Chub Mackerel Fishery Information Document

May 2018

This document provides a brief overview of the biology, stock condition, management system, and recent fishery information for Atlantic chub mackerel (*Scomber colias*) in U.S. waters.

1. Biology and Life History

Atlantic chub mackerel are a schooling pelagic species that are found on the continental shelf to depths of about 250-300 meters throughout much of the western and eastern Atlantic Ocean. In the western Atlantic, their range spans from Nova Scotia (where they are rare) through Argentina, including the Gulf of Mexico (Collette and Nauen 1983, Collette 2002).

Chub mackerel can be found throughout U.S. Atlantic waters (Collette and Nauen 1983, Collette 2002). However, they are not commonly encountered in the Northeast Fisheries Science Center's (NEFSC's) bottom trawl survey. Most chub mackerel catches in this survey occur south of the Hudson Shelf Valley in warm water temperatures (i.e. generally higher than about 20°C or about 68°F; personal communication, John Manderson, Michele Traver, and Chris Tholke). State trawl surveys and recreational catch data suggest that chub mackerel can also be found in inshore waters.

The stock structure of chub mackerel in the western Atlantic Ocean has not been well studied. Studies from other regions suggest, based on differences in morphology, spawning seasons, and/or sizes at maturity, that sub-stocks may exist (Chen et al. 2009, Weber and McClatchie 2012, Cerna and Plaza 2014, Yasuda et al. 2014). However, chub mackerel have been found to be genetically uniform across wide areas (Scoles et al. 1998, Zardoya et al. 2004). For example, Scoles et al. (1998) found no significant genetic differentiation between chub mackerel from the eastern Mediterranean Sea, the Ivory Coast, and South Africa; however, they did find significant genetic differentiation between chub mackerel from the western and eastern Atlantic.

Migratory patterns in the western North Atlantic are also not well understood. In the northern hemisphere, chub mackerel migrate between northern areas in warmer months and southern areas in cooler months (Collette and Nauen 1983). Adults prefer temperatures of 15-20°C (about 60-70°F; Collette and Nauen 1983, Perotta et al. 2001). Some studies suggest that juveniles tend to be found closer inshore than adults (Castro 1993).

Atlantic chub mackerel grow rapidly during the first year of life (Krivospitchenko 1979, Lorenzo et al. 1995, Lorenzo and Pajuelo 1996, Hernández and Ortega 2000, Kiparissis et al. 2000, Perrota et al. 2005, Velasco et al. 2011, Daley 2018). For example, Lorenzo and Pajuleo (1996) found that chub mackerel attain 40% of their maximum length in the first year of life. Females and males do not exhibit differences in growth rates (Lorenzo and Pajuelo 1996, Vasconcelos et al. 2011, Velasco et al. 2011) or age at maturity (Lorenzo and Pajuelo 1996). Daley (2018) suggested that chub mackerel in the northwest Atlantic may grow faster and reach smaller

average lengths at age compared to other regions; however, these differences may be partly due to the influence of fishery selectivity on the samples collected.

Chub mackerel have been documented to reach at least age 13 (Carvalho et al. 2002); however, in most regions, ages 0-5 or younger are most commonly observed in commercial fishery and survey catches (e.g. Krivospitchenko 1979, Perotta 1992, Lorenzo and Pajuelo 1996, Martins et al. 2013, Daley 2018). Daley (2018) sampled chub mackerel from commercial fishery and survey catches off the northeast U.S. in 2016 and 2017. Estimated ages ranged from 0 to 7 years, with ages 2 – 4 being the most common.

Atlantic chub mackerel spawn in several batches (Collette and Nauen 1983). They typically spawn in water temperatures of 15-20°C (about 60-70°F). Berrien (1978) found evidence of chub mackerel spawning from North Carolina to Florida during January - July. Richardson et al. (2010) documented Atlantic chub mackerel larvae in the straits of Florida in nearshore waters during January – May. Daley (2018) suggested that spawning occurs in the winter in the Gulf of Mexico based on larval and juvenile concentrations, which were highest during January, February, March, and April. The closely related Pacific chub mackerel (*Scomber japonicus*) is believed to spawn several times throughout the year whenever oceanographic conditions are favorable and sufficient food is available (Crone and Hill 2015). The same may be true for Atlantic chub mackerel.

Daley (2018) performed a histological analysis of chub mackerel caught in commercial fisheries off the mid-Atlantic and found that chub mackerel reach maturity around age two.

2. Ecosystem Considerations

Chub mackerel have a unique ecosystem role as both a forage species and a predator of other forage species (Okey et al. 2014).

No studies of the diet composition of chub mackerel off the U.S. east coast have been found to date. Studies from other regions suggest that they are opportunistic predators with a seasonally-variable diet of small crustaceans (especially copepods), small fish, and squid (Habashi and Wojeiechowski 1973, Collette and Nauen 1983, Castro and Del Pino 1995, Server et al. 2006, Bachiller and Irigoien 2015). Adults tend to consume larger prey and more fish prey than juveniles (Castro 1993).

It can be difficult to visually distinguish partially-digested chub mackerel from other small scombrids such as Atlantic mackerel (*Scomber scomber*), bullet mackerel (*Auxis rochei*), and frigate mackerel (*Auxis thazard*; Paine et al. 2007; John Graves, personal communication; Steve Poland, personal communication; Michelle Staudinger, personal communication). For this reason, there are limited quantitative estimates of the contribution of chub mackerel to the diets of any predator species. Manooch et al. (1984) found that chub mackerel made up 0.2% (by frequency of occurrence) of the diets of dolphinfish sampled off North Carolina through Texas. They have also been documented as important prey for blue marlin at certain times of year off Portugal (Veiga et al. 2011) and Cabo San Lucas (Abitia-Cardenas et al. 1999).

