluefin tuna sub-quota limits.

8. LISTENING SESSIONS

Staff from the Northeast Regional Office's Protected Resources Division hosted five listening sessions with bluefin tuna fishermen in January 2011. Given bluefin tuna fishermen's knowledge and experience with this species, these meetings were designed to provide them with an opportunity to present information for the SRT to consider in the status review process. The listening sessions were held in Sandy Hook, New Jersey; Boston, Massachusetts; Portland, Maine; Pascagoula, Mississippi; and New Bern, North Carolina. Prior to initiating the sessions, participants were provided a list of discussion topics to help focus the discussion at these sessions. These topics included the following: general impressions of the abundance and distribution of bluefin tuna over time; trends observed in bluefin tuna catches over time; perception of the cause of any change in trends– change in abundance, shift in distribution, change in availability, gear changes, regulatory effects, etc.; bluefin tuna "hot spots" - locations (inshore or offshore); spatial and temporal fluctuations; average size of bluefin tuna being caught by different gear types or fisheries; other information relevant to the review of the status of bluefin tuna (except information on the potential economic impact of a listing).

Bluefin tuna fishermen presented information on distribution and abundance, trends they have observed, and general impressions on the health of western Atlantic bluefin tuna. The following is a summary of the information presented at these meetings.

Information presented in Massachusetts, Maine, New Jersey, and North Carolina was similar. There was general agreement that multiple size classes are present in abundance from Maine to North Carolina, and abundance has been steadily increasing since 2006.

A representative of the Atlantic Tuna Project presented data in New Jersey on recreational and charter boat catch of bluefin tuna including both retained and released catch. These data showed an upward trend in catch, with increases of approximately 22 percent over the past two years (see Figure 8.1). Approximately 90 percent of this catch was released or tagged and released. Although catch has steadily increased with the highest catch in 2010, the average number of trips taken for bluefin tuna in 2010 decreased, indicating less effort for increased catch rates (see Figure 8.2).

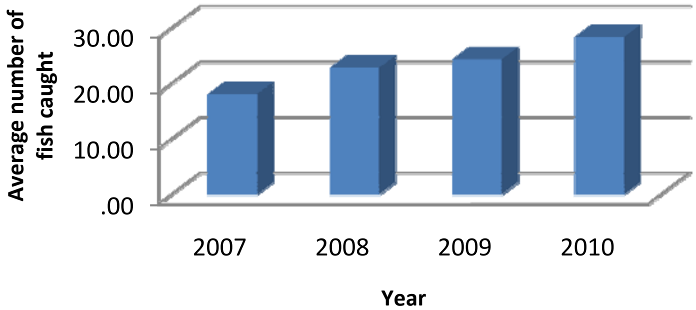


Figure 8.1. Average number of bluefin tuna caught per year by individual recreational and charter boat fishermen in Massachusetts (MA), New York (NY), and New Jersey (NJ) from a survey administered through the Atlantic Tuna Project.

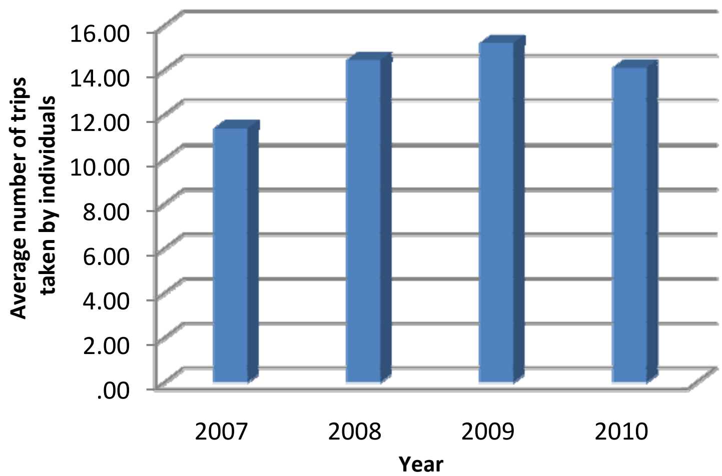


Figure 8.2. Average number of trips taken for bluefin tuna in Massachusetts (MA), New York (NY), and New Jersey (NJ) by individual recreational and charter boat fishermen from a survey administered through the Atlantic Tuna Project.

One captain noted that his catch of bluefin tuna in New Jersey was made up of several year classes, with the majority in the 50-60 in (127-152.4 cm) range, the next highest was the 30-45 in (76.2-114.3 cm) range, and the size range with the least amount caught was 70-80 in (177.8-203.2 cm). Additionally, the percentage of size ranges caught in Massachusetts, New York, and New Jersey was calculated from a survey conducted by the Atlantic Tuna Project. The overall lowest catch included bluefin tuna less than 27 in FL and sizes greater than 73 in (185 cm) FL. For percent size range caught in Massachusetts, New York, and New Jersey, see Figure 8.3. The average distance from shore where various size ranges were caught was also presented and it showed a positive correlation between size and distance from shore. The survey data indicated that the 30-45 in (76 - 114 cm) FL size range was caught within 45 miles of shore, the 50-60 in (127-152 cm) FL size range around 60 miles from shore, and the largest fish in the 70-80 in (178-203 cm) FL range being found greater than 75 miles from shore.

