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Updating the records of *Diretmichthys parini* in the North East Atlantic: limited effect of temperature and potential role of social media

by

Pierre CRESSON* (1), Samuel P. IGLÉSIAS (2), Klara JAKOBSDÓTTIR (3) & Arve LYNGHAMMAR (4)

Résumé. – Mise à jour des signalements de *Diretmichthys parini* en Atlantique Nord-Est : effet limité de la température et rôle potentiel des médias sociaux.

Les signalements opportunistes, notamment pour les espèces rares, sont souvent les premières données disponibles révélant des expansions géographiques dans un contexte de changement global des écosystèmes marins. Sur la base d'un premier signalement au nord de la mer du Nord du poisson mésopélagique *Diretmichthys parini* (Post et Quéro, 1981), initialement décrit comme tropical et subtropical, une hypothèse d'expansion géographique en relation avec le réchauffement climatique a été formulée en 2017. L'analyse d'un plus grand jeu de données spatiales et temporelles, incluant notamment des signalements anciens (1992-2016) en Islande et récents en Norvège (2015-2017), induit la révision de cette hypothèse et permet de reconsidérer les préférences thermiques des adultes de cette espèce. Ce travail illustre également l'importance de prendre en compte les réseaux sociaux pour suivre les signalements opportunistes, car la surprise liée à la capture de ces poissons inhabituels y entraîne souvent la publication des photos par le grand public.

Key words. – Range expansion – Distribution – Rare species – Opportunistic record – Global change.

Global warming is currently changing marine ecosystems worldwide. Poleward movement is commonly considered as one of the major biological effects of global change on fish species (McLean *et al*., 2018). In this context, opportunistic records of rare fishes, for instance by scientists, professional fishermen, anglers or divers, are considered powerful to document shifts in species distribution and the establishment of non-native species (Iglesias *et al*., 2020). Nevertheless, opportunistic records can suffer from several biases related to the heterogeneous, discontinuous and mainly observational nature of the data, generally obtained without protocol. Consequently, the hypotheses on trends of distribution shifts based on few records can only be indicative, and lack robustness. Furthermore, the collection of this type of records is complicated by the fact that they are often dispersed in grey literature, newspaper article or social media posts.

Based on a single record of a specimen captured off Norway in 2015, Cresson *et al*. (2017) documented some aspects of the biology of an adult individual of Parin's spinyfin *Diretmichthys parini* (Post and Quéro, 1981) at an unusually high latitude, about 62.1°N (Fig. 1). The type and comparative material have usually been collected in tropical and subtropical waters (between 39.1°S and 33°N) but not in equatorial waters (between 07°N and 17°S). Indeed, the vast majority of published records are from tropical areas, and some rare records in the NE Atlantic, off Spain, Scotland and the Faroe Islands (summarized in the supplementary material of Cresson *et al*., 2017: fig. 1). Based on these available records, the catch from 2015 was reported as the northernmost so far. Unfortunately, previous records between 60.8 and 65.8°N, both published in an Icelandic field guide for fishes (Jónsson and Pálsson, 2013) as well as unpublished records, were overlooked. Few years later, in 2017, the northern distribution limit was expanded even further when Lynghammar *et al*. (2020) reported the catch of an individual off northern Norway, close to the limit of the Arctic Sea at 71.4°N.

Increasing water temperatures related to global change was proposed as a potential driver of the new records in the North Sea by Cresson *et al*. (2017). The analysis of Icelandic fishery records provides an opportunity to test this hypothesis, based on a larger dataset. Water temperatures at all catch localities were retrieved from the Copernicus GLOBAL_REANALYSIS_PHY_001_026 model, which provides daily-mean temperature values (https://resources.marine.copernicus.eu). The potential temporal, spatial and vertical movements of the fish before its capture were considered by using averaged temperature for the 30 days surrounding the date of capture, the 30 to 100 m depth range around the reported depth of catch, and using 1° resolution cells, respectively. When exact information about day or depth of capture were missing, a larger range of values was considered, *i.e.* using the average temperature for the whole year, or for a larger depth range (500-1000 m).

