



Scomber scombrus Image © Scandinavian Fishing Year Book

The annual catch of Atlantic mackerel, *Scomber scombrus*, in North East Atlantic waters was around 735,000 tonnes live weight (t) in 2009, of which UK landings were 148,000 t. In the Northwest Atlantic, USA and Canadian landings total around 60,000 t per annum. Catches of other Atlantic *Scomber* species, most notably *Scomber colias*, average around 60,000 t per annum and occur in the Bay of Biscay and further south. All the assessment and catch data in this guide relate to *Scomber scombrus*, although all species of the genus *Scomber* can be described as mackerel on the UK market (1).

There are two assessed mackerel stocks in the North Atlantic. The status of the North East Atlantic stock (with the exception of the North Sea component) has improved with the spawning stock biomass at an all time high.

Although a number of measures designed to improve sustainability have been implemented there is serious concern that there is no comprehensive management regime. The current situation, with no internationally agreed limit on Total Allowable Catches

(TAC), may not result in a sustainable fishery.

The USA and Canadian stocks are now assessed as one stock. However its status is considered unknown.

The purpose of this guide is to outline status and trends in North Atlantic mackerel stocks distribution. The guide describes measures being taken to protect mackerel and discusses future prospects for sustainability in relation to the fisheries management regime.

BUYERS' TOP TIPS

Know your source of supply and stock status

Mackerel populations inhabit vast areas, within which individual spawning components are recognised. Find out about the management stock and its spawning component from which your mackerel has been caught.

Ensure your supplies are from legal fisheries

In recent years there have been serious problems with illegal fishing of some mackerel stocks. Traceability systems (2, 3) can help to assure the origin of product.

An informed buying policy

Buyers need an informed approach to stock status and management. Whilst it is clear that the North East Atlantic mackerel stocks are currently in good condition, there is at present no internationally agreed limit on catches although the EU and Norway set their annual TAC based on a 10 year mackerel agreement (p 3-8).

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Status of mackerel stocks October 2011

Biology

Mackerel (*Scomber scombrus*) is a pelagic fish; it lives in shoals swimming above the sea bed. It is highly migratory, inhabiting vast areas within which there are large-scale seasonal movements between spawning and feeding areas that are influenced by water temperature. In the North East (NE) Atlantic, mackerel is considered to have a single stock (though with three separate spawning components) that extends from southern Portugal to northern Norway. Mackerel in the Northwest (NW) Atlantic is also assessed as a single stock (North Carolina to Labrador, with northern and southern spawning components). Table 2 gives an overall picture of the status and overall catch by stock area North Atlantic mackerel (4).

Fishing gear

Most mackerel fisheries target large shoals offshore using either midwater trawls, pair trawls or purse seines, and the adoption of dual and triple frequency sonar technology on some vessels has enabled skippers to differentiate between pelagic species. In inshore areas, small vessels use handlines and gillnets, including a substantial Spanish fleet (4,950 vessels in 2009) and handline fleets off the South West coast of England and coast of Scotland. Most mackerel caught in European waters are landed fresh, or chilled in refrigerated seawater (RSW), to shore processors, although the large freezer vessels process and pack their catch at sea. Mackerel is also an important quarry species for recreational anglers.

Assessments

The concept of sustainable management of a fish stock is based on balancing fish that are removed by fishing and natural deaths, against additions due to growth and new recruits (young fish) entering the fishery each year. Various techniques are used by scientists to estimate these parameters.

For NE Atlantic mackerel, an analytical model is used with catch numbers-at-age data from fishery and fishery-independent abundance indices from egg surveys (4). Research cruises are undertaken to obtain quantitative samples of planktonic eggs produced over the whole spawning period. Knowing the number of eggs produced per female, and the size and sex composition of the population, allows scientists to estimate the abundance of adult mackerel in the stock – the spawning stock biomass (SSB) (5). This survey has been carried out every three years since 1977, the latest in 2010. These estimates are used to make an assessment of the status of the stock in relation to Maximum Sustainable Yield (MSY) and precautionary reference points. See Page 3.

In the NW Atlantic, a similar survey is conducted in southern Gulf of St. Lawrence and has been used to assess stock status in Canadian waters (latest 2008). The first assessment of the whole NW Atlantic stock (Canadian and USA waters) was carried out in March 2010, using a population model from three fishing surveys (6), but uncertainty in the results meant they can't be used as a basis for management advice. There have been no new assessments since.