Many diet studies quantify scombrids at the family or genus level, rather than the species level. The family Scombridae, which includes mackerels and tunas, contributes to the diets of many

predators, including common dolphins, pilot whales, yellowfin tuna, wahoo, and others (e.g. Manooch and Hogarth 1983, Manooch and Mason 1983, Smith et al. 2015, Duffy et al. 2017).

In 2018, the Council funded a study to assess the contribution of chub mackerel to the diets of white and blue marlins and bigeye and yellowfin tunas. These predators were identified as priority species by stakeholders. Sampling will occur in commercial and recreational fisheries from New Jersey through North Carolina during 2018 and 2019. This study will use a combination of traditional stomach content analysis, genetic barcoding techniques, and stable isotope analysis.

3. Status of the Stock

The stock status of Atlantic chub mackerel in the western Atlantic Ocean is unknown as there have been no quantitative assessments of this species in this region.

Large fluctuations in Atlantic chub mackerel abundances have been reported around the world, including in the mid-Atlantic and New England (Goode 1884, Hernández and Ortega 2000). These fluctuations may be partly the result of environmental influences such as temperature and upwelling strength on recruitment (Hernández and Ortega 2000). Given that chub mackerel are a fully pelagic species, ocean processes likely influence their availability in any given area, as well as their recruitment.

The stock assessment for the closely-related Pacific chub mackerel suggests that periods of high recruitment success occur "no more frequently than at least every few decades" (Crone and Hill 2015). Several studies suggest that environmental factors, especially sea surface temperature, influence recruitment and abundance of Pacific mackerel (e.g. Sinclair et al. 1985, Avalos-García et al. 2003, Yatsu et al. 2005, Chen et al. 2009, Martins et al. 2013, Yasuda et al. 2014, Crone and Hill 2015, Hilborn et al. 2017).

4. Fishery Characteristics

Commercial Fisheries

Commercial catch and landings data for the northeast (mid-Atlantic and New England) and the southeast (South Atlantic and Gulf of Mexico) were extracted from separate datasets and are summarized separately. Northeast landings and price data for 2017 are preliminary. Southeast landings and price data for 2017 were not available at the time of writing this document.

Mid-Atlantic and New England Commercial Fisheries

Commercial chub mackerel landings from the mid-Atlantic and New England show a notable increase starting in 2013 (Table 1, Figure 1). According to dealer data, during 1998-2012 commercial landings in the mid-Atlantic and New England averaged 62,293 pounds per year with an average ex-vessel price of $0.29 per pound (adjusted to 2016 dollars). Landings reached a peak of 5.25 million pounds in 2013. Average landings from 2013 through 2017 were about 1.84 million pounds, with an average ex-vessel price of $0.38 per pound (adjusted to 2016 dollars; Table 1).

This increase in landings is the result of a small number of vessels targeting chub mackerel in some years. According to participants in this fishery, there was little market demand for chub mackerel from this region until recently. This changed due to the efforts of certain commercial fish dealers and changes in other fisheries around the globe.

A small number of bottom trawl vessels which also participate in the *Illex* squid fishery have been responsible for the vast majority of chub mackerel landings since 2013. Some fishermen describe chub mackerel as a "bailout" species which they harvest when they are not able to harvest *Illex* squid. Chub mackerel tend to be harvested in the same areas and times of year when *Illex* squid are also harvested; however, fishermen say they typically will not harvest both species at the same time because the quality of the chub mackerel suffers when the two are stored together. Commercial chub mackerel landings from the mid-Atlantic and New England show an inverse correlation with *Illex* squid landings in recent years (Figure 2).

According to public comments, a small number of vessels on the east coast are large and fast enough to harvest this fast-swimming, low-value species in profitable quantities. Landings data seem to support this. Public comments suggest that most of the chub mackerel landed in this region are processed for use as human food and lesser amounts are used as bait in other fisheries.

During 1998-2017, as many as 29 federally-permitted vessels per year landed chub mackerel in the mid-Atlantic and New England.[1] As many as 9 federally-permitted dealers per year in 4 northeast states purchased these landings. However, a small subset of these vessels and dealers accounted for the majority of landings.

According to data from the Northeast Fisheries Observer Program (NEFOP), during 1997-2016, bottom otter trawls accounted for 93% of observed chub mackerel catch, midwater trawls accounted for 7% of observed catch, and all other gear types accounted for less than 1% of observed catch.

According to northeast dealer data, northeast vessel trip reports (VTRs), NEFOP, and data from vessels participating in the NEFSC's study fleet, nearly all chub mackerel landings (>95%) over the past 20 years occurred during June-October. The highest proportion of landings occurred in September (35-65%, depending on the dataset), followed by August (16-17%, depending on the dataset).

According to NEFOP data, during 1998-2017, about 90% of the observed chub mackerel catch was kept and about 10% was discarded. VTR data over the same time period show that 97% of the catch was kept and 3% was discarded.

According to VTR data, over 90% of the landings originated from statistical areas south of New York. Much of these landings came from statistical areas which overlap with the shelf break (Figure 5). About 80% of the landings reported through VTRs, the study fleet, and NEFOP resulted from catch at about 50-100 fathoms depth.

[1] The number of vessels without federal permits which landed chub mackerel is unknown.

South Atlantic and Gulf of Mexico Commercial Fisheries

Chub mackerel landings in the South Atlantic and Gulf of Mexico have not shown the same increasing trend as mid-Atlantic and New England landings (Figure 3). Nearly all dealer-reported chub mackerel landings from this region during 1997-2016 occurred in Florida. At least 90% of the landings in each year were reported by Florida Gulf coast dealers. Landings averaged 87,505 pounds per year with an average ex-vessel price of $0.34 per pound (adjusted to 2016 dollars; Table 2, Figure 2).

