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OPINION PAPER

Comment on "The global ecological niche of lumpfish (*Cyclopterus lumpus*) and predicted range shifts under climate change"

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Abstract Rodríguez-Rey and Whittaker (Hydrobiologia 850:2089–2100, 2023, https://doi.org/10.1007/s10750-023-05220-8) recently investigated the ecological niche of lumpfish (Cyclopterus lumpus) in the Atlantic Ocean using species distribution models. They utilise occurrence records of lumpfish from the Global Biodiversity Information Facility (GBIF) and environmental data extracted from Bio-ORACLE v2.0. A premise of their analysis is that that the GBIF data reflects the relative distribution of lumpfish in the North Atlantic. However, this assumption does not hold true, as evident from the geographic imbalance observed between the GBIF samples and the data obtained from commercial fisheries for lumpfish, as well as fish surveys conducted across the North Atlantic. There is also a concern that only 11% of the individuals listed in the dataset overlapped with the time period from when environmental parameters were estimated (2000–2014). Comparing the suitability index calculated using output from the species distribution models raises concerns about its reliability as it conflicts with the actual distribution of lumpfish from survey data in the eastern Atlantic. This conflict suggests serious problems with the model, and any projections into the future should be treated with caution.

Keywords Lumpfish · *Cyclopterus lumpus* · Distribution · IESSNS

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In their recent paper in Hydrobiologia, Rodríguez-Rey & Whittaker (2023) investigated the ecological niche of lumpfish, Cyclopterus lumpus Linnaeus, 1758, in the Atlantic Ocean using species distribution models with occurrence records of lumpfish from the Global Biodiversity Information Facility (GBIF) (https://doi.org/10.15468/dl.hjwebg) and environmental data extracted from Bio-ORACLE v2.0 as input data. GBIF occurrence records for lumpfish are open access and consist of location data where lumpfish specimens have been observed and reported. These observations of occurrence are categorised as human observation, machine observation, material sample and preserved specimens, with the records spanning a period of 380 years (1639–2019) (Table 1). Regarding the eastern Atlantic Ocean, the samples are primarily distributed along the coastal areas of Europe (Fig. 1). There are only a few samples from northern Norway and almost absent from Iceland, two areas where there are substantial lumpfish fisheries (Kennedy et al., 2019). There are also very few samples

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Table 1 Number of lumpfish records from GBIF by year using the link provided in Rodríguez-Rey & Whittaker (2023)

Year	Number of records	Percentage
1639	1	0.0
1800–1899	27	0.3
1900–1949	104	1.1
1950–1959	19	0.2
1960–1969	583	6.1
1970–1979	1383	14.5
1980–1989	3639	38.1
1990–1999	2322	24.3
2000–2014	1045	11.0
2015–2019	219	2.3
Unknown	201	2.1

Records from the Baltic Sea and records with no location information were removed

in the open sea outside coastal areas. In the western Atlantic, there are very few samples from the coast of Greenland (Fig. 1), which supports a substantial fishery for lumpfish. While in Canada, which does have a fishery but substantially lower landings than Greenland in the past 20 year, it has a much greater number of samples which come from fish surveys carried out by Fisheries and Ocean Canada.

A premise of the methodology used by Rodríguez-Rey & Whittaker (2023) is that the distribution of samples from the GBIF represents the relative distribution of lumpfish in the North Atlantic Ocean. There are several lines of evidence to suggest that this is not the case. One is the imbalance between samples that originate from areas where lumpfish are fished commercially and those from areas that do not. It would be expected that lumpfish are more abundant in areas which support a commercial fishery, which is contrary to the distribution of samples. A second line of evidence is when the suitability map is compared with the actual distribution of lumpfish in the eastern Atlantic Ocean from survey data. There are two surveys which give information on the relative distribution of lumpfish, the International Ecosystem Summer Survey of the Nordic Seas (IESSNS) (Nøttestad et al., 2022) and