Maximum Sustainable Yield (MSY) and the precautionary approach

Current ICES advice on mackerel stocks given on the basis of the multi annual plan (7) which has been assessed as precautionary (8). However, this plan is not fully in operation at present see page 8.

Advice is also given in terms of Maximum Sustainable Yield (MSY) and the precautionary approach (9). MSY means fishing at a level that take the maximum catch (yield) from a fish stock that can safely be removed on a continuous basis, whilst maintaining its productive capacity in the long-term, keeping the stock above the biomass action point $B_{MSY-trigger}$. The precautionary approach aims to limit fishing to levels that avoid depleting the stock's reproductive capacity (SSB), and its biomass reference level is defined as B_{pa} . Fish stocks can be classified into six categories under the twin MSY/precautionary approach strategy (Table 1).

Categories 1 to 3 will result in advice for catches consistent with fishing levels that would result in MSY, in the case of those in category 3 (9) transition to MSY by 2015. Catches are also advised in relation to the precautionary approach which relates to whether a stock is able to reproduce sufficiently to support a commercial fishery. For many fish stocks, including NE Atlantic mackerel, parties exploiting the stock have management plans (7,8 see above), and ICES provides advice on catches compatible with such plans.

Categories 4 and 5 will result in advice to rebuild stocks through reducing catches or other measures.

Although the Transboundary Resources Assessment Committee (TRAC) has proposed MSY reference points for NW Atlantic mackerel (6), their adoption has not been recommended in view of the uncertainties in the assessment.

Table 1: SEAFISH MSY / PRECAUTIONARY APPROACH CATEGORIES; Table 2 & Fig 1
<p>1. Inside safe biological limits and fished at MSY. The stock is of a sufficient size for reproduction to support a commercial fishery, that exploits it at MSY.</p>
<p>2. Inside safe biological limits but fished below MSY. The stock is of a sufficient size for reproduction to support a commercial fishery, but fishing could be increased to achieve MSY.</p>
<p>3. Inside safe biological limits but fished above MSY. The stock is of a sufficient size for reproduction to support a commercial fishery, but corrective action is required to reduce fishing to levels that are consistent with MSY.</p>
<p>4. Stocks at risk of being outside safe biological limits and below the biomass action point $B_{MSY-trigger}$. There is concern that the stock needs to be rebuilt and fishing should be reduced to a level that allows this. In most cases, $B_{MSY-trigger}$ is set at the precautionary biomass reference level B_{pa}; for western mackerel there is a slight difference, related to the method of calculation $B_{MSY-trigger} = 2.3 \text{ M t}$ and $B_{pa} = 2.2 \text{ M t}$.</p>
<p>5. Stock outside safe biological limits. The stock is depleted to the extent that that reproduction may be impaired. Action should be taken appropriate to each stock to further reduce fishing and encourage stock rebuilding.</p>
<p>6. Reference points not defined. Where precautionary or MSY reference points are not defined or could not be used as basis for assessment of stock status. There may be indications that the stock is in good or poor condition, which are described in Table 2.</p>

Table 2: Management Stock (colour keyed to Table 1 and Figure 1 on page 5)	ICES estimate of catches for 2011 (t) (10)	Advisory TAC 2011 (t)	Scientific advice, for management see section 'Management and Conservation' page 8 (October 2011 ICES advice) (10) www.ices.dk/advice/icesadvice.asp
North East Atlantic (NEA)			
Category 1. Inside safe biological limits			
NEA; All components: ICES Division and Sub-areas IIa & Vb; III & IV, V, VI, VII, VIIIa, b, d, e; VIIIc, IXa & X	927,000	Between 592,000 and 646,000 for entire stock under management plan	<p>Stock components The western component of this stock comprises 76% of the entire NE Atlantic stock. The Southern component makes up most of the rest, along with the small North Sea component.</p> <p>Stock status In August 2011, ICES estimated that the SSB had more than doubled from a low of 1.68 million (M) t in 2002 to around 3.1 mt in 2009, and is currently at 2.9 M t, well above the action level ($B_{MSYtrigger} = 2.3$ M t). Fishing mortality (F) was high during the 1990s, then declined and has been relatively stable since 2006, and was estimated at 0.26 in 2010, just, above F_{MSY} (0.22). The 2005 and 2006 year classes are the highest on record, helping SSB in 2009 to reach the highest level for the last 30 years. The 2007, 2008 and 2009 year classes are about average. Nine NE Atlantic mackerel fisheries are MSC certified (11).</p> <p>See Management and Conservation section for management.</p>
Western Component: ICES IIa & V, parts of div IVa, Sub-areas VI, VII & Division VIIIa,b,d,e	Included in above		
Southern Component: ICES division VIIIc, Sub-areas IXa & X	Included in above		
Category 5. Stock outside safe biological limits. The stock is in a condition where there is concern that reproduction may be impaired. Action should be taken appropriate to each stock to further reduce fishing and encourage stock rebuilding.			
NEA North Sea Component Sub-areas IV & IIIa	Included in above	Maximum protection - closed areas & seasons -minimum landing size	Very large catches were taken in the 1960s, peaking at around 1 M t in 1967, but the fishery collapsed and catches declined to less than 100,000 t in the late 1970s. Catches during the last five years are assumed to be about 10,000 t pa. The 2002 and 2005 triennial egg surveys in the North Sea indicate similar SSB levels (the highest for 20 years), but egg production in the 2008 and 2011 egg surveys had decreased by around 25%.
Organisation key:			
<p>ICES: International Council for the Exploration of the Sea. Responsible for providing scientific advice for North East Atlantic fishery management.</p> <p>EU: The European Union manages fisheries within the European Economic Zone.</p> <p>FAO: Food and Agriculture Organisation of the United Nations. Acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy.</p> <p>MSC: The Marine Stewardship Council is an independent, non-profit organisation that promotes responsible fishing practices.</p>			

