

**Stock name:** North Sea saithe

**Latin name:** *Pollachius virens*

**Geographical area:** North Sea, West of Scotland and Skagerrak (ICES subareas 4, 6 and division 3.a)

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### Stock Sensitivity Attributes

**HABITAT SPECIFICITY:** Saithe occurs (*Pollachius virens*, Gadidae) both demersally and pelagically. The species is widely distributed in coastal and fjordic waters, as well as on the shelf and the slope restricted to 400 m bottom depth (Heino et al., 2012; Jakobsen, 1985; Olsen et al., 2010). Typically, younger age classes (0-2 years) are present in shallow coastal areas and fjords. Older age classes (3+) are also distributed in deeper waters further offshore, including banks in the northern North Sea (NS) and along the Norwegian Trench (Heino et al., 2012; Jakobsen, 1985) (Reecht, unpublished data). Adult NS saithe displays extended migrations into the waters of the neighbouring stocks, i.e. Northeast Arctic, Faroese and Icelandic stocks (E. í Homrum et al., 2013; Saha et al., 2015).

**PREY SPECIFICITY:** Adult NS saithe prey on a diversity of species, including blue whiting (*Micromesistius poutassou*), Norway pout (*Trisopterus esmarkii*), sandeel (*Ammodytes marinus*), herring (*Clupea harengus*), and krill (Nedreaas, 1987; Mehl, unpublished data). Juvenile fish prey primarily on appendicularians (*Oikopleura dioica*), copepods (*Calanus finmarchicus*) and krill (*Thysanoessa inermis*) (E. í Homrum et al., 2012).

**SPECIES INTERACTION:** NS saithe is a top predator, and feeds at the same trophic level as cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Its habitat overlaps to a large degree with that of coastal cod (and seasonally with NS cod), haddock, pollack (*Pollachius pollachius*) and European hake (*Merluccius merluccius*) (Cormon et al., 2014). Inter-specific competition will therefore be directly affected by changes in abundance of the NS haddock and cod stock. The expansion of European hake in the Northern North Sea and associated emergence of stronger competition for Norway pout in particular, is expected to have negative effects on saithe (Cormon et al., 2014; Cormon, Kempf, et al., 2016). Diet analyses show that European hake as well as cod feed to a limited degree on saithe (Werner, 2015), whereas particularly the more littoral distributed juvenile fish (0-2-year-old) are preyed on by sea birds (Lorentsen et al., 2018).

**ADULT MOBILITY:** Saithe, as a species, is distributed along the continental shelf from (occasionally) the northern Bay of Biscay northwards into the Barents Sea and North Sea and is found on the shelf around Greenland and Iceland. Genetic analyses indicate high degree of gene flow in the North Atlantic (Saha et al., 2015), where temperature ranges between 3 and 12 °C. Juvenile fish in comparison to 3+ year old fish are dependent on the protective habitats of the shallow coastal areas and littoral zones (Jakobsen, 1985).

**DISPERSAL OF EARLY LIFE STAGES:** Saithe in the North Sea and the Norwegian Sea spawns both on shallow (200 m) banks and coastal areas (Jakobsen, 1974; Olsen et al., 2010), where water temperatures are between 5.5-10 °C (Reinsch, 1976). From the spawning areas in the North Sea eggs and larvae are transported mainly southwards by the Atlantic inflow and inshore along the Norwegian west coast (Sundby et al., 2017). One smaller fraction of the pelagic larvae is carried northwards by the Norwegian Coastal Current and lost from the North Sea to the inshore areas of Mid Norway (e.g. Møre coast). The larvae develop mainly inshore, and juveniles spend their first 2-3 years there. The range of dispersal is likely quite high, given that genetic variation between the North Sea and the southern parts of the Norwegian Sea (north of 62 °N) is low (high level of gene flow) (Eiríksson & Árnason, 2015; Saha et al., 2015).

However, from the pelagic offspring dispersal pattern, the Northeast Arctic stock receives pelagic juvenile from the Icelandic, the Faroese and the North Sea stocks, while transport is unlikely to occur vice versa from the Northeast Arctic stock to the three afore-mentioned stocks (Bjørke & Sætre, 1994). Pelagic juvenile exchanges among the Icelandic, Faroese and North Sea stock are less likely to occur, although a certain transport from the Faroese to the North Sea stock is possible. A major part of possible exchange among the four stock has to occur from adult migration.

**EARLY LIFE HISTORY SURVIVAL AND SETTLEMENT REQUIREMENTS:** Saithe eggs are spawned and subsequently rise to the surface layer. Development until hatching is shorter at 9 °C compared to 6 °C (Svetovidov, 1962), and larvae hatch in the pelagic zone at 3.4-3.8 mm total length (Ehrenbaum, 1964). When saithe reaches the juvenile stage at 3-5 cm total length, it is assumed to perform a demersal lifestyle (Reinsch, 1976). Spawning takes place from January until end of March (Reinsch, 1976; Rogers & Stocks, 2001), implying that the spring bloom is of importance in the development of the larvae. Spawning areas are confined to the northern North Sea and partly southward along the western slope of the Norwegian Trench (Sundby et al., 2017). Modelling of transport and dispersal of eggs and larvae (Sundby et al., 2017) shows that initial transport occurs southwards by the inflowing Atlantic Current along the western slope of the Norwegian Trench. Thereafter, the pelagic early juveniles are carried in the Norwegian Coastal Current and transported northwards. The early juveniles are found along the coastal shoreline from Rogaland and northward to Stad. The modelling study also indicates one fraction of the pelagic offspring being transported northeastward from the major spawning area at Vikingbanken and onto the Møre plateau, which carries the offspring into the southernmost spawning areas of Northeast Arctic saithe. It is unknown whether such intermixing in the early stages results in gene flow from the North Sea saithe to the Northeast Arctic saithe.