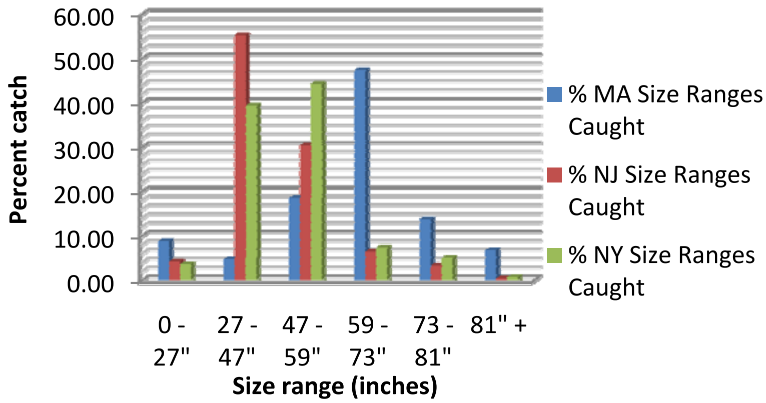


Figure 8.3. Percentage of catch from various size ranges of bluefin tuna from Massachusetts (MA), New York (NY), and New Jersey (NJ) in 2010 from a survey administered through the Atlantic Tuna Project.

It was also noted that catch rate of bluefin tuna has been increasing. One participant stated that four to five years ago bluefin tuna bites were sporadic; however, during the past two to three years, in June through October and March through early May there has been a consistent presence of bluefin tuna. The larger, 70-80 in (177.8-203.2 cm) FL fish are available, but they are found further offshore where recreational boats cannot readily travel. The correlations between size class and distance from shore were restated from Maine to North Carolina; however, it was also reported that in late September, 2010, recreational boats started catching fish from 20-100 lbs in the same area. Also, in November, fish 10-500 lbs were present just 5 miles offshore. In addition, it was noted that the size of fish caught in New Jersey changed from smaller to larger fish from summer to fall.

A steady increase in the number of school size tuna has also been observed by fishermen. Bluefin tuna fishermen from Maine through North Carolina noted on the availability of school sized fish (<27-59 in FL; 68.58-149.86 cm), stated that at a given time the past year, up and down the coast, fishermen from Maine through North Carolina were seeing schools of juvenile bluefin tuna surrounding the boats, indicating a coast-wide distribution of juveniles. One participant noted that typically the schools will break-up or disperse when the boats approach; however, this past year, the schools were so large that vessels transiting the area did not break up the school.

A general theme presented at all of the sessions in regards to bluefin tuna distribution was that the fish follow the bait (i.e, forage fish), and where bait is present, bluefin tuna can be readily found. It was stated that the juveniles have been feeding on sand eels which have recently been abundant coast-wide and closer inshore than in past years. When sand eels or other baitfish are not present, bluefin tuna are often found with codfish in their stomachs. The larger fish are feeding primarily on mackerel and herring which have moved further offshore, therefore leading the larger fish to move further offshore than the juveniles. Commercial boats reported having to travel hundreds of miles offshore to avoid the catch of juvenile bluefin tuna in order to comply with existing minimum size regulations. It was also stated that the commercial herring fishery with paired mid-water trawlers has negatively affected the bluefin tuna forage base. Several fishermen remarked on the stark absence of bluefin tuna (along with other marine life including whales, dolphins, birds, and baitfish) after these mid-water trawlers went through an area. Since more management restrictions were adopted for this fishery, bluefin tuna fishermen have noted an increase in baitfish and bluefin tuna presence.

It was reported by several bait and tackle shop owners that there has been an increase in sales of bluefin tuna gear in recent years. There were numerous reports coast-wide of recreational fishermen targeting striped bass, cod, or haddock, who would return to shore in order to purchase bluefin tuna gear because they were seeing such large numbers of bluefin tuna schooling. According to one party boat operator, he was jigging for groundfish within 35 miles from shore, but they started hooking bluefin tuna. However, their tackle was too light causing the bluefin tuna to break off. The captain indicated that he had to use the boat's sonar to avoid the numerous schools of bluefin tuna, noting that they were becoming a nuisance to his groundfishing charter.

A general trend of larger bluefin tuna moving north and eastward was also noted. In regards to this shifting trend in distribution, fishermen noted that it has caused effort for bluefin tuna in the United States to decrease. The shift in distribution of commercial sized fish further offshore and further north, as well as other compounding factors such as the economy (e.g., increased gas prices) and weather, has affected fishing effort. Commercial boats have to travel further offshore to catch the commercially sized fish, and therefore, have to determine whether it is economically feasible with high gas prices to travel that far offshore. Adverse weather conditions also affect effort as it becomes unsafe for boats to travel offshore where the commercial sized fish are available. In addition, the harpoon category relies primarily on sight, and thus, this requires fairly calm waters in order to see the fish. It was noted that the sea surface temperature (SST) in North Carolina waters has been colder than normal this past year which has affected catch rates. Bluefin tuna are present, but are staying further offshore in the warmer waters such as the Gulf Stream and warm edges off North Carolina, so only boats that are able to travel offshore are capable of catching fish.

