

1 **Are critically endangered fish back on the menu? Analysis of U.K. fisheries**
2 **data suggest post-ban landings of prohibited skates in European waters**

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Abstract

5 Skates (Rajidae) have been commercially exploited in Europe for hundreds of years with some
6 species' abundances declining dramatically during the twentieth century. In 2009 it became
7 "prohibited for EU vessels to target, retain, tranship or land" certain species in some ICES areas,
8 including the critically endangered common skate and the endangered white skate. To examine
9 compliance with skate bans the official UK landings data for 2011-2014 were analysed. Surprisingly,
10 it was found that after the ban prohibited species were still reported landed in UK ports, including 9.6
11 tonnes of common skate during 2011-2014. The majority of reported landings of common and white
12 skate were from northern UK waters and landed into northern UK ports. Although past landings could
13 not be validated as being actual prohibited species, the landings' patterns found reflect known
14 abundance distributions that suggest actual landings were made, rather than sporadic occurrence
15 across ports that would be evident if landings were solely due to systematic misidentification or data
16 entry errors. Nevertheless, misreporting and data entry errors could not be discounted as factors
17 contributing to the recorded landings of prohibited species. These findings raise questions about the
18 efficacy of current systems to police skate landings to ensure prohibited species remain protected. By
19 identifying UK ports with the highest apparent landings of prohibited species and those still landing
20 species grouped as 'skates and rays', these results may aid authorities in allocating limited resources
21 more effectively to reduce landings, misreporting and data errors of prohibited species, and increase
22 species-specific landing compliance.

23 **Key words** Fisheries; conservation; elasmobranch; overfishing; IUCN red list; *Dipturus batis*

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1. Introduction

29 Humans have exploited fish for thousands of years [1] and have had a major impact on key species as
30 well as their ecosystems [2-4]. Since the industrialisation of fishing in the late 19th and early 20th
31 centuries, fishing has caused depletions of many species that have, in numerous cases, been masked
32 by increasing catch efficiencies enabled by advances in technology, geographic expansion of fishing
33 ranges and the exploitation of previously rejected species [5]. Prior to industrialised fisheries there
34 appeared little or no need to collect catch data and to manage a longstanding traditional human food
35 source, which at that time was thought to be inexhaustible [6, 7].

36 Despite anecdotal evidence suggesting a rapid increase in marine fishing *ca.* 1000 A.D. in Europe,
37 fisheries statistics were first collected about 110 years ago by the newly formed International Council
38 for the Exploration of the Sea (ICES) [8]. With these data, investigations assessed the impact of
39 fishing and were used to inform advice on sustainable levels of fishing for specific species. From
40 these long-term records it has been documented for example that in England and Wales annual
41 demersal fish landings from bottom trawl catches have significantly declined since the
42 industrialisation of fishing in the 19th century [9].

43 On a global scale stock collapses due to overfishing have been well documented for some
44 commercially important fish species, such as Atlantic cod in Canada [10] and Pacific anchovies [11],
45 but many other marked declines in abundances of large fish species have gone largely unnoticed [12-
46 15]. There are several examples of longstanding, unregulated exploitation of large fish leading to
47 dramatic declines, particularly so among the elasmobranchs (sharks, skates and rays). Elasmobranchs
48 have life-history characteristics that make them vulnerable to overfishing, including slow growth, late
49 age at maturity and low fecundity, making them less resilient than bony fishes to overexploitation [16,
50 17]. According to the International Union for the Conservation of Nature (IUCN) Red List of
51 threatened species, a quarter of all assessed sharks, skates and rays are thought to be 'threatened' due
52 to overfishing. Of the seven most threatened families, five are skates and rays, with an increasing
53 global catch of elasmobranchs now being made up of more skates and rays than sharks [16, 17].

