9 Shortfin mako in the North Atlantic (North of 5°N)

Shortfin mako shark *Isurus oxyrinchus* is a large, highly mobile, pelagic predator that inhabits tropical and temperate waters circumglobally, and subject to both recreational and commercial fisheries (Campana *et al.*, 2005).

The North Atlantic shortfin mako stock is assessed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). ICCAT conducted a stock assessment for shortfin mako in June 2017 (ICCAT, 2017b), with an update in 2019 (ICCAT, 2019a). The available catch, effort and size data, and tagging data were reviewed at a prior Data Preparatory Meeting (ICCAT, 2017a), when the models to be used during the assessment and their assumptions were also discussed.

9.1 Stock distribution

One stock of shortfin mako has been considered to exist in the North Atlantic (e.g. Kohler *et al.*, 2002) as genetic studies found no evidence to separate east and west populations in the Atlantic, but indicate differences between the North Atlantic and the South Atlantic and other oceans (Heist *et al*., 1996; Schrey and Heist, 2002). The relationship between shortfin mako in the North Atlantic and Mediterranean Sea is unclear, and so the ICCAT assessment includes data from the North Atlantic only. A short account of the Mediterranean Sea is given at the end of this chapter.

Based on the oceanography of equatorial waters, and that other large pelagic species (e.g. swordfish) have a southern stock boundary of 5°N, this latitudinal extent is used as the southern boundary of the North Atlantic shortfin mako stock. The stock area broadly equates with FAO Areas 27, 21, 31 and 34 (in part).

Preliminary results indicate that there is stock mixing, with males moving more between regions while the females seem to show philopatric behaviour (ICCAT, 2016). These population differences may imply different biological parameters between regions. Thus, the study of the biology of the species and further genetic studies are required for the clarification of stock boundaries (ICCAT, 2016).

9.2 The fishery

9.2.1 History of the fishery

Shortfin mako is a highly migratory species that is a frequent catch in pelagic longline fisheries targeting tuna and billfish, and in other high seas tuna fisheries. Like porbeagle, it is a relatively high-value species (cf. blue shark, which is of lower commercial value) and normally retained (Campana *et al*., 2005). Recreational fisheries on both sides of the North Atlantic also catch this species, with relatively large quantities reported from sport (rod and reel) fisheries reported to ICCAT (178 t in 2011). Some specimens are released alive from these fisheries.

Shortfin mako is also taken in Mediterranean Sea fisheries (STECF, 2003). For example, Tudela *et al*. (2005) observed 542 shortfin mako taken as bycatch in 4140 km of driftnets set in the Alboran Sea between December 2002 and September 2003.

Shortfin mako is an important shark species captured in pelagic longline fisheries targeting tunas and swordfish. As part of an on-going cooperative program for fisheries and biological data collection, information collected by fishery observers and scientific projects from several fishing nations in the Atlantic (EU-Portugal, Uruguay, Chinese Taipei, USA, Japan, Brazil and

Venezuela) were analysed at the 2017 ICCAT shortfin mako Data Preparatory Meeting (ICCAT, 2017a).

9.2.2 The fishery in 2021

Reported landings of North Atlantic shortfin mako decreased in 2019–2020, in comparison to preceding years, which may relate to the introduction of more conservative management Recommendations from ICCAT (ICCAT Recommendation 19-06).

9.2.3 Advice applicable

ICES does not provide advice for this stock. Assessment of this stock is considered to be the responsibility of ICCAT, who coordinate Recommendations to Contracting Parties, and Cooperating non-Contracting Parties, Entities or Fishing Entities (referred to as CPCs).

ICCAT Recommendation 14-06 on "shortfin mako caught in association with ICCAT fisheries" states that CPCs shall improve their reporting systems for the provision of Task I and Task II catch, effort and size data for shortfin mako. CPCs should also report to ICCAT information on the domestic actions taken to "*monitor catches and to conserve and manage shortfin mako sharks*".

ICCAT Recommendation 19-06 on "the conservation of North Atlantic stock of shortfin mako caught in association with ICCAT fisheries" requires CPC vessels flying their flag to promptly release North Atlantic shortfin mako, albeit with a range of derogations for the retention of dead bycatch (with appropriate observer coverage of electronic monitoring) or where size restrictions apply.

9.2.4 Management applicable

EC Regulation No. 1185/2003 (updated by EU Regulation No 605/2013) prohibits the removal of shark fins of these species, and subsequent discarding of the body. This regulation is binding on EC vessels in all waters and non-EC vessels in Community waters.

Whilst there is no agreed TAC for this stock, Council Regulation (EU) 2021/92 of 28 January 2021 identifies a catch limit of 288 537 t for EU fleets taking North Atlantic shortfin mako (SMA/AN05N). The associated conditions for this catch limit are that "*Only fish already dead when brought alongside the vessel can be retained on-board under this catch limit*" and that "*Only vessels with either an observer or a functioning electronic monitoring system on board, which can identify whether the fish is dead or alive, can retain on-board shortfin mako*".

ICCAT Recommendation 21-09 on the conservation of the North Atlantic stock of shortfin mako caught in association with ICCAT fisheries. This requires that "CPCs shall implement a prohibition on retaining on board, transhipping and landing, whole or in part, North Atlantic shortfin mako caught in association with ICCAT fisheries in 2022 and 2023 as a first step in rebuilding the stock". The Recommendation also provides an initial approach for potential levels of retention in 2023 onwards.

Shortfin mako was listed on Appendix II of CITES, and so international trade, including the retention of fish caught in international waters, now requires a Non-Detriment Finding (see Section 9.12).

9.3 Catch data

9.3.1 Landings

Nominal catch statistics stock, flag and gear, are presented in Table 9.1. Several updates were made to the historical catch series in 2017, namely for EU-Spain LLHB; South Africa; Japan (2014, 2015) and some other minor corrections (ICAT, 2017). For the rest of the flags, only the most recent years of official catches were added/updated and duly incorporated into T1NC. Substantial historical revisions have been made and the current Task I catches (new) were considered acceptable for use in the assessment models. As a result, the historical catches to be used in the 2017 assessment are lower than those documented in the report of the 2012 shortfin mako stock assessment.

In 2015, 3227 t of shortfin mako catch was reported to ICCAT (Table 9.1) in the North Atlantic (89% from longline fleets, the rest from sport fishing and other fleets). Landings have been relatively stable over recent decades. The main countries reporting catches in the North Atlantic in 2015 are Spain, Morocco, USA and Portugal, accounting for 42, 29, 16 and 7% respectively (Table 9.1). National landings reported to ICES for 2015 were 216 t for the northeast Atlantic, with the majority of this from Subarea 9.a by the UK. Smaller amounts were reported from areas 4, 6, 7 and 8, by Spain and the UK.

In the Mediterranean Sea, total reported landings to ICCAT were 0 t. Since 2007, reported landings in the Mediterranean Sea have been between 0–2 t.

Landings reported from the northeast Atlantic have been small in recent years (25 to 34 tonnes from 2016 to 2019). Further work is needed to check the consistency of landings data submitted in response to ICES data with ICCAT data.