According to commercial landings data, about 89% of commercial chub mackerel landings in the Gulf of Mexico during 1997-2016 came from bottom trawls or unspecified trawls and about 8% came from purse seines. All other gear types combined accounted for less than 3% of landings from the Gulf of Mexico. Landings from the South Atlantic were much lower (generally accounting for 10% or less of total annual landings from the South Atlantic and Gulf of Mexico) and were harvested with a greater variety of gear types, including purse seines, hand lines, cast nets, gill nets, and other gears, none of which accounted for more than about one third of the total South Atlantic landings.

Southeast landings were not as seasonally concentrated as northeast landings. About 72% of southeast landings during 1997-2016 occurred during June-October. The highest proportion of southeast landings occurred during August (20%), followed by June (19%).

Southeast dealer data are not compiled in such a way that the number of vessels can be determined. As previously stated, nearly all commercial southeast landings during 1997-2016 occurred in Florida. As many as 7 Florida dealers per year (with an average of 5) reported chub mackerel landings per year.

Fewer details on the locations of commercial chub mackerel catches are available from the South Atlantic and Gulf of Mexico, compared to the mid-Atlantic and New England. Southeast logbook data include information on effort and areas fished; however, they contain very few records of chub mackerel representing only 11 trips since 2000. It is unlikely that informative conclusions could be drawn from these data due to the small number of records.

Commercial Fisheries Bycatch

During development of the Unmanaged Forage Omnibus Amendment (MAFMC 2017a), individuals familiar with the recent targeted commercial chub mackerel fishery said vessels have little incentive to land fewer than about 40,000 pounds of chub mackerel at a time. Forty thousand pounds of chub mackerel can fill a bait truck. Given the low value of chub mackerel (Table 1), and the limited market for chub mackerel in this region, fishermen may have a hard time selling fewer than 40,000 pounds at a time. Thus, for the purposes of examining bycatch in the mid-Atlantic and New England, targeted chub mackerel trips were defined as trips where at least 40,000 pounds of chub mackerel were landed. On such trips, the other species most commonly caught (by weight) were *Illex* squid, longfin squid, butterfish, and round herring, according to NEFOP data for 1998-2017.

Bycatch in South Atlantic and Gulf of Mexico fisheries has not yet been examined; however, based on the information presented above, chub mackerel do not appear to be targeted in these regions to the same extent as in the mid-Atlantic and New England in recent years.

Table 1: Northeast dealer-reported landings and average price per pound of chub mackerel and *Illex* squid, 1998-2017. Data from some years are combined to protect confidential information representing fewer than three vessels and/or dealers. Prices are adjusted to 2016 dollars using the gross domestic product deflator index. Landings and price data for 2017 are preliminary. 2017 average prices are unadjusted.

Northeast region (mid-Atlantic and New England)				
Year	**Chub mackerel landings (lb)**	**Average chub mackerel price per pound**	***Illex* squid landings (lb)**	**Average *Illex* squid price per pound**
1998	40,219	$0.13	51,958,751	$0.13
1999	6,443	$0.26	16,289,021	$0.17
2000	16,246	$0.24	19,866,592	$0.14
2001	4,384	$0.74	8,837,567	$0.16
2002	471	$0.33	6,061,729	$0.18
2003	488,316	$0.04	14,090,521	$0.22
2004	126	$0.41	57,534,687	$0.23
2005	0	--	26,526,087	$0.26
2006	0	--	30,740,382	$0.22
2007-2009	21,039	$0.26	95,549,924	$0.20
2010-2011	192,301	$0.16	76,326,551	$0.37
2012	164,846	$0.36	25,813,134	$0.39
2013	5,249,567	$0.19	8,359,998	$0.27
2014	1,230,311	$0.26	19,327,085	$0.30
2015	2,108,337	$0.23	5,339,292	$0.29
2016	610,783	$0.17	14,736,843	$0.49
2017	2,202	$1.20	22,164,447	$0.45
1998-2017 Average	506,780	$0.25	26,349,909	$0.22

Table 2: Southeast dealer-reported landings and average price per pound of chub mackerel, 1997-2016. Data from the Gulf of Mexico and South Atlantic, and for some years, are combined to protect confidential information representing fewer than three dealers. Prices are adjusted to 2016 dollars using the gross domestic product deflator index.

Southeast region (South Atlantic and Gulf of Mexico)		
Year	**Chub mackerel landings (lb)**	**Average chub mackerel price per pound**
1997	113,621	$0.69
1998	93,669	$0.20
1999	67,665	$0.37
2000	46,907	$0.20
2001	268,110	$0.66
2002	172,914	$0.35
2003	204,382	$0.36
2004	170,807	$0.36
2005	30,069	$0.37
2006	13,393	$0.17
2007	18,244	$0.24
2008	41,841	$0.36
2009	2,767	$0.26
2010	82,424	$0.14
2011	178,006	$0.19
2012-2013	193,976	$0.21
2014	117,686	$0.23
2015	98,503	$0.24
2016	57,499	$0.20
1997-2016 average	103,815	$0.31

