GOLDEN REDFISH

Stock name: Golden redfish
Latin name: *Sebastes norvegicus*
Geographical area: Barents Sea (ICES subarea 1)
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Stock Sensitivity Attributes

HABITAT SPECIFICITY: Golden redfish (*Sebastes norvegicus*, Sebastidae) is a more shelf-bound species than the partially co-occurring *Sebastes mentella* and is generally absent in Arctic water (Barsukov et al., 1986; Zakharov et al., 1977). Therefore, its distribution is more limited to the southern and western Barents Sea. Juveniles can be found from below 0 °C to around 8 °C, moving to deeper water as coastal areas cool with the onset of winter (Pozdnyakov, 1970; Travin, 1952). In the western Atlantic species of the genus *Sebastes* were shown to avoid sandy substrate, preferring either coarse substrates, from gravel onwards or fine-grained sediment like silt (Scott, 1982b). Golden redfish is mostly absent from the southeastern Barents Sea where sandy substrates are abundant, though this may also be governed by the predominance of Arctic water. Otherwise, the species is widespread in the Barents Sea.

PREY SPECIFICITY: Like other *Sebastes* species, golden redfish prefers relatively small prey, large zooplankton and small or juvenile fish (Dolgov & Drevetnyak, 2011). Due to shallower habitats (shelf) and preference for higher temperatures it can feed on juvenile fish more than *S. mentella*. However, the diet of *S. norvegicus* shifted from juvenile fish towards zooplankton in the 20th century (Zakharov et al., 1977). Since then, large zooplankton remains the main prey.

SPECIES INTERACTION: Juvenile golden redfish experiences similar predation pressures as juvenile beaked redfish (ICES, 2019). However, since the species is not migrating to the open Norwegian Sea and therefore remains on interacting with other demersal fish in the Barents Sea, adults are more likely to profit from the availability of small and juvenile fish compared to beaked redfish (Dolgov & Drevetnyak, 2011; Hureau & Litvinenko, 1987).

ADULT MOBILITY: Suitable habitats for golden redfish are widespread in the Barents Sea (Barsukov et al., 1986; Travin, 1952), and it is unlikely that climate change will decline habitats substantially. However, golden redfish is more limited to changing conditions compared to beaked redfish as it largely remains in the Barents Sea (Sorokin, 1961; Travin, 1952). This restricts golden redfish also in vertical dimensions. Vulnerability to climate change may therefore be somewhat higher.

DISPERSAL OF EARLY LIFE STAGES: Like beaked redfish and many other demersal fishes of the Barents Sea, golden redfish releases its larvae along the shelf break (Travin, 1952). These larval extrusion areas are better defined than for beaked redfish and the transport to the nurseries is more concentrated towards the southern Barents Sea and closer to the coast (Berger et al., 1966; Berger & Cheremisina, 1970; Sorokin, 1961). This renders golden redfish more vulnerable to changing ocean processes like currents than *S. mentella*.

EARLY LIFE HISTORY SURVIVAL AND SETTLEMENT REQUIREMENTS: Golden redfish larvae are extruded at a rather developed state able to immediately start feeding. As they can digest copepod-eggs they may be somewhat protected from the effects of a slight mismatch with the spring bloom (Anderson, 1994; Konchina, 1970). Given that their transport to nursery areas is more telic than that of beaked redfish settlement may be more difficult in the future (Berger et al., 1966; Berger & Cheremisina, 1970).

COMPLEXITY IN REPRODUCTIVE STRATEGY: Although being limited to the shelf and continental slope golden redfish exhibits similar migration patterns as beaked redfish, but on a smaller scale. Males and females mate in summer on their widespread feeding grounds. Later in the year, the males overwinter on the slope, whilst the females migrate southwards to the larval extrusion areas (Boldovskiy, 1944; Sorokin, 1961; Travin, 1952). Similar to beaked redfish the sperm is stored in the body of the female for some time before fertilizing the eggs , potentially entailing high levels of atresia (St-Pierre & De Lafontaine, 1995) and failed fertilization.

SPAWNING CYCLE: Golden redfish releases larvae somewhat later than beaked redfish, from mid-April, peaking in May and declining throughout June and extrusion starts earlier in the South than in the North (Barsukov et al., 1986; Jakobsen & Ozhigin, 2011; Mukhina et al., 1992). Some females may extrude their larvae late, in July or even August but their numbers are normally low (Jakobsen & Ozhigin, 2011).

SENSITIVITY TO TEMPERATURE: Fishbase indicates a temperature range of golden redfish at 3-7 °C (Muus et al., 1999). However, juveniles are observed in the Barents Sea at temperatures down to below 0 °C (Maslov, 1944; Pozdnyakov, 1970), and a study on redfish in the Gulf of Maine has indicated an overall range for the genus of 0-13 °C (Kelly & Barker, 1961; Scott, 1982a). The species may be generally more vulnerable to temperature changes than beaked redfish because of the limited depth range in the Barents Sea. However, its vulnerability may be small due to its preference for somewhat higher temperatures, 4-5 °C as opposed to 2-3 °C observed for beaked redfish (Pethon, 2019).

