Revised article

Biodiversity defrosted: unveiling non-compliant fish trade in ethnic food stores

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Abstract

Out of nearly 30,000 teleosts dwelling in our planet's water bodies, only hundreds of them are commercially exploited and prevail on the global food market. Yet, our estimates of the species actually underpinning global trade is severely hampered by inaccuracy and non-compliance in labelling and reporting. Here, we target ethnic food stores in two British cities (Liverpool and

Manchester metropolitan areas), whose numbers are increasing throughout Europe, to examine accuracy of traceability information available to consumers. Despite the existence of thorough EU labelling regulations, we unveil a high level of non-compliance, with a diverse range of poorly-known fish species, often sold without any label, or with erroneous information, as demonstrated by DNA barcoding. Results indicate that about 41% of the samples were mislabelled, in stark contrast with a recent study that, in 2015, found less than 5% mislabelling in EU supermarkets and fishmongers. These results highlight that inspectors and governments might not be fully aware of the wide diversity of fish species traded, indicating the need for a stronger enforcement of the EU labelling legislations. Compliance with regulations is required not only to protect consumers, but also fish stocks, as for many of the species identified in this survey, population assessment is poor or lacking altogether.

Key words: DNA barcoding, species substitution, conservation, ethnic food, snapper, UK

1. Introduction

Global fish production has grown steadily in the last five decades, with fish food supply increasing at an average annual rate of 3.2% (FAO, 2014). World per capita fish consumption increased from an average of 9.9 kg in the 1960s to 19.7 kg in 2013 with preliminary estimates for 2014 and 2015 pointing towards a further growth beyond 20 kg (FAO, 2016). This remarkable development is mainly a consequence of the global population growth expected to reach 9 billion people by 2050 (FAO, 2016). The need to feed this increasing number of people asking for protein sources has driven the rapid growth of the aquaculture sector, which, for the first time in 2014, overtook wild-caught fish production (FAO, 2016). China has played a major role in this growth as it represents more than 60 percent of world aquaculture production (FAO, 2016).

This notwithstanding, half of the seafood consumed by humans still depends on the capture of wild organisms, which amounts to the vast majority of the 1,200 species commercialised in the European Union (EU; EUMOFA, 2016), of which the majority is imported as frozen or prepared meals (EUMOFA, 2016). Seafish (Seafood Industry Factsheet, 2015) reports that 70% of the seafood that enters the UK supply chain is imported from abroad or landed by foreign ships. In 2015 UK imported seafood accounted for 5% of the global EU trade. In terms of value, the top UK import species are *Gadus spp.* (cod), *Salmonidae spp.* (mostly farmed Atlantic salmon), *Thunnus spp.* (tuna), *Melanogrammus aeglefinus* (haddock), *Pollachius pollachius* (pollack) and *Scomber spp.* (mackerel).

Data from the retail sector, gathered in 2014, demonstrate that British people preferred to buy frozen seafood (5,729 tonnes of the overall seafood sold) as opposed to fresh products (1,082 tonnes) or canned seafood (43 tonnes) (Seafood Industry Factsheet, 2015). The increasing demand for frozen seafood, which to a large extent is marketed filleted, beheaded and/or further processed (dried, pre-cooked), makes species identification more difficult. Furthermore, the increase in multiculturalism of Western societies has led to an increase of alternative food stores that trade a wide range of ethnic products (Lee, Hwang & Mustapha, 2014; Armani *et al*., 2015), many of which purvey a wide assortment of imported seafood products.

Ethnic food stores are often characterized by deficiencies in traceability systems and, as a consequence, mislabelling can be a significant issue (Armani *et al*., 2013; D'Amico *et al*., 2014; Armani *et al*., 2015). Seafood is at particular risk, due to the increased globalisation of the trade, the increased imports of newly-exploited and exotic species (Armani *et al*., 2015, Watson *et al.*, 2015) and the lack of knowledge of seafood products by the average consumer (Velasco *et al*., 2016). Morphological identification of seafood remains arduous for filleted samples or even for whole, but unusual, newly-marketed species, which would require identification by expert fish taxonomists. DNA-based techniques are currently considered as the gold standard for species identification, in particular through the universal mtDNA COI barcoding fragment (Ward *et al*., 2005) and a variety of mini-barcodes (e.g. Leray *et al*., 2013).

In this study, we applied this approach for the identification of frozen fish collected from ethnic retailers in the British cities of Manchester and Liverpool. Food labelling is essential to ensure consumer safety and choice awareness. Considering the recently improved legislation (EC, 2013), which requires seafood to be labelled with commercial and scientific name, production method, catch area and fishing gear category, the mainstream EU retail sector appears to have a stronghold over seafood trade malpractice (Mariani *et al*., 2015). However, while the main retail sector typically hinges on a handful of commonly traded fish species, ethnic stores purvey small quantities of a much greater spectrum of species caught and farmed worldwide, for which EU Member States have to draw up a list of the commercial designations that are consistently acceptable for specific taxa (i.e. species, genera and, in some cases, entire families). Commercial names permitted in the UK are provided in a governmental publication, “Commercial Designations of Fish” (DEFRA, 2013), which is updated every few years. The scientific name should be in accordance with the FishBase Global Information System on Fish or the Aquatic Sciences and Fisheries Information System database of the Food and Agriculture Organisation.

The main goals of this study were: i) to provide a realistic picture of global biodiversity underpinning the ethnic seafood retail sector in Britain; ii) to verify if the greater diversity of traded species and the lesser profile of the sector would result in high levels of seafood mislabelling; iii) to examine the environmental consequences of poor labelling and traceability of marketed species.

2. Materials and Methods

2.1 *Samples collection*

A total of 88 frozen fish were sampled in 21 different retailers between Liverpool (43 specimens) and Manchester (38 specimens). The final sample size (*N* = 88) of our study is same order of magnitude of comparable investigations carried out in Italy (Armani et al., 2015; D’Amico et al., 2014). Furthermore, during sample collection, we reached a point where it was difficult to locate new stores or find new species that had not already been sampled, therefore reaching a sort of

"retail type/product" saturation. Samples were collected in Asian and Afro-Caribbean food shops located mainly in the China town areas of those cities or in Manchester's "Curry Mile" area.
Frozen fish samples ranging from fillets to the whole animal (Fig.1), were gathered between October 2014 and December 2015, trying to maximise the diversity of fish on sale, and focusing on those that did not use standard packaging (e.g. wrapped in a plastic bag, piled in a large freezer with labels hand-written with marker pen, etc.). Samples included wild caught or farmed fish and some were processed (e.g. dried or pre-cooked).
Once collected, samples were dissected in order to remove a little piece of tissue (from muscle or from the caudal fin) suitable for the subsequent genetic analyses.
Tissues samples were placed into 2ml labelled tubes filled with 95% ethanol and stored at -20°C. Details of each sample were collected, including place of purchase, species designation, standard body length (without caudal fin), total length, sex (if the animal was not gutted) and a photograph.

