1 Ecosystem productivity and ecosystem approach in WGDEEP stocks

1.1 Ecosystem productivity and ecosystem approach for deep-water stocks

Most deep-water stocks present a lower biological productivity than continental shelf and coastal stocks: natural mortality (M) is lower for deep-water stocks, age-at-maturity higher and growth rate lower. The lower productivity of deep-water ecosystems, which is well documented and was subject to a review for the west of the British Isles (Vieira *et al*, 2019), is *de facto* accounted for in population dynamics models of these stocks.

For ICES category 1 stocks this is conveyed in the assessment, forecast and advice by using the stock specific life history traits. For the numerous Category 3 stock assessed by WGDEEP, a population indicator (usually a biomass index from a scientific survey or CPUE series from the fisheries) is used to estimate the stock trend in recent years. By its very nature such indicator is expected to change with both the exploitation rate and the biological productivity of the stock as these factors are confounded in the indicator. In none of the WGDEEP Category 3 stocks these two factors can be quantitatively disentangled. However, for some stocks some ecosystems factors have been identified or hypothesised to influencing observed trends.

Note that decreasing productivity and increasing exploitation would have the same effect of decreasing a biomass indicator.

1.2 Ecosystem considerations for selected WGDEEP stocks

Ecosystem considerations are presented for those WGDEEP stocks where appropriate and relevant knowledge is available. Not all 30 WGDEEP stocks have been subject to this ecosystem consideration so far, and this listing is thus not complete.

1.2.1 Blackspot sea bream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

The strait of Gibraltar has been the main area where this stock has been fished since the 1980s. Based on a biomass indicator in the Strait of Gibraltar, the stock biomass decreased in the last decade as a consequence of increasing exploitation. The EU TAC covers Subarea 9 but the Strait of Gibraltar is the path between the Atlantic ocean and the Mediterranean sea and is divided at 36°N between the CECAF and the ICES areas. Blackspot seabream moves across these areas where management regimes differ, while the ICES advice only applies to the ICES area.

In ICES Division 9, in addition to catches from the targeted fishery in the Strait of Gibraltar, there are catches from coastal areas of Northern Spain (Galicia) and Portugal. The stock structure is unclear and the level of mixing of population from Gulf of Cadiz with those at the occidental Iberian coast still unknown. Preliminary genomic studies confirmed low connectivity between the Azorean population and the Atlantic eastern continental margin locations and suggested genetic differentiation between the Strait of Gibraltar and locations further north in Iberian waters (Castilho *et al*., 2022). The overexploited status of the stock is derived from data from the Spanish fishery in the Strait of Gibraltar where in addition the high fishing mortality resulting from the

high value of the species and the absence of catch limits in the Mediterranean and CECAF areas, natural mortality may have increased as a consequence of the predation from the recovering blue fin tuna stocks.

Sanz-Fernández *et al*. (2019) suggests that the main factor responsible for the decline in the abundance of blackspot seabream in the Strait of Gibraltar is fishery overexploitation and that environmental conditions (such as water temperature anomaly, salinity anomaly and the NAO index) had a one-off effect which, depending on the year, favoured or harmed the recovery of the stock.

1.2.2 Blackspot seabream (*Pagellus bogaraveo*) in subareas 6, 7, and 8 (Celtic Seas and the English Channel, Bay of Biscay)

This stock collapsed in the 1980s and remains at a historically low level. The stock annex reports that environment has changed in the Bay of Biscay, in particular with a documented warming of the upper layer of water. This warming was considered unlikely to be unfavourable to blackspot seabream, as other stocks of the species are distributed in warmer areas in the Gulf of Cadiz and the Mediterranean Sea.

1.2.3 Blackspot sea bream (*Pagellus bogaraveo*) in Subarea 10 (Atlantic Iberian waters)

The stock reported in this section is from the Azores EEZ (ICES 10.a2). It is distributed along the coastal areas of the islands and seamounts up to 700m. Recruitment occurs on the coastal areas and juveniles migrate subsequently to offshore seamounts. The assessment of the stock is based on the survey trends and currently it is considered intensively exploited. Survey relative abundance indices trends presents high inter annual variability. Causes for this variability may be related to catch dynamics between fish and gear (competition, gear saturation, forage behaviour, etc.) or with environmental effects. Both factors seem to affect catchability. Further studies are necessary to better understand both effects on the abundance estimates.

1.2.4 Blue ling (*Molva dypterygia*) in Subarea 14 and Division 5.a (East Greenland and Iceland grounds)

In 2019, the expert group considered to include further ecological consideration in the assessment used for this stock. In 2018, the biomass indicator was at high level and implied an increase of the catch advice according to survey trend-based assessment. However, as the index of small fishes indicated that the recruitment had been very low since 2010, an increase of adult stock catches seemed inappropriate. The driving factor for the low recruitment might be environmental as the adult biomass continues to be high. In terms of environmental changes, warming of sea temperature and expansion of distribution area of warm-water species such as anglerfish has been observed in Icelandic waters (see stock annex). The effect of these on blue ling recruitment is unknown. Nevertheless, the low recruitment was taken into account in the assessment and advice for the stock. The recruitment is still at low levels.

1.2.5 Roundnose grenadier (*Coryphaenoides rupestris*) in Division 3.a (Skagerrak and Kattegat)

The stock was depleted by a directed fishery that lasted from 2000–05. This stock, compared to other deep-water stock, is distributed in a restricted area. Recruitment was observed to be

intermittent (Bergstad *et al*., 2014). Recovery from the depleted status is unlikely to occur until a new strong recruitment event, which is unpredictable. The previous one dates back from the early 1990s.