SENSITIVITY TO OCEAN ACIDIFICATION: Effects of ocean acidification (OA) are potentially direct and indirect and may affect early life stages more than adults. At least one study indicated a sensory effect of CO_2 levels on the congener *Sebastes diploproa* (Sebastidae), increasing the anxiety which lasted for a certain period after the pH was returned to normal (Hamilton et al., 2014). This may affect golden redfish more than beaked redfish, since the larvae are transported to more narrowly defined areas than those of beaked redfish. Indirectly, juveniles attempting to hide from predators among benthic structures may lose refuges if calcifying biota are negatively affected by OA (Andersson et al., 2008; Turley et al., 2007). Additionally, lowered crustacean zooplankton abundances due to OA may negatively affect growth in golden redfish (Whiteley, 2011).

POPULATION GROWTH RATE: *Sebastes norvegicus* is a long-lived, slow growing and late maturing species (ICES, 2019). Therefore, it scores high in most indicators of the table provided and must be considered as highly vulnerable.

STOCK SIZE/STATUS: Golden redfish is on the Norwegian red list. The total biomass is estimated to be just 78% of the limiting reference point for spawning stock biomass (B_{lim}), and about half of the trigger precautionary reference point for biomass (B_{pa}). Due to late maturity, the spawning stock biomass is not more than one third of B_{pa} (ICES, 2019).

OTHER STRESSORS: The only stressor not yet considered is the potential future exploration and subsequent extraction of oil in the Barents Sea connected with larval extrusion areas (Sundby et al., 2013). Apart from a small fishery with handlines during the summer, there is no directed fishery on golden redfish in Norwegian waters. However, bycatch, in the fishery for beaked redfish and as juveniles in the shrimp fishery are other sources of stress.

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 Golden redfish (*Sebastes norvegicus*) stock in ICES subarea 1. 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.

Golden redfish (*Sebastes norvegicus*) in ICES subarea 1

SENSITIVITY ATTRIBUTES	L	M	H	VH	$Mean_w$	Usage	Remark
Habitat Specificity	1	3	1	0	**2.0**		
Prey Specificity	1	2	2	0	**2.2**		
Species Interaction	1	2	2	0	**2.2**		
Adult Mobility	2	2	1	0	**1.8**		
Dispersal of Early Life Stages	2	3	0	0	**1.6**		
ELH Survival and Settlement Requirements	0	2	3	0	**2.6**		
Complexity in Reproductive Strategy	0	2	3	0	**2.6**		
Spawning Cycle	1	3	1	0	**2.0**		
Sensitivity to Temperature	0	2	3	0	**2.6**		
Sensitivity to Ocean Acidification	1	3	1	0	**2.0**		
Population Growth Rate	0	0	2	3	**3.6**		
Stock Size/Status	0	0	1	4	**3.8**		
Other Stressors	1	3	1	0	**2.0**		
Grand mean					**2.38**		
Grand mean SD					**0.66**		

CLIMATE EXPOSURE	L	M	H	VH	$Mean_w$	Usage	*Directional Effect*
Surface Temperature	0	0	0	0		N/A	
Temperature 100 m	0	0	0	0		N/A	
Temperature 500 m	0	0	0	0		N/A	
Bottom Temperature	3	2	0	0	**1.4**		1
O_2 (Surface)	0	0	0	0		N/A	
pH (Surface)	3	2	0	0	**1.4**		-1
Gross Primary Production	3	2	0	0	**1.4**		1
Gross Secondary Production	3	2	0	0	**1.4**		1
Sea Ice Abundance	0	0	0	0		N/A	
Grand mean					**1.4**		
Grand mean SD					**0.0**		
Accumulated Directional Effect					**–**		**2.8**

***Accumulated Directional Effect*: POSITIVE**	**2.8**

References

Anderson, J. T. (1994). Feeding ecology and condition of larval and pelagic juvenile redfish *Sebastes* spp. *Marine Ecology Progress Series*, *104*, 211–226.

Andersson, A. J., Mackenzie, F. T., & Bates, N. R. (2008). Life on the margin: Implications of ocean acidification on Mg-calcite, high latitude and cold-water marine calcifiers. *Marine Ecology Progress Series*, *373*, 265–273.

Barsukov, V., Shestova, L., & Mukhina, N. (1986). Redfish of *Sebastes* genus. In G. Matishov (Ed.), *Ichthyofauna and its Living Conditions in the Barents Sea* (pp. 48–52). KF AN Press.

Berger, T., & Cheremisina, R. (1970). *Distribution of redfish juveniles in the Barents Sea in 1967*.