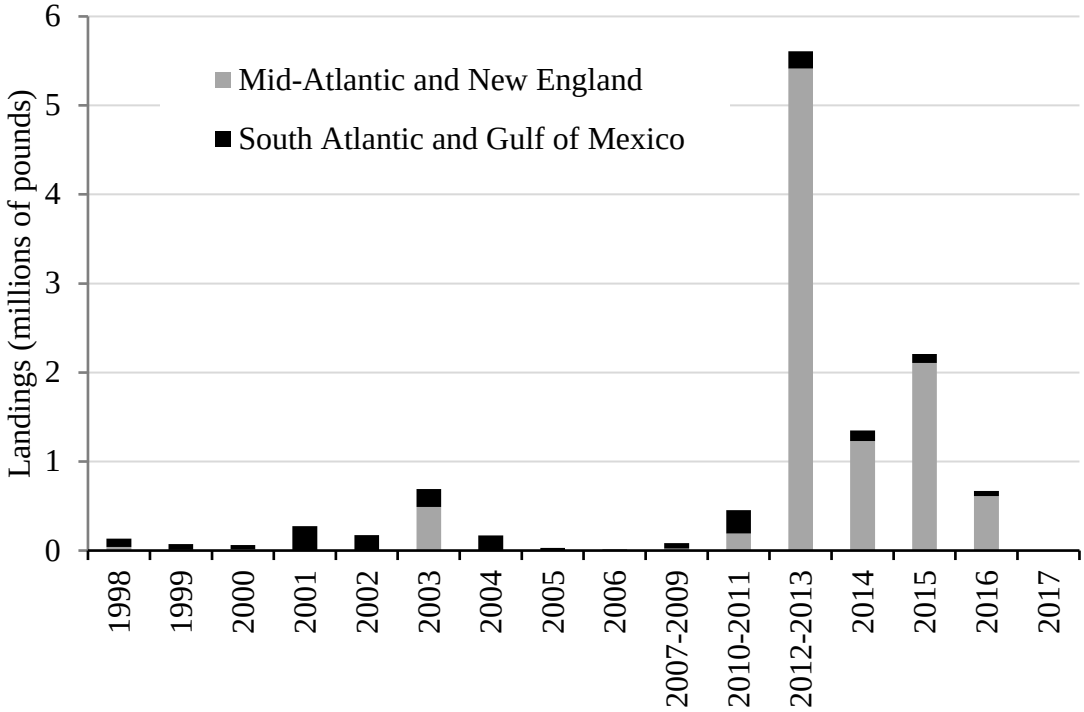

Figure 1: Dealer-reported chub mackerel landings, 1998-2017. Data are combined into two regions and some years are combined to protect confidential information representing fewer than three vessels and/or dealers. Mid-Atlantic and New England data for 2017 are preliminary. South Atlantic and Gulf of Mexico landings data for 2017 are not currently available.

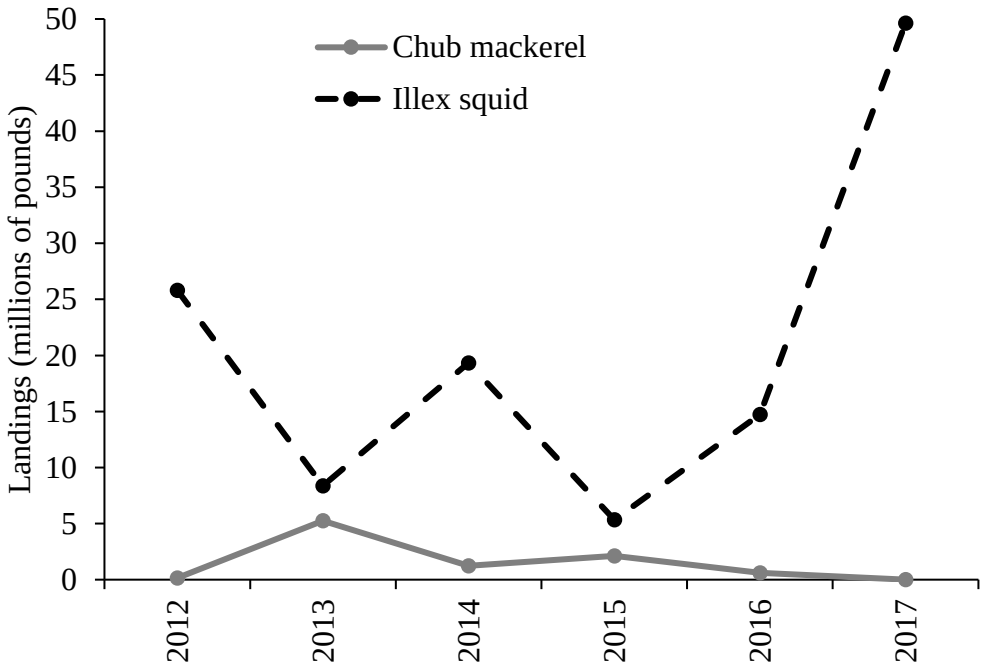

Figure 2: Landings of chub mackerel and *Illex* squid, 2012 - 2017, as shown in northeast commercial dealer data. 2017 landings are preliminary.