54 In the north-east Atlantic Ocean and in the UK in particular, the main commercial interest for
55 elasmobranchs is the family Rajidae (skates), of which there are 16 principal species. Prior to the
56 expansion of marine fisheries in the 20th century, skates were of low value in the UK and were often
57 rejected from fish markets [18]. However, by the beginning of the 1900s they became an increasingly
58 important fishery, notably around the southern coast of England where they made up the highest
59 quantity and value of any species group within the fishery [18, 19]. In the 1930s, during investigations
60 of the catches of skates in fish markets in south-west England, it was noted that it was difficult to
61 assess which species were of importance to the fishery because individuals were not landed as species
62 but instead under the broad group ‘skate and ray’ [20]. Despite this early observation foreseeing the
63 difficulties of accurate assessment without species data, it was not until 2009 that it became
64 mandatory in European waters to land skates as species-specific groups rather than as ‘skates and ray’
65 [21]. During this period of increasing fishing pressure and unmonitored species catches (*ca.* 1900-
66 2009), several species of skates declined in abundance. For example, in the late 19th century, common
67 skate (*Dipturus batis*) were abundant in the waters around the UK and were caught throughout the
68 year [22, 23]. By the 1920s there were reports that former areas of abundance in shallower coastal
69 zones were now devoid of common skate [24], but during the 1930s fishermen were still landing
70 significant quantities of *D. batis* from deeper waters [18]. However, by 1981 it was reported that *D.*
71 *batis* had been extirpated from its former range due to overfishing. Indeed, records from > 800 trawls
72 in the Irish Sea by the Ministry of Agriculture, Fisheries and Food (MAFF) in the 1970s showed no
73 common skate were caught [12].

74 In addition to mandatory landing of ‘skates and rays’ by species after 2009, it became “*prohibited for*
75 *EU vessels to fish for, to retain on board, to tranship or to land*” certain species in specific ICES
76 areas. This protection includes common skate (*D. batis*) and white skate (*Rostroraja alba*) [21, 25]
77 principally due to *D. batis* being IUCN Red List assessed as ‘critically endangered’, and the white
78 skate *Rostroraja alba* as ‘endangered’. Importantly, recent studies used morphometric and molecular
79 genetic markers to demonstrate that there were cryptic species of common skate (*D. batis*), with two
80 species in the north-east Atlantic having distinct but overlapping distributions [26, 27]. However, UK

81 landings data groups these two species (*D. batis* species-complex) into one ‘common skate’ group that
82 will, in this study, be referred to as such. The undulate ray (*Raja undulata*) was also a prohibited
83 species from 2009, however in 2015 the IUCN Red List assessment for European species downgraded
84 its classification to ‘near threatened’ [28], essentially opening up the fishery for this species once
85 more.

86 The Marine Management Organisation (MMO) and Marine Scotland are the authorities responsible
87 for the enforcement of marine regulations including landing of restricted species in England and
88 Wales, and in Scotland respectively. The MMO record data on the fish landings made at the ports,
89 including both weight and value, which are collected from fishermen’s log books and market sales
90 notes. These agencies can also have representatives based at fish markets around the UK that inspect
91 catches landed at market and those held in market cold stores. Data are then checked and verified by
92 port staff as well as database managers and statisticians at the data input and archiving stages [29].
93 For data to support fisheries management measures reliably it is essential that landings and discard
94 data are recorded accurately. This is especially important because landings data are widely used to
95 inform and support the development and delivery of government decision-making at the UK and
96 European level to enact components of the European Union Common Fisheries Policy. This includes
97 contribution to stock assessment for estimation of total allowable catches (TACs), quota management,
98 effort control and fleet management [29]. These data are also crucial to ongoing assessment of
99 whether particular management policies are effective for sustainable exploitation of European fish
100 stocks.

101 In a previous study the species composition of skates in UK commercial landings and discards was
102 examined between 2007 and 2010, a period spanning the implementation of the bans [21]. The latter
103 study concluded that reported landings of prohibited species had decreased after 2009, in line with
104 conservation measures [21]. In the current study it was investigated whether the landings of prohibited
105 skates have further declined toward zero, as would be expected if bans are being adhered to and are
106 being policed effectively. Therefore, to investigate the effectiveness of the 2009 changes for skate
107 landings in the UK with respect to prohibited species and the need for landings of species-specific

108 groups, data from 2011-2014 were obtained from the UK MMO for analysis. The expectation was that
109 if the restrictions in place are effective, monitored and enforced, with sufficient resources available
110 for error checking, data should be categorised as individual species and none of the prohibited species
111 should appear in the data [30].