Temperature data for the most recent catches appeared consistent with a limited effect of increasing temperature on *D. parini* expansion (Fig. 2). In the North and Norwegian Seas, temperatures were low (3 to 5°C) and fell within the lower range of values also observed for Icelandic catches (3.5 to 9°C). These occurrences of *D. parini* in cold waters may question the previously assumed affin-

(1) Ifremer, RBE/HMMN, Laboratoire Ressources Halieutiques Manche Mer du Nord, 62 200 Boulogne sur Mer, France. pierre.cresson@ifremer.fr
(2) Institut de Systématique, Évolution, Biodiversité (ISYEB), Muséum national d'Histoire naturelle, CNRS, Sorbonne Université, EPHE, Université des Antilles ; Station Marine de Concarneau, Place de la Croix, 29900 Concarneau, France. samuel.iglesias@mnhn.fr
(3) Marine and Freshwater Research Institute Iceland, Fornubúðir 5, 220 Hafnarfjörður, Iceland. klara.jakobsdottir@hafogvatn.is
(4) The Norwegian College of Fishery Science, UiT The Arctic University of Norway, Muninbakken 21, NCFS-building, 9037 Tromsø, Norway. arve.lynghammar@uit.no
* Corresponding author

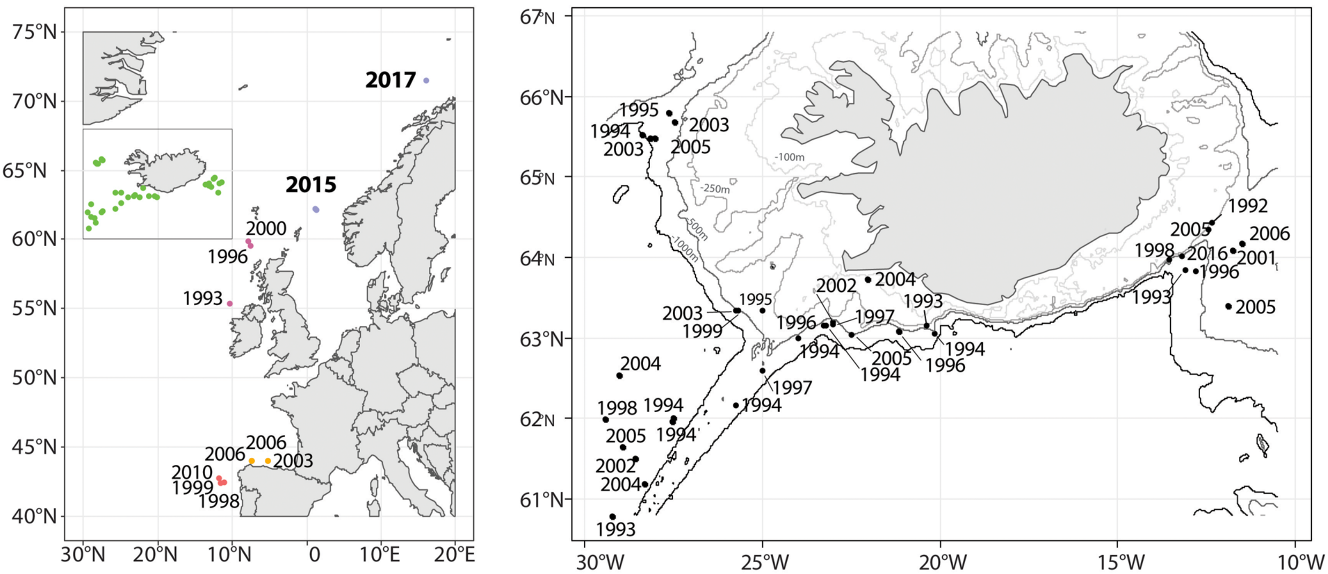

Figure 1. – Records of *Diretmichthys parini* in the NE Atlantic. Year of catch is indicated near each dot. For graphical purposes, years of catches around Iceland and isobaths –100 m, –250 m, –500 m and –1000 m are reported in the detailed map only. The three individuals caught in the North Sea (2015) and the Norwegian Sea (2017), and specifically discussed in the present paper are highlighted with bold font. The three southern records (in 1998, 1999 and 2010) are personal observations by R. Bañon. Colours of the dots in the general map are consistent with figure 2.