9.3.2 Discards

Discard data are also given in Table 9.1, these are considered largely underestimated, with the USA longline being the fleet with the longest time-series of discard quantities, for 1987–1996 (1–38 t) and 2007–2015 (7–20 t). There are no reported discards from the Mediterranean Sea. Actual level of shortfin mako bycatch is difficult to estimate, as available data are limited and documentation is incomplete. A report of the US pelagic longline observer programme stated that of the sharks caught alive, 23% were released alive and 61% retained (ICCAT, 2005).

Shortfin mako discards (alive and dead) from Canadian fisheries in the Northwest Atlantic Ocean were provided in 2017. The report included records from all fisheries within the Canadian EEZ (both national and ICCAT managed) that capture shortfin mako and the data was partitioned into live releases and dead discards (ICCAT, 2017a, b).

Shortfin mako is a high value species, and many European fisheries land shortfin mako gutted (usually with the head on). Although often landed for their meat in some fisheries, finning (the practice of removing the fins of a shark and returning the remainder of the carcass to the sea) may occur in some fleets, which may result in undocumented catches and mortality. Finning regulations are in force in various fisheries, but the extent of finning in IUU fisheries is unknown.

9.3.3 Quality of catch data

Catch data are considered underestimates, and the extent of finning in high seas fisheries is unclear. The historical use of generic shark categories is problematic, although many European countries have begun to report species-specific data in recent years. Despite some important recovery of historical catch series in recent years, ICCAT considers that the overall catch is underestimated, particularly before 2000.

There have been major discrepancies between reported landings in databases from ICCAT, FAO and EuroStat. The ICCAT Secretariat consolidated these three data sources into a unique database, and currently progress is being made on its validation and the associated data mining task (analysis of equivalent data series at various aggregation levels; Palma *et al.*, 2012). FAO data have been revised in recent years, and historical catch figures have increased from what was reported previously. The catches by FAO area (Figure 9.4) and the total North Atlantic catch are shown along with ICCAT catch totals (Figure 9.2) for comparison.

Previous ICCAT assessments of shortfin mako used two different estimates of landings for this stock, the tuna ratio (logged observations of shark catches relative to tuna catches) and the fin trade index (shark fin trade observations from the Asian market used to calculate caught shark weights based on catch effort data; Clarke *et al.*, 2006; ICCAT 2005, 2008). These figures were much higher than reported landings.

The methodology adopted to estimate historic catches of blue shark was considered inappropriate for this species. It was noted that shortfin mako had always had commercial value and thus discards have been less (cf. blue shark),. Hence. for shortfin mako, historical estimation of catches is based on observer data, as well as other potential techniques. And where no additional information is available, catch ratios will be used to make these estimations. The highest priority for this exercise is given to Morocco, before 2011; EU-Spain, before 1997 and Canada, before 1995 (ICCAT, 2017a, b).

9.3.4 Discard survival

Several studies have reported the at-vessel mortality of shortfin mako to broadly range from about 30–50% in longline fisheries (summarised in Ellis *et al.*, 2017). Discard survival in such fisheries can be influenced by several factors, including hook type, soak time and size of shark.

9.4 Commercial catch composition

9.4.1 Conversion factors

Shortfin mako can be landed in various forms (e.g. gutted, dressed, with or without heads). It is therefore important that appropriate conversion factors for these landings are used. FAO (based on Norwegian data) use conversion factors for fresh, gutted, and gutted and headed sharks of 87% and 77%, respectively (Hareide *et al.*, 2007). Scientific estimates for various conversion factors for shortfin mako are summarised for length–weight relationships (Table 9.2) and different length measurements (Table 9.3).

9.5 Commercial catch and effort data

Recent CPUE time series were provided for both the North and South Atlantic stocks along with a lowess smoother fitted to CPUE each year using a general additive model (GAM) to compare trends by stock (North Atlantic and South Atlantic) (Figure 9.5.). The overall trend for the Northern indices is an initial decrease followed by an increase from 2000 and a decline in the recent years. Residuals from the lowess fits to CPUE are compared to look at deviations from the overall trends (Figure 9.6.). This comparison allows conflicts between indices (e.g. highlighted by patterns in the residuals) and autocorrelation within indices (which may be due to year-class effects or the importance of factors not included in the standardization of the CPUE) to be identified.

Figure 9.7 presents the correlations between North Atlantic CPUE indices; the lower triangle shows the pairwise scatter plots between indices with a regression line, the upper triangle provides the correlation coefficients, and the diagonal provides the range of observations. The correlation between US observer and Chinese Taipei is high at 0.78; however, this is likely to be due to a single point (i.e. 2009). Also, a strong correlation could be found by chance if two series only overlap for a few years. Figure 9.8 shows the results from a hierarchical cluster analysis evaluated for the North Atlantic using a set of dissimilarities. All series appear to be similar, with the US observer and Chinese Taipei having the greatest similarity, but, as mentioned above, this could be due to one influential point. Cross-correlations for the North Atlantic are plotted in in Figure 9.8; the US logbook (3rd diagonal element) shows strong autocorrelation over 3 years, this could be due to year-class effects. This could also be a reason for strong cross-correlations between series. A strong negative or positive cross-correlation could be due to series being dominated by different age-classes, e.g. Portuguese longline and US observer has a negative lag of 2–3 that could be due to the US series catching younger individuals.

Although the relationship between Atlantic and Mediterranean Sea shortfin mako is unclear, Tudela *et al*. (2005) estimated CPUE based on driftnetters from Al Hoceima and Nador fishing in the Alboran Sea. Di Natale and Pelusi (2000) reported data from the Italian large pelagic longline fishery in the Tyrrhenian Sea (1998–1999), and calculated a mean CPUE of 1.1 kg per 1000 hooks.

9.6 Fishery-independent surveys

No fishery-independent data from the NE Atlantic are available.

Fishery-independent data are available from the NW Atlantic (Simpfendorfer *et al.*, 2002; Hueter and Simpfendorfer, 2008). Babcock (2010) provided an index of abundance of shortfin mako catch rates from the US East Coast from the National Marine Fisheries Service Marine Recreational Fishery Statistics Survey (MRFSS). A total of 711 shortfin mako were reported from 1981–2010. There were 252 686 trips of which about 0.2% caught at least one shortfin mako.

A Portuguese research project on mitigation measures for shark bycatch in pelagic longline fisheries was presented to the 2014 ICCAT Inter-sessional meeting of the shark subgroup (ICCAT, 2014). An electronic tagging experiment will be carried out during this research project to evaluate post-release mortality of shortfin mako.

There is a large set of mark-recapture data available at ICCAT for shortfin mako, with 9316 individuals tagged since 1962 and 1255 specimens recaptured (ICCAT, 2016). The ICCAT Shark Species Group suggested that these data could be used to provide information for the growth curve, and proposed an age and growth workshop for shortfin mako (ICCAT, 2016).

9.7 Life-history information

Various studies have provided biological information for this species (see also Stevens, 2008). Data available for the North Atlantic stock are given in Table 9.2 (length–weight relationships), Table 9.4 (growth parameters), and Table 9.5 (other life-history parameters).