Berger, T., Cheremisina, R., & Bizova, O. (1966). *Distribution of redfish juveniles in the Bear Island—Spitsbergen area in the southern part of the Barents Sea in fall-winter 1964-1965*.

Boldovskiy, G. (1944). Feeding of redfish of the Barents Sea. *Trudy PINRO*, *8*, 307–330.

Dolgov, A., & Drevetnyak, K. (2011). Feeding of three species from the genus *Sebastes* in the Barents Sea. *ICES Council Meeting Papers*, *A: 26*, 13.

Hamilton, T. J., Holcombe, A., & Tresguerres, M. (2014). CO2-induced ocean acidification increases anxiety in rockfish via alteration of GABAA receptor functioning. *Proceedings of the Royal Society B: Biological Sciences*, *281*(1775), 20132509.

Hureau, J., & Litvinenko, N. (1987). *Scorpaenidae*. In P. Whitehead (Ed.), *Fishes of the North-Eastern Atlantic and the Mediterranean* (Vol. 3, pp. 1211–1473). UNESCO.

ICES. (2019). *Arctic Fisheries Working Group (AFWG)* (ICES Scientific Reports 1: 30; p. 934). ICES.

Jakobsen, T., & Ozhigin, V. K. (Eds.). (2011). *The Barents Sea: Ecosystem, Resources, Management. Half a Century of Russian-Norwegian Cooperation*. Tapir Akademisk Forlag.

Kelly, G. F., & Barker, A. M. (1961). Observations on the behavior, growth, and migration of redfish at Eastport, Maine. *International Commission for the Northwest Atlantic (ICNAF) Special Publication*, *3*, 263–275.

Konchina, U. (1970). Feeding of sea redfish larvae in the Barents Sea. *Trudy molodyh uchenyh - Papers of young scientists*, *3*, 166–181.

Maslov, N. (1944). *Harvest for sea redfish in the Barents Sea and off the northwestern coast of Norway*.

Mukhina, N., Drevetnyak, K., & Dvinina, E. (1992). Redfish spawning grounds in the Barents Sea and adjacent waters. *ICES Council Meeting Papers*, *G: 54*, 21.

Muus, B., Nielsen, J., Dahlstrom, P., & Nystrom, B. (1999). *Sea Fish. Scandinavian Fishing Year Book–Hedehusene* (Narayana Press). Odder, Hedehusene.

Pethon, P. (2019). *Aschehougs Store Fiskebok: Artsfiske, Artsbestemmelse, Artsutbredelse*.

Pozdnyakov, Y. (1970). On the issue of distribution and feeding of golden redfish juveniles of the coasts of Eastern Murman. *Results of Fisheries Investigations in the North Fisheries Basin*, *14*, 59–64.

Scott, J. (1982a). Depth, temperature and salinity preferences of common fishes of the Scotian Shelf. *Journal of Northwest Atlantic Fishery Science*, *3*(1), 29–39.

Scott, J. (1982b). Selection of bottom type by groundfishes of the Scotian Shelf. *Canadian Journal of Fisheries and Aquatic Sciences*, *39*(7), 943–947.

Sorokin, V. (1961). The redfish gametogenesis and migrations of the *Sebastes marinus* L. and *Sebastes mentella* Travin. *International Commission for the Northwest Atlantic (ICNAF) Special Publication*, *3*, 245–250.

St-Pierre, J.-F., & De Lafontaine, Y. (1995). *Fecundity and reproduction characteristics of beaked redfish (*Sebastes fasciatus *and* S. mentella*) in the Gulf of St. Lawrence* (2059: 32; Canadian Technical Report of Fisheries and Aquatic Sciences, p. vii). Canadian Technical Report of Fisheries and Aquatic Sciences.

Sundby, S., Fossum, P., Sandvik, A. D., Vikebø, F., Aglen, A., Buhl-Mortensen, L., Folkvord, A., Bakkeplass, K., Buhl-Mortensen, P., & Johannessen, M. (2013). *KunnskapsInnhenting Barentshavet–Lofoten–Vesterålen (KILO)* (Vol. 3). Havforskningsinstituttet.

Travin, V. (1952). *Scorpaenidae* family. In I. Lagunov (Ed.), *Commercial Fishes of the Barents and White Seas* (pp. 183–198). VNIRO/PINRO Press.

Turley, C., Roberts, J. M., & Guinotte, J. (2007). Corals in deep-water: Will the unseen hand of ocean acidification destroy cold-water ecosystems? *Coral Reefs*, *26*(3), 445–448.

Whiteley, N. (2011). Physiological and ecological responses of crustaceans to ocean acidification. *Marine Ecology Progress Series*, *430*, 257–271.

Zakharov, G., Nikolskaya, T., Sorokin, V., Chekhova, V., & Shestova, L. (1977). Deep-sea redfish. In *Commercial Biological Resources of the North Atlantic and Adjacent Waters of the Arctic Ocean Part 2* (pp. 72–87). Pishchevaya Promyshlennost Press.