2.2 *Molecular analysis*

Total DNA was extracted following the standard protocol of Estoup *et al*. (1996), using Chelex® resin. Tubes containing DNA suspension were then stored at -20°C for long-term preservation.
The amplification of the partial COI gene was carried out using the FishF2 and FishR2 universal primers described by Ward *et al*. (2005). PCR reactions were performed in a total volume of 20 µl following a protocol by Serra-Pereira *et al*. (2010). Each amplification contained: 2 µl 10x reaction buffer, 1 µl $MgCl_2$ (50 mM), 0.2 µl of each primer (0.01 mM), 0.1 Units of DNA Taq Polymerase (PROMEGA, Madison, WI, USA) and 0.4 µl dNTP (10 mM). PCR conditions entailed an initial denaturating step at 94°C for 2 min, then 35 cycles of denaturation at 94°C for 30 s, annealing at 52°C for 40 s and extension at 72°C for 1 min followed by a final extension at 72°C lasting 10 min.
If amplifications were unsuccessful with the FishF2 and FishR2 primers due to low DNA quality, COI mini-barcode primers (mICOIlintF and jgHCO2198) were used following the protocol described in Leray *et al*. (2013). PCR products were visualized on 1% agarose gels with 6 µl of GelRed by means of ultraviolet transilluminator. Amplicons were sequenced by Source Bioscience

Sequencing Service (Cambridge, UK) using the forward primer. Sequences quality was checked by eye using the chromatogram visualization software BioEdit v7.2.5 (Hall, 1999). Samples were identified using two online databases, 1) the GenBank database (http://www.ncbi.nlm.nih.gov/) and 2) the Barcode of Life Data system (BOLD, http://boldsystems.org/; Ratnasingham & Hebert, 2007). The "Public Record Barcode Database" was used in the latter case, where identification was determined by sequence similarity to the reference dataset (Wong & Hanner, 2008) and checked by “Tree based identification” (Costa *et al*., 2012).

The BLAST platform allows the assignment of a DNA sequence to a species by means of sequence comparison with database entries. However for an accurate identification, the *E*-value, as an evidence of error probability, should go as far as possible to zero and the sequence match should be ≥ 98% identity.

Lastly, in order to assess the reliability of the sequences, each matching sequence was aligned with our unknown sequence using the Clustal W alignment algorithm in BioEdit.

Statistical analysis of the results present in this study show 95% confidence intervals for binomial distribution and were carried out using MASS package (Venable & Ripley, 2002) within the statistical software R (version 3.3.3, R Development Core Team 2017).

2.3 *Determination of labelling accuracy and substitutions*

Samples labelling accuracy was checked against the European legislation EU no 404/2011 further implemented with the EC No 1379/2013, which relates to consumers’ information and labelling provisions for fishery and aquaculture products marketed within the Community. These products, irrespective of their origins, must be appropriately labelled at the point of the retail, reporting the scientific name, the commercial designation, the production method (caught at sea or inland waters or farmed), the catch area and the fishing gear used.

In order to confirm whether substitutions occurred within our dataset, the species IDs obtained via molecular analysis were checked against the official DEFRA list of seafood product denominations (DEFRA, 2013).

3. Results

Based on the requirements of the most recent EU labelling regulation (EC No 1379/2013), none of the samples provided comprehensive and mandatory information. 18% [10-26] of samples lacked any type of label and, in 77% [69-84] of the cases, the scientific name was not indicated on the package/label, which must be reported as from 1st January 2012 (EU No 404/2011 art. 68, Suppl. Info). One sample was sold as "*Frozen Freshwater Fish*" and was considered as having no label as it did not specify any criterion that is stipulated in the EU regulation. The geographical area was missing in 73% [63-83] of samples. One sample of farmed fish was sold as "*Farmed in seawater*", lacking detail about the country of origin, which is expected for farmed fish (EU No 1379/2013, Suppl. Info). Labels of eight wild-caught fish samples specified the country of origin, but not the FAO area where the fish was caught. Furthermore, another sample labelled as "caught in Iceland" was missing sub-area or division indication, which is required for all the fish caught in the Northeast Atlantic, Mediterranean and Black Sea. Finally, in no case was there any information on the type of fishing gear (Suppl. Info).

Molecular analysis generated interpretable sequences for 81 of the 88 (92% [86-98]) samples collected. The remaining 7 samples were excluded from further analyses. For eight of the 81 samples, the mini-COI primers were used due to degraded tissues (Table 1).

The search with the BOLD engine identified 37 samples to species level, 30 to the genus and 13 to family level. All searches yielded matches that were within the 98% similarity to database records.

GenBank search provided 33 species-level sample identifications, 37 to genus and 11 to family level. Only one sample sold as Croaker failed to reach the match through BOLD search, but was identified with GenBank.

Twenty-eight (ca. 34% [24-44]) samples were identified as belonging to different families than the ones indicated on their labels; four samples were identified as belonging to different genera and for one sample the substitution involved two species within the same genus (Table 1 and Fig.2). The highest number of mislabelled specimens collected were sold as Snapper (Red Snapper, Yellow

Snapper, White Snapper), as sixteen samples out of seventeen were misrepresented (Fig.2). DNA barcoding revealed sequence match with *Pagrus pagrus* (3 samples), *Pagellus erythrinus* (2 samples) and *Pagellus bellottii* (1 sample), which all belong to the *Sparidae* family ('sea breams' or 'porgies') and 3 other samples were identified as *Nemipterus japonicus* (family: *Nemipteridae*, 'threadfin breams'). Following the guidelines set out by the UK government (DEFRA, 2013), only species belonging to the *Lutjianidae* family may be labelled as 'snappers'. Four samples were identified as redfish (*Sebastes spp.*), hence placed in a different order altogether (*Scorpaeniformes*) (Table 1). The Snapper sample sold under the common name of "Ruby Snapper" and identified as belonging to the *Lutjianidae* family was considered mislabelled as, according to UK designation list, this common name refers to the species *Etelis carbunculus,* a species that did not appear in the search results of neither BOLD nor Genbank (Table 1). Lastly, within the Snapper substitutions we included two samples sold as *Negatine*, a name unknown to the scientific community (DEFRA 2013; http://www.fishbase.org/; http://www.marinespecies.org/; www.fao.org/fishery/collection/asfis/en) and genetically identified as *Argyrozona argyrozona* (common name carpenter seabream, Family: Sparidae) because when we asked to the seller for more information he specified they were a kind of snapper.

Another common substitution observed here is for fish labelled as 'pomfret', which should belong to the *Brama*, *Pampus* and *Stromateus* genera, but identified as a *Trachinotus spp*., whose official accepted common name is 'pompano' (DEFRA, 2013). This substitution was found in each of the six specimens sold under the common name of pomfret (Table 1 and Fig.2).

Some samples, despite being incorrectly labelled, were not listed as mislabelled. A specimen sold as 'jackfish' was genetically identified as *Pseudocaranx dentex* using both BOLD and Genbank. Following databases such as Fishbase (http://www.fishbase.org/) and WoRMS (http://www.marinespecies.org/), the accepted common names for *Pseudocaranx* in the UK are: Silver trevally, Toothed crevally or White trevally; yet 'Jackfish' is the term used in New Zealand; moreover, the scientific name *Pseudocaranx spp*. is not on the official list of commercial designation of fish in the United Kingdom (DEFRA, 2013) and, as a consequence, we considered the term jackfish as a fair attempt to describe the product.

