NORTH EAST ATLANTIC MACKEREL

Stock name: North east Atlantic mackerel
Latin name: *Scomber scombrus*
Geographical area: Northeast Atlantic Ocean (ICES subareas 1-2, 4-8, division 3a)
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Date: 07 February 2020

Stock Sensitivity Attributes

HABITAT SPECIFICITY: Northeast Atlantic mackerel (*Scomber scombrus*, Scombridae) is widely distributed in the Northeast Atlantic (Hamre, 1980; ICES, 2019; Iversen, 2004; Trenkel et al., 2014). Mackerel is also present in high latitudes in the Barents Sea and north to Isfjorden in Svalbard at 78 °N (Berge et al., 2015; Nøttestad, Utne, et al., 2016). The stock is therefore a habitat generalist and utilizes very common and diverse habitats in pelagic waters over a very large range (ICES, 2019; Nøttestad, Utne, et al., 2016; Nøttestad, 2019; Olafsdottir et al., 2019).

PREY SPECIFICITY: Mackerel can feed on a whole variety of prey types depending on availability (Debes et al., 2012; Langøy et al., 2012; Prokopchuk & Sentyabov, 2006). Mackerel has a wide niche in both number of prey species and prey size groups ranging from micro-zooplankton to fish larvae, juveniles and adults. They may also exhibit cannibalistic feeding behaviour. The stock is therefore a pronounced prey generalist (Bachiller et al., 2016, 2018; Langøy et al., 2012). Earlier studies have shown clear density-dependent growth rate for mackerel. Thus, food availability is known to significantly affect growth rate and condition (weight and length at age) (Olafsdottir et al., 2016).

SPECIES INTERACTION: The interspecific interaction may particularly be present between mackerel and herring, but also between mackerel and blue whiting (Bachiller et al., 2016, 2018; Debes et al., 2012; Huse et al., 2012; Langøy et al., 2012; Nøttestad et al., 2014; Prokopchuk & Sentyabov, 2006; Utne et al., 2012). The stock is thus somewhat influenced by the feeding activity of other abundant competing pelagic planktivorous fish stocks but also predators in the same area (Bachiller et al., 2016, 2018; Huse et al., 2012; Nøttestad et al., 2014; Utne et al., 2012).

ADULT MOBILITY: Mackerel may stay in a broad range of environmental conditions, from cold (4-5 °C) to warm (20-25 °C) waters and with different prey types (ICES, 2019; Nøttestad, Diaz, et al., 2016; Nøttestad, Utne, et al., 2016). Adults cover a significantly broader geographical area than younger specimens, although juvenile mackerel may also have very broad distribution areas (Bjørdal, 2019; ICES, 2019; Jansen et al., 2015; Nøttestad, Utne, et al., 2016). There might be homing behaviour both when it comes to spawning and feeding. Nevertheless, during the last 10-15 years mackerel have shown a remarkable dynamic in space and time during their annual migration routes. Mackerel is thus considered highly mobile and non-site dependent.

DISPERSAL OF EARLY LIFE STAGES: Mackerel may spawn from November to July (> 6 months) and over an extensive area covering several million km^2 (ICES, 2019; O'Hea et al., 2019). Mackerel has therefore highly dispersed eggs and larvae in space and time. Duration of planktonic eggs and larvae is > 8 weeks and > 100 km from spawning locations.

EARLY LIFE HISTORY SURVIVAL AND SETTLEMENT REQUIREMENTS: The typical temperature range at egg development has been noticed to be around 12-13 °C for samples taken in waters off south Portugal (January) to Scotland (June) (Ibaibarriaga et al., 2007). The larval stage is resilient to environmental change (ICES, 2019; O'Hea et al., 2019).

COMPLEXITY IN REPRODUCTIVE STRATEGY: The reproductive success of mackerel is likely little dependent on specific environmental conditions (ICES, 2019; Jansen et al., 2015; O'Hea et al., 2019). However, one uncertainty is whether mackerel is a deterministic or non-deterministic spawner.

Several spawning grounds exist, although there are still some disagreements among scientists whether Northeast Atlantic mackerel is a metapopulation with overlapping spawning areas or three distinct spawning components (southern, western and North Sea). The stock is nevertheless managed as one stock over its entre distribution area.

