PORBEAGLE

Stock name: Porbeagle
Latin name: *Lamna nasus*
Geographical area: Northeast Atlantic (ICES subareas 1-2, 4-8, division 3a)
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Stock Sensitivity Attributes

HABITAT SPECIFICITY: The porbeagle (*Lamna nasus*, Lamnidae) is found in cold-temperate waters of the North Atlantic, the South Atlantic and the South Pacific Oceans (Compagno, 2001). There are no records from equatorial seas. It most commonly occurs in epipelagic waters over the continental shelf, shelf edges, offshore banks, and in the open ocean reaching depths of 1,300 m. Porbeagles exhibit diel vertical migration, spending their time in deeper water during daylight hours than during the night. They show considerable plasticity in diel depth changes within and between individuals and as a function of habitat type (S. E. Campana, Joyce, et al., 2010; Curtis et al., 2016; Francis et al., 2008, 2015; Pade et al., 2009).

PREY SPECIFICITY: Porbeagles are active predators of fish (including other sharks) and cephalopods. In the Northwest (NW) Atlantic their diet is dominated by pelagic fish and squid in deep water and by pelagic and demersal fish in shallow water (Joyce et al., 2002). They can feed on a wide variety of prey species but are generally feeding on only those three prey types mentioned above (pelagic fish, demersal fish, squid).

SPECIES INTERACTION: Porbeagles compete with other apex predators in the Northeast Atlantic for food. Those could be other sharks like the mako shark (*Isurus oxyrinchus*, Lamnidae) or marine mammals (Víkingsson & Kapel, 2000). Overfishing may be the major source of food competition for porbeagles as they feed on many commercially targeted species within the prey groups of pelagic fish, demersal fish, and squid. Porbeagles are no prey species for any other species.

ADULT MOBILITY: Porbeagles are highly mobile. Based on primarily NW Atlantic data, they migrate seasonally for specific purposes, such as mating and pupping. Satellite tagging data from the Northeast Atlantic show that, after migrations that can extend up to 2,000 km away from the point of release, the tagged porbeagles is able to return to their location of tagging. Recaptures were mainly along the western European coast rather than across the Atlantic, despite the large dispersal capacities. Only two cases have ever been documented and it is therefore assumed that ocean-basin-scale movements are very rare (Biais et al., 2017; Cameron et al., 2018; S. E. Campana et al., 2003; S. E. Campana, Joyce, et al., 2010; ICES, 2019; Jensen et al., 2002; Rigby et al., 2019; Saunders et al., 2011).

DISPERSAL OF EARLY LIFE STAGES: The porbeagle does not have planktonic early life stages. In addition, it has been suggested that juveniles and sub-adults may have more restricted ranges and movements and might be limited to lower latitudes than larger sharks (Cameron et al., 2019).

EARLY LIFE HISTORY SURVIVAL AND SETTLEMENT REQUIREMENTS: As an elasmobranch, this sensitivity attribute has marginal relevance.

COMPLEXITY IN REPRODUCTIVE STRATEGY: Spatial and temporal complexity due to the following reproductive behaviours: 1. seasonal reproduction (i.e. initiation with environmental cues) and 2. migration to specific mating and pupping areas (S. E. Campana, Gibson, et al., 2010; S. E. Campana, Joyce, et al., 2010; Francis et al., 2008; Jensen et al., 2002).

SPAWNING CYCLE: The reproductive cycle is one year. The porbeagle is an aplacental viviparous species and reproduces with a gestation of 8-9 months. Litter size averages four pups but ranges from one to five (Francis et al., 2008; Jensen et al., 2002).

SENSITIVITY TO TEMPERATURE: The porbeagle is regionally endothermic (warm-blooded) and prefers temperate waters less than 18 °C (Compagno, 2001). Porbeagles appear to occupy well defined and relatively constant temperatures throughout the year. Their preferred range is 5-16 °C and it has been suggested that they adjust their distribution in the waters column to stay in this preferred temperature range. Although it has been reported from studies in the NW Atlantic that sharks moved through temperatures ranging from 2-26 °C, they seem to spend the vast majority of time within the 75th percentile of that temperature range (S. E. Campana, Gibson, et al., 2010; S. Campana & Joyce, 2004; Carey et al., 1985; Curtis et al., 2016; Francis et al., 2008; Pade et al., 2009; Skomal et al., 2009). Changes in temperature in the range of those projected under various climate scenarios are unlikely to have a significant impact on the species.