Beside showing the mislabelling rate for frozen fish products, this study also illustrated the high fish diversity that can be found in ethnic food shops. Overall, in a total of 88 fish, sampled over a period of fourteen months, we found approximately thirty-seven species belonging to thirty-three different genera, representing fifteen families and seven orders (see Fig. 3).

4. Discussion

Labelling regulations are in place to ensure that seafood can be tracked throughout the supply chain by providing clear and accurate information for the consumer. Despite the strict labelling legislation implemented across the EU, and thus in the UK, a high rate of non-compliance was unveiled in specialised markets, such as ethnic food stores. Our results echo other studies performed in similar retail stores in Italy by Armani *et al.*, (2015) and D'amico *et al.* (2014) which albeit requiring future expansion in terms of sampling effort, already indicate a rather more worrying state of things, compared to the mainstream EU retail sectors, such as supermarkets and fishmongers (Mariani *et al*., 2015).

4.1 *Fish Species identification and mislabelling*

Overall, seven samples resulted too degraded to yield quality reads. Fish products are highly perishables and can quickly spoil compared to any other food, this result might indicate a lack of care during post-harvest handling, processing, preservation, packaging, storage and transportation practices, which may lead to a degree of product's quality degradation that could even be of concern for consumer health.

Generally, the methodological approach applied in this study appears very robust to identify frozen fish samples, as both BOLD and GenBank produced similar identification matches, albeit BOLD searches had a slightly higher success rate in species-specific identification (Table 1). With

GenBank 60% [64-84] of the samples failed to match the species level, while on the BOLD search engine 54% [56-76] did not reach a species-specific match. Problems to identify samples down to the species level are well known for very closely related species, like *Sebastes*, *Thunnus*, and *Oreochromis* species, arising from incomplete lineage sorting, occasionally hybridization, or both (Meyer *et al*., 2016; Hanner *et al*., 2011; Steinke *et al*. 2009). Inaccurate molecular IDs might also be due to erroneous or limited reference sequences availability in the public databases (Shum et al., in press). Although in these cases identification can only be made to a congeneric species complex, this level of resolution was still sufficient to say whether or not the sample was mislabelled.

Our results confirmed others studies (Warner *et al*., 2013; Cawthorn *et al*., 2012; Logan *et al*., 2008; Marko *et al.*, 2004) where species sold as snapper were found to be among the most vulnerable for substitutions; indeed only one sample was correctly labelled while the other sixteen samples sold as snapper were mislabelled. These misrepresentations could be considered as an intentional attempt of economic fraud where highly-value species are substituted for lower value ones (Wong *et al*., 2011; Wong & Hanner, 2008; Marko *et al*., 2004) or as unintentional mistake by seafood traders (Barendse & Francis, 2015), especially considering that in the UK snappers are not a popular product. Frauds are often concealed under attractive 'umbrella' terms (Griffiths *et al*., 2013), usually referring to fish morphological features, which mislead consumers choices (e.g. juvenile, white coloured fish = "small white snapper"; not processed, golden coloured fish = raw golden pomfret; red coloured tilapia = red tilapia) (Table 1). In any case these substitutions invariably lead to misperception of species and stock abundance among consumers (Miller & Mariani, 2010). For instance, Red Snapper (*Lutjanus campechanus*) from the Western Atlantic Ocean began showing signs of stock depletion more than half a century ago (Anderson *et al.*, 2015; Warner *et al*., 2013, Cass-Calay *et al.*, 2015) and nowadays is listed as a fully to overexploited stock according to the *General situation of world fish stocks* (FAO). The misuse of this widespread market name may drive consumers to a false sense of resource availability.

Unintentional fish species misrepresentations may occur when species involved in the substitution are very similar, such is the case of pompano species sold as pomfret. According to the official list of commercial designations (DEFRA, 2013), the fish species allowed to be sold under the common name pomfret belong to *Brama* (Bramidae), *Pampus* and *Stromateus* genera (Stromateidae), while our analyses identified all pomfret specimens as *Trachinotus spp*. (Carangidae) whose common name should be pompano. These families and species look really similar to a non-expert, however they have different distribution range, life cycle and biology. The most commercially common species of Pomfret is *Brama brama*, a commercially valuable, oceanodromous and circumglobally distributed fish species for which specific management actions are in place because of its highly migratory behaviour. *Brama brama* stocks are protected in some coastal areas, whereas no conservation plan or stock assessment is available for *Trachinotus spp.* which, however, appear more popular on the market even if in disguise.

4.2 *The world's oceans in a freezer: diversity of products*

Within this large biodiversity that came to light, fourteen freshwater fish species were found: five *Oreochromis spp.* from Africa (though this genus is farmed all over the world) and nine Asian species mostly caught in the Chao Phraya and Mekong river basins which are among the longest and most productive rivers in the world for inland fisheries. These Asian rivers host a rich and diverse fish faunas including at least 328 different species living in the Mae Klong – Chao Phraya watercourses and 500 species living in the Mekong (Kottelat *et al.*, 2012). Species such as *Pangasius bocourti*, *Clarias macrocephalus* or *Trichoodus pectoralis* are jeopardized by habitat loss and degradation, dam development and genetic contamination or competition with hybrids created by the aquaculture industry for better performances (Baird *et al.*, 2004; Baran *et al.*, 2005; Na-Nakorn, 2004; Welcomme *et al.*, 2015). For species such as *Ompok bimaculatus*, *Clarias batrachus* or *Barbonymus altus*, the major threat is overfishing for food consumption and/or aquarium trade (Ng *et al*., 2010; Allen *et al.*, 2011a, Allen *et al.*, 2011b). It is really difficult to estimate or assess the actual fishery pressure on these stocks as it occurs at both commercial and artisanal fishery and most catches still remain largely unreported (Lymer *et al.*, 2008; Coates, 2002; Welcomme *et al*., 2015).

Sixty-two specimens identified were marine and almost half of them, twenty-seven fish, belong to tropical habitats and are mostly distributed among the Indo-Pacific area with some reef-associated individuals (e.g. grouper: *Epinephelus areolatus*; snapper: *Lutjanus erythropterus*, *L. bohar*; parrotfish: *Scarus schegeli*, *Hipposcarus longiceps*; Croaker: *Chrysochir aureus*, *Pennahia pawak*; mackerel: *Rastrelliger kanagurta*). These taxa are particularly threatened by loss of habitats and/or habitats degradation. Even though their distribution range often overlaps with marine protected areas (MPAs), the existing global MPA system is not large enough (Mouillot *et al*., 2016) or adequately managed to protect fish species within coral reef communities. Overall, Newton *et al*. (2007) reported that coral reef fisheries are currently taking catches that are 64% higher than can be sustained.

Furthermore, some species in our dataset are amphidromous (*Chanos chanos*), anadromous (*Tenualosa ilisha*) or migratory species (spending part of their life cycles in brackish estuaries/sheltered lagoons) which obviously require a more integrated conservation plan that in turn can promise more successful outcomes, while usually conservation actions include only one environmental realm (marine or freshwater) because of logistical, institutional and political constraints (Beger *et al.*, 2010).