There was also an update of life-history parameters in the report of the 2014 inter-sessional meeting of the ICCAT shark sub-group (ICCAT, 2014) and again in 2017 (ICCAT, 2016). At the 2017 ICCAT Data Preparatory Meeting, it was decided that the two phases of the Shark Research and Data Collection Plan were devoted to shortfin mako, as the species to be assessed in 2017. While considerable work has been produced, there are still uncertainties on some important biological parameters, and it is important to continue biological investigations. Additionally, ICCAT Recommendation 14–06 on shortfin mako caught in association with ICCAT fisheries supports this in saying that: "Paragraph 3: *CPCs are encouraged to undertake research that would provide information on key biological/ecological parameters, life-history and behavioural traits, as well as on the identification of potential mating, pupping and nursery grounds of shortfin mako sharks. Such information shall be made available to the SCRS*".

Within the ICCAT Shark Research and Data Collection Programme (SRDCP) progress has been made in the study on age and growth of South Atlantic shortfin mako. Samples have been collected and age readings will start soon (https://www.iccat.int/Documents/Meetings/Docs/2022/REPORTS/2022_SHK_ENG.pdf).

9.7.1 Habitat

Shortfin mako is a common, extremely active epipelagic species found in tropical and warm-temperate seas from the surface down to at least 500 m (Compagno, 2001). The species is seldom found in waters <16°C, and in the western North Atlantic they only move onto the continental shelf when surface temperatures exceed 17°C. Observations from South Africa indicate that the species prefers clear water (Compagno, 2001).

9.7.2 Nursery grounds

Published records of potential nursery grounds are lacking. Buencuerpo *et al.* (1998) suggested that the western basin of the Mediterranean Sea was a nursery area. Stevens (2008) suggested that nursery areas would likely be situated close to the coast in highly productive areas, based on the majority of reports, with nursery grounds potentially off West Africa in the North Atlantic.

9.7.3 Diet

Shortfin mako feed primarily on fish, both pelagic and demersal species, and cephalopods (Compagno, 2001). Shortfin mako sampled off southwest Portugal had teleosts as the principal component of their diet (occurring in 87% of the stomachs and accounting for >90% of the contents by weight), and crustaceans and cephalopods were also relatively important, whilst other elasmobranchs were only present occasionally (Maia *et al*., 2006).

In the NW Atlantic, bluefish *Pomatomus saltatrix* is the most important prey species and comprises about 78% of the diet (Stillwell and Kohler, 1982). These authors estimated that a 68 kg shortfin mako consumes about 2 kg of prey per day, and could eat about 8–11 times its body weight per year. Stillwell (1990) subsequently suggested that shortfin mako may consume up to 15 times their weight per year.

The diet of shortfin mako in South African waters indicated that elasmobranchs could be important prey, and marine mammals can also make up a small proportion of the diet (Compagno, 2001).

9.7.4 Movements

Shortfin mako have a wide distribution and habitat use patterns (Casey and Kohler, 1992; Rogers *et al*. 2015; Vaudo *et al*. 2016). The species showed diel diving behaviour, with deeper dives occurring primarily during the daytime. A strong influence of thermal habitat on species movement behaviour suggests potentially strong impacts of rising ocean temperatures on the ecology of this highly migratory top predator. Integrating knowledge of fish movements into spatially explicit population dynamics models is being urged for improving stock assessments and management (Braccini *et al.*, 2016).

9.8 Exploratory assessment models

No new exploratory assessment was undertaken.

9.9 Stock assessment

An ICCAT assessment for shortfin mako was carried out in 2017 (ICCAT, 2017b). The models agreed that the northern stock was overfished and was undergoing overfishing. The results obtained in 2017 were not comparable with those obtained in the earlier assessment in 2012, as the input data and model structures had changed significantly.

ICCAT updated the assessment for shortfin mako in 2019. New projections were made using two Stock Synthesis model scenarios that incorporated important aspects of shortfin mako biology, which had not been available previously (ICCAT, 2019a). These projections were considered by the ICCAT Shark Group as a better representation of the stock dynamics. For the North Atlantic stock, the Group stated that "it is likely the current status (2018) had a lower B/B_{MSY} and higher F/F_{MSY} than the stock status in 2015 estimated in the 2017 assessment because the population continued to decline due to high catch levels". A number of catch scenarios were given in the report, but the ICCAT Shark Group stated that "regardless of the TAC (including a TAC of 0 t), the stock will continue to decline until 2035 before any biomass increases can occur" and "although there is large uncertainty in the future productivity assumption for this stock, the Stock Synthesis projections show that there is a long lag time between when management measures are implemented and when stock size starts to rebuild" (ICCAT, 2019a).

9.10 Quality of assessment

Assessments undertaken by ICCAT are conditional on several assumptions, including the estimates of historical shark catch, the relationship between catch rates and abundance, the initial state of the stock, as well as uncertainty in some life-history parameters.

9.11 Reference points

ICCAT uses F/F_{MSY} and B/B_{MSY} as reference points for stock status. These reference points are relative metrics. The absolute values of B_{MSY} and F_{MSY} depend on model assumptions and results and are not presented by ICCAT for advisory purposes.

9.12 Conservation considerations

The most recent IUCN Red List Assessment for shortfin mako is that it is Endangered (Rigby *et al.*, 2019).

In 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Atlantic population of the shortfin mako as threatened (DFO, 2006).

In 2008, shortfin mako was listed on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS).

In 2019 both shortfin mako and the related longfin mako *Isurus paucus,* were listed on Appendix II of CITES. In 2020 the CITES Scientific Review Group of the EU developed an EU-wide negative

Non-Detriment Finding (NDF) for shortfin mako in the North Atlantic (https://species-plus.net/species#/taxon_concepts/98243/legal). This means that no permits will be given by any of the EU countries for international trade in wild caught individuals and those caught in waters outside national jurisdiction ('introduction from the sea').

9.13 Management considerations

Shortfin mako has been one of the most common species in the global fin trade (Clarke *et al*. 2006). Thus, fishery exploitation is a major source of mortality for mako populations, which, because of their life-history characteristics, have a high risk of overexploitation (Cortés *et al*. 2010).

Catch data of pelagic sharks are considered unreliable, as many sharks are not reported on a species-specific basis, and some fisheries may have only landed fins. As already stated, the landings data are unreliable and data prior to 2000 should be considered as underestimates. Reporting procedures must be strengthened so that all landings are reported, and that landings are reported to species level, rather than generic "*nei*" categories. The consolidation of three databases (ICCAT, FAO and EUROSTAT) by the ICCAT Secretariat should also strengthen the reliability of catch data in the future.

The 2019 Report of the Standing Committee on Research and Statistics (SCRS) stated that, "*i) a zero TAC will allow the stock to be rebuilt and without overfishing (in the green quadrant of the Kobe plot) by 2045 with a 53% probability; ii) regardless of the TAC (including a TAC of 0 t), the stock will continue to decline until 2035 before any biomass increases can occur; iii) a TAC of 500 t, including dead discards has only a 52% probability of rebuilding the stock to the green quadrant in 2070; iv) to be in the green quadrant of the Kobe plot with at least 60% probability by 2070, the realized TAC has to be 300 t or less; v) lower TACs achieve rebuilding in shorter time frames; and vi) a TAC of 700 t would end overfishing immediately with a 57% probability, but this TAC would only have a 41% probability of rebuilding the stock by 2070.*" (ICCAT, 2019b). Furthermore, "*Given the vulnerable biological characteristics of this stock and the pessimistic projections, to accelerate the rate of recovery and to increase the probability of success the Committee recommends that the Commission adopt a non-retention policy without exception in the North Atlantic as it has already done with other shark species caught as bycatch in ICCAT fisheries*".

