NORTH EAST ARCTIC SAITHE

Stock name: North east Arctic saithe
Latin name: *Pollachius virens*
Geographical area: Norwegian Sea and Barents Sea (ICES subareas 1 and 2)
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Stock Sensitivity Attributes

HABITAT SPECIFICITY: Northeast Arctic saithe (*Pollachius virens*, Gadidae) occurs 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-old) are present in shallower coastal areas and fjords, compared to older age classes (3+) that are also distributed in deeper waters further offshore, including banks (Heino et al., 2012; Jakobsen, 1985). Northeast Arctic saithe displays extended migrations into the North Sea and adjacent waters (E. í Homrum et al., 2013; Saha et al., 2015).

PREY SPECIFICITY: Adult Northeast Arctic 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(*Trisopterus esmarkii*), sandeel (*Ammodytes marinus*), herring (*Clupea harengus*), and krill (Nedreaas, 1987; Mehl, unpublished data).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*, Oikopeuridae), copepods (*Calanus finmarchicus*) and krill (*Thysanoessa inermis*) (E. Í. Homrum et al., 2012).

SPECIES INTERACTION: Northeast Arctic 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 Northeast Arctic cod), haddock, pollack (*Pollachius pollachius*, Gadidae) and to some extent European hake (*Merluccius merluccius*) in the southern coastal area of the Norwegian Sea (Staby, unpublished data). Interspecific competition will therefore be directly affected by changes in abundance of the generally large Northeast Arctic haddock and cod stock. It is likely that competition with other top predators for food resources, as illustrated for the expanding European hake in the North Sea with Norway pout, will have negative effects on saithe (Cormon 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 is distributed along the continental shelf from the 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/littoral zone (Jakobsen, 1985). Although 0-group saithe have been reported in August/September off Svalbard already at the end of the 1960s these juveniles often did not survive the cold winter temperatures (Hylen & Jakobsen, 1971).

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 eggs and larvae are transported mainly northwards and inshore where larvae develop, and juveniles spend their first 2-3 years. 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). Juvenile saithe has been observed as far north as Svalbard (Hylen & Jakobsen, 1971). The absence of spawning fish in this area implies that these juveniles were produced further south along the Norwegian coast and that developing larvae were transported

northwards by currents.

EARLY LIFE HISTORY SURVIVAL AND SETTLEMENT REQUIREMENTS: Saithe eggs are spawned, rise to the surface layer, and are transported northwards and towards the coast (Mehl et al., 1988). 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). Though larvae are also found offshore, they occur mainly in costal and fjordic areas, where individuals grow until 2-3 years of age, before returning to the open ocean (Mehl et al., 1988). Spawning takes place from late February until end of March (Reinsch, 1976), implying that the spring bloom is of importance in the development of the larvae.

COMPLEXITY IN REPRODUCTIVE STRATEGY: Little is known about the spawning behaviour of Northeast Arctic saithe, but the species is considered a group-synchronous, and determinate batch spawner, like cod (Murua & Saborido-Rey, 2003). Saithe starts maturing when 4-5 years old and at a corresponding length of 47-53 cm (Staby, unpublished data). Spawning occurs at 100-200 m bottom depth. Spawning success depends on temperature and currents during the spawning period (Reinsch, 1976). Established areas where Northeast Arctic saithe spawns include Haltenbanken, Langgrunna, Eggagrunnen and Røstbanken, as well as the western slope of Vestfjorden (Bjørke et al., 1988). However, at what time spawners arrive on the spawning grounds and where they come from is uncertain.

SPAWNING CYCLE: Saithe starts gonad development by late October/early November (Skjæraasen et al., 2017), while spawning takes place in the period 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). Changes in temperature in the Norwegian Sea will likely have a similar effect as those observed in the North Sea.

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), resulting in a negative impact on 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 5 and 6 years. Saithe can reach lengths > 100 cm (estimated length at infinity > 90 cm) and an age of >15 years (E. Í. Homrum et al., 2012).

STOCK SIZE/STATUS: The Northeast Arctic saithe stock is not managed according to biomass maximum sustainable yield (B_{MSY}) level, but according to a management plan with mortality (F_{mgt}=0.32). The spawning stock biomass has been above the limit reference point for spawning stock biomass (B_{lim}), since the mid-1990s and above the biomass precautionary approach reference point (B_{pa}) since the end of the 1990s (ICES, 2019).

OTHER STRESSORS: Commercial fishing is the major stressor on the Northeast Arctic stock (ICES, 2019). The impact of climate/ecosystem changes on the stock is unknow. It can be assumed though that as

for cod, recent increase in sea temperature may act positively on the growth of the stock.

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 Arctic saithe (*Pollachius virens*) in ICES subareas 1 and 2. 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 Arctic saithe (*Pollachius virens*) in ICES subareas 1 and 2

SENSITIVITY ATTRIBUTES	L	M	H	VH	$Mean_w$	Usage	Remark
Habitat Specificity	3	0	2	0	**1.8**		
Prey Specificity	1	4	0	0	**1.8**		
Species Interaction	3	2	0	0	**1.4**		
Adult Mobility	4	1	0	0	**1.2**		
Dispersal of Early Life Stages	3	2	0	0	**1.4**		
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	4	1	0	0	**1.2**		
Other Stressors	5	0	0	0	**1.0**		
Grand mean					**1.86**		
Grand mean SD					**0.77**		

CLIMATE EXPOSURE	L	M	H	VH	$Mean_w$	Usage	*Directional Effect*
Surface Temperature	0	0	0	0		N/A	
Temperature 100 m	0	3	2	0	**2.4**	3	1
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**	2	-1
pH (Surface)	4	1	0	0	**1.2**	1	-1
Gross Primary Production	4	1	0	0	**1.2**	2	1
Gross Secondary Production	0	3	2	0	**2.4**	2	1
Sea Ice Abundance	4	1	0	0	**1.2**	1	1
Grand mean					**1.60**		
Grand mean SD					**0.62**		
Accumulated Directional Effect					**–**		**4.8**

***Accumulated Directional Effect*: POSITIVE**	**4.8**

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