Spotter plane pilots from Maine to Massachusetts waters reported recently observing schools of bluefin tuna in the 65-75 inch (165-191 cm) FL range inshore, and fish in the 40-75 in (102-191 cm) FL range have been spotted from 25-70 miles offshore. Large schools of 50 in (127 cm) FL fish have been routinely observed by spotter pilots in the past few years, but their presence has been greatest in November through December. It was theorized that these large schools are not likely to be caught by recreational fishermen primarily because safety is an issue when traveling offshore in smaller recreational boats.

According to some, fishing effort has also been affected by the rebounding spiny dogfish stocks which have forced fishing methods for catching bluefin tuna to change. It was noted that one main technique employed by bluefin tuna fishermen used to be chumming. Chumming is no longer a viable method because it attracts the spiny dogfish, making it difficult to keep bait on the hooks long enough to catch bluefin tuna. Because of this, bluefin tuna fishermen have mostly abandoned the method of chumming, which, in turn, affects fishing effort.

Currently, age-structure stock assessments models used for bluefin tuna (i.e., VPA) are tuned using abundance indices (CPUE). Many participants noted that the estimated CPUE used in the assessments does not take into account the catch that is not reported, nor does it assess what is observed but not caught. Fishermen indicated that there is a need for a fishery independent method to provide data for the stock assessments in order to more accurately determine abundance. Commercial boats are catching a large number of fish in the 60-72 in FL range which are not commercial size, and therefore, are not landed and in many instances not recorded. Boats have been observing an abundance of smaller bluefin tuna, but these fish are hard to catch particularly when they are feeding on their preferred prey when it is abundant. There are also concerns with the recreational catch data and underreporting, as well as catch and release data not being reported.

Information presented by bluefin tuna fishermen from the Gulf of Mexico at the Pascagoula, MS meeting was much different from discussions at the other four meetings as there is no directed fishery for bluefin tuna in the Gulf of Mexico. Tuna fishermen in the Gulf of Mexico target yellowfin tuna and have learned how to avoid the areas where bluefin tuna are present. In the yellowfin tuna fishery, a few vessels have started using weak hooks on a voluntary basis in the event that they incidentally catch a bluefin tuna.

Dr. Molly Lutcavage (University of Massachusetts/ Large Pelagics Research Lab) presented recent bluefin tuna tagging efforts (which are described in Section 3) to the SRT after the listening sessions were concluded. Similar to reports from the fishermen during the listening sessions, Dr. Lutcavage reported that they saw large schools of juvenile fish. The information presented by Dr. Lutcavage confirms statements by the fishermen regarding the difficulty in catching that size class (M. Lutcavage, 2011, pers. comm.). In addition, Dr. Lutcavage noted that preliminary tagging data indicate that juveniles remain near the continental shelf rather than migrating further offshore, which supports what the recreational fleet observed with regard to an abundance of juveniles inshore (M. Lutcavage, 2011, pers. comm.).

9. EXTINCTION RISK ANALYSIS

Risks of extinction analyses are performed to help summarize the status of the species, and do not represent a decision by the SRT on whether the species should be proposed for listing as endangered or threatened under the ESA. There are no standard methods or protocols employed to estimate the risk of extinction. Instead, the method used is dependent on the availability of data for the species in question, and its life history. Information such as geographic range, population numbers, population trends, and expert opinion can be used in a purely qualitative methodology (reviewed in Regan *et al.*, 2005), or through the use of ranking or scoring systems, in a semi-quantitative analysis. Models relying on stochasticity and variability in genetics, birth-death demography, ecology and interactions among mechanisms can be employed in a highly quantitative methodology, such as Population Viability Analysis (PVA) (Boyce, 1992; Ludwig, 1999).

9.1. Extinction Risk Analysis Results and Status of Each DPS

Long-term (2010-2100) projections of abundance of the two bluefin tuna DPSs (western Atlantic and eastern Atlantic Mediterranean) were conducted using the protocols adopted by the ICCAT SCRS (SCRS, 2010).

9.1.1. Western Atlantic DPS

For the western bluefin tuna DPS, the projections were conducted exactly as specified in SCRS (2010). One thousand bootstraps were made of the base assessment model by resampling the residuals of the fitted indices of abundance. Each bootstrap result was then projected under a range of future catch levels (assuming that the total catch in 2010 was 1,800 mt in accordance with ICCAT current regulations (i.e., the 2010 TAC)) and two alternative scenarios of the future abundance of yearling bluefin tuna (the so-called high and low recruitment potential models). The low recruitment potential scenario assumes future recruitment will fluctuate about the average level estimated during 1976-2006 unless the spawning biomass falls below historical lows, in which case recruitment decreases linearly with spawning biomass (the so-called "two-line" model, developed ostensibly to reflect a change in the environment that may have caused the western bluefin tuna DPS to be less productive than they were in the past). The high recruitment potential scenario, in contrast, allows recruitment to increase as a continuous function of spawning biomass such that the high levels of recruitment estimated during the 1970s would be attainable if the number of spawners were allowed to increase sufficiently.