In 2021 the ICCAT SCRS recommended that "*CPCs shall implement a prohibition on retaining on board, transhipping and landing whole or in part, North Atlantic shortfin mako caught in association with ICCAT fisheries in 2022 and 2023 as a first step in rebuilding the stock.*" (ICCAT, 2021) In the same document, ICCAT has described a process upon which future permissible retention shall be pursuant.

In 1995, the Fisheries Management Plan for pelagic sharks in Atlantic Canada established a catch limit of 100 t annually for the Canadian pelagic longline fishery as well as advising release of live catch.

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Table 9.1. Shortfin mako in the North Atlantic (ATN) and Mediterranean (MED). Available landings (t) of shortfin mako by country from ICCAT Task I catch data. These data are considered underestimates, especially prior to 2000. Landings of <0.5 t are data for 2012, 2013 and 2014 from ICCAT (2015). Landings for ATN Sport and other gear codes are given as one value from 2012 onwards.

				1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TOTAL				5841	8406	7701	5727	5861	4469	5179	4792	5531	7225	6528	6970	6620	6946	5682	6605	7254	6979	7338	5778	6126	5739	6111	5902	5547
	ATN			3659	5306	5306	3534	3845	2858	2587	2677	3426	3987	4000	3695	3574	4158	3800	4541	4767	3718	4431	3595	2852	2964	3347	3116	2388
	MED			0	0	0	6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	2	0	0	0	0	0	1
Landings	ATN		Longline	3306	3828	5053	3351	3670	2756	2267	2446	3155	3970	3572	3387	3302	3976	3622	4344	4587	3496	4145	3312	2576	2638	3118	2713	1990
			Other surf.	331	1448	252	183	175	99	320	231	271	17	429	308	273	175	169	177	178	213	267	278	264	316	221	397	369
	MED		Longline	0	0	0	6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	2	0	0	0	0	0	
			Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Discards	ATN		Longline	21	29	1	0	0	0	0	0	0	0	0	0	0	7	9	20	2	9	19	5	12	10	8	4	28
			Other surf.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
	MED		Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Landings	ATN	CP	Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	3	**0**
			Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	28	69	114	99	1	1	1	9	12
			Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
			Canada	0	111	67	110	69	70	78	69	78	73	80	91	71	72	43	53	41	37	29	35	55	85	82	109	53
			China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	81	16	19	29	18	24	11	5	2	4	2	**0**
			Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
			EU.España	2164	2209	3294	2416	2223	2051	1561	1684	2047	2068	2088	1751	1918	1814	1895	2216	2091	1667	2308	1509	1481	1362	1574	1784	1165
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	2	0	0	0	1	1	2	1	0
			EU.Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
			EU.Portugal	649	657	691	354	307	327	318	378	415	1249	473	1109	951	1540	1033	1169	1432	1045	1023	820	219	222	264	276	272
			EU.United Kingdom	0	0	0	0	0	2	3	2	1	1	1	0	0	0	1	15	0	0	0	0	0	0	0	0	**0**
			FR.St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	4	0	0	4	0	0	0	0	**0**
			Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
			Japan	214	592	790	258	892	120	138	105	438	267	572	0	0	82	131	98	116	53	56	33	69	45	74	89	20
			Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	27	15	8	2	1	3	5
			Maroc	0	0	0	0	0	0	0	0	0	147	169	215	220	151	283	476	636	420	406	667	624	947	1050	450	594
			Mauritania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	**0**
			Mexico	0	10	0	0	0	0	10	16	0	10	6	9	5	8	6	7	8	8	8	4	4	4	3	5	2
			Panama	0	0	0	0	0	1	0	0	0	0	0	0	0	49	33	39	0	0	0	19	7	0	0	0	**0**
			Philippines	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
			Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	8	17	21	0	0	2	0	2	2	2	68	68
			St. Vincent and Grenadines	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	**0**
			Trinidad and Tobago	0	0	0	0	0	1	0	1	2	3	1	2	1	1	1	1	1	0	2	1	1	1	1	2	2
			U.S.A.	574	1658	400	345	296	198	414	350	372	106	477	422	353	319	296	314	335	331	365	355	345	255	262	299	165
			UK.Bermuda	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
			Venezuela	7	7	17	9	8	6	9	24	21	28	64	27	14	19	8	41	27	20	33	9	13	7	7	9	
		NCC	Chinese Taipei	29	32	45	42	47	75	56	47	53	37	70	68	40	6	23	11	14	13	14	8	4	13	7	1	**0**
				1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
		NCO	Sta. Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	
	MED	CP	EU.Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	**0**
			EU.España	0	0	0	6	7	5	3	2	2	2	2	2	4	1	0	0	1	2	2	0	0	0	0	0	**0**
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**

				1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
			EU.Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
			EU.Portugal	0	0	0	0	1	0	1	5	0	0	0	15	5	0	0	0	0	0	0	0	0	0	0	0	**0**
			Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
			Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Discards	ATN	CP	Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
			Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			El Salvador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
			Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
			Mexico	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Russian Federation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			U.S.A.	21	28	1	0	0	0	0	0	0	0	0	0	0	7	10	20	2	9	18	5	11	8	6	4	1
			UK.Bermuda	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	3
MED		CP	EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 9.2. Shortfin mako in the North Atlantic. Length–weight relationships for *Isurus oxyrinchus* (sexes combined) from different populations. Lengths in cm, and weights in kg unless specified in equation. W_R = round weight; W_D = dressed weight.

Stock	L (cm) W (kg) relationship	n	Length range (cm)	Source
Central Pacific	log W (lb) = –4.608 + 2.925 x log L_T			Strasburg, 1958
Cuba	W = 1.193 x 10–6 x L_T 3.46	23	160–260 (L_T)	Manday, 1975
Australia	W = 4.832 x 10–6 x L_T 3.10	80	58–343 (L_T)	Stevens, 1983
South Africa	W = 1.47 x 10–5 x L_{PC} 2.98	143	84–260 (L_{PC})	Cliff *et al*., 1990
NW Atlantic	W_R = (5.2432 x 10–6) L_F 3.1407	2081	65–338 (L_F)	Kohler *et al*., 1995.
NW Atlantic	W = 7.2999 x L_T (m) 3.224	63	2.0–3.7 m (L_T)	Mollet *et al*., 2000
Southern hemisphere	W = 6.824 x L_T (m) 3.137	64	2.0–3.4 m (L_T)	Mollet *et al*., 2000
NE Atlantic	W_D = (2.80834 x 10–6) L_F 3.20182	17	70–175 (L_F)	García-Cortés and Mejuto, 2002
Tropical east Atlantic	W_D = (1.22182 x 10–5) L_F 2.89535	166	95–250	García-Cortés and Mejuto, 2002
Tropical central Atlantic	W_D = (2.52098 x 10–5) L_F 2.76078	161	120–185	García-Cortés and Mejuto, 2002
Southwest Atlantic	W_D = (3.1142 x 10–5) L_F 2.7243	97	95–240	García-Cortés and Mejuto, 2002

Table 9.3. Shortfin mako in the North Atlantic. Length–length relationships for male, female and sexes combined from the NE Atlantic and Straits of Gibraltar (L_S = standard length; L_F = fork length; L_T = total length; L_{UC} = upper caudal lobe length). Source: Buencuerpo *et al*. (1998).