SPAWNING CYCLE: Mackerel may spawn from November in Portuguese waters in the south of the distribution area to July in Norwegian waters in the north (ICES, 2019; O'Hea et al., 2019). This means that the stock may spawn continuously throughout most of the year (6-9 months). The implication is that there is a large probability for successful spawning each year within at least part of the extensive spawning season and spawning area, and thus not suffer from spawning failure.

SENSITIVITY TO TEMPERATURE: Mackerel is very robust to changes in temperature due to their wide distribution and pronounced possibility for vertical migration and swimming (ICES, 2019; Iversen, 2004; Nøttestad, Diaz, et al., 2016; Nøttestad et al., 2019; Nøttestad, Utne, et al., 2016; Olafsdottir et al., 2016, 2019). They may survive and thrive in sea temperatures ranging from 3 °C to 25 °C (ICES, 2019).

SENSITIVITY TO OCEAN ACIDIFICATION: There is no indication that Northeast Atlantic mackerel is sensitive to potential ocean acidification. The updated stock assessment and stock status on abundance and recruitment indicate that mackerel is at present on a record high spawning stock biomass (SSB) level with historically high recruitment during the last 10-15 years (ICES, 2019).

POPULATION GROWTH RATE: The Northeast Atlantic mackerel has a high population growth rate with a high productivity of the stock (ICES, 2019).

STOCK SIZE/STATUS: Biomass/biomass maximum sustainable yield ≥ 1.2. SSB and stock status are presently on a very high level, including historically high recruitment during the last years (ICES, 2019).

OTHER STRESSORS: The stock is experiencing no known stress other than fishing. On the other hand, a range of predators probably perform similar stress on the mackerel than fishing.

Scoring of the considered sensitivity attributes

Sensitivity attributes, climate exposure based on climate projections allowing the evaluations of impacts of climate change, and accumulated directional effect scoring for Northeast Atlantic mackerel (*Scomber scombrus*) in ICES subareas 1-2, 4-8, division 3a. L: low; M: moderate; H: high; VH: very high, $Mean_w$: weighted mean; N/A: not applicable. Usage: this column was used to make ad hoc notes, including considerations about the amount of relevant data available: 1 = low, 2 = moderate; 3 = high. N/A = not applicable.

Northeast Atlantic mackerel (*Scomber scombrus*) in ICES subareas 1-2, 4-8, division 3a

SENSITIVITY ATTRIBUTES	L	M	H	VH	$Mean_w$	Usage	Remark
Habitat Specificity	1	3	1	0	**2.0**		
Prey Specificity	0	3	2	0	**2.4**		
Species Interaction	0	1	3	1	**3.0**		
Adult Mobility	0	0	3	2	**3.4**		
Dispersal of Early Life Stages	0	1	3	1	**3.0**		
ELH Survival and Settlement Requirements	5	0	0	0	**1.0**		
Complexity in Reproductive Strategy	1	3	1	0	**2.0**		
Spawning Cycle	1	3	1	0	**2.0**		
Sensitivity to Temperature	0	3	2	0	**2.4**		
Sensitivity to Ocean Acidification	5	0	0	0	**1.0**		
Population Growth Rate	0	1	3	1	**3.0**		
Stock Size/Status	2	3	0	0	**1.6**		
Other Stressors	1	3	1	0	**2.0**		
Grand mean					**2.22**		
Grand mean SD					**0.75**		

CLIMATE EXPOSURE	L	M	H	VH	$Mean_w$	Usage	*Directional Effect*
Surface Temperature	0	3	2	0	**2.4**		1
Temperature 100 m	0	0	0	0		N/A	
Temperature 500 m	0	0	0	0		N/A	
Bottom Temperature	0	0	0	0		N/A	
O_2 (Surface)	4	1	0	0	**1.2**		-1
pH (Surface)	4	1	0	0	**1.2**		-1
Gross Primary Production	1	3	1	0	**2.0**		1
Gross Secondary Production	1	3	1	0	**2.0**		1
Sea Ice Abundance	0	0	0	0		N/A	
Grand mean					**1.76**		
Grand mean SD					**0.54**		
Accumulated Directional Effect					**–**		**4.0**

***Accumulated Directional Effect*: POSITIVE**	**4.0**

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