9.1.2. Eastern Atlantic/Mediterranean DPS

The projections for the eastern bluefin tuna DPS were also conducted in accordance with SCRS (2010). In that case, two base model configurations (referred to as runs 13 and 15, see Section 5.2.1.) were applied to two assumptions about historical catch levels (reported versus SCRS best estimates). These four models were each bootstrapped 500 times. The four sets of 500 bootstrap results were then projected for a range of future catch levels (assuming that the total catches in 2010 and 2011 were 13,500 mt and 12,900 mt, respectively, in accordance with ICCAT current regulations (i.e., the 2010 TAC)) and 6 different combinations of management uncertainty (perfect and imperfect implementation of size limit) and recruitment (high, low, medium). The high, low and medium recruitment levels used by the SCRS all assume future recruitment will fluctuate about a prescribed constant value that does not change with changes in spawning biomass. Constant recruitment scenarios are not necessarily unreasonable for projection analyses that focus on the probability of achieving MSY because the level of recruitment at very low numbers of spawners is of little consequence to that calculation (fishing practices that drive the population near extinction will also not support the MSY). However, assuming constant recruitment is problematic when calculating the probability of extinction because one spawner is assumed to produce as many recruits as a healthy population. For this reason, the SRT projections for the eastern bluefin tuna DPS used two-line models with recruitment fluctuating about the high, low or medium levels specified by the SCRS as long as the spawning biomass stays above historical lows, but declining linearly with spawning biomass otherwise. The two-line relationship, so prescribed, is more precautionary than constant recruitment and allows for the potential that low SSB could reduce expected recruitment.

9.1.3. Extinction Risk Analysis

The probability of extinction was calculated for each DPS separately (assuming low intermixing) from the number of bootstrap runs where the number of spawners was reduced below 2 fish (and reproduction was therefore no longer possible). In point of fact, the total population will still exceed two fish owing to the presence of juveniles; however, the population can still be considered functionally extinct because the extant fishing level will prevent those juveniles from reaching maturity. It is also possible that bluefin tuna need to form aggregations in order to spawn successfully, in which case the population might become functionally extinct if the number of spawners falls below some threshold greater than 2. Moreover, several authors have suggested that populations with fewer than about 500 individuals are doomed to eventual extinction owing to the loss of genetic diversity (Franklin 1980, Soule 1980). Matsuda et al. (1998) used 500 mature animals as the threshold for their extinction risk assessment of southern bluefin tuna. Accordingly, a second set of analyses was performed with the threshold set at 500 spawners, rather than 2.

An example of the projected spawning biomass trends resulting from this type of projection exercise is provided in Figure 9.1 to assist readers in understanding the extinction risk projection tables. The SCRS used 80% confidence limits for their projections, which means the lower limit represents 10% of the runs. Figure 9.1 depicts the median and 80 percent confidence limits of the 2,000 bootstrap runs for the combined high and low recruitment potential scenarios of the western bluefin DPS. The figure assumes a future catch level of 2,250 mt for illustrative purposes; however it should be noted that the 2010 TAC is 1,800 mt. As can be seen, the lower confidence interval intersects the horizontal axis around the year 2055, which is to say that 10 percent of the bootstraps runs indicated the stock went extinct by 2055.