Females	Males	Combined
L_F = 1.086 L_S + 1.630 (n=852)	L_F = 1.086 L_S + 1.409 (n=911)	L_F = 1.086 L_S + 1.515 (n=1763)
L_T = 0.817 L_S + 0.400 (n=852)	L_T = 1.209 L_S + 0.435 (n=681)	L_T = 1.207 L_S + 0.971 (n=1533)
L_{UC} = 3.693 L_S + 13.094 (n=507)	L_{UC} = 3.795 L_S + 10.452 (n=477)	L_{UC} = 3.758 L_S + 11.640 (n=1054)
L_T = 1.106 L_F + 0.052 (n=853)	L_T = 1.111 L_F – 0.870 (n=911)	L_T = 1.108 L_F – 0.480 (n=1746)

Table 9.4. Shortfin mako in the North Atlantic. Published growth parameters, assuming two vertebral bands formed annually. Data give von Bertalanffy growth parameters (Gompertz growth function) used, t_0 in cm. L_∞ in cm (Fork Length), k in years^{-1}.**

Area	L∞	k	t_0	L_0^*	Sex	Study
Northwest Atlantic	302	0.266	–1	-	Male	Pratt and Casey, 1983
Northwest Atlantic	345	0.203	–1	-	Female	Pratt and Casey, 1983
Atlantic	373.4	–0.203	1.0		Female	Cortés, 2000
Northwest Atlantic	253	0.125	-	71.6	Male	Natanson *et al*., 2006**
Northwest Atlantic	366	0.087	-	88.4	Female	Natanson *et al*., 2006**

*: size-at-birth

Table 9.5. Shortfin mako in the North Atlantic. Life-history information available from the scientific literature.

Parameter	Values	Sample Size	Area	Reference
Reproduction	Ovoviviparous with oophagy			Campana *et al*., 2004
Litter size	4–25	35	Worldwide	Mollet *et al*., 2000
	12–20			Castro *et al*., 1999
Size at birth (L_T)	70 cm	188+	Worldwide	Mollet *et al*., 2000
Sex ratio (males: females)	1:1	2188	NW Atlantic	Casey and Kohler, 1992
	1:0.4		NE Atlantic (Spain, Azores)	Mejuto and Garces, 1984
	1:0.9		NE, N central Atlantic and Med	Buencuerpo *et al*., 1998
	1.0:1.4	17	NE Atlantic	García-Cortés and Mejuto, 2002
Gestation period	15–18	26	Worldwide	Mollet *et al*., 2000
Male age-at-first maturity (years)*	2.5			Pratt and Casey, 1983
	9			Cailliet *et al*., 1983
Male age-at-median maturity (years)	7	145	New Zealand	Bishop *et al*., 2006
Female age-at-first maturity (years)*	5			Pratt and Casey, 1983
Female age maturity (years)	19	111	New Zealand	Bishop *et al*., 2006
	7			Pratt and Casey, 1983
Male length-at-first maturity (T_L)	195 cm			Stevens, 1983
Male length-at-maturity (T_L)	197–202 cm (median)	215	New Zealand	Francis and Duffy, 2005
	180 cm (L_F)		NE Atlantic (Portugal)	Maia *et al*., 2007
	200–220		Worldwide	Pratt and Casey, 1983; Mollet *et al*., 2000
Female length-at-first maturity (T_L)	265–280 cm			Cliff *et al*., 1990
Female length-at-maturity (T_L)	301–312 (median)	88	New Zealand	Francis and Duffy, 2005
	270–300 cm (L_T)		Worldwide	Pratt and Casey, 1983; Mollet *et al*., 2000
Age-at-recruitment (year)	0–1			Stevens and Wayte, 1999
Male maximum length (L_T)	296 cm			Compagno, 2001
Female maximum length (L_T)	396 cm 408 cm (estimated)			Compagno, 2001
Lifespan (years)	11.5–17 (oldest aged)			Pratt and Casey, 1983

Parameter	Values	Sample Size	Area	Reference
	45 (estimated longevity)			Cailliet *et al.*, 1983
Natural mortality (M)	0.16		Pacific	Smith *et al.*, 1998
Annual survival estimate	0.79 (95% C.I. 0.71–0.87)			Wood *et al.* 2007
Growth parameters	61.1 cm year–1 first year 40.6 cm year–1 second year 5.0 cm month–1 in summer 2.1 cm month–1 in winter	262	NE Atlantic (Portugal)	Maia *et al.*, 2007
Maximum age (estimated from von Bertalanffy growth eqn.)	28			Smith *et al.*, 1998
Productivity (R2m) estimate: intrinsic rebound	0.051 (assuming no fecundity increase)		Pacific	Smith *et al.*, 1998
Potential rate of increase per year	8.5%		Atlantic	Cortés, 2000
Population doubling time T_D (years)	13.6 (assuming no fecundity increase)		Pacific	Smith *et al.*, 1998
Generation time (years)	~ 9		Atlantic	Cortés, 2000
Trophic level	4.3	7		Cortés, 1999

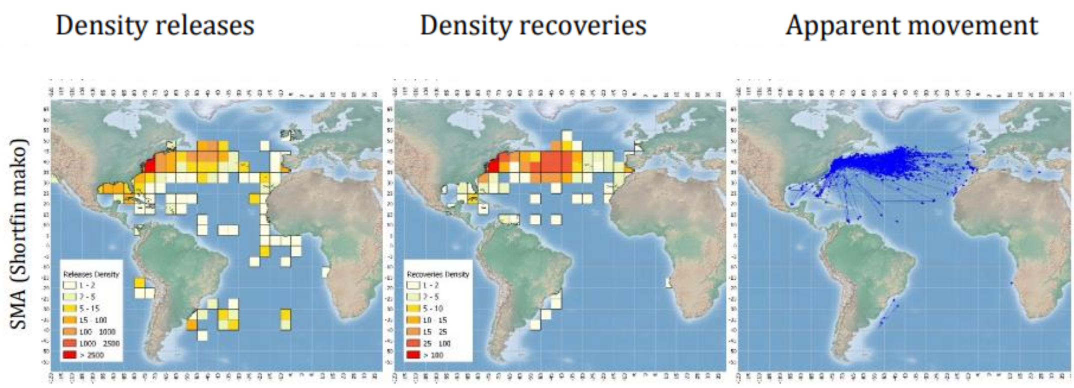

Figure 9.1. Shortfin mako in the North Atlantic. Tag and release distributions for shortfin mako in the Atlantic Ocean showing (a) density of releases in a 5x5 grid, (b) density of recoveries in a 5x5 grid, and (c) the apparent movement (straight line from the release to the recovery locations. Recaptures were 13.4%. Source: ICCAT (2022).