According to the International Union for Conservation of Nature (IUCN) Red List, which assesses the species extinction risk, 44% [44-64] of the species detected are listed as “Least Concern” status and 36% [34-54] as “Not Evaluated” or “Data Deficient” status because they are not yet been assessed (Table 1). This means that – if the studied sample is a realistic representation of global imports in the sector – more than half the fish species traded are either somewhat endangered or lacking information on population status or stock heath. Catch statistics for these taxa are usually poor and life history, recruitment data and current population trends are unknown mainly because of the lack of surveys. The risk for these poorly-monitored fish species is to be neglected by conservation programs (Bland et al., 2015; Luiz et al., 2016), which is in sharp contrast to highly commercialized fish species such as tuna, herring, cod and Pollock (Barbeaux *et al*., 2014; Andersson *et al*., 2009; Rose, 2004; Arrizabalaga *et al*., 2009) whose population status is closely monitored through catch statistics and genetic monitoring.

Therefore, the consistent harvesting and trade of poorly known species, sold under generic/incorrect names, may potentially deplete stocks or even threaten species existence, while scientists, fisheries managers, consumers, etc. remain unaware of the situation.

The presence of poorly-monitored species on the UK market means that these species are not only used as a food source by local communities, but that they are actually globally traded. Not all the species collected during this survey are on the UK designation list and this might indicate that their presence on the UK market is recent. Governments are obliged by EU laws to prevent illegal trade of species and should enforce the correct label requirements (EC No 1379/2013) to protect consumers and fish stocks at the same time.

The high level of mislabelling (41% [31-52] of samples) and even the complete lack of labels (18% [10-26] of samples) in these stores suggests that a greater rate of control would be desirable, especially because ethnic shops are becoming increasingly popular amongst European and UK consumers.

This study highlights that regardless of the strict legislations in place throughout European countries, a huge effort is still needed to monitoring less popular fish species sold in our markets. The requirement of more accurate trade controls should not rely only on local economies within third-countries, but should be the responsibility of global traders of fisheries products, whose attention is increasingly shifting to new, emerging resources.

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References

Allen, D., J. (2011a). *Barbonymus altus*. The IUCN Red List of Threatened Species 2011: e.T181084A7658510. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T181084A7658510.en.

Allen, D., J. (2011b). *Clarias batrachus*. The IUCN Red List of Threatened Species 2011: e.T166613A6247551. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T166613A6247551.en.

Anderson, W., Claro, R., Cowan, J., Lindeman, K., Padovani-Ferreira, B. & Rocha, L.A. (2015). *Lutjanus campechanus*. The IUCN Red List of Threatened Species 2015: e.T194365A2322724. http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T194365A2322724.en.

Andersson, L., Ryman, N., Rosenberg, R. and Stahl, G. (2009). Genetic variability in Atlantic herring (Clupea harengus harengus): description of protein loci and population data. *Hereditas*, 95(1), pp.69-78.

Armani, A., Guardone, L., La Castellana, R., Gianfaldoni, D., Guidi, A. and Castigliego, L. (2015). DNA barcoding reveals commercial and health issues in ethnic seafood sold on the Italian market. *Food Control*, 55, pp.206-214.

Armani, A., Tinacci, L., Giusti, A., Castigliego, L., Gianfaldoni, D. and Guidi, A. (2013). What is inside the jar? Forensically informative nucleotide sequencing (FINS) of a short mitochondrial COI gene fragment reveals a high percentage of mislabelling in jellyfish food products. *Food Research International*, 54(2), pp.1383-1393.

Arrizabalaga, H., Restrepo, V., Maunder, M. and Majkowski, J. (2009). Using stock assessment information to assess fishing capacity of tuna fisheries. *ICES Journal of Marine Science*, 66(9), pp.1959-1966.

Baird, I. G., Flaherty, M. S., Phylavanh, B. (2004). Mekong river *Pangasiidae* catfish migrations and the Khone Falls wing trap fishery in Southern Laos. *Natural History Bulletin of the SIAM Society* 52(1):81-109.

Baran, E., Baird, I. G., Cans, G. (2005). Fisheries bioecology at Khone Falls (Mekong river, Southern Laos). *WorldFish Center*. 84 pp.

Barbeaux, S., Horne, J. and Ianelli, J. (2014). A novel approach for estimating location and scale specific fishing exploitation rates of eastern Bering Sea walleye pollock (Theragra chalcogramma). *Fisheries Research*, 153, pp.69-82.

Barendse, J. and Francis, J. (2015). Towards a standard nomenclature for seafood species to promote more sustainable seafood trade in South Africa. *Marine Policy*, 53, pp.180-187.

Beger, M., Grantham, H., Pressey, R., Wilson, K., Peterson, E., Dorfman, D., Mumby, P., Lourival, R., Brumbaugh, D. and Possingham, H. (2010). Conservation planning for connectivity across marine, freshwater, and terrestrial realms. *Biological Conservation*, 143(3), pp.565-575.

Bland, L., Collen, B., Orme, C. and Bielby, J. (2014). Predicting the conservation status of data-deficient species. *Conservation Biology*, 29(1), pp.250-259.

Cass-Calay, S. L., Porch, C. E., Goethel, D. R., Smith, M. W., Matter, V., & McCarthy, K. J. (2015). Stock Assessment of Red Snapper in the Gulf of Mexico, 1872–2013, with Provisional 2014 landings. *SEDAR Update Assessment*.

Cawthorn, D., Steinman, H. and Witthuhn, R. (2012). DNA barcoding reveals a high incidence of fish species misrepresentation and substitution on the South African market. *Food Research International*, 46(1), pp.30-40.

Coates, D. (2002). Inland Capture Fishery Statistics of Southeast Asia: Current Status and Information Needs. Publication No. 2002/11. Bangkok: Asia-Pacific Fishery Commission.

Costa, F., Landi, M., Martins, R., Costa, M., Costa, M., Carneiro, M., Alves, M., Steinke, D. and Carvalho, G. (2012). A Ranking System for Reference Libraries of DNA Barcodes: Application to Marine Fish Species from Portugal. *PLoS ONE*, 7(4), p.e35858.

D'Amico, P., Armani, A., Castigliego, L., Sheng, G., Gianfaldoni, D. and Guidi, A. (2014). Seafood traceability issues in Chinese food business activities in the light of the European provisions. *Food Control*, 35(1), pp.7-13.

DEFRA (2013). Commercial designation of fish: United Kingdom. Available at: https://www.gov.uk/government/publications/commercial-designations-of-fish-united-kingdom

Estoup, A., Largiadèr, C. R., Perrot, E., Chourrout, D. (1996). Rapid one-tube DNA extraction for reliable PCR detection of fish polymorphic markers and transgenes. *Molecular Marine Biology and Biotechnology*, 3(4), pp.295-298.

EUMOFA (2016). The EU fish market 2016 Edition. 94 pp.

FAO (2016). The state of the world fisheries and aquaculture 2016. Contributing to food security and nutrition for all. Rome, 200 pp.

FAO (2014). The state of the world fisheries and aquaculture. Rome, 243 pp.