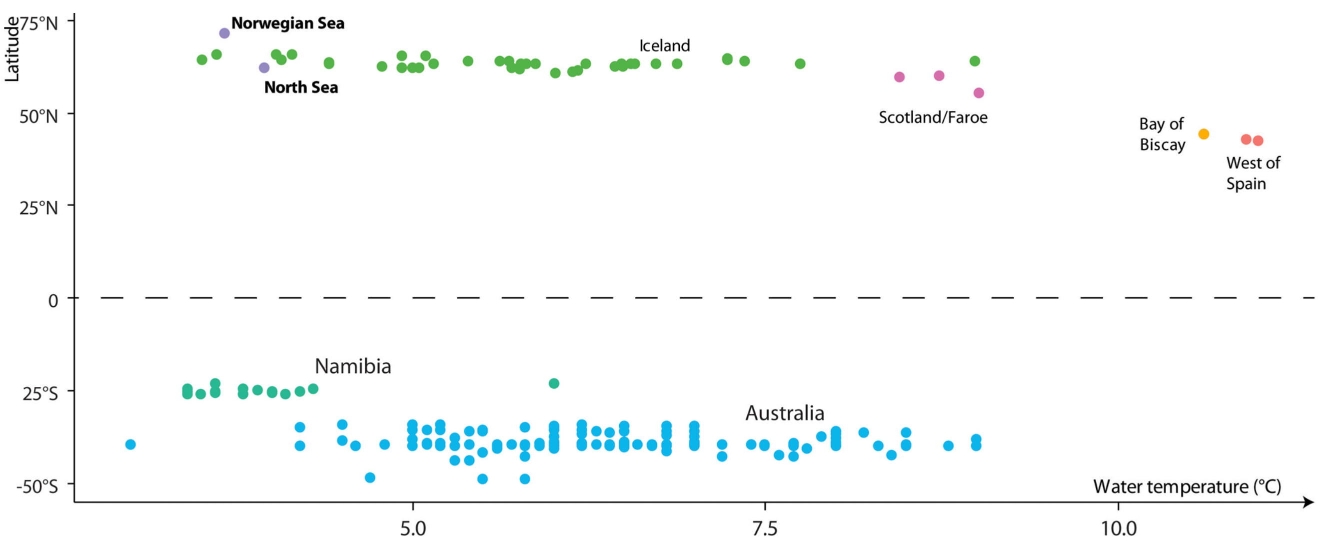

Figure 2. – Relationship between temperature and latitude of catch. Horizontal dashed line separates northern and southern hemispheres. Colour of the symbol represent the catch area, and are consistent with map figure 1. Please note this figure represent only a subset of all *Diretmichthys parini* catches, with temperature values retrieved from Copernicus database in the northern hemisphere, or provided in the GBIF database in the southern.

ity for warm-waters of a species originally described in tropical and subtropical area, but rather confirm that this fish withstands low temperatures in deep waters (Lynghammar *et al.*, 2020). These cold values are also consistent with the low temperatures reported in the GBIF database for *D. parini* catches (https://doi.org/10.15468/dl.ackhc2; Fig. 2). Even though temperatures are reported for a small subset of the catches, around Australia and Namibia only, these values also range within 3 and 9°C. Available data currently support that this fish has an affinity for low temperatures in deep waters.

The time series of water temperatures at the three sampling stations in the North and Norwegian Sea is also informative on the limited influence of warmer waters on the new records. Deep-water temperatures retrieved in the Norwegian Sea (71.4°N) where the individual ZMUB 23826 was caught (Lynghammar *et al.*, 2020) and the North Sea (62.2°N, where individual ZMUB 23827 (Lynghammar *et al.*, 2020) and the individual reported by Cresson *et al.* (2017) were caught) show some contrasting trends (Fig. 3). The pattern in the North Sea shows some temporal variation but no major increasing trend. These three individuals were caught at the end of a warming phase of the Atlantic Multidecadal Oscillation (AMO), a natural climate cycle that was previously demonstrated to have affected pelagic fish populations in the North Sea (McLean *et al.*, 2018). These authors demonstrated an indirect effect of warming