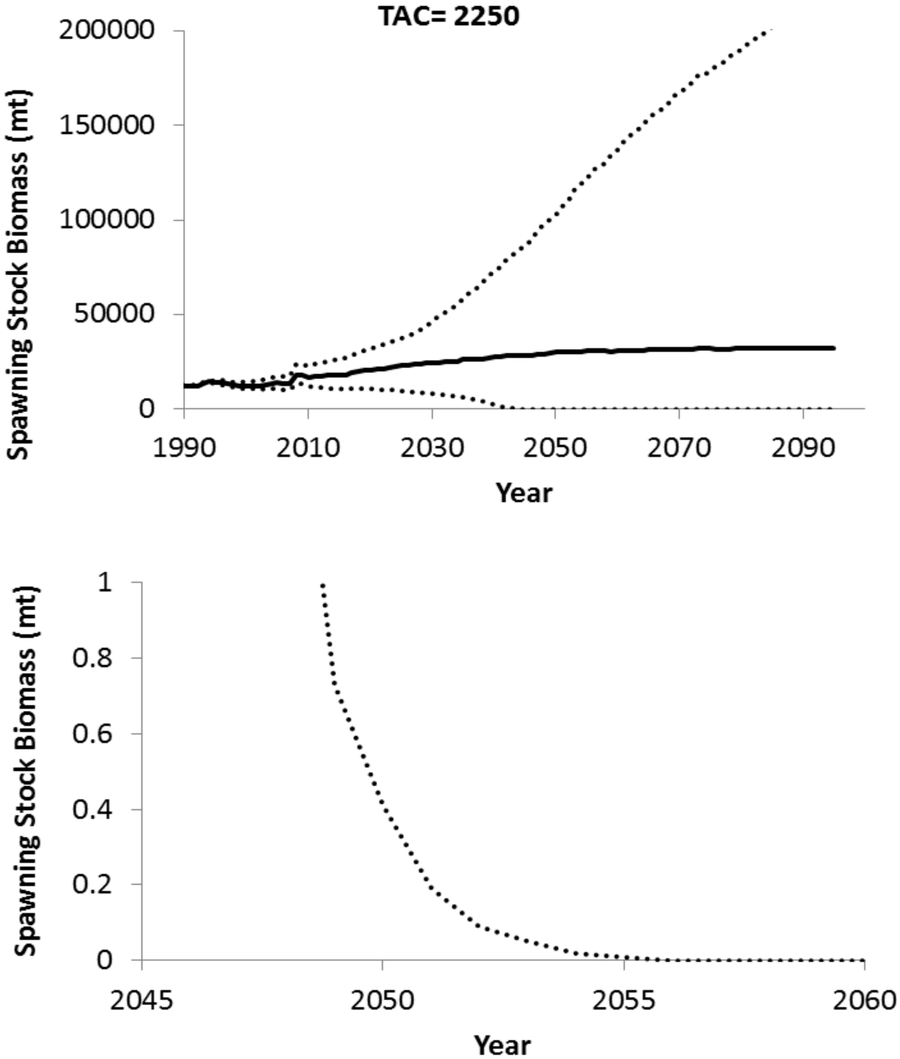


Figure 9.1. Summarized projections of the spawning biomass of the western Atlantic bluefin tuna DPS (combined high and low recruitment potential scenarios) assuming a constant TAC of 2,250 mt after 2010 as an example of extinction risk projections. The solid line represents the median of 2000 bootstrap runs and the dashed lines represent the upper and lower 80 percent confidence limits. The lower panel focuses in on the point where the lower confidence limit nears the horizontal axis (around 2055), i.e., the year where 10 percent of the bootstrap runs indicated the spawning biomass had dipped to the equivalent of two fish (about 2055). This can be compared with Table 9.2., which indicates that 8.4 percent of the runs led to extinction by 2050 and 11.7 percent by 2060.

Table 9.1. Forecasted probability that the eastern bluefin tuna DPS will go extinct by year and catch level (all 24 scenarios combined). Current management recommendations under ICCAT specify a TAC of 12,900 mt.

Catch	2010	2011	2020	2030	2040	2050	2060	2100
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12,900	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%
17,000	0.0%	0.0%	0.0%	0.0%	0.4%	0.9%	1.3%	1.5%
20,000	0.0%	0.0%	0.0%	0.1%	1.5%	3.0%	3.7%	4.2%
25,000	0.0%	0.0%	0.0%	0.5%	5.8%	9.9%	11.8%	13.2%
30,000	0.0%	0.0%	0.0%	1.7%	13.0%	21.5%	26.8%	34.1%
40,000	0.0%	0.0%	0.0%	6.9%	35.9%	48.2%	52.5%	57.2%
50,000	0.0%	0.0%	0.0%	15.0%	54.1%	64.3%	66.7%	67.7%
60,000	0.0%	0.0%	0.0%	24.1%	64.5%	70.8%	72.1%	72.8%
70,000	0.0%	0.0%	0.0%	31.9%	70.5%	78.2%	81.8%	85.0%

Table 9.2. Forecasted probability that the western bluefin tuna DPS will go extinct by year and catch level (assuming the high and low recruitment potential scenarios are equally plausible). Current management recommendations under ICCAT specify a TAC of 1,750 mt.

Catch (mt)	2010	2011	2020	2030	2040	2050	2060	2100
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,250	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
1,500	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.5%	0.7%
1,750	0.0%	0.0%	0.0%	0.1%	0.7%	1.4%	1.6%	2.3%
2,000	0.0%	0.0%	0.0%	0.5%	2.1%	3.4%	4.7%	5.4%
2,250	0.0%	0.0%	0.0%	0.8%	4.3%	8.4%	11.7%	14.8%
2,500	0.0%	0.0%	0.0%	2.3%	9.2%	19.0%	24.7%	29.5%
2,750	0.0%	0.0%	0.0%	4.2%	19.6%	33.8%	41.9%	54.0%
3,000	0.0%	0.0%	0.0%	6.5%	33.0%	51.0%	62.2%	77.9%
3,500	0.0%	0.0%	0.0%	17.8%	63.0%	83.7%	90.6%	95.4%
4,000	0.0%	0.0%	0.0%	35.4%	84.9%	96.4%	97.9%	98.9%
5,000	0.0%	0.0%	0.3%	73.1%	98.7%	99.7%	99.9%	99.9%