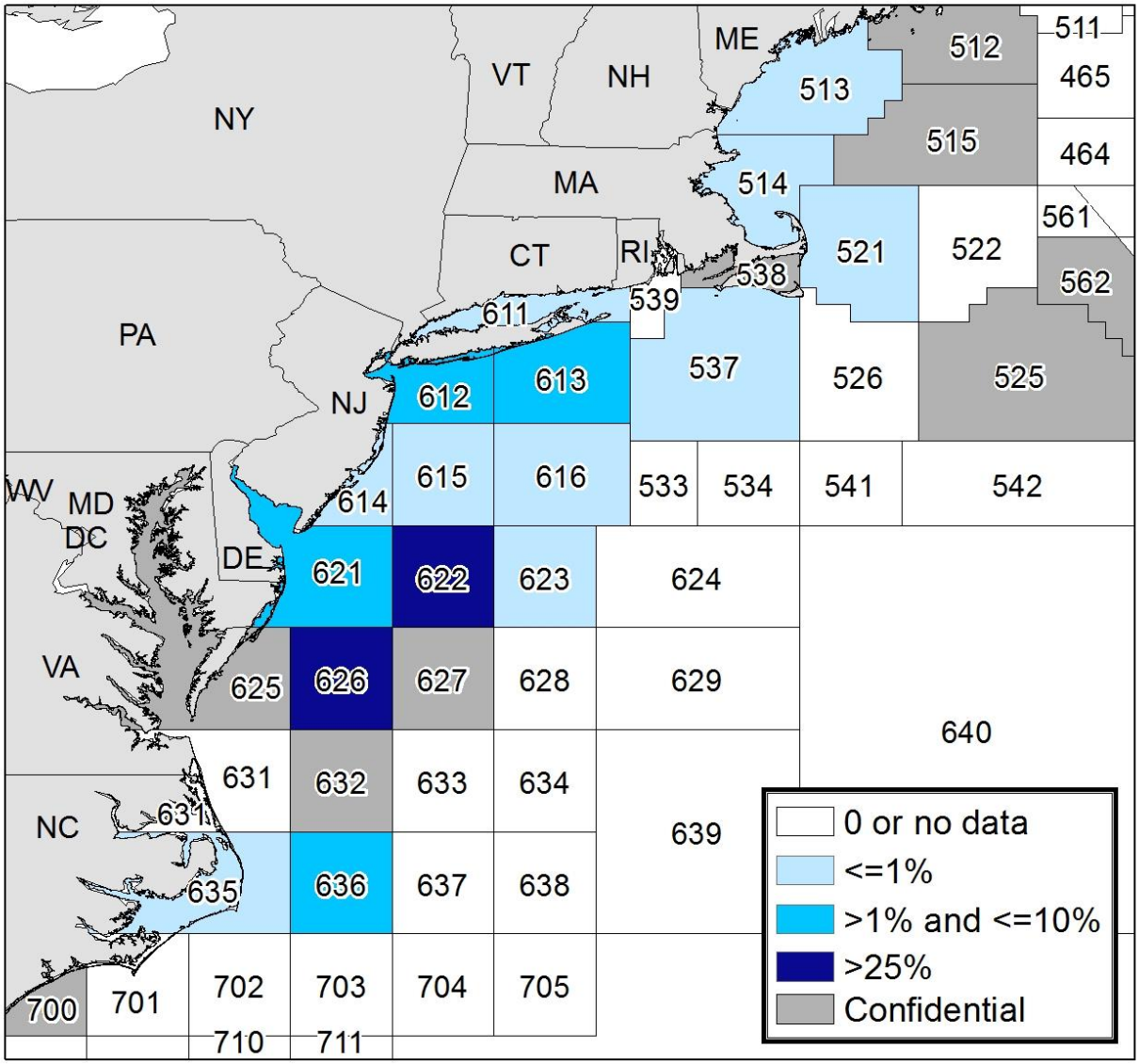

Figure 3: Percent of commercial chub mackerel landings (by weight) by statistical area, 1998-2017 as shown in northeast Vessel Trip Report data. Data associated with fewer than three vessels and/or dealers is confidential. Confidential landings collectively accounted for less than 10% of the total.

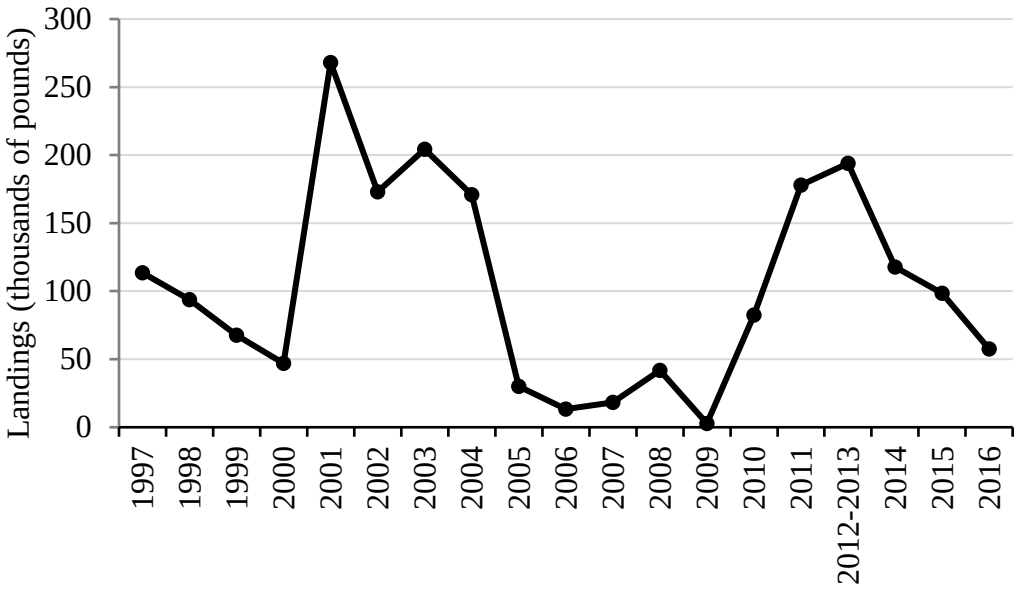

Figure 4: Dealer-reported chub mackerel landings from the Gulf of Mexico and South Atlantic, 1997-2016. Data for both regions and for some years are combined to protect confidential information representing fewer than three dealers.

Recreational Fisheries

Data on recreational chub mackerel catch, landings, and effort are available from the Marine Recreational Information Program (MRIP) and the southeast region headboat survey. Both data sets show sporadic catches. MRIP data for the entire Atlantic coast and the Gulf of Mexico show an average of 10,620 pounds of estimated recreational chub mackerel landings per year during 1998-2017. In about half of those years, no recreational landings were estimated (Table 3, Figure 5). According to self-reported angler data, about 25% of these landings were caught in state waters, with the remaining 75% in federal waters.

Chub mackerel may be rarely encountered on recreational trips. There may also be instances of misreporting chub mackerel as Atlantic mackerel, especially in datasets that rely on self-reported angler data, such as MRIP. Recreational chub mackerel data are should be considered uncertain and imprecise.