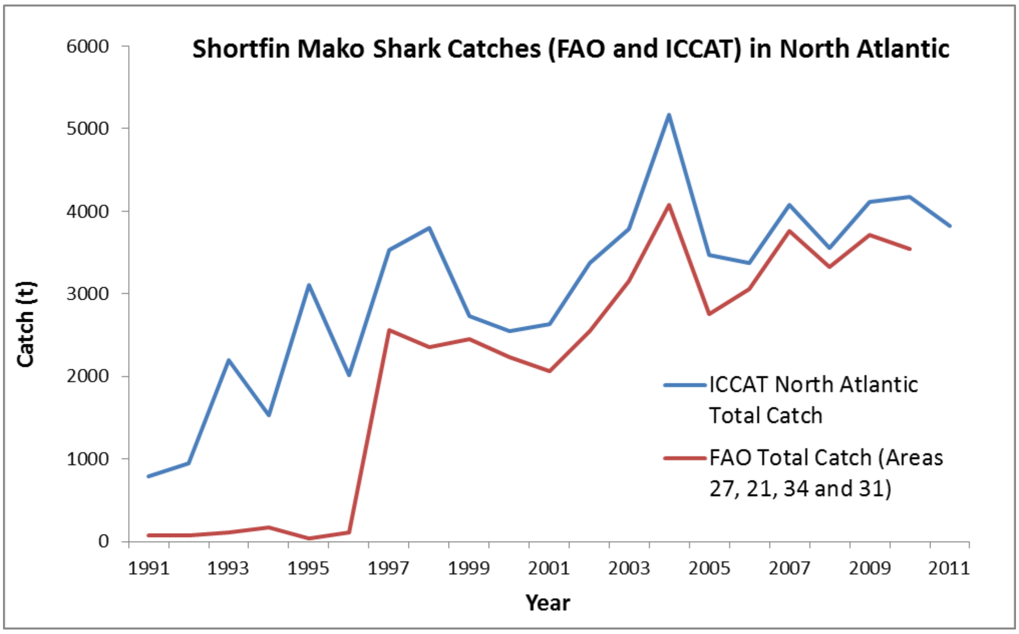

Figure 9.2. Shortfin mako in the North Atlantic. Total catches (t) of shortfin mako in the North Atlantic reported to FAO and ICCAT.

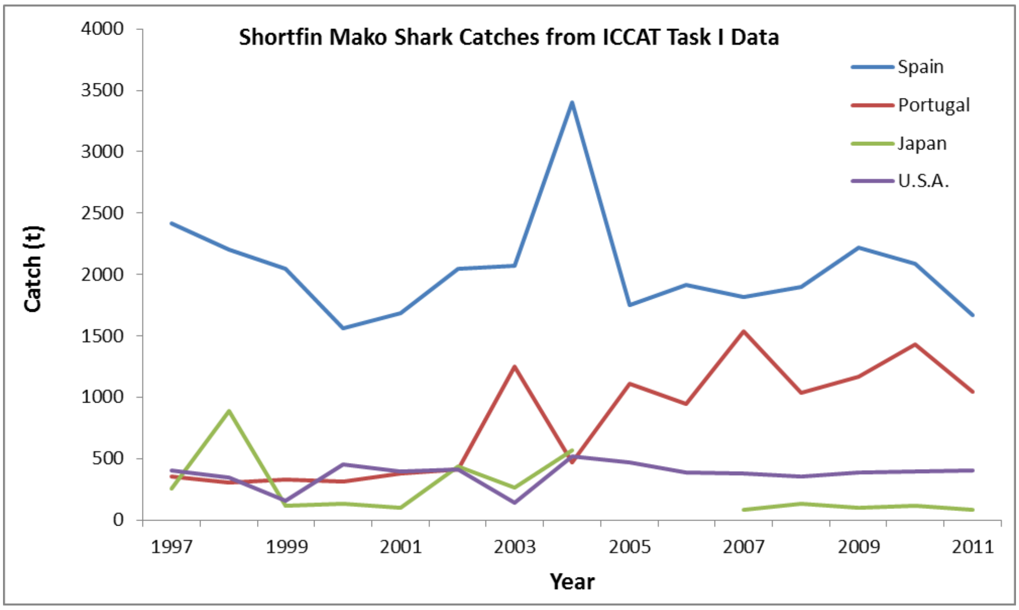

Figure 9.3. Shortfin mako in the North Atlantic. Total catches (t) made by the major countries (accounting for 84% of total landings) landing shortfin mako in the North Atlantic reported to ICCAT.

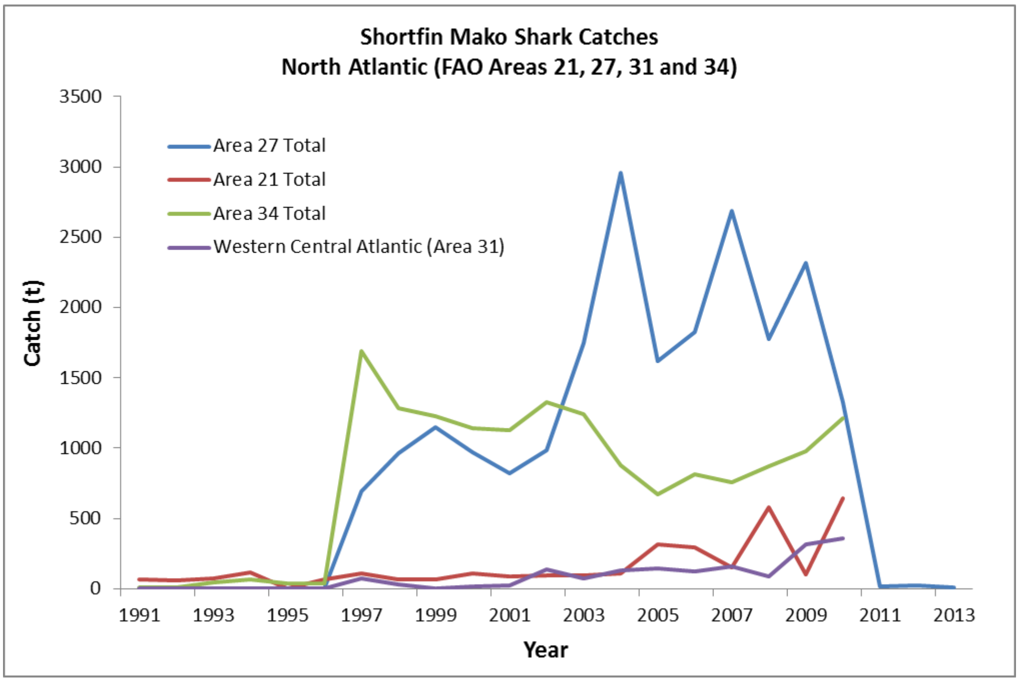

Figure 9.4. Shortfin mako in the North Atlantic. Total catches (t) of shortfin mako reported to FAO by major fishing area.