**COMPLEXITY IN REPRODUCTIVE STRATEGY:** Little is known about the spawning behaviour of NS saithe, but the species is considered a group-synchronous, and determinate batch spawner, like cod (Murua & Saborido-Rey, 2003). Saithe sometimes starts maturing at age 3 but most individuals mature at age 4-6 and at a corresponding length of about 46-61 cm (ICES, 2017). However, surveys on spawning grounds in the NS, since 2017, suggest an even later maturation in recent years, occurring mostly at age 5-7 (53-68 cm; Reecht, unpublished data). Spawning occurs at 100-200 m bottom depth. Spawning success depends on temperature and currents during the spawning period (Reinsch, 1976). The main spawning areas extend from Viking Bank to west of Shetland as well as, to a lower degree, along the western slope of the Norwegian Trench (Rogers & Stocks, 2001; Sundby et al., 2017).

**SPAWNING CYCLE:** Saithe starts developing gonads by late October/early November (Skjæraasen et al., 2017), while spawning takes place in January to May (Sundby et al., 2017), with a peak period expected around mid-February to mid-March, slightly earlier than in the southern component of Northeast Arctic saithe in late February-March (Bjørke et al., 1988). Temperature between the surface and 50 m depth during the spawning season ranges between 6-9 °C (Mehl et al., 1988).

**SENSITIVITY TO TEMPERATURE:** Saithe is considered a boreal species, preferring a cold thermal environment with a temperature range of 4-15 °C, similar to cod (Dulvy et al., 2008). In the North Sea a deepening of the saithe's distribution, probably due to an increase of bottom temperatures, has occurred between 1980 and 2004 (Dulvy et al., 2008). While growth of saithe is dependent on prey availability and population density, no effect of temperature is shown (Cormon, Ernande, et al., 2016).

**SENSITIVITY TO OCEAN ACIDIFICATION:** The diet of juvenile saithe includes a range of crustaceans (Nedreaas, 1987), which may be negatively affected, i.e. experience reduced growth, by a decrease in marine pH (Whiteley, 2011), and resultingly negatively impact growth of juvenile fish (van Deurs et al., 2015). However, fish become more dominant in saithe diet with increasing size, thereby reducing the potential of cascading negative impacts of ocean acidification.

**POPULATION GROWTH RATE:** Age at maturity ( $L_{50}$ ) is estimated between 4 and 5 years (ICES, 2017), although most recent winter survey data, since 2017, suggest a later maturation (Reecht, unpublished data). Saithe can reach lengths  $> 100$  cm (estimated length at infinity  $> 90$  cm) and an age  $>15$  years (E. Í. Homrum et al., 2012).

**STOCK SIZE/STATUS:** The NS saithe stock is managed following a maximum sustainable yield (MSY) approach. The spawning stock biomass (SSB) has been over the precautionary reference point for biomass ( $B_{pa}$ ) since the mid-1990s, but has been decreasing in recent years following an increase in the instantaneous rate of fishing mortality (F) (above precautionary reference point for F ( $F_{pa}$ ) in 2019) (ICES, 2020a, 2020b). The SSB is estimated, as of beginning of 2020, to about 167,000 tonnes, slightly above MSY  $B_{trigger}$  (149,000).

**OTHER STRESSORS:** Commercial fishing is the major stressor on the NS stock (ICES, 2020b). The impact of climate change/ecosystem changes on the stock is unknown.

**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 North Sea saithe (*Pollachius virens*) in ICES subareas 4, 6, division 3.a. L: low; M: moderate; H: high; VH: very high, Mean<sub>w</sub>: 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.

North Sea saithe (*Pollachius virens*) in ICES subareas 4, 6, division 3.a

SENSITIVITY ATTRIBUTES	L	M	H	VH	Mean <sub>w</sub>	Usage	Remark
Habitat Specificity	3	0	2	0	1.8		
Prey Specificity	1	4	0	0	1.8		
Species Interaction	1	2	2	0	2.2		
Adult Mobility	4	1	0	0	1.2		
Dispersal of Early Life Stages	2	3	0	0	1.6		
ELH Survival and Settlement Requirements	0	1	2	2	3.2		
Complexity in Reproductive Strategy	2	3	0	0	1.6		
Spawning Cycle	0	1	4	0	2.8		
Sensitivity to Temperature	0	2	3	0	2.6		
Sensitivity to Ocean Acidification	4	1	0	0	1.2		
Population Growth Rate	0	0	5	0	3.0		
Stock Size/Status	2	3	0	0	1.6		
Other Stressors	5	0	0	0	1.0		
<b>Grand mean</b>					<b>1.97</b>		
<b>Grand mean SD</b>					<b>0.73</b>		

CLIMATE EXPOSURE	L	M	H	VH	Mean <sub>w</sub>	Usage	Directional Effect
Surface Temperature	0	0	0	0		N/A	
Temperature 100 m	0	0	2	3	3.6	3	-1
Temperature 500 m	0	0	0	0		N/A	
Bottom Temperature	0	0	0	0		N/A	
O <sub>2</sub> (Surface)	3	2	0	0	1.4	2	0
pH (Surface)	4	1	0	0	1.2	2	-1
Gross Primary Production	4	1	0	0	1.2	1	1
Gross Secondary Production	0	2	2	1	2.8		-1
Sea Ice Abundance	0	0	0	0		N/A	
<b>Grand mean</b>					<b>2.04</b>		
<b>Grand mean SD</b>					<b>1.10</b>		
<b>Accumulated Directional Effect</b>					<b>-</b>		<b>-6.4</b>

**Accumulated Directional Effect: NEGATIVE**

**-6.4**

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