Table 2: Management Stock (colour keyed to Table 1 and Figure 1 below)	Total landed catches for 2009 (t) (12)	Advisory TAC 2011 (t)	Scientific advice and management
North West Atlantic (NEA)			
Reference points not defined			
Mackerel in Canadian waters: Gulf of St Lawrence, Scotian Shelf, Newfoundland (NAFO 2,3 and 4)	Canadian 41,610	<80,000 (combined NAFO Subareas 2-6)	NW Atlantic mackerel (NAFO Subareas 2-6) is assessed as a single stock with northern and southern spawning components that mix in Canadian and USA waters. Commercial landings in the Canadian fishery peaked at over 50,000 t between 2004 and 2007, and in the USA fishery at 56,640 t in 2006. In April 2010, the TRAC observed that there was no reliable analytical assessment of stock status relative to reference points, and no new assessment has been performed to date (Oct. 2011). Based on indications of reduced productivity and lack of older fish in the survey and catch (the SSB is estimated to have declined from > 300,000 t in 2001–2002, to 150,000 t or less in 2006-2008, accompanied by an increase in fishing mortality). TRAC recommended that annual total catches should not exceed the average landings (80,000 t) over the last three years (2006-2008) until such time that new information suggests otherwise.
Mackerel in USA waters: Cape Hatteras, Rhode Island, Georges Bank, Gulf of Maine. (NAFO 5 and 6)	USA 23,144		

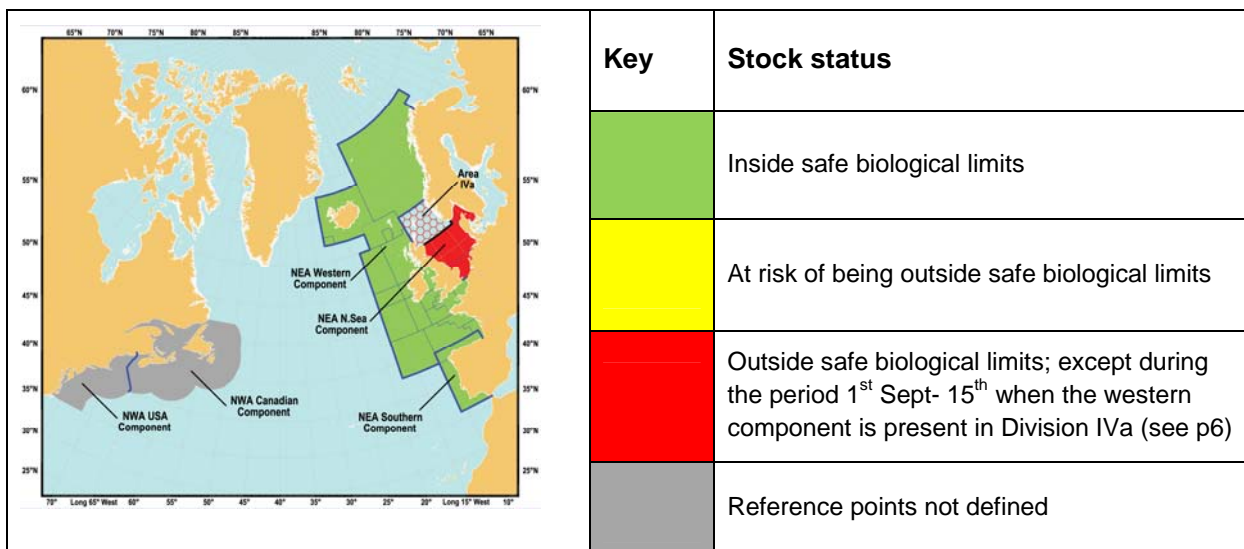
Organisation key:

NAFO: Northwest Atlantic Fisheries Organisation. Provides science and management in Northwest Atlantic international waters.

NEAFC: North East Atlantic Fisheries Commission. Recommends measures to maintain rational exploitation of fish stocks in the high seas Atlantic and Arctic Oceans.

MAFMC: The Mid-Atlantic Fishery Management Council. Responsible for management of fisheries in United States federal waters off the mid-Atlantic coast of America.

Figure 1: Management stocks of North Atlantic mackerel (colour keyed to tables 1 and 2)



Management and conservation measures

The key to successful management of fisheries is to design regulations to control them and which take account of the biology of the fish and environmental factors that influence the populations' dynamics and production. The main measures for control of mackerel fisheries and their environmental effects are described below, whilst major trends in stocks and implications for management are discussed overleaf.

The major part of mackerel catches are taken in a single species fishery by relatively few large vessels, using purse seine or trawl. It should, therefore, be easier to enforce catch limits and bans on mackerel fisheries, than on mixed fisheries using many vessels. However, there were substantial levels of illegal landings from the NE Atlantic mackerel fishery, mainly before the introduction of the Registration of Buyers and Sellers legislation in 2005/6 (13). This should have almost eliminated illegal catches.

Another source of uncertainty is discarding, due to the size or species composition of the catch not being suited to market needs. ICES' estimates that 1% of the catch is discarded, but this is considered to be an underestimate. The EU-Norway agreement (14) includes a ban on high grading and slipping (letting fish go before they are landed on deck). These measures should enhance conservation of mackerel in EU and Norwegian waters.

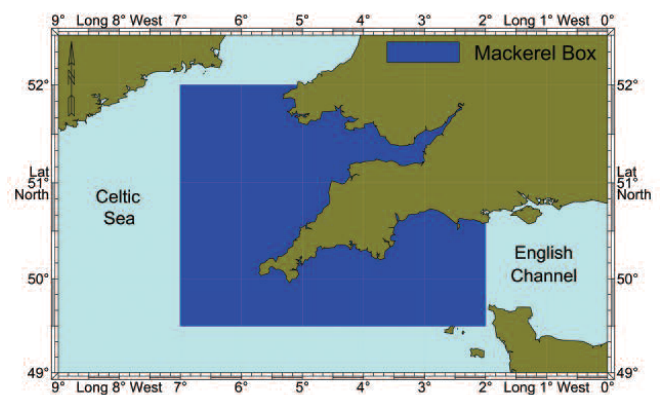
Seasonal and spatial management

Strict management measures remain in force to aid continued recovery of the North Sea spawning component, including:

- No targeted fishing for mackerel in ICES Division IIIa and IVb and c at any time;

- A seasonal restriction on fishing in Division IVa (the fishery is open from 1 Jan to 15 Feb and 1 Sept to 31 Dec when the Western component of the NE Atlantic stock is present in this area). See Figure 1.
- Juvenile mackerel are protected within the 'mackerel box' off the Cornish coast and in the South Western Approaches (15) (Figure 2), in which there is a ban on targeted fishing for mackerel by trawlers and purse seiners and where a handline fishery operates with a separate quota allocation.

Figure 2: The South West of England Mackerel Box



Management and conservation measures contd

Environmental effects

There is a small risk of cetaceans (dolphin and porpoise) being taken in pelagic-trawl fisheries. Recent monitoring of UK vessels required by EU regulations (16,17) found no by-catches of cetaceans in mackerel trawl fisheries. However, a by catch of salmon has been reported from Norwegian mackerel fisheries and, most recently, from areas off eastern and north east Iceland during the early summer (18). MSC certified fisheries are required to report sightings and catches of Protected or Endangered species (PETS).

Mackerel feed mainly on zooplankton and small pelagic fish (19). They are eaten by large demersal fish, cetaceans and other species (20). Depletion of mackerel stocks by fishing has the potential to affect these feeding relationships, but good management can help to avoid any adverse ecological effects on food chains.