Froese, R. and D. Pauly (2016). FishBase. Available at: www.fishbase.org

Garibaldi, L., Busilacchi, S. (2016). ASFIS List of Species for Fishery Statistics Purposes. Available at: www.fao.org/fishery/collection/asfis/en

Griffiths, A.M., Miller, D.D., Egan, A., Fox, J., Greenfield, A., Mariani, S. (2013). DNA barcoding unveils skate (Chondrichthyes: Rajidae) species diversity in 'ray' products sold across Ireland and the UK. *PeerJ* 1:e129 https://doi.org/10.7717/peerj.129.

Hall, T. A. (1999). BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Oxford University Press. Nucleic Acid Symposium Series 41:95-98.

Hanner, R., Becker, S., Ivanova, N. and Steinke, D. (2011). FISH-BOL and seafood identification: Geographically dispersed case studies reveal systemic market substitution across Canada. *Mitochondrial DNA*, 22(sup1), pp.106-122.

Horton, T., Kroh, A., Bailly, N., Boury-Esnault, N., Brandão, S.N., Costello, M.J., Gofas, S., Hernandez, F., Mees, J., Paulay, G. *et al.*, (2016). World Register of Marine Species. Available at: http://www.marinespecies.org at VLIZ. Accessed 2016-12-15. doi:10.14284/170.

IUCN, (2016). *The IUCN Red List of Threatened Species. Version 2016-3*. http://www.iucnredlist.org. Downloaded on 07 December 2016.

Kottelat, M., Baird, I. G., Kullander, S. O., Ng, H. H., Parenti, L. R., Rainboth, W. J., Vidthayanon, C. (2012). Chapter 3: The status and distribution of freshwater fishes of Indo-Burma. The Status and Distribution of Freshwater Fishes of Indo-Burma. 38-65 pp.

Lee, J., Hwang, J. and Mustapha, A. (2013). Popular Ethnic Foods in the United States: A Historical and Safety Perspective. *Comprehensive Reviews in Food Science and Food Safety*, 13(1), pp.2-17.

Leray, M., Yang, J., Meyer, C., Mills, S., Agudelo, N., Ranwez, V., Boehm, J. and Machida, R. (2013). A new versatile primer set targeting a short fragment of the mitochondrial COI region for metabarcoding metazoan diversity: application for characterizing coral reef fish gut contents. *Frontiers in Zoology*, 10(1), p.34.

Logan, C., Alter, S., Haupt, A., Tomalty, K. and Palumbi, S. (2008). An impediment to consumer choice: Overfished species are sold as Pacific red snapper. *Biological Conservation*, 141(6), pp.1591-1599.

Luiz, O., Woods, R., Madin, E. and Madin, J. (2016). Predicting IUCN Extinction Risk Categories for the World's Data Deficient Groupers (Teleostei: Epinephelidae). *Conservation Letters*, 9(5), pp.342-350.

Lymer, D., Funge-Smith, S., J., Clausen, J., Weimin, M. (2008). Status and potential of fisheries and aquaculture in Asia and the Pacific. RAP Publication 2008/15. Bangkok: FAO Regional Office for Asia and the Pacific.

Mariani, S., Griffiths, A., Velasco, A., Kappel, K., Jérôme, M., Perez-Martin, R., Schröder, U., Verrez-Bagnis, V., Silva, H., Vandamme, S., Boufana, B., Mendes, R., Shorten, M., Smith, C., Hankard, E., Hook, S., Weymer, A., Gunning, D. and Sotelo, C. (2015). Low mislabeling rates indicate marked improvements in European seafood market operations. *Frontiers in Ecology and the Environment*, 13(10), pp.536-540.

Marko, P., Lee, S., Rice, A., Gramling, J., Fitzhenry, T., McAlister, J., Harper, G. and Moran, A. (2004). Fisheries: Mislabelling of a depleted reef fish. *Nature*, 430(6997), pp.309-310.

Meyer, B., Matschiner, M. and Salzburger, W. (2016). Disentangling Incomplete Lineage Sorting and Introgression to Refine Species-Tree Estimates for Lake Tanganyika Cichlid Fishes. *Systematic Biology*, p.syw069.

Miller, D.D. and Mariani, S. (2010). Smoke, mirrors, and mislabelled cod: poor transparency in the European seafood industry. *Frontiers in Ecology and the Environment*, 8(10), pp. 517-521, doi: 10.1890/090212.

Mouillot, D., Parravicini, V., Bellwood, D., Leprieur, F., Huang, D., Cowman, P., Albouy, C., Hughes, T., Thuiller, W. and Guilhaumon, F. (2016). Global marine protected areas do not secure the evolutionary history of tropical corals and fishes. *Nature Communications*, 7, p.10359.

Na-Nakorn, U., Kamonrat, W. and Ngamsiri, T. (2004). Genetic diversity of walking catfish, Clarias macrocephalus, in Thailand and evidence of genetic introgression from introduced farmed C. gariepinus. *Aquaculture*, 240(1-4), pp.145-163.

Newton, K., Côté, I., Pilling, G., Jennings, S. and Dulvy, N. (2007). Current and Future Sustainability of Island Coral Reef Fisheries. *Current Biology*, 17(7), pp.655-658.

Ng, H., H., Tenzin, K., Pal, M. (2010). *Ompok bimaculatus*. The IUCN Red List of Threatened Species 2010: e.T166616A6248140. http://dx.doi.org/10.2305/IUCN.UK.2010-4.RLTS.T166616A6248140.en.

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://R-project.org/.

Ratnasingham, S. and Hebert, P. (2007). BARCODING: bold: The Barcode of Life Data System (http://www.barcodinglife.org). *Molecular Ecology Notes*, 7(3), pp.355-364.

Rose, G. (2004). Reconciling overfishing and climate change with stock dynamics of Atlantic cod (Gadus morhua) over 500 years. *Canadian Journal of Fisheries and Aquatic Sciences*, 61(9), pp.1553-1557.

SEAFISH (2015). Seafood Industry factsheet, December 2015. 26 pp.

Serra-Pereira, B., Moura, T., Griffiths, A., Serrano Gordo, L. and Figueiredo, I. (2010). Molecular barcoding of skates (Chondrichthyes: Rajidae) from the southern Northeast Atlantic. *Zoologica Scripta*, 40(1), pp.76-84.

Shum, P., Moore, L., Pampoulie, C., Di Muri, C., Vandamme, S., Mariani, S. (in press). Harnessing mtDNA variation to resolve ambiguity in 'Redfish' sold in Europe. *PeerJ*.

Steinke, D., Zemlak, T., Boutillier, J. and Hebert, P. (2009). DNA barcoding of Pacific Canada's fishes. *Marine Biology*, 156(12), pp.2641-2647.

Velasco, A., Aldrey, A., Pérez-Martín, R. and Sotelo, C. (2016). Assessment of the labelling accuracy of Spanish semipreserved anchovies products by FINS (forensically informative nucleotide sequencing). *Heliyon*, 2(6), p.e00124.

Venables, W.N. & Ripley, B.D. (2002). Modern Applied Statistics with S. Fourth Edition. Springer, New York. ISBN 0-387-95457-0.

Ward, R. D., Zemlak, T. S., Innes, B. H., Last, P. R., Hebert, P.D.N., 2005. DNA barcoding Australia's fish species. *Philosophical transaction of the royal Society of London. Series B, Biological Sciences* 360 (1462): 1847-1857.