Owing to the large number of catch scenarios involved, the complete results of the projections are summarized by year and catch level in Tables 9.1-9.6. The level of extinction risk is only slightly higher when the threshold for extinction is set to 500 spawners rather than 2 spawners (under most constant catch scenarios, a population reduced to 500 spawners will normally be reduced below 2 spawners during the very next year). The probability of extinction is projected to be near zero for both DPSs over the five to ten year horizon normally examined by the SCRS, even for catch quotas that are much larger than allowed under the current ICCAT management regulations. Even after 20 years, the probability of extinction does not exceed 5 percent unless the level of sustained catch after 2010 is 3,000 mt or more for the western DPS and 40,000 mt or more for the eastern DPS (recall that the 2011 TACs for the western and eastern DPSs are 1,750 t and 12,900 t respectively, with the adjusted quota for the eastern fishery being below 11,599 t in 2011 and 2012). The probability of extinction increases substantially over the long term, but still remains quite low for the catch levels permitted under current management (about 2 percent for the western DPS and less than 1 percent for the eastern DPS).

The increased probability of extinction with time occurs for two reasons: (1) for higher quotas the population is gradually driven down to lower and lower levels, so a series of poor recruitments coupled with continued heavy fishing, will finally finish the population off, and (2) for low quotas the population is not 'expected' to decline, but more time means a greater chance to get a series of poor recruitment events, which translates to a greater probability of extinction (albeit still low). The conclusions are similar regardless of the recruitment scenario assumed (see Table 9.3).

The probability that the western DPS will go extinct by the year 2100 is projected to exceed 5 percent with sustained catches greater than 2,000 mt. Similarly, the probability that the eastern DPS will go extinct by the year 2100 is projected to exceed 5 percent with sustained catches greater than 20,000 mt. However, it is important to reiterate that these projections assume that the indicated catches commence immediately after 2011. This amounts to a tacit assumption that management will disregard existing rebuilding plans after next year. Under that assumption, the projections suggest that neither stock will have increased sufficiently in biomass to sustain substantially higher catch levels (> 2,000 mt in the west or 20,000 mt in the east) without also significantly increasing the risk of extinction. If, on the other hand, one were to assume existing levels of catch would be maintained through the rebuilding period (2018 for western bluefin and 2022 for eastern bluefin), then both stocks would have been projected to support much larger catches (close to the MSY) with a very low risk of extinction.

Table 9.3. Forecasted probability that the western bluefin tuna DPS will go extinct by year and catch level assuming either the (a) low recruitment potential or (b) high recruitment potential scenarios. Current management recommendations under ICCAT specify a TAC of 1,750 mt.

Low recruitment potential

Catch (mt)	**2010**	**2011**	**2020**	**2030**	**2040**	**2050**	**2060**	**2100**
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,250	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,500	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.4%
1,750	0.0%	0.0%	0.0%	0.0%	0.4%	0.8%	1.0%	1.0%
2,000	0.0%	0.0%	0.0%	0.4%	1.0%	1.8%	2.4%	2.8%
2,250	0.0%	0.0%	0.0%	0.6%	3.0%	4.8%	6.6%	7.4%
2,500	0.0%	0.0%	0.0%	1.4%	5.4%	12.0%	16.2%	21.6%
2,750	0.0%	0.0%	0.0%	3.4%	13.4%	26.6%	34.6%	53.6%
3,000	0.0%	0.0%	0.0%	5.0%	26.4%	45.4%	59.8%	82.8%
3,500	0.0%	0.0%	0.0%	14.0%	59.4%	85.2%	93.2%	99.6%
4,000	0.0%	0.0%	0.0%	30.4%	85.4%	98.0%	99.0%	100.0%
5,000	0.0%	0.0%	0.2%	71.0%	99.2%	100.0%	100.0%	100.0%

High recruitment potential

Catch (mt)	**2010**	**2011**	**2020**	**2030**	**2040**	**2050**	**2060**	**2100**
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,250	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
1,500	0.0%	0.0%	0.0%	0.0%	0.4%	0.6%	0.6%	1.0%
1,750	0.0%	0.0%	0.0%	0.2%	1.0%	2.0%	2.2%	3.6%
2,000	0.0%	0.0%	0.0%	0.6%	3.2%	5.0%	7.0%	8.0%
2,250	0.0%	0.0%	0.0%	1.0%	5.6%	12.0%	16.8%	22.2%
2,500	0.0%	0.0%	0.0%	3.2%	13.0%	26.0%	33.2%	37.4%
2,750	0.0%	0.0%	0.0%	5.0%	25.8%	41.0%	49.2%	54.4%
3,000	0.0%	0.0%	0.0%	8.0%	39.6%	56.6%	64.6%	73.0%
3,500	0.0%	0.0%	0.0%	21.6%	66.6%	82.2%	88.0%	91.2%
4,000	0.0%	0.0%	0.0%	40.4%	84.4%	94.8%	96.8%	97.8%
5,000	0.0%	0.0%	0.4%	75.2%	98.2%	99.4%	99.8%	99.8%