The Mid-Atlantic Fishery Management Council has heard anecdotal descriptions of recreational chub mackerel harvest, including reports of catch on for-hire vessels out of New York and New Jersey. There have also been reports of chub mackerel harvest for use as live bait on recreational trips out of Maryland and Virginia for species like white and blue marlin, sailfish, spearfish, yellowfin tuna, bigeye tuna, and wahoo. According to public comments, this live bait fishery occurs on the edges of certain offshore canyons, especially Norfolk Canyon, where chub mackerel and their predators are concentrated in the late summer and early fall (see MAFMC 2016 and MAFMC 2017b for more details).

Table 3: MRIP estimated recreational landings and discards of chub mackerel from New England, the Mid-Atlantic, and Gulf of Mexico combined, 1998-2017. No landings or discards from the South Atlantic was estimated during this time period.

Year	**Estimated landings** (pounds)	**Estimated landings** (numbers of fish)	**Estimated discards** (numbers of fish)	**Percent of catch discarded**
1998	363	742	0	0%
1999	0	0	0	0%
2000	2,773	1,797	0	0%
2001	0	83,339	28,722	26%
2002	43,676	246,302	18,354	7%
2003	0	0	914	100%
2004	96,344	85,986	786	1%
2005	2,499	2,180	0	0%
2006	6,745	5,883	0	0%
2007	0	5,541	0	0%
2008	0	0	0	0%
2009	0	0	0	0%
2010	0	5,269	771	13%
2011	17	55,016	0	0%
2012	0	481	4,659	91%
2013	0	0	0	0%
2014	48,215	84,157	10,382	11%
2015	0	0	0	0%
2016	1,660	21,810	367	2%
2017	10,103	31,587	2,610	8%
1998-2017 average	10,620	31,505	3,378	13%

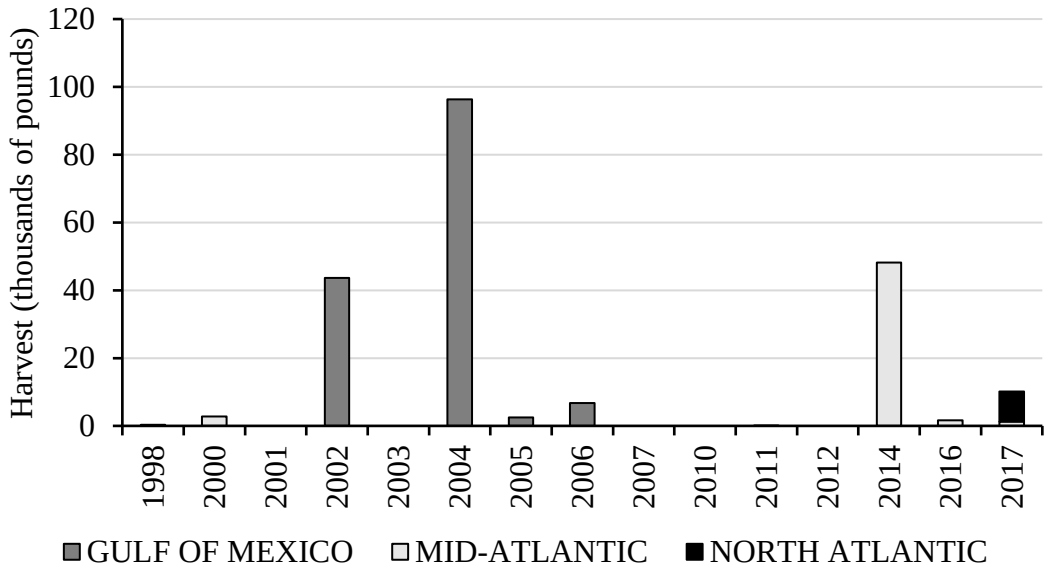

Figure 5: MRIP-estimated recreational landings of chub mackerel by region, 1998-2017. No harvest from the South Atlantic was estimated during this time period.

5. Management System

The Mid-Atlantic Fishery Management Council developed the first management measures for Atlantic chub mackerel in U.S. waters through the Unmanaged Forage Omnibus Amendment (MAMFC 2017a). These measures have been in effect since September 2017 and include the following:

- A 2.86 million pound annual landings limit for all chub mackerel landed by commercial fishermen in the mid-Atlantic and New England
- A 40,000 pound possession limit which applies only to commercial fishermen in the mid-Atlantic after the annual landings limit is reached
- A requirement for all commercial vessels which possess chub mackerel in mid-Atlantic federal waters to have a commercial fishing permit from the Greater Atlantic Regional Fisheries Office

The 2.86 million-pound annual landings limit is equivalent to average annual landings in the mid-Atlantic and New England from 2013 through 2015, according to commercial fish dealer reports.

Forty thousand pounds was chosen as the possession limit to be enforced after the annual landings limit is reached because, as described above, it is approximately the amount of chub mackerel needed to fill a bait truck. Given the low value of chub mackerel (Table 1), vessels may not target chub mackerel when restricted to a 40,000-pound possession limit; however, they would have an incentive to land chub mackerel caught incidentally. A 40,000 pound possession limit could, therefore, discourage discards.

All the chub mackerel management measures listed above will expire after December 31, 2020. The Council intended for these measures to be replaced by longer-term management measures which will be developed through an amendment to add chub mackerel as a stock in the Mackerel, Squid, and Butterfish Fishery Management Plan. If new management measures are not implemented or additional action is not taken by December 31, 2020, then Atlantic chub mackerel will be unmanaged in U.S. waters starting January 1, 2021.

6. References

Abitia-Cardenas, L. A., F. Galvan-Magaña, F. J. Gutierrez-Sanches, J. Rodriquez-Romero, B. Aguilar-Palomino, and A. Moehl-Hitz. 1999. Diet of blue marlin *Makaira mazara* off the coast of Cabo San Lucas, Baja California Sur, Mexico. *Fisheries Research.* 44(1999):95-100.