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2. Method

Species-specific skate and ray data were obtained by written request from the UK MMO. The data were provided on 26th January 2015 and comprised data for UK flagged vessels landing into the UK and abroad, and foreign flagged vessels landing into the UK over the period from 2011 to 2014 inclusive. The data provided included landings of species in addition to the grouping ‘skates and rays’. The dataset also included ICES area of capture, Food and Agriculture Organisation of the United Nations (FAO) area of capture, port where a landing was made and the live weight (metric tonnes) and value (£) of the landed catch. Live weight data were mapped in ArcGIS (10.2.2) according to ICES area and port. Relative quantities of common skate were also calculated to investigate whether higher landings of this species in northern ICES areas were a function of the higher overall landings from these areas. For each ICES area total common skate landings in 2014 were divided by the total skate and ray landings in 2014 for that respective ICES area. ‘Skate and ray’ landings by port were only mapped for ports when total landings were greater than 5 tonnes. The 2014 data were considered ‘provisional’ by the MMO at the time the analysis was undertaken.

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3. Results

3.1 Prohibited species

Between 2011 and 2014, 9.6 tonnes of common skate (*D. batis*-species complex) were reported as landed all around the UK (Figure 1). There were higher landings in the north western and eastern ICES areas VIa (2.43 t; north-west Scotland) and IVb (1.89 t; central North Sea), respectively. Ports with particularly high total reports of landings of common skate were Scrabster (1.4 t), Mallaig (2.3 t), Peterhead (1.6 t), Oban (0.7 t), and Portavogie (0.7 t), all in Scotland, and Exmouth (0.6 t) in south-west England (Figure 2). Landings of common skate did not necessarily occur at all ports in every year. For example, Scrabster reported no landings in 2014 whereas Oban and Portavogie reported their highest landings of common skate in 2014 (0.4 t and 0.6 t respectively).

The general pattern of higher recorded landings of common skate from northern ICES areas, e.g. VIa north-west Scotland (Fig. 1), were not dependent on the higher overall landings of skates and rays made into northern UK ports. Rather, the landings of common skate from northern areas remained relatively higher than those from more southerly ICES areas even after accounting for the total skate and ray landings made from each area (Fig. 3). This pattern indicates landings of common skate were not distributed randomly around UK ports, but appeared to reflect latitudinal abundance differences.

The reported landings of white skate were 17.89 t in ICES area VIa (north-west Scotland), whereas in IVa (northern North Sea) the reported landings were higher at 29.49 t. In the latter area, however, it was not prohibited to fish for, retain or land white skate (Figure 4), indicating that the reported landings of white skate were of the same magnitude in weight irrespective of whether a ban for that species in that area was in place. In terms of ports, Mallaig (12.3 t) had relatively high quantities of prohibited landings of white skate, with lower numbers in other ports around the UK (Figure 5). Mallaig had its first year of zero reported landings of white skate in 2014, in contrast to Kinlochbervie in the same ICES area which had its highest reported landings in 2014 (0.5 t).

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178 [Fig. 2 here]

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181 [Fig. 5 here]

182 **3.2 Other species**

183 Undulate ray (*R. undulata*) was also a prohibited species over the time period covered by the data.

184 Indeed, only minor landings of this species were reported in Newlyn in 2012 (1.6 kg), which likely

185 represented a single individual. The data also report some species landings which are not prohibited

186 but seem less reliable based on their species range. Data show that Arctic skate (*Amblyraja*

187 *hyperborea*) were landed off the southern coast of England between 2011 and 2014. The areas of note

188 are IVc (southern North Sea; 1.59 t), VIId (eastern English Channel; 0.13 t) and VIIe (western English

189 Channel; 0.13 t). Norwegian skate (*Dipturus nidarosiensis*) (1.1 kg), likely a single individual, was

190 reported landed in area VIId (eastern English Channel).