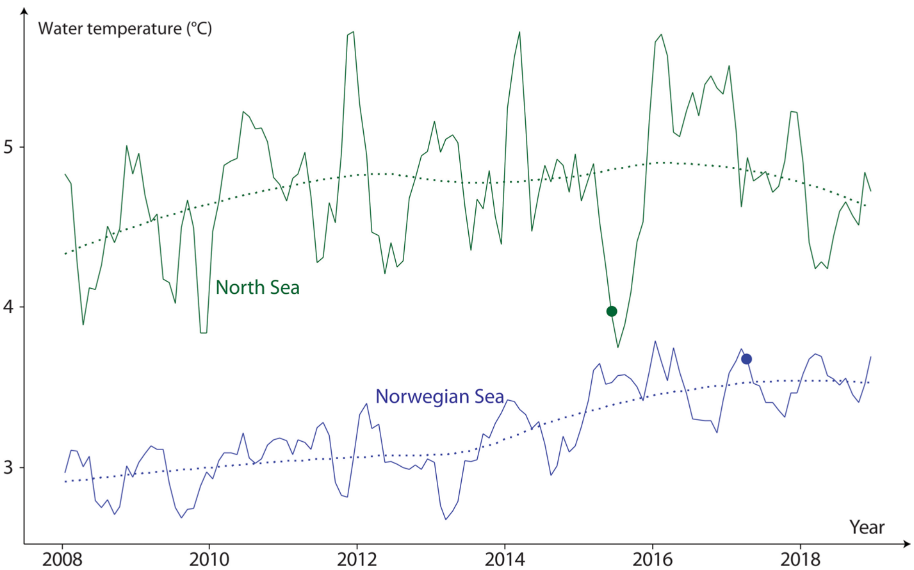

Figure 3. – Time series of monthly average deep (370-565 m depth) water temperatures at the two *Diretmichthys parini* catches location in the North (61-62°N; green curve) and the Norwegian Sea (71.5°N-blue curve), during the decade surrounding the catches. Data are monthly averages, retrieved from Copernicus GLOBAL_REANALYSIS_PHY_001_026 model. Blue and green dots on the curves stands for the date of records, in June 2015 for the two southern records and April 10th, 2017 for the northern record. Dotted line represents the temperature trends fitted by a LOESS regression.

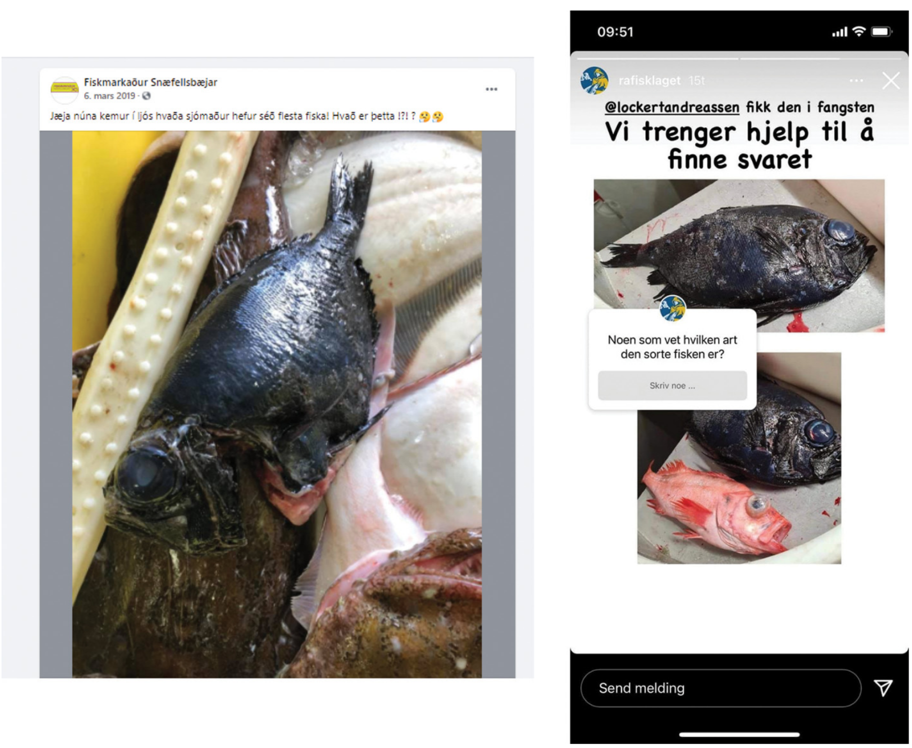

Figure 4. – Screenshots of social media occurrences of *Diretmichthys parini*. Left: Facebook post form the Snæfellsbær fish market. Caption translation: “Well …now we will find out which fisherman has seen most fish species! What is this!?!? »; Right: Instagram post by the Norges råfisklag (The Norwegian Fishermen’s Sales Organization. Upper text translation: “@lockertandreassen caught this. We need help to find the answer”. Lower text: “Does anyone recognize the black fish?”