Avalos-García, C., L. Sánchez-Velasco, and B. Shirasago. 2003. Larval fish assemblages in the Gulf of California and their relation to hydrographic variability (autumn 1997 – summer 1998). *Bulletin of Marine Science*. 72(1):63-76.

Bachiller, E. and X. Irigoien. 2015. Trophodynamics and diet overlap of small pelagic fish species in the Bay of Biscay. *Marine Ecology Progress Series.* 534:179-198.

Berrien, P. L. 1978. Eggs and larvae of *Scomber scombrus* and *Scomber japonicus* in continental shelf waters between Massachusetts and Florida. *Fishery Bulletin.* 76(1):95-115.

Carvalho, N., R. G. Perrotta, and E. Isidro. 2002. Age, growth and maturity in the chub mackerel (*Scomber japonicus* Houttuyn, 1782) from the Azores. *Arquipélago Life and Marine Sciences.* 19A: 93-99.

Castro, J. J. 1993. Feeding ecology of chub mackerel *Scomber japonicus* in the Canary Islands area. *South African Journal of Marine Science.* 13(1): 323-328.

Castro, J. J. and A. S. Del Pino. 1995. Feeding preferences of *Scomber japonicus* in the Canary Islands area. *Scientia Marina*. 59(3-4):352-333.

Cerna, F. and G. Plaza. 2014. Life history parameters of chub mackerel (*Scomber japonicus*) from two areas off Chile. *Bulletin of Marine Science*. 90(3):833-848.

Chen, X., G. Li, B. Feng, and S. Tian. 2009. Habitat suitability index of chub mackerel (*Scomber japonicus*) fromJuly to September in the East China Sea. *Journal of Oceanography*. 65: 93-102.

Collette, B. B. and C. E. Nauen. 1983. FAO species catalogue. Vol. 2 Scombrids of the word: An annotated and illustrated catalogue of tunas, mackerels, bonitos, and related species known to date. Available at: http://www.fao.org/docrep/009/ac478e/ac478e00.htm

Collette, B. B. 2002. Mackerels, family Scombridae. In: Collette, B. B. and G. Klein-MacPhee, editors. *Bigelow and Schroeder's Fishes of the Gulf of Maine.* Third edition. Smithsonian Institution Press.

Crone, P. R., and K. T. Hill. 2015. Pacific mackerel (*Scomber japonicus*) stock assessment for USA management in the 2015-16 fishing year. Report to Pacific Fishery Management Council. NOAA Fisheries Southwest Fisheries Science Center. La Jolla, CA. 135 pp.

Daley, T. 2018. Growth and reproduction of Atlantic chub mackerel (*Scomber colias*) in the Northwest Atlantic. Master's thesis. University of Southern Mississippi.

Duffy, L. M., P. M. Kuhnert, H. R. Pethybridge, J. W. Young, R. J. Olson, J. M. Logan, N. Goñi, E. Romanov, V. Allain, M. D. Staudinger, M. Abecassis, C. A. Choy, A. J. Hobday, M. Simier, F. Galván-Magaña, M. Potier, F Ménard. 2017. Global trophic ecology of yellowfin, bigeye, and albacore tunas: Understanding predation on micronekton communities at ocean-basin scales. *Deep-Sea Research II.* 140(2014):55-73.

Goode, G. B. 1884. The food fishes of the U.S. part 3: natural history of useful aquatic animals. In: *The Fisheries and Fishery Industries of the United States.* U.S. Government Printing Office. Washington, D.C. Available at: http://celebrating200years.noaa.gov/rarebooks/fisheries/welcome.html

Habashi, B. and J. Wojciechowski. 1973. Observations on the biology of *Scomber japonicus* off northwest Africa. *ICES document* C.M. 1973/J:20.

Hernández, J. J. C. and A. T. S. Ortega. 2000. Synopsis of biological data on the chub mackerel (*Scomber japonicus* Houttuyn, 1782). FAO Fisheries Synopsis No. 157.

Hilborn, R., R. O. Amoroso, E. Bogazzi, O. P. Jensen, A. M. Parma, C. Szuwalski, and C. J. Walters. 2017. When does fishing forage species affect their predators? *Fisheries Research.* In press.

Kiparissis, S., G. Tserpes, and N. Tsimenidis. 2000. Aspects on the demography of chub mackerel (*Scomber japonicus* Houttuyn, 1782) in the Hellenic Seas. *Belgian Journal of Zoology.* 130: 3-7.

Krivospitchenko, S.G. 1979. Mackerel *Scomber japonicus* of the Saharan littoral region. Meeting of the Ad Hoc Working Group on West African Coastal Pelagic Fish from Mauritania to Liberia. Dakar, Senegal. June 19, 1978. FAO Fisheries Department, Rome. Available at: http://www.fao.org/docrep/003/N0952E/n0952e0t.htm

Lorenzo, J. M., J. G. Pajuelo, and A. G. Ramos. 1995. Growth of the chub mackerel *Scomber japonicus* (Pisces: Scombridae) off the Canary Islands. *Scientia Marina.* 59(3-4):287-291.

Lorenzo, J. M. and J.M. Pajuelo. 1996. Growth and reproductive biology of chub mackerel *Scomber japonicus* off the Canary Islands. *South African Journal of Marine Science.* 17(1):275-280.

MAFMC (Mid-Atlantic Fishery Management Council). 2016. Unmanaged Forage Omnibus Amendment public hearing summary. Available at: http://www.mafmc.org/actions/unmanaged-forage

MAFMC (Mid-Atlantic Fishery Management Council). 2017a. Unmanaged Forage Omnibus Amendment. Available at: http://www.mafmc.org/actions/unmanaged-forage

MAFMC (Mid-Atlantic Fishery Management Council). 2017b. Summary of November 9, 2017 webinar on chub mackerel in HMS diets. Available at: http://www.mafmc.org/actions/chub-mackerel-amendment

Manooch, C. S. and W. T. Hogarth. 1983. Stomach contents and giant trematodes from wahoo, *Acanthocybium solanderi*, collected along the South Atlantic and Gulf Coasts of the United States. *Bulletin of Marine Science.* 33(2):227-238.