Warner, K., Timme, W., Lowell, B., & Hirshfield, M. (2013). Oceana study reveals seafood fraud nationwide. *Oceana*, *11*, 1-69.

Watson, R., Green, B., Tracey, S., Farmery, A. and Pitcher, T. (2015). Provenance of global seafood. *Fish and Fisheries*, 17(3), pp.585-595.

Welcomme, R. L., Baird, I. G., Dudgeon, D., Halls, A., Lamberts, D., Mustafa, Md G. (2015). Fisheries of the rivers of Southeast Asia. *Freshwater Fisheries Ecology*, pp.363-376.

Wong, E. and Hanner, R. (2008). DNA barcoding detects market substitution in North American seafood. *Food Research International*, 41(8), pp.828-837.

Wong, L., Peatman, E., Lu, J., Kucuktas, H., He, S., Zhou, C., Na-nakorn, U. and Liu, Z. (2011). DNA Barcoding of Catfish: Species Authentication and Phylogenetic Assessment. *PLoS ONE*, 6(3), p.e17812.

Tables and figures

Table 1. Results of the identifications obtained using BOLD “Public Record Barcode” database and Genebank public database. Samples marked with (*) were identified by means of miniCOI primers and shaded rows indicate the species mislabelled. The column “Expected label” shows the official commercial designations laid down by DEFRA for each specimen ID (DEFRA, 2013). Samples with ([1]) are not listed and, hence, we have reported the UK common name according to FishBase database.

SOLD AS	LOCATION	BOLD Public Record Barcode Databse (% match)	GeneBank (% match)	Expected label	IUCN status
Bangus milkfish	Manchester	*Chanos chanos* 100%	*Chanos chanos* 99%	Milkfish	NE
Basa fish (*Pangasius bocourti*)	Manchester	*Pangasius bocourti* 100%	*Pangasius bocourti* 99%, *P. djambal* 99%	Basa or panga(s) or pangasius or river cobbler or any of these together with the additional word ‘catfish’ or royal basa	LC
Beltfish (*Trichiurus haumela*)	Manchester	*Trichiurus lepturus* 99.81%, *Trichiurus sp.* 98.3%	*Trichiurus gangeticus* 99%, *T. lepturus* 99%, *T. russelli* 98%	Cutlassfish or ribbonfish or scabbard fish	LC
Bullet tuna (*Auxis Rochei*)	Manchester	*Auxis rochei* 100%, *Sarda orientalis* 100%, *Auxis thazard* 99.67%	*Auxis rochei* 100%, *Sarda orientalis* 100%, *Auxis thazard* 99%	Bullet tuna or melva	LC
Catfish	Liverpool	*Clarias macrocephalus* 99.8%, *C. batrachus* 99.02%	*Clarias macrocephalus* 99%, *C. batrachus* 99%,	Catfish	NT
Catfish (Yellow - *Clarias macrocephalus*)	**Manchester**	***Clarias batrachus* 100%, *C. macrocephalus* 99.83%**	***Clarias batrachus* 100%, *C. macrocephalus* 99%**	**Magur or catfish**	**LC**
Catfish (Yellow - *Clarias spp.*)	Manchester	*Clarias macrocephalus* 100%, *C. batrachus* 99.31%	*Clarias macrocephalus* 100%, *C. batrachus* 99%	Catfish	NT
Catfish (Yellow)	**Liverpool**	***Nemipterus japonicus* 100%**	***Nemipterus japonicus* 100%**	**Threadfin bream**	**NE**
Croaker	Liverpool		*Micropogonias furnieri* 91%, *M. megalops* 90%, *M. ectenes* 90%, *M.*	Croaker or drum or	LC

			altipinnis 90%	jewfish	
Croaker	Liverpool	*Micropogonias furnieri* 100%	*Micropogonias furnieri* 100%, *M. megalops* 98%	Croaker or drum or jewfish	LC
Croaker	**Liverpool**	***Sebabstes norvegicus* 99.84%, *S. mentella* 99.83%, *S. fasciatus* 99.83%, *S. viviparus* 98.86%, *S. alutus* 98.01%**	***Sebastes mentella* 99%, *S. norvegicus* 99%, *S. fasciatus* 99%, *S. viviparus* 98%, *S. baramenuke* 98%**	**Ocean perch or redfish or rose fish**	**EN (*S. fasciatus*); LC (*S. mentella*); NE (others)**
Croaker	**Liverpool**	**Sebabstes norvegicus 99.84%, S. mentella 99.84%, S. fasciatus 99.84%, S. viviparus 98.9%, S. alutus 98.09%**	**Sebastes mentella 99%, S. norvegicus 99%, S. fasciatus 99%, S. viviparus 98%, S. baramenuke 98%**	**Ocean perch or redfish or rose fish**	**EN (S. fasciatus); LC (S. mentella); NE (others)**
Croaker	Liverpool	*Chrysochir aureus* 98.34%	*Chrysochir aureus* 98%	Croaker or drum or jewfish	NE
***Croaker (Yellow - *Pseudosciaena crocea*)**	**Manchester**	***Pennahia pawak* 100%**	***Pennahia pawak* 100%**	**Croaker or drum or jewfish**	**NE**
Croaker (Yellow - *Pseudosciaena polyactis*)	Manchester	*Larimichthys polyactis* 100%	*Larimichthys polyactis* 100%, *Collychthys niveautus* 99%	Croaker or drum or jewfish	NE
Gourami (*Trichogaster pectoralis*)	Manchester	*Trichopodus pectoralis* 99.23%	*Trichopodus pectoralis* 100%	[1]Snakeskin gourami	LC
Gourami (*Trichogaster pectoralis*)	Manchester	*Trichopodus pectoralis* 100%	*Trichopodus pectoralis* 99%	[1]Snakeskin gourami	LC
Grouper (*Cephalopholis boenak*)	**Manchester**	***Epinephelus areolatus* 100%**	***Epinephelus areolatus* 100%**	**Grouper**	**LC**
Grouper (*Epinephelus areolatus*)	Liverpool	*Epinephelus areolatus* 100%	*Epinephelus areolatus* 100%	Grouper	LC