waters on pelagic species, through the alteration of the planktonic community. In the North Sea, C and N stable isotope ratios measured for *D. parini* were similar with those of zooplankton feeders (Cresson *et al.*, 2017). Depth and temperature ranges observed here may testify the ability of *D. parini* to perform vertical feeding migrations between deep and cold living areas and shallower and warmer epipelagic area, to consume zooplankton. Such an increase of dietary resources may thus represent an additional explanation for the presence of the two individuals in the North Sea. Nonetheless, the climate-driven shift occurred at the end of the 1990’s, *i.e.* two decades before the catches, which may limit the link between the two events. In the North Sea, even if the specific temperature at the time of the catches was low, and may appear as an outlier of the series, temperature may not be considered as a major factor explaining the presence of *D. parini* in the area.

On the contrary, the temperature trend in the Norwegian Sea shows an inflexion and separate two periods, before and after 2014. Model data used here also confirms a pattern described with field observations (Merchel and Walczowski, 2020). The magnitude of the temperature change over the considered decade (~0.5°C) is consistent with values reported elsewhere (0.04°C per year between 1997 and 2015, Merchel and Walczowski, 2020). Warming rate is also higher in this area than in the global ocean. At this very north latitude, as the magnitude of the change is higher and as the initial water temperature was lower, an effect of temperature might be more plausible to explain the presence of *D. parini*.

Diretmichthys parini was first described in 1981. There is therefore only 40 years of hindsight in the documentation of its distribution. The records of this species in the North Atlantic are mainly associated with the bycatch of deep trawl fishing on the continental slope, which reached its peak in the years 1990-2010 for EU countries. As an example, *D. parini* is included in a photo guide of mesopelagic fish distributed to the Dutch pelagic fleet operating in this area (Schilling *et al*., 2019). Similarly, locations of the three clusters of catches in Iceland are consistent with the area harvested by the *Sebastes mentella* fishery. The records were mainly carried out by fishery observers in parallel with their work and occasionally by the fishermen themselves. Consequently, the frequency of these records is strongly influenced by personal approaches motivated by the encounter of a rare species, or by personal interest for biodiversity. Sightings are unlikely to be reported again as the species becomes more familiar to the observer. The lack of records in the time series (for example during 2007 to 2015 in the Icelandic series) could be related to the latter reason and not to environmental or ecological reasons. Similar lack of records could have occurred in the North and Norwegian Seas, and may limit the discussion about the effect of temperature on geographic expansion of the species. This is corroborated by several unreported observations of the species from commercial trawlers operating in Scotland and Western Ireland during the same period (S. Iglesias, pers. obs.) and by a recent catch (autumn 2020) by a lobster trawler operating off SW Iceland (K. Jakobsdóttir, pers. obs.).

Otherwise, social media has recently proven to be an additional source for new fish records. Recent records of *D. parini* from North Atlantic were posted on Facebook by the Snæfellsbær fish market (Iceland) in 2019 (https://www.facebook.com/fmsnb1/posts/2259451590991260) and on Instagram by the Norwegian Fishermen's Sales Organization in 2021, after catching this specimen at almost the same location than the 2017's individual off northern Norway (Fig. 4).

The species *Diretmoides pauciradiatus* (Woods, 1973), mainly known from the intertropical zone, is a species morphologically close to *D. parini*. It cannot be ruled out that its report in Greenland waters (Møller *et al*., 2018) may represent a misidentified *D. parini*. The cumulative records of these two species would tend to support an intertropical distribution for *D. pauciradiatus* and an antitropical distribution for *D. parini*. The record of *D. parini* in 2015 in the northern North Sea was initially perceived as the "northernmost" (Cresson *et al*., 2017) but repeated recent records may testify the usual presence of this species in cold waters of the north Atlantic now. This new interpretation confirmed the need for caution when using superlatives in science (Mammola, 2020) and the need to consider large datasets, including grey literature and long time series for powerful statistical analyses on the shifting distribution of species related to climate change (*e.g*. McLean *et al*., 2018; Merchel and Walczowski, 2020).

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