Manooch, C. S. and D. L. Mason. 1983. Comparative food studies of yellowfin tuna, *Thunnus albacares*, and blackfin tuna, *Thunnus atlanticus*, (Pisces: Scombridae) from the southeastern and Gulf coast of the United States. *Acta Ichthyologica et Piscatoria*. 8(2):25-42.

Manooch, C. S., D. L. Mason, and R. S. Nelson. 1984. Food and gastrointestinal parasites of dophin Coryphaena hippurus collected along the southeastern and Gulf coasts of the United States. *Bulletin of the Japanese Society of Scientific Fisheries.* 50(9):1511-1525.

Martins, M. M., D. Skagen, V. Marques, J. Zwolinski, and A. Silva. 2013. Changes in the abundance and spatial distribution of the Atlantic chub mackerel (*Scomber colias*) in the pelagic ecosystem and fisheries off Portugal. *Scientia Marina.* 77(4): 551-563.

Okey, T. A., A. M. Cisneros-Montemayor, R. Pugliese, U. R. Suaila. 2014. Exploring the trophodynamic signatures of forage species in the U.S. South Atlantic Bight ecosystem to maximize system-wide values. The University of British Columbia Fisheries Centre working paper #2014-14.

Paine, M. A., J. R. McDowell, and J. E. Graves. 2007. Specific identification of western Atlantic Ocean scombrids using mitochondrial DNA cytochrome C oxidase subunit I (COI) gene region sequences. *Bulletin of Marine Science.* 80(2):353-367.

Perrotta, R. G. 1992. Growth of mackerel (*Scober japonicus* Houttuyn, 1782) from the Buenos Aires-north patagonian region (Argentine Sea). *Scientia Marina.* 56(1):7-16.

Perrotta, R. G., M. D. Viñas, D. R. Hernandez, and L. Tringali. 2001. Temperature conditions in the Argentine chub mackerel (*Scomber japonicus*) fishing ground: implications for fishery management. *Fisheries Oceanography*. 10(3):275-283.

Perrotta, R. G., N. Carvalho, and E. Isidro. 2005. Comparative study on growth of chub mackerel (*Scomber japonicus* Hottuyn, 1782) from three different regions: NW Mediterranean, NE and SW Atlantic. *Rev. Invest. Desparr. Pesq.* 17(2005):67-79.

Richardson, D. E., J. K. Llopiz, C. M. Guignard, and R. K. Cowen. 2010. Larval assemblages of large and medium-sized pelagic species in the Straits of Florida. *Progress in Oceanography*. 86(2010):8-20.

Scoles, D. R., B. B. Collette, and J. E. Graves. 1998. Global phylogeography of mackerels of the genus *Scomber*. *Fishery Bulletin.* 96: 823-842.

Sever, T. M., B. Bayhan, M. Bilecenoglu, and S. Mavili. 2006. Diet composition of the juvenile chub mackerel (*Scomber japonicus*) in the Aegean Sea (Izmir Bay, Turkey). *Journal of Applied Ichthyology*. 22(2006):145-148.

Sinclair, M., M. J. Tremblay, and P. Bernal. 1985. El Niño evens and variability in a Pacific mackerel (*Scomber japonicus*) survival index: support for Hjort's second hypothesis. *Canadian Journal of Fisheries and Aquatic Science*. 42(3):602-608.

Smith, L. A., J. S. Link, S. X. Cadrin, and D. L. Palka. 2015. Consumption by marine mammals on the Northeast U.S. continental shelf. Ecological Applications. 25(5):373-389.Vasconcelos, J. V., M. A. Dias, and G. Faria. 2011. Age and growth of the Atlantic chub mackerel *Scomber colias* Gmelin, 1789 off Madeira Island. *Arquipelago – Life and Marine Sciences*. 28: 57-70.

Veiga, P., J. C. Xavier, C. A. Assis, and K. Erzini. 2011. Diet of the blue marlin, *Makaira nigricans*, off the south coast of Portugal. *Marine Biology Research*. 7:820-825.

Velasco, E. M., J. D. Arbol, J. Baro, and I. Sobrino. 2011. Age and growth of the Spanish chub mackerel *Scomber colias* off southern Spain: a comparison between samples from the NE Atlantic and the SW Mediterranean. *Revista de Biolgía Marina y Oceanografía.* 46(1):27-34.

Weber, E. D. and S. McClatchie. 2012. Effect of environmental conditions on the distribution of Pacific mackerel (*Scomber japonicus*) larvae in the California Current System. *Fishery Bulletin*. 110:85-97.

Yasuda, T., R. Yukai, and S. Ohshimo. 2014. Fishing ground hotspots reveal long-term variation in chub mackerel *Scomber japonicus* habitat in the East China Sea. *Marine Ecology Progress Series*. 501: 239-250.

Yatsu, A., T. Watanabe, M. Ishida, H. Sugisaki, and L. D. Jacobson. 2005. Environmental effects on recruitment and productivity of Japanese sardine *Sardinops melanostictuus* and chub mackerel *Scomber japonicus* with recommendations for management. *Fisheries Oceanography*. 14(4):263-278.

Zardoya, R., R. Castilho, C. Grande, L. Favre-Krey, S. Caetano, S. Marcato. 2004. Differential population structuring of two closely related fish species, the mackerel (*Scomber scombrus*) and the chub mackerel *Scomber japonicus*), in the Mediterranean Sea. *Molecular Ecology.* 13:1785-1798.