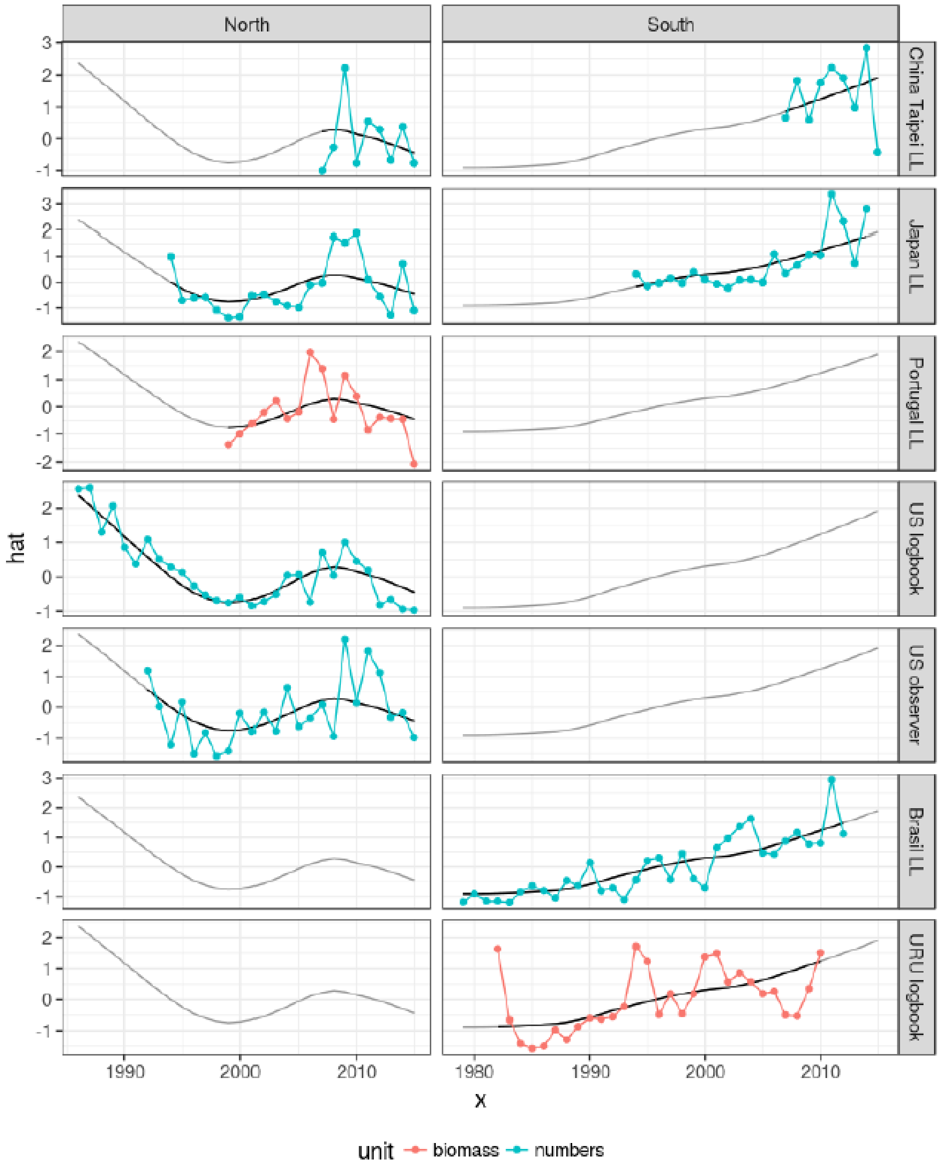

Figure 9.5. Shortfin mako in the North and South Atlantic. Time series of agreed CPUE indices, points are the standardised values, continuous black lines are a loess smoother showing the average trend by area (i.e. fitted to year for each area with series as a factor). X-axis is time, Y-axis are the scaled indices. Source: ICCAT.

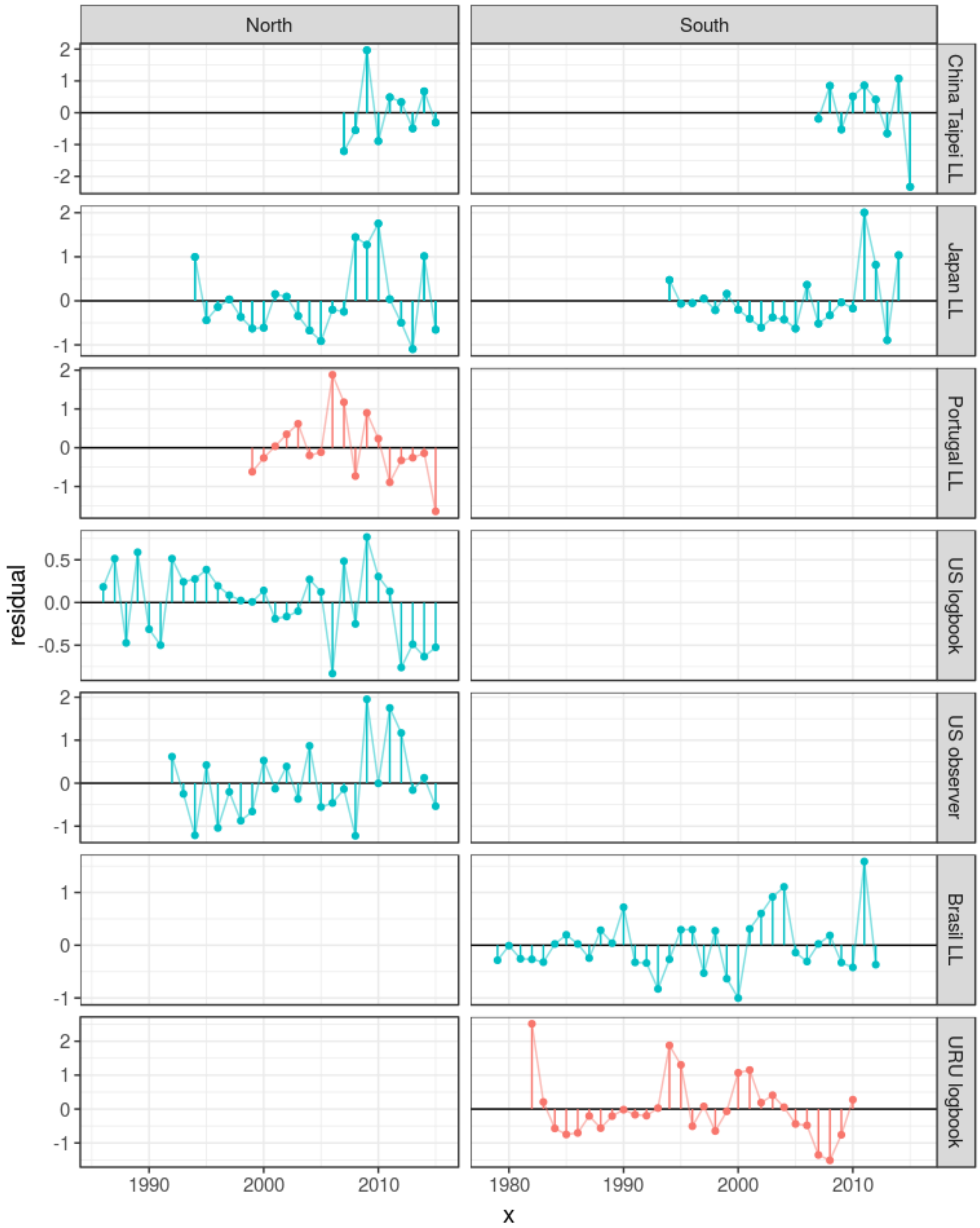

Figure 9.6. Shortfin mako in the North and South Atlantic. North and South Atlantic time series of residuals from the loess fit to agreed indices. X-axis is time, Y-axis are the scaled indices. Source: ICCAT.