191 **3.3 Skates and rays**

192 Overall, the MMO landings data records that 769.6 tonnes of ‘skates and rays’ were landed as one

193 group between 2011 and 2014 in all areas of the UK (Figure 6). The amount of the former ‘skates and

194 rays’ group landed as species was 96% in 2014, with that remaining as ‘skates and rays’ amounting to

195 133 tonnes. The areas with the highest total landings during 2011-2014 were VIa (north-west

196 Scotland; 154.03 tonnes) and IVa (north-east Scotland; 287.60 t). For the ‘skates and rays’ landing

197 group, the highest landing ports were Peterhead (148.4 t) and Scrabster (163.4 t) followed by Lervick

198 (41.5 t), Lochinver (40.7 t) (all in Scotland), and Padstow (34.7 t) in south-west England (Figure 7).

199 For Padstow, the majority of this total (34.6 t) was landed in 2011, however since that time landings

200 ascribed to the ‘skates and rays’ group have been very low. For Scrabster, the highest landing port for

201 ‘skates and rays’ landings have increased during the period, indeed almost doubling from 2011 (37.0

202 t) to 2014 (64.4 t). For the other ports mentioned here, all showed some decrease in this landing

203 group, although landings remained substantial. The lowest was Lochinver recording 1.6 tonnes in
204 2014.

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4. Discussion

224 This study reveals that prohibited skate species were recorded as landed all around the UK between
225 2011-2014 following the bans in 2009. The recorded landings were not distributed evenly, but instead,
226 some areas and ports reported notably higher landings than others. Overall, the areas in the north of
227 the UK reported higher landings of both common skate and white skate. Exmouth in the south also
228 reported a relatively high number of common skate in the landings data (0.56 t between 2012 and
229 2014). These data indicate annual landings of prohibited species were still being made, or being
230 recorded as made, across the UK at a time when bans for these species were in place within European
231 waters. As well as the possibility that these may be actual landings of the prohibited skate species,
232 there may also be factors that contribute to errors in reporting that mean these data may not represent
233 actual landings. Therefore, three possible explanations are proposed for the occurrence of prohibited
234 species in the UK landings statistics: (i) prohibited skate species were being caught, retained, landed
235 and sold as the correctly named species; (ii) misidentification of skate species means no actual
236 prohibited species were being caught, landed and sold; and, (iii) data entry errors at ports or elsewhere
237 were occurring that mean no actual prohibited species were being caught, landed and sold. These
238 principal possibilities are discussed in turn prior to making some conclusions based upon the available
239 information presented here and that found elsewhere in the literature.

240 1. **Are prohibited, endangered skates being landed into UK ports from fishing areas where**
241 **bans are in place?**

242 A recent study -reported that the prohibited *D. batis*-species complex was recorded in both
243 commercial and observer data as having been landed in the UK following capture in the central and
244 northern North sea areas [21]. For example, the observer programme in the central and northern North
245 Sea recorded 2.1 t of *D. batis*-complex being retained from the catch during 2010, after the 2009 ban
246 was in place, a quantity that was higher than the 0.3 t reported as landed by the commercial otter trawl
247 fleet from those areas in 2010. Our results confirm these prior landings by showing for the period
248 2011-2014 that common skate were still being recorded as landed by fishers after 2010 and that this