Jackfish	Liverpool	*Pseudocaranx sp*. 99.84%, *P. dentex* 99.84%, *P. georgianus* 99.84%, *P. ferdau* 99.69%	*Pseudocaranx dentex* 99%	[1]Silver travally, [1]silver or white trevally, [1]toothed crevally	LC
Mackerel	**Liverpool**	***Tenuolosa ilisha* 99.2%**	***Tenualosa toli* 92%, *T. ilisha* 92%**	**Hilsa**	**LC**
Mackerel	**Liverpool**	***Rastrelliger kanagurta* 100%, *R. brachysoma* 99.53%, *R. faughni* 99.37%**	***Rastrelliger kanagurta* 99%, *R. brachysoma* 99%**	**Indian mackerel**	**DD**
Mackerel	**Liverpool**	***Chanos chanos* 100%**	***Chanos chanos* 99%**	**Milkfish**	**NE**
Mackerel (Indian)	Liverpool	*Rastrelliger kanagurta* 100%, *R. brachysoma* 99.81%, *R. faughni* 99.84%	*Rastrelliger kanagurta* 100%, *R. brachysoma* 99%	Indian mackerel	DD
***Monk fish**	Manchester	*Lophius americanus* 100%	*Lophius americanus* 100%	Angler(fish) or monk(fish)	NE
Padba	Curry Mile	*Ompok bimaculatus* 99.81%	*Ompok bimaculatus* 99%	Catfish	NT
Parrotfish (Blue)	Liverpool	*Scarus schlegeli* 100%, *S. quoyi* 98.47%, *S. russelii* 98.28%	*Scarus schlegeli* 100%, *S. quoyi* 98%, *S. russelii* 98%	Parrotfish	LC
Parrotfish (Light)	Liverpool	*Hipposcarus longiceps* 99.76%	*Hipposcarus longiceps* 99%	Parrotfish	LC
Pomfret	**Liverpool**	***Trachinotus ovatus* 100%, *T. anak* 99.17%**	***Trachinotus ovatus* 100%, *T. anak* 100%**	**[1]Pompano or Derbio**	**LC**
Pomfret (Golden)	**Manchester**	***Trachinotus ovatus* 100%, *T. anak* 98.97%**	***Trachinotus ovatus* 100%, *T. anak* 100%**	**[1]Pompano or Derbio**	**LC**
Pomfret (Golden)	**Liverpool**	***Trachinotus ovatus* 100%, *T. anak* 98.97%**	***Trachinotus ovatus* 100%, *T. anak* 99%**	**[1]Pompano or Derbio**	**LC**
Pomfret (Raw Golden - *Trachinotus blochii*)	**Liverpool**	***Trachinotus ovatus* 99.83%, *T. anak* 98.8%**	***Trachinotus ovatus* 99%, *T. anak* 99%**	**[1]Pompano or Derbio**	**LC**
Pomfret (Vietnamese - *spp. argenteus*)	**Manchester**	***Trachinotus blochii* 100%**	***Trachinotus blochii* 100%**	**[1]Asian pompano**	**NE**

Pomfret (Vietnamese)	**Manchester**	***Trachinotus blochii* 100%**	***Trachinotus blochii* 100%**	**[1]Asian pompano**	**NE**
***Red big eyes fish (*Priacanthus macracanthus*)**	Manchester	*Priacanthus macracanthus* 98.91%	*Priacanthus macracanthus* 98%	Bigeye	NE
Red fish	Manchester	*Sebastes mentella* 99.79%, *S. fasciatus* 99.79%, *S. norvegicus* 99.79%, *S. viviparus* 98.93%, *S. alutus* 98.07%	*Sebastes sp*. 99%, *S. mentella* 99%, *S. fasciatus* 99%, *S. norvegicus* 99%, *S. viviparus* 98%, *S. reedi* 98%	Ocean perch or redfish or rose fish	EN (*S. fasciatus*); LC (*S. mentella*); NE (others)
***Red spot emperor**	Manchester	*Lethrinus lentjan* 100%	*Lethrinus lentjan* 100%	Emperor	NE
***Red tail tinfoil barb (*Puntius altus*)**	Manchester	*Barbonymus altus* 100%	*Barbonymus altus* 100%	Carp	LC
Ribbon fish (*Trichiurus lepturus*)	Manchester	*Trichiurus lepturus* 100%, *T. lepturus nanhaiensis* 100%, *T. nanhaiensis* 100%	*Trichiurus lepturus* 96%, *T. lepturus nanhaiensis* 96%	Cutlassfish or ribbonfish or scabbard fish	LC
Scad (*Decapterus macrosoma*)	Manchester	*Decapterus macrosoma* 99.82%, *D. muroadsi* 99.22%	*Decapterus macrosoma* 99%, *D. muroadsi* 99%	Horse mackerel or jack or scad or trevally	NE
***Seabass**	Manchester	*Dicentrarchus labrax* 100%	*Dicentrarchus labrax* 100%	Bass or sea bass	LC
***Seabass**	Manchester	*Dicentrarchus labrax* 100%	*Dicentrarchus labrax* 100%	Bass or sea bass	LC
***Seabass**	Liverpool	*Dicentrarchus labrax* 100%	*Dicentrarchus labrax* 100%	Bass or sea bass	LC
Seabream	**Liverpool**	***Nemipterus japonicus* 100%**	***Nemipteru japonicus* 100%**	**Threadfin bream**	**NE**
Snapper	**Liverpool**	***Pagrus pagrus* 100%, *Oblada melanura* 99.09%**	***Pagrus pagrus* 100%, *Oblada melanura* 99%, *Pagellus erythrinus* 99%**	**Porgy or sea bream**	**LC**
Snapper	**Liverpool**	***Pagrus pagrus* 100%, *Oblada melanura* 99.31%**	***Pagrus pagrus* 100%, *Oblada melanura* 99%, *Pagellus erythrinus***	**Porgy or sea bream**	**LC**

			99%		
Snapper	Liverpool	*Pagellus erythrinus* 100%, *Oblada melanura* 99.76%	*Pagellus erythrinus* 100%, *Oblada melanura* 99%	Porgy or sea bream	LC
Snapper	Liverpool	*Pagrus pagrus* 100%, *Oblada melanura* 99.02%	*Pagrus pagrus* 100%, *Oblada melanura* 99%	Porgy or sea bream	LC
Snapper (Negatine)	Liverpool	*Argyrozona argyrozona* 100%	*Argyrozona argyrozona* 100%	Porgy or sea bream	NT
Snapper (Negetine)	Liverpool	*Argyrozona argyrozona* 100%	*Argyrozona argyrozona* 100%	Porgy or sea bream	NT
Snapper (Red)	Liverpool	*Pagellus erythrinus* 100%, *Oblada melanura* 99.19%	*Pagellus erythrinus* 100%, *Oblada melanura* 99%	Porgy or sea bream	LC
Snapper (Red)	Liverpool	*Sebastes mentella* 100%, *S. fasciatus* 100%, *S. norvegicus* 100%, *S. viviparus* 98.73%, *S. alutus* 98.31%	*Sebastes fasciatus* 100%, *S. mentella* 100%, *S. norvegicus* 100%, *S. alutus* 98%, *S. baramenuke* 98%	Ocean perch or redfish or rose fish	EN (*S. fasciatus*); LC (*S. mentella*); NE (others)
Snapper (Red)	Liverpool	*Sebastes mentella* 99.79%, *S. fasciatus* 99.79%, *S. norvegicus* 99.79%, *S. viviparus* 98.95%, *S. alutus* 98.1%	*Sebastes mentella* 99%, *S. norvegicus* 99%, *S. fasciatus* 99%, *S. viviparus* 98%, *S. baramenuke* 98%	Ocean perch or redfish or rose fish	EN (*S. fasciatus*); LC (*S. mentella*); NE (others)
Snapper (Red)	Liverpool	*Sebastes mentella* 99.8%, *S. fasciatus* 99.8%, *S. norvegicus* 99.8%, *S. viviparus* 98.8%	*Sebastes mentella* 99%, *S. fasciatus* 99%, *S. norvegicus* 99%, *S. viviparus* 98%, *S. alutus* 98%	Ocean perch or redfish or rose fish	EN (*S. fasciatus*); LC (*S. mentella*); NE (others)
Snapper (Red)	Liverpool	*Sebastes mentella* 99.52%, *S. fasciatus* 99.52%, *S. norvegicus* 99.52%, *S. viviparus* 98.57%, *S. alutus* 98.33%	*Sebastes sp.* 99%	Ocean perch or redfish or rose fish	EN (*S. fasciatus*); LC (*S. mentella*); NE