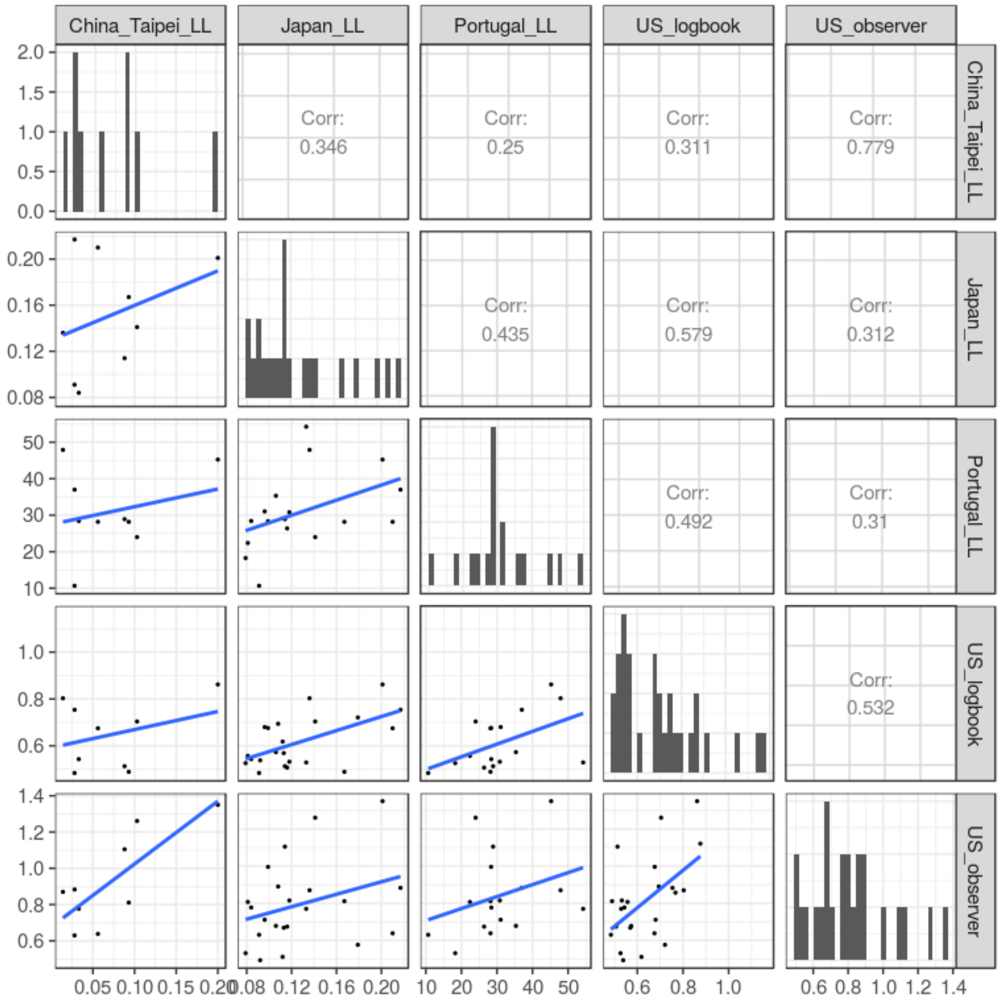

Figure 9.7. Shortfin mako in the North Atlantic. North Atlantic pairwise scatter plots for agreed indices. X- and Y-axis are scaled indices. Source: ICCAT.

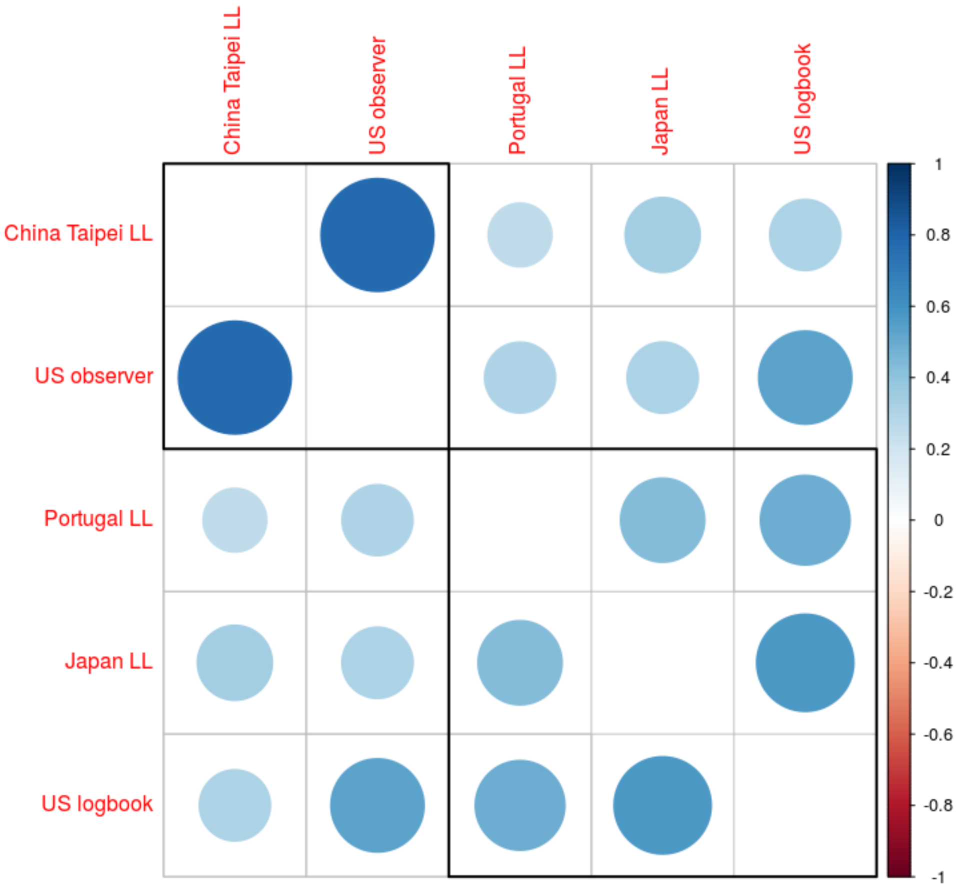

Figure 9.8. Shortfin mako in the North Atlantic. North Atlantic correlation matrix for the agreed indices; blue indicates positive and red negative correlations, the order of the indices and the rectangular boxes are chosen based on a hierarchical cluster analysis using a set of dissimilarities. Source: ICCAT.