249 quantity appears to be not insignificant. This study found that 9.6 t of common skate were recorded
250 landed in UK ports between 2011 and 2014. If an average-sized individual common skate is
251 considered to be between 3.5 kg [27] and 33.17 kg [31] in total body mass, this estimates that between
252 289 and 2,743 individuals were landed (mean, 72-686 per year) in 2011-2014. Furthermore, it was
253 evident that the apparent landing pattern was not random, with most recorded landings occurring in
254 northern UK ports and caught within northern UK sea areas (see Figs 1 and 2). This pattern of catches
255 and landings of common skate appears to be consistent with their currently known centres of
256 abundance within their distributional range, which are thought to be greater in northern UK waters
257 [26]. Clearly, this northern bias in common skate landings in 2011-2014 in the raw data may be a
258 consequence of a higher number of skates generally being landed into northern ports as opposed to
259 southern ones. However, even after accounting for the higher landings of skate species generally
260 made from northern UK ICES areas, the current study still found the recorded landings of common
261 skate to be relatively higher in the north of the UK (areas VIa, IVa and IVb), a pattern that would be
262 expected if they were in higher abundance there (Figure 3). This implies that the recorded landings of
263 common skate in 2011-2014 reflect the expected patterns of landings based on abundance and
264 distribution. In support of this, common skate are occasionally reported from VIIa (Irish Sea), VIIf
265 (Bristol Channel) and IVb (central North Sea), though it is suggested that its range is now limited to
266 VIa (north-west Scotland) and the VIIh (Celtic Sea) [32]. That the relative landings of common skate
267 reflect their reported latitudinal abundance trends argues against the pattern being largely due to
268 misidentification of skates by fishers or officials, or due to erroneous data inputs occurring more often
269 in northern areas, given that these types of errors should theoretically be equally likely in all areas and
270 ports. Therefore, our results cannot entirely discount the possibility that common skate have actually
271 been retained and landed into the UK in at least four of the years after 2009 when the ban came in
272 force.

273 Despite these recorded landings in official data, there appears at present to be no evidence of common
274 skate products entering the UK retail chain. Griffiths *et al* [33] analysed DNA sequences in tissue
275 from 98 skate wings purchased in retail outlets, such as supermarkets and restaurants, but found no

276 evidence for the presence of prohibited or vulnerable skates for sale. This result may be a
277 consequence of sample size however, since it may be expected that very few individuals of critically
278 endangered species are likely to be sampled in markets or food outlets because they are naturally at
279 low abundance and hence few are landed compared to other species. This assertion is supported by
280 considering common skate numbers compared to total skate landed in 2014 for example, which
281 estimates there would be a 0.054% chance of sampling a common skate, equivalent to finding one
282 common skate for every 1,852 skates examined. Therefore, nearly two thousand individual skate
283 would need to be tissue sampled for DNA before a single positive identification is likely statistically,
284 even if they are entering the retail chain. Therefore, the possibility that common skate are entering the
285 retail chain cannot be discounted on the basis of forensic studies undertaken to date.

286 2. **Are fishers misidentifying or misreporting prohibited skate species?**

287 Species misidentification is a major potential problem in skate fisheries that can contribute in
288 important ways to confusion with interpreting prohibited species landings data. For instance, a recent
289 study using molecular genetic markers found that in supermarkets where skate pectoral fins (marketed
290 as ‘skate wings’) were labelled with a species name, 33% of the labels were incorrect [33]. Therefore,
291 it seems misidentification of skate species occurs frequently and is being introduced somewhere along
292 the retail chain from the point of skate capture to the location of sale to consumers. Of course, once
293 the skate wings have been processed (skinned), it becomes much more difficult for retailers to identify
294 the species correctly without molecular genetic analysis. Moreover, UK skate species are also difficult
295 to identify even when alive. The spot pattern and/or colouration that is often used by fishers to
296 distinguish between skate species can be highly variable within a species which enhances the
297 problems of easy identification soon after capture [27]. The problem of persistent misidentification is
298 well illustrated by two examples. One recent study [21] found significant discrepancies in the
299 quantity of skate reported in commercial landings and that recorded by observers. In the North Sea in
300 2010 it was found that commercial otter trawlers reported 3.4 % of their skate catch as the spotted ray
301 *Raja montagui*, whereas observers on otter trawlers in the same year reported that 50.9% was *R.*
302 *montagui* [21]. In addition to that investigation, in this study the presence of Arctic and Norwegian

303 skate on the south coast of the UK in the landings data would also suggest ongoing issues with
304 misidentification. Our investigation found recorded landings data supporting one or two individual
305 Norwegian skate and a significant quantity of Arctic skate being ‘landed’ on the southern coast of
306 England. However, the southern coast of England does not fall within the distributional range of these
307 species, so it would seem highly unlikely that these species were in fact caught there or subsequently
308 landed nearby. It is more likely that the individuals landed were misidentified or were incorrectly
309 entered into the landings data. It is evident that correct identification is a significant and continuing
310 problem in reporting landings.