					(others)
Snapper (Red)	Manchester	*Lutjanus bohar* 100%	*Lutjanus bohar* 100%	Snapper	NE
Snapper (Ruby snapper)	**Liverpool**	***Lutjanus erythropterus* 100%, *L. malabaricus* 99.81%, *L. lutjanus* 99.25%**	***Lutjanus erythropterus* 99%, *L. malabaricus* 97%**	**Snapper – Ruby snapper is *Etelis carbunculus***	**NE**
Snapper (Small white)	**Liverpool**	***Pagellus bellottii* 99.67%, *P. natalensis* 99.66%**	***Pagellus affinis* 99%, *P. bellotti* 99%, *P. natalensis* 99%**	**Porgy or sea bream**	**LC**
Snapper (Yellow)	**Liverpool**	***Nemipterus japonicus* 100%**	***Nemipterus japonicus* 99%**	**Threadfin bream**	**NE**
Snapper (Yellow)	**Liverpool**	***Nemipterus japonicus* 100%**	***Nemipterus japonicus* 100%**	**Threadfin bream**	**NE**
Snapper (Yellow)	**Liverpool**	***Nemipterus japonicus* 100%**	***Nemipterus japonicus* 100%**	**Threadfin bream**	**NE**
Tilapia (Black - *Tilapia nilotica*)	Manchester	*Oreochromis mossambicus* 100%, *O. niloticus* 100%, *Gobius personatus* 100%	*Oreochromis mossambicus* 100%, *O. niloticus* 100%, *O. aureus* 100%, *O. karongae* 98%	Tilapia	NT
Tilapia (Black - *Tilapia nilotica*)	Manchester	*Oreochromis mossambicus* 100%, *O. niloticus* 100%, *Gobius personatus* 100%	*Oreochromis mossambicus* 100%, *O. niloticus* 100%, *O. aureus* 100%, *O. karongae* 98%	Tilapia	NT
Tilapia (Red)	Manchester	*Oreochromis niloticus* 100%, *O. mossambicus* 100%, *Coptodon zillii* 99.82%	*Oreochromis niloticus* 100%, *O. aureus* 100%, *O. mossambicus* 100%, *Coptodon zillii* 99%	Tilapia	NE
Tilapia (Red)	Manchester	*Oreochromis niloticus* 100%, *O. mossambicus* 100%, *Coptodon zillii* 99.83%	*Oreochromis sp.* 100%, *O. aureus* 100%, *O. niloticus* 100%, *O. mossambicus* 100%, *Coptodon zillii* 99%	Tilapia	NE
Trevally	**Liverpool**	***Nemipterus japonicus* 100%**	***Nemipterus japonicus* 100%**	**Threadfin bream**	**NE**
Unnamed	Liverpool	*Sebastes norvegicus* 99.84%, *S. mentella* 99.84%, *S. fasciatus* 99.84%, *S. viviparus*	*Sebastes mentella* 99%, *S. norvegicus* 99%, *S. fasciatus* 99%, *S. viviparus*	Ocean perch or redfish or	EN (*S. fasciatus*); LC (*S.*

		98.86%, *S. alutus* 98.03%	98%, *S. baramenuke* 98%	rose fish	*mentella*); NE (others)
Unnamed	Liverpool	*Sebastes norvegicus* 99.84%, *S. mentella* 99.84%, *S. fasciatus* 99.84%, *S. viviparus* 98.86%, *S. alutus* 98.03%	*Sebastes mentella* 99%, *S. norvegicus* 99%, *S. fasciatus* 99%, *S. viviparus* 98%, *S. baramenuke* 98%	Ocean perch or redfish or rose fish	EN (*S. fasciatus*); LC (*S. mentella*); NE (others)
Unnamed	Manchester	*Trachinotus ovatus* 99.84%, *T. anak* 99.19%	*Trachinotus ovatus* 100%, *T. anak* 99%	[1]Pompano or Derbio	LC
Unnamed	Manchester	*Channa striata* 100%, *C. marulius* 98.21%	*Channa striata* 98%, *C. marulius* 98%	Shol	LC
Unnamed	Manchester	*Rastrelliger kanagurta* 99.66%, *R. faughni* 99.14%, *R. brachysoma* 99.12%	*Rastrelliger kanagurta* 99%, *R. faughni* 99%, *R. brachysoma* 98%	Indian mackerel	DD
Unnamed	Manchester	*Tenualosa ilisha* 100%	*Tenualosa ilisha* 100%, *T. toli* 99%	Hilsa	LC
Unnamed	Manchester	*Oreochromis niloticus* 100%, *Oreochromis mossambicus* 100%, *Coptodon zillii* 99.51%	*Oreochromis sp.* 100%, *O. niloticus* 100%, *O. mossambicus* 100%, *O. aureus* 99%, *Coptodon zillii* 99%	Tilapia	NE
Unnamed	Curry Mile	*Trachinotus ovatus* 99.83%, *T. anak* 98.84%	*Trachinotus ovatus* 99%, *T. anak* 99%	[1]Pompano or Derbio	LC
Unnamed	Curry Mile	*Rastrelliger kanagurta* 100%, *R. faughni* 99.47%, *R. brachysoma* 99.47%	*Rastrelliger kanagurta* 100%, *R. faughni* 99%, *R. brachysoma* 99%	Indian mackerel	DD
Unnamed	Curry Mile	*Pseudocaranx dentex* 100%, *P. georgianus* 100%, *Pseudocaranx sp*. 100%, *Carangoides ferdau* 99.83%	*Pseudocaranx dentex* 100%	[1]Silver travally, [1]silver or white trevally, [1]toothed crevally	LC
Unnamed	Liverpool	*Pagellus erythrinus* 99.78%, *Oblada melanura* 99.56%	*Pagellus erythrinus* 99%, *Oblada melanura* 99%	Porgy or sea bream	LC
Unnamed	Liverpool	*Nemipterus japonicus* 100%	*Nemipterus japonicus* 100%	Threadfin bream	NE

Unnamed	Liverpool	*Nemipterus japonicus* 100%	*Nemipterus japonicus* 100%	Threadfin bream	NE
Unnamed	Liverpool	*Chrysochir aureus* 98.37%	*Chrysochir aureus* 98%	Croaker or drum or jewfish	NE
Unnamed (Frozen Freshwater Fish)	Curry Mile	*Tenualosa ilisha* 99.5%	*Tenualosa ilisha* 99%, *T. toli* 99%	Hilsa	LC

DD = Data Deficient; NE = Not Evaluated; LC = Least Concern; NT = Near Threatened; EN = endangered.

Figure 1. Images portraying the collection of frozen fish products available to consumers among ethnic food stores in Britain. Note the pervasive absence of labels and inadequate packaging.