SENSITIVITY TO OCEAN ACIDIFICATION: Indirect food web effects of ocean acidification (OA) have been shown particularly strong for some mammal, shark and demersal fish functional groups with modelled declines by more than 50% (Kroeker et al., 2013; Olsen et al., 2018). For example, porbeagles are feeding on squid as one of their three prey types and it is expected that cephalopods will experience negative impacts of OA due to their calcified vital structures. It is assumed that active animals have a higher capacity for buffering pH changes, and that the tolerance of CO_2 by marine fish appears to be very high (Fabry et al., 2008). As porbeagle is an active, highly mobile species, it is assumed that it has the ability to tolerate changes in CO_2 and buffer pH changes. This is however with respect to tolerance, and not taking potential negative behavioural and physiological effects into consideration. Those types of negative effects on e.g. hunting behaviour and growth have been shown for other predatory shark species and were pronounced when coupled with other stressors like increasing temperatures (Dixson et al., 2015; Pistevos et al., 2015, 2017; Rosa et al., 2017). A major limitation of the currently published studies on the effect of OA on sharks is that all of them have involved relatively sedentary, benthic sharks that are capable of buccal ventilation – no studies have investigated pelagic sharks that depend on ram ventilation. The North Sea and the Norwegian Sea are predicted to decline in pH between 0.8 and 1.2 by 2046 (NORWECOM.E2E). As porbeagles migrate between vital areas of e.g. mating and pupping, they will be exposed to a variety of OA levels.

POPULATION GROWTH RATE: The species matures late, is long-lived and has a small litter size, and is hence very vulnerable to overharvesting (Cassoff et al., 2007; ICES, 2019; ICES/ICCAT, 2009).

STOCK SIZE/STATUS: The International Commission for the Conservation of Atlantic Tunas (ICCAT) working group ran a range of model scenarios, the majority of which predicted that this stock was overfished, biomass $(B)_{2009} < B/ ½ B$ maximum sustainable yield (MSY), but that overfishing was not occurring in recent years, with fishing mortality (F) either near or below sustainable levels (F_{MSY}). The working group concluded that current management efforts were likely to result in the stock remaining stable and indicated that the stock would recover within 15-34 years under no fishing mortality (ICES/ICCAT, 2009).

OTHER STRESSORS: There is no targeted fishery for porbeagle, but it is reported as bycatch of many fisheries. The species is highly valued by recreational fishers, and although many practice catch and release, recreational fishing could be a threat due to post-release mortality (Rigby et al., 2019). Extensive boat traffic is expected to impact on the sharks, as seen for other larger marine species.

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 Porbeagle (*Lamna nasus*) 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.

Porbeagle (*Lamna nasus*) in ICES subareas 1-2, 4-8, division 3a

SENSITIVITY ATTRIBUTES	L	M	H	VH	$Mean_w$	Usage	Remark
Habitat Specificity	4	1	0	0	**1.2**		
Prey Specificity	3	2	0	0	**1.4**		
Species Interaction	4	1	0	0	**1.2**		
Adult Mobility	3	2	0	0	**1.4**		
Dispersal of Early Life Stages	0	0	0	5	**4.0**		
ELH Survival and Settlement Requirements	5	0	0	0	**1.0**		
Complexity in Reproductive Strategy	1	4	0	0	**1.8**		
Spawning Cycle	0	0	5	0	**3.0**		
Sensitivity to Temperature	1	4	0	0	**1.8**		
Sensitivity to Ocean Acidification	0	1	4	0	**2.8**		
Population Growth Rate	0	0	0	5	**4.0**		
Stock Size/Status	0	0	3	2	**3.4**		
Other Stressors	4	1	0	0	**1.2**		
Grand mean					**2.17**		
Grand mean SD					**1.12**		

CLIMATE EXPOSURE	L	M	H	VH	$Mean_w$	Usage	*Directional Effect*
Surface Temperature	0	0	0	0		N/A	
Temperature 100 m	0	1	2	2	**3.2**	2	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**	1	-1
pH (Surface)	4	1	0	0	**1.2**	2	-1
Gross Primary Production	4	1	0	0	**1.2**	1	0
Gross Secondary Production	4	1	0	0	**1.2**	1	1
Sea Ice Abundance	0	0	0	0		N/A	
Grand mean					**1.60**		
Grand mean SD					**0.89**		
Accumulated Directional Effect					**–**		**2.0**

***Accumulated Directional Effect*: POSITIVE**	**2.0**

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