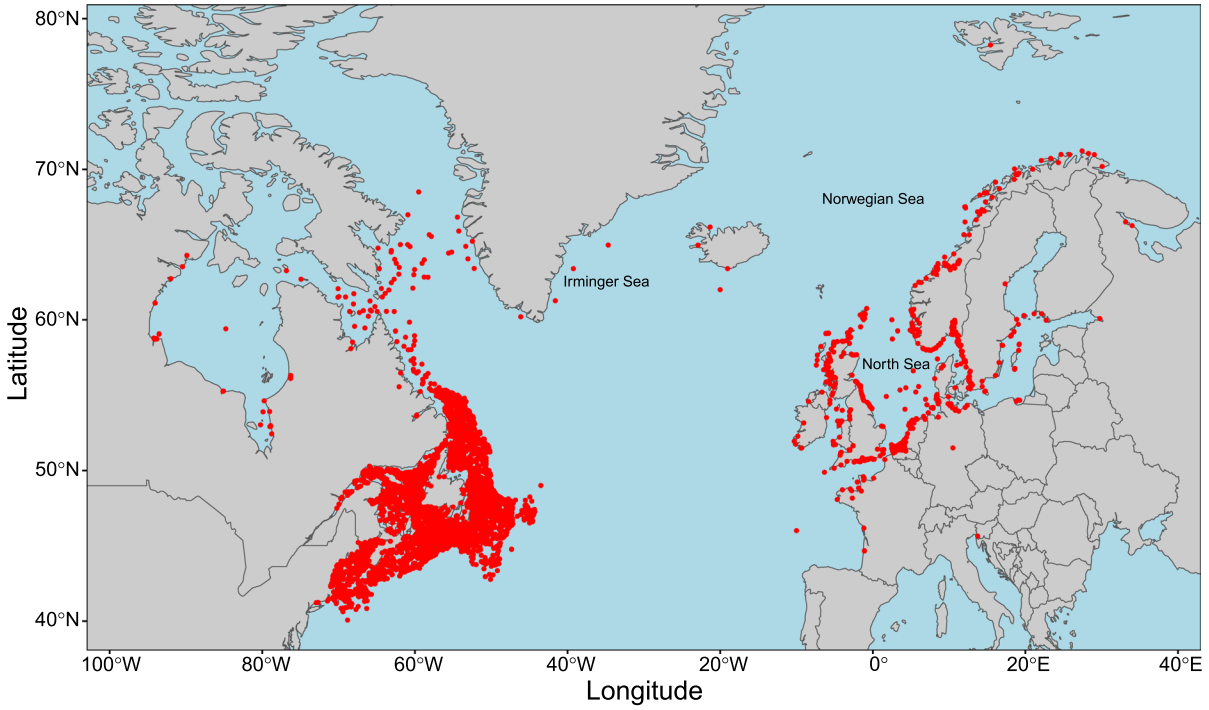

Fig. 1 Location of Global Biodiversity Information Facility (GBIF) samples of lumpfish. Seventeen samples outside of the plot area are not shown

the Norwegian-Russian 0-group fish survey in the Barents Sea (Eriksen et al., 2014). The IESSNS covers large parts of the Nordic Seas, which includes the Irminger Sea, Norwegian Sea and the North Sea, with trawl stations as far north as Svalbard and as far south as the central North Sea while the 0-group survey covers the Barents Sea including areas around Svalbard. During the IESSNS, lumpfish are caught in almost every epipelagic station (0 to ~ 40 m depth), but usually in low amounts (< 10 kg) (Fig. 2), likely a result of low population density. Similarly, the survey conducted in the Barents Sea shows a substantial distribution of lumpfish, with consistent captures recorded across the majority of stations. Comparing the suitability index derived from by Rodríguez-Rey & Whittaker (2023) and the actual distribution shows quite distinct contrasts, most noticeably in the North Sea which has the highest suitability index, but lumpfish are infrequently captured during the IESSNS in this area, suggesting a lower abundance than in other areas. Some of the highest catches of lumpfish during the IESSNS are generally in the north-west along the outer edge of the survey, which is noted to have a low suitability index according to the model. This lack of agreement between the suitability index and the actual distribution of lumpfish suggests major problems with model´s output.

Rodríguez-Rey & Whittaker (2023) lacks a description of the period used to determine the environmental parameters or the period covered by the GBIF recordings. However, upon exploring Bio-ORACLE v2.0 on bio-oracle.org, it appears that Rodríguez-Rey & Whittaker (2023) utilised an average from 2000 to 2014. As mentioned earlier, the GBIF data cited in the paper comprises records from 1639 to 2019, with only ~ 11% of the records from 2000 to 2014, the assumed period for which the environmental parameters were estimated (Table 1). Consequently, we also have significant reservations regarding the fidelity of the environmental conditions employed in the models to represent the actual environment experienced by the observed fish at the time of registration.

It should also be pointed out that the authors seem to have misinterpreted some aspects of lumpfish ecology. The authors suggest that "these findings imply lumpfish prefer dark and/or deep environments". It is well established that lumpfish, outside of their spawning period, are pelagic and primarily (but not