In summary, the projections suggest that the probability of extinction would be negligible within the generation time of both DPSs unless the catches were nearly doubled over those allowed by current regulations. The long-term projections indicate that current regulations are sufficient to avoid a significant probability of extinction, but suggest a significant risk of extinction if management abandons the existing rebuilding plans in favor of substantially higher catches. The analyses presented may be somewhat optimistic if there are significant density dependent dynamics that cause the effective extinction threshold to far exceed 500 mature fish (see Tables 9.4-9.6). On the other hand, they may also be regarded as pessimistic in the sense that they assume the current rebuilding plans will be abandoned in 2011 and that management will not respond to apparent decreases in abundance by reducing the quota. Finally, it is well to keep in mind the difficulties associated with quantifying the uncertainties in recruitment, fishery selectivity, growth, stock intermixing and other factors that affect the outcomes of the projections. For example, it is likely that the asymptotic recruitment level is a function of the carrying capacity or productivity of the system, which could be expected to vary with climatic factors (Ravier and Fromentin, 2004). Inasmuch as the level of uncertainty increases with time, the accuracy of predictions of the effects of any given event or management action necessarily deteriorates with the length of the forecast.

Table 9.4. Forecasted probability that fewer than 500 adult bluefin tuna will survive in the East Atlantic and Mediterranean Sea by year and catch level (all 24 scenarios combined). Current management recommendations under ICCAT specify a total allowable catch of 12,900 mt.

Catch (mt)	2010	2011	2020	2030	2040	2050	2060	2100
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
12,900	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.2%
17,000	0.0%	0.0%	0.0%	0.2%	0.7%	1.2%	1.4%	1.5%
20,000	0.0%	0.0%	0.0%	0.6%	2.6%	3.5%	3.9%	4.2%
25,000	0.0%	0.0%	0.0%	3.4%	8.7%	11.2%	12.3%	13.2%
30,000	0.0%	0.0%	0.0%	8.5%	19.0%	25.1%	28.8%	34.8%
40,000	0.0%	0.0%	0.2%	25.9%	45.9%	51.5%	54.0%	57.6%
50,000	0.0%	0.0%	0.9%	46.1%	63.0%	66.4%	67.2%	67.8%
60,000	0.0%	0.0%	2.1%	59.9%	70.6%	72.0%	72.5%	72.8%
70,000	0.0%	0.0%	3.7%	67.9%	77.7%	81.5%	83.1%	85.2%

Table 9.5. Forecasted probability that fewer than 500 adult bluefin tuna will survive in the West Atlantic by year and catch level (assuming the high and low recruitment scenarios are equally plausible). Current management recommendations under ICCAT specify a total allowable catch of 1,750 mt.

Catch (mt)	2010	2011	2020	2030	2040	2050	2060	2100
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,250	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
1,500	0.0%	0.0%	0.0%	0.0%	0.2%	0.5%	0.6%	0.7%
1,750	0.0%	0.0%	0.0%	0.3%	0.8%	1.5%	1.9%	2.3%
2,000	0.0%	0.0%	0.0%	1.0%	3.1%	3.9%	5.0%	5.4%
2,250	0.0%	0.0%	0.0%	2.9%	7.4%	10.5%	12.8%	14.9%
2,500	0.0%	0.0%	0.3%	5.9%	16.7%	23.0%	26.2%	29.8%
2,750	0.0%	0.0%	0.5%	11.8%	30.3%	39.4%	45.2%	55.1%
3,000	0.0%	0.0%	1.1%	21.9%	46.2%	58.9%	67.4%	79.3%
3,500	0.0%	0.0%	3.1%	49.8%	78.6%	88.8%	93.4%	95.4%
4,000	0.0%	0.0%	8.7%	76.7%	95.9%	97.6%	98.6%	98.9%
5,000	0.0%	0.0%	35.4%	97.7%	99.7%	99.9%	99.9%	99.9%

Table 9.6. Forecasted probability that fewer than 500 adult bluefin tuna will survive in the West Atlantic by year and catch level assuming either the (a) low recruitment or (b) high recruitment scenarios. Current management recommendations under ICCAT specify a total allowable catch of 1,750 mt.

Low recruitment potential

Catch (mt)	2010	2011	2020	2030	2040	2050	2060	2100
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,250	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,500	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.4%
1,750	0.0%	0.0%	0.0%	0.2%	0.4%	1.0%	1.0%	1.0%
2,000	0.0%	0.0%	0.0%	0.8%	1.8%	2.2%	2.8%	2.8%
2,250	0.0%	0.0%	0.0%	1.8%	4.6%	5.8%	6.6%	7.4%
2,500	0.0%	0.0%	0.2%	4.2%	10.0%	15.4%	17.2%	22.2%
2,750	0.0%	0.0%	0.4%	8.2%	23.2%	32.2%	39.0%	55.8%
3,000	0.0%	0.0%	0.8%	16.2%	39.6%	55.2%	66.6%	85.6%
3,500	0.0%	0.0%	2.2%	44.0%	77.4%	91.8%	97.0%	99.6%
4,000	0.0%	0.0%	7.0%	75.0%	97.4%	99.0%	99.6%	100.0%
5,000	0.0%	0.0%	30.0%	98.4%	100.0%	100.0%	100.0%	100.0%