311 Misidentification can take two forms. It could simply be unintentional error on the part of the fishers
312 when faced with individuals from different species that look similar. This may happen frequently for
313 more common species and remain undetected because the misidentifications are effectively lost
314 among the large quantities of correctly identified individuals. However, equally, there may be
315 intentional misidentification that manifests as misreporting. For example, at the fish market each of
316 the main species of skate landed and traded (thornback ray *Raja clavata*; blonde ray, *R. brachyura*;
317 spotted ray, *R. montagui*; cuckoo ray, *Leucoraja naevis*; and smalleyed ray, *R. microocellata*) has a
318 separate price for species and for size class. Although prices fluctuate, blonde ray generally obtains
319 the highest value, with thornback ray obtaining the lowest. Therefore, fishers may have an incentive
320 to misreport a species for one most likely to obtain a higher price. Indeed, other studies have shown
321 that misidentification has occurred purposefully in order to obtain a higher price or to hide the capture
322 of a restricted species [34, 35]. The discrepancy in common skate reported as landed by fishers (0.3 t
323 in 2010) and that recorded by observers as retained species (2.1 t in 2010) in the central and northern
324 North Sea [21] could be explained by intentional misreporting of common skate as blonde ray, for
325 example. However, this does not explain in the context of the current study why a fisher would record
326 a common skate in the logbook of catches. It seems unlikely that a fisher would identify a common
327 skate (rightly or wrongly), and regardless, attempt to land it for sale as common skate when a ban is
328 known to be in operation for the species. Furthermore, the common skate is prohibited so there should
329 in effect be no price for it, thus it would seem more likely that a fisher would log it as a different

330 species if their intention was to command a higher price. However, the recorded landings of common
331 skate in 2011-2014 in this study were officially reported as having a monetary value of £10,456,
332 implying that common skate were openly landed and sold as common skate unless of course these
333 data were entirely incorrect (see section 3).

334 There is good reason to assume that misidentifications involving prohibited species should have a
335 greater chance of being detected. It is not only the fishers that are involved in the process of catching
336 fish right through to data collection and input by the management authorities, but there are other
337 stages at which identification errors could be corrected. The fish merchants employ staff that sort and
338 grade fish so that it can be priced according to species. The UK authoritative agencies also visit fish
339 markets and cold stores to verify the catches. The skate are then sold to buyers that often prefer one
340 species over another, because some species are easier to process than others, hence the higher price
341 for blonde ray for example. There are then multiple steps with data cross checks and data validation
342 that occur at the port with the fisheries' authorities and also their central database statisticians [29].
343 Given the number of steps involved from fish capture to identification and data entry, it is possible
344 that apparent landings of prohibited species would most likely be checked and contraventions
345 identified at the ports. Therefore, it seems unlikely that systematic misidentifications of a prohibited
346 species, mainly in northern UK ports, can account for the relatively large quantities of these rare
347 species appearing in official UK landings statistics.

348 3. Are systematic errors in data input being made?

349 Fishers input data into their log books, and in port the market agents then sort and grade species, as
350 well as providing sales notes for the fish sold. The observers appointed by authoritative agencies
351 inspect catches and enter the species they find onto data collection forms. There are many stages in
352 this process where human error in data input could be introduced. Simply an incorrect box ticked
353 could cause errors in allocations of landings to individual species. The entire chain from fishers to
354 regulatory agencies' data input uses codes to identify each species. These codes are based on species
355 scientific names, although the landings data uses common names. For example, RJB is the market

356 code for common skate *Dipturus batis*, however it is easy to appreciate that this may be confused with
357 blonde ray *Raja brachyura*, whose code is actually RJH.