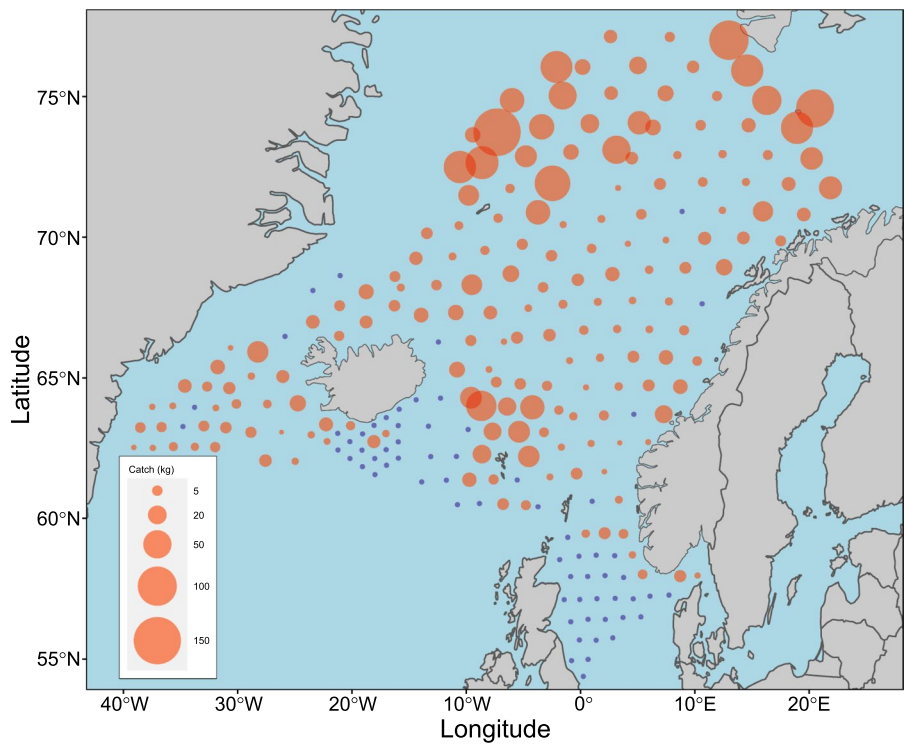

Fig. 2 Lumpfish catches of surface trawl stations during the International Ecosystem Survey of the Nordic Seas (IESSNS) in 2022. The colours indicate stations where lumpfish were caught (red) and not caught (blue). Redrawn from data taken from Nøttestad et al. (2022)

exclusively) inhabit the upper 50 m of the water column (Schultz, 1981; Blacker, 1983; Holst, 1993; Rosen & Holst, 2013; Eriksen et al., 2014). It appears that it is only when they are performing their spawning migration that they frequently move between the demersal and pelagic zones (Kennedy et al., 2016; Kennedy & Jónsson, 2017).

An additional level of uncertainty in the model is that the life stages of the GBIF samples are not clear. Rodríguez-Rey & Whittaker (2023) state that the samples are mainly adult specimens. However, the source of this information is unclear as these data are not included in the publicly accessible dataset referenced by the author. Inferences about whether they are juvenile or adults cannot be made based upon location. The spatial distribution of lumpfish exhibits significant overlap across several life stages, with both juveniles and adults found in coastal areas after hatching and during the breeding season, respectively (Daborn & Gregory, 1983; Moring, 1990; Kennedy et al., 2015). Furthermore, they share an overlap in offshore regions (Holst, 1993), highlighting the coexistence of multiple life stages.

Fish face multiple challenges due to climate change, e.g. temperatures becoming too high for successful reproduction, changes in the abundance of larvae prey and alterations in their migrations due to changes in their distribution (Kjesbu et al., 2023). Many species may be limited in their ability to shift their distribution because specific habitat needs unrelated to temperature. Lumpfish inhabit offshore areas for most of their lifecycle but need to return to coastal areas to spawn. Each life stage will, thus, be impacted differently by alterations in temperature. The optimum temperature for growth changes as fish grow (Lindmark et al., 2022) and the suitable temperature range for feeding and growth is likely different to that suitable for breeding. Lumpfish can make long-distance migrations, which have been observed directly (Kennedy et al., 2015), and are evident from the distance between feeding areas and known breeding areas. Thus, feeding areas may remain suitable outside the non-breeding season, but adults could migrate to alternative areas for spawning, or vice versa. Given that the life stage of the GBIF samples was unknown, it is unclear what life stage the suitability index refers to. The specific requirements of each life stage, thus, need to be carefully considered when predicting the suitability of a habitat due to a changing climate on any fish species.

We welcome the effort made by Rodríguez-Rey & Whittaker (2023) to further our knowledge of lumpfish, and we are sure we can all agree that it is an extremely fascinating and unusual species. However, the results of Rodríguez-Rey & Whittaker (2023) are based upon a dataset that does not reflect the actual distribution on lumpfish and that the output of the model is at odds with the actual distribution of lumpfish. There is also considerable uncertainty due to what life stage the suitability index refers to. Altogether, this indicates that the species distribution model is questionable and that the projected suitability index for the present and future scenarios is unreliable.

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Data availability The data from this manuscript are publicly available from the Global Biodiversity Information Facility and from Nøttestad et al. (2022).

Declarations

Conflict of interest The authors have no conflict of interest.

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