High recruitment potential

Catch (mt)	2010	2011	2020	2030	2040	2050	2060	2100
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1,250	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
1,500	0.0%	0.0%	0.0%	0.0%	0.4%	0.6%	0.8%	1.0%
1,750	0.0%	0.0%	0.0%	0.4%	1.2%	2.0%	2.8%	3.6%
2,000	0.0%	0.0%	0.0%	1.2%	4.4%	5.6%	7.2%	8.0%
2,250	0.0%	0.0%	0.0%	4.0%	10.2%	15.2%	19.0%	22.4%
2,500	0.0%	0.0%	0.4%	7.6%	23.4%	30.6%	35.2%	37.4%
2,750	0.0%	0.0%	0.6%	15.4%	37.4%	46.6%	51.4%	54.4%
3,000	0.0%	0.0%	1.4%	27.6%	52.8%	62.6%	68.2%	73.0%
3,500	0.0%	0.0%	4.0%	55.6%	79.8%	85.8%	89.8%	91.2%
4,000	0.0%	0.0%	10.4%	78.4%	94.4%	96.2%	97.6%	97.8%
5,000	0.0%	0.0%	40.8%	97.0%	99.4%	99.8%	99.8%	99.8%

One important source of uncertainty not considered in the above projections is the nature of intermixing between the eastern and western DPSs. Two-stock virtual population analyses used by SCRS (2008) to estimate the level of mixing from stock composition (otolith microcontituent) data produced estimates of spawning biomass that were similar to the levels estimated without mixing (Figure 9.2). However, similar models that estimated mixing from tagging data produced estimates of spawning biomass that were generally higher than the models without mixing, particularly for recent years (Figure 9.2). If spawning biomass is indeed higher than estimated by the base (no-mixing) models, then the short-term extinction risk may be lower than suggested in the analyses above by virtue of the fact that any given catch level will amount to a lower percentage of the adult population. This is especially true for the western DPS where the effect of estimating mixing is most profound as discussed previously. The long-term implications for extinction risk are less clear as they would involve changes in the estimated productivity of the two stocks, which have not yet been evaluated. It should be emphasized, however, that ICCAT (2008) regarded their analyses of mixing as not reliable enough to be used as the basis for management advice because both the tagging and stock composition data were regarded as incomplete in the sense that they did not represent random samples of the overall Atlantic bluefin tuna population.

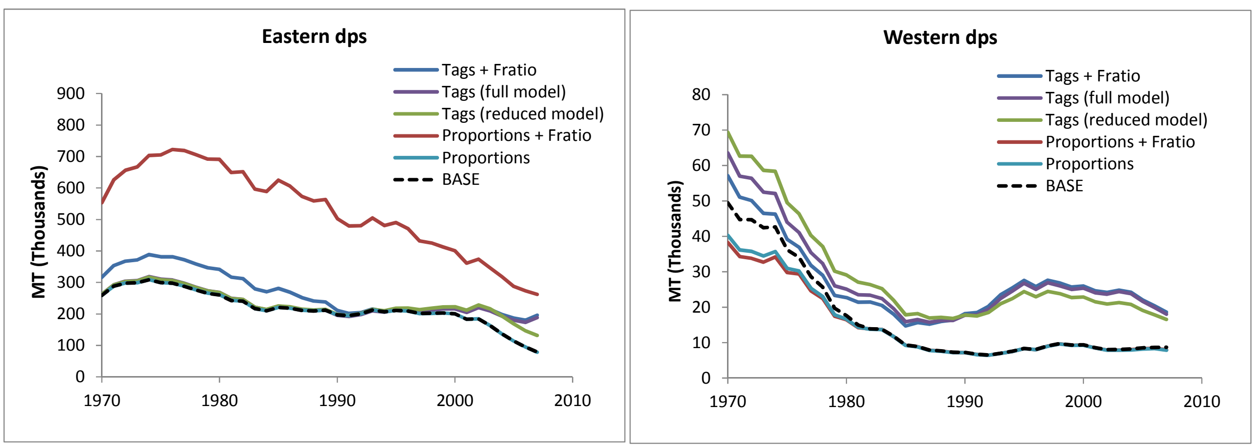


Figure 9.2. Spawning biomass estimates (tons) for the eastern (left) and western (right) populations of bluefin tuna for the five scenarios compared to the corresponding base cases without mixing (dashed line).

10. RESEARCH NEEDS

Currently, NMFS is developing an integrated research plan from Atlantic Highly Migratory Species (including Atlantic bluefin tuna). Among some of the research needs identified in the plan are the development of a systematic sampling program for the collection of biological samples across of all U.S. fisheries and areas. To reduce uncertainty in the results of stock assessments and, therefore, to improve management for this species there is also need to further improve our knowledge on areas such as stock structure, age and growth, maturity, and habitat utilization and feeding ecology. A detailed explanation of the different of research needs for Atlantic bluefin can be obtained from the mentioned plan.

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