Ocean warming and mackerel distributions

Trawl and acoustic surveys in the Norwegian Sea indicate that NE Atlantic mackerel stock distribution has recently extended further north and west during the summer feeding migration (4). This is reflected in the pattern of spawning by the western component. A statistically significant northward shift in mackerel egg distribution (1977–2010) is correlated with the mean sea surface temperature of the NE Atlantic: for every 1 °C of warming the annual centre of spawning has moved around 39 km north (21).

A similar temperature-related distribution shift has been observed in the overwintering distribution of NW Atlantic mackerel (22).

Between 1968 and 2008, the stock moved progressively from the deeper offshore mid-Atlantic region to the shallower southern New England continental shelf, a shift of about 250 km to the north, most recently moving onto Georges Bank. This shift is associated with warming of continental shelf waters, leading to an increase in the area over which the stock can be distributed (Atlantic mackerel prefer water above 5 °C). Whilst the coastal Canadian commercial mackerel fishery has continued to thrive, the U.S. mackerel fishery has declined in recent decades.

These changes in mackerel distribution are related to large-scale environmental forces, or climate drivers such as the North Atlantic Oscillation and the Atlantic Multi-decadal Oscillation, which support a general warming trend on the continental shelf. At present, it is not known whether these distribution changes are a direct consequence of observed warming (habitat availability), changes in food availability, or increased stock size in which more large individuals are able to migrate long distances during their search for food (4).

The increased temperature observed in the Nordic Seas during recent summers (23) might have increased the potential habitat for mackerel, though a decline in zooplankton biomass since 2002 could be increasing feeding competition between mackerel and herring, forcing the pelagic species to expand their feeding areas. Since mackerel plays a central role in the food web of the ecosystem, there may be implications of these distribution changes for other species, but no evidence of impacts has been published.

Management implications of distribution changes

Between 2001 and 2009, the internationally agreed TACs for NE Atlantic mackerel have covered most of the stock's distribution area. The advised TAC covered Northern (ICES Subareas and Divisions IIa, IIIa,b,d, IV, Vb, VI, VII, VIIIa,b,d,e, XII, XIV) and Southern components (Divisions VIIIc and IXa).

However, there has been a rapid expansion in the previously insignificant fisheries for mackerel in Icelandic and Faeroese waters since 2006. Catches in this area in 2010 represented approximately 21% of the total reported NE Atlantic mackerel landings.

The TAC for 2009 was set in accordance with the long-term management plan, evaluated by ICES as precautionary, and agreed in October 2008. This formalised the Coastal States/NEAFC agreements between the EU, Norway and the Faeroe Islands, which were in force from 1999 to 2009, and were designed to ensure sustainable exploitation of NE Atlantic mackerel and stability of the catches.

Unilateral action in 2010

In 2010, Iceland, and the Faeroe Islands, unilaterally set high mackerel fishing quotas outside the Coastal States/NEAFC agreements. The present situation, with no international agreements on management of mackerel fisheries and no overall TAC, risks causing the collapse of the NE Atlantic mackerel stock, to the detriment of all the fleets and industries concerned.

ICES advice

The consequences of overfishing in 2010 and 2011 were explored by ICES (4). ICES estimated a total catch of ~870,000 t in 2010, corresponding to a fishing mortality (0.26) that is above that recommended by the management plan (0.2-0.22).

No formal TAC was agreed for any areas for 2011. However, ICES estimated that the planned catches, by the EU, Norway, the Faeroes and Iceland, represent a total catch of nearly 930,000 t of mackerel in 2011. If this level of catch is maintained in 2012 and 2013 the spawning stock biomass (SSB) in 2013 could decline to 2.391 million t. ($B_{MSY\ trigger}$ set at 2.2 million t). Whilst the stock is not predicted to be in the at risk category in 2013 (category 4 on Table 1) there is a clear imperative to set an overall TAC aimed to be compatible with sustainable long-term yields and avoid risks to the spawning stock.

On the basis of the management plan ICES advises a catch in 2012 of between 586,000 t and 639,000 t. These catch levels are predicted to lead to a fishing mortality of 0.22 which is compatible with the management plan and MSY, and result in a spawning stock biomass in 2013 to around 2.7 million t, well above $B_{MSY-trigger}$.

The EU and Norway have set a provisional TAC of 420,000 t (26). However, this must be set in the context of the catch for the whole stock which had not yet been agreed in January 2012. Negotiations are continuing.