358 The scale of erroneous data entry appears to be significant. For example the MMO have reported that
359 80% of all electronic logs for fishing vessels in 2013 had to be amended due to incorrect information
360 [29]. This only serves to indicate the large potential for error in data input that can be introduced from
361 the very start of the data chain and right up to data transfer from fishers to fisheries managers. As part
362 of data validation and review, statisticians also check for unlikely combinations of ICES area and
363 species landing. However, the records found in this study after the data was provided to us on
364 26/01/2015 showing the occurrence of Arctic skate in ICES VIIe (western English Channel) in 2011
365 and 2012, suggests that likely errors are not being identified and corrected/deleted in a time frame that
366 is relevant to management needs. For example, the 2011 data that held the likely errors noted above
367 were still being sent to researchers in 2015. A previous study using recent UK landings data also
368 questioned the accuracy of some of the commercial landings data, where skate species were
369 apparently caught outside of their natural range [21].

370 **Concluding Remarks**

371 In the above discussion some of the data and arguments relevant to each possible cause of the reported
372 landings of prohibited skate present in the UK official landings data has been set out. It was not
373 possible to determine precisely which of the factors was largely responsible for the apparent illegal
374 landings of protected species because there was no way to identify *post hoc* what actual species made
375 up the landings reported. It is very likely that these three possible explanations are not mutually
376 exclusive, making identifying the cause even more difficult. Nevertheless, there does appear to be
377 support from this study and from a previous investigation [21] for the conclusion that common skate
378 were landed and sold in UK ports after the 2009 ban. It is also possible that captured common skate
379 were misidentified or misreported as being other skate species, while errors in allocating and
380 recording market codes, and other data entry errors prior to finalising the official landings data may
381 also play a significant role in misrepresenting landings of prohibited skate species.

382 Regardless of which of the three principal explanations was the most likely to account for prohibited
383 skate landings, there appears to be a lack of official investigation to determine the origin of the
384 apparent prohibited landings and to correct them where necessary. For example, this study was
385 provided with possible error-laden data by the regulatory authority some 3 years after it first appeared
386 in the UK official fish landings statistics. The persistence of erroneous data in official records may
387 reflect unequal resources available at ports across the UK for early detection of prohibited skate
388 landings, misidentifications, misreporting and data entry errors. Misreporting is more difficult to
389 identify generally in mixed catches of skates but should be possible with sufficient surveillance. The
390 UK spends significant public funds on the monitoring and enforcement of fisheries regulations, yet it
391 seems that some potential errors that can be straightforward to check are not only still occurring but
392 are remaining within the official statistics for at least three years.

393 There has been significant progress however in greater reporting of skate catches according to species
394 rather than the generic 'skates and rays' grouping. The current study supports the findings of Silva *et*
395 *al* [21], in that since the 2009 regulations were implemented improvements have been made in terms
396 of landing species-specific skates. Silva *et al* [21] report that in 2010, 92% were landed as species
397 specific. By the end of 2014 our analysis shows that this figure had risen to 96%. However, the 4%
398 that were not landed as species represent 133.3 tonnes of unknown species. Therefore it remains
399 possible that prohibited, endangered skates may make up some of this grouping.

400 Furthermore, there have been some improvements to reduce landings within the 'skates and rays'
401 group between 2011 and 2014 at certain ports, but such reductions are not consistent across the UK.
402 ICES areas and certain ports in northern Scotland appear to be relatively high in landing 'skates and
403 rays' grouped. Although it is possible that this could occur because of a lack of fisheries enforcement
404 offices in these more remote areas, it was evident that there are Marine Scotland compliance offices
405 based at all of the main ports including those with relatively high landings of prohibited species, such
406 as Mallaig, Scrabster and Fraserburgh. This suggests more needs to be done to enforce the landing of
407 skates in species-specific groups, not only to reduce the potential for prohibited species to be included

408 in landings of ‘skates and rays’, but to improve the accuracy of fisheries management advice for skate
409 species.

410 In summary, this study draws attention to the recorded landings of prohibited skate species in each
411 year from 2011-2014 since the European Union ban was put into effect in UK waters in 2009. That
412 common skate have actually been openly landed and sold in UK ports since 2009 could not be entirely
413 discounted. This possibility emphasises the need for greater efforts to enforce the ban across major
414 UK fishing ports if these endangered species of fish are to be adequately protected according to the
415 management measures put in place to safeguard their populations.

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