1.2.6 Ling (*Molva molva*) in Subareas 6-9, 12, and 14, and Divisions 3.a and 4.a (Northeast Atlantic and Arctic Ocean)

CPUE indices from areas where the main fisheries occur are used to assess the stock. These show an increasing trend since the early 2000s. The application of the ICES Category 3 rule lead to an advice catch for 2020-2021 slightly higher than the previous advice. However, the Spanish survey on the Porcupine bank (SPPGFS-WIBTS-Q3) covering ICES divisions 7c,k shows a strong declining trend on abundance and on biomass. The advice was not changed because 90% of the catch from this stock come from Subareas 4 and 6. However, it was considered likely that there are different trends by area. Landings in Subarea 7 have decreased since the late 1980s where they were comparable to landings in each of subareas 4 and 6. WGDEEP considered likely that environmental changes have made Subarea 7 less suitable to ling.

1.2.7 Black scabbardfish (*Aphanopus carbo*) in the Northeast Atlantic and Artic Ocean

The stock structure in the whole Northeast Atlantic is still uncertain. Although available information does not unequivocally support the assumption of a single stock, most available evidences support it. Juveniles are mesopelagic and adults are benthopelagic. The species does not complete its life cycle in one area and either small- or large-scale migrations occur. So far, the known spawning grounds occur in CECAF areas (Madeiran and Canary Islands waters). Juveniles recruit in Northern areas. These particularities are taken into consideration by ICES model adopted to monitor the stock dynamics.

After 2012, both the annual biomass and annual abundance indices are at higher levels, indicating that the population at the Northern component has been increasing. However in recent years, the Icelandic abundance index, the French LPUE index from the west of Scotland show a decreasing trend while both the Icelandic and the Scottish survey biomass indices have been increasing. The analysis of these trends suggests that the level of recruitment have been decreasing. This effect is unlikely to result from an increasing fishing pressure because (1) the TAC set for black scabbardfish have been stable for several years and (2) in EU waters the ban of trawling in areas deeper than 800 m has strongly reduced the fraction of the species habitat which can be exploited as the depth range of the species extends down to 2000 m. Therefore, the observed decrease might be due to ecosystem effect**s**. Acting ecosystem factors may be:

- Changes in the abundance of prey species. In particular the black scabbardfish preys upon blue whiting, which SSB increased in 2011-2016 and have decreased in more recent year (ICES, 2019);
- Changes in abundance of predators. After the heavy exploitation in the 1990s and early 2000, TACs for deep-water species were introduced in 2003 and gradually decreased thereafter. The black scabbardfish fish is one of the most productive deep-water species, with a faster growth than its potential predators particularly deep-water sharks. Target fishing from deep-water sharks have been strongly restricted since 2006 with the ban of deep-water nets and was further restricted in 2012 after the introduction of a 0 TAC for deep-water sharks that applies for all gears. The latter might have been an incentive to diverge fishing to locations where sharks were a small proportion of commercial catches. Lastly the ban, in 2016, of trawling deeper than 800 m in EU waters might have resulted

in reduction of deepwater-sharks bycatch to low levels in trawl fisheries. Although no reliable indicator of deep-water shark abundance is available, population might be increasing in recent years and thus increasing the predation on black scabbardfish.

1.2.8 Greater forkbeard (Phycis blennoides) in all ecoregions

ICES currently considers greater forkbeard as a single-stock for the entire NE Atlantic, although the stock structure be more complex. Further studies would be required to justify change to the current assumption. Fishing is a major disturbance factor of the continental shelf communities of the regions. As the fishery of greater forkbeard is mainly a bycatch of trawler fishery in all ecoregions the main ecosystem effects are the impact on the sediment compound.

1.3 The percentage of the total catch that has been taken, and emerging fisheries, in the NEAFC regulatory areas last year

WGDEEP stocks are distributed broadly across the NEAFC Convention Area, with catches of some stocks occurring within the NEAFC Regulatory Area (RA). In the table 1.1 in the WGDEEP 2020 report the WG presented the most likely landings from these RA areas in 2019 based on the official reports and discussions within the WG. For relevant stocks with advice this year the estimated percentage of the total catch that has been taken in the NEAFC Regulatory Area last year is reported in the advice sheets.

No new emerging deep-water fishery were discovered with the available data in the NEAFC Regulatory Area.

1.4 References

Bergstad, O. A., H. O. Hansen, and T. Jorgensen. 2014. Intermittent recruitment and exploitation pulse underlying temporal variability in a demersal deep-water fish population. ICES Journal of Marine Science 71:2088-2100.

Castilho1, R., Robalo J. I., Regina Cunha, R., Francisco S. M., Farias, I and Figueiredo I. 2022. Genomics goes deeper in fisheries science: the case of the blackspot seabream (*Pagellus bogaraveo*). ICES AFWG 2022, WD5.

Sanz-Fernández, V., J.C. Gutiérrez-Estrada, I. Pulido-Calvo, J. Gil-Herrera, S. Benchoucha, S. el Arraf. 2019. Environment or catches? Assessment of the decline in blackspot seabream (*Pagellus bogaraveo*) abundance in the Strait of Gibraltar. Journal of Marine Systems, 190: 15-24 (https://doi.org/10.1016/j.jmarsys.2018.08.005).

Vieira RP, Trueman CN, Readdy L, Kenny A, Pinnegar JK. Deep-water fisheries along the British Isles continental slopes: status, ecosystem effects and future perspectives. J Fish Biol. 2019;1–12. https://doi.org/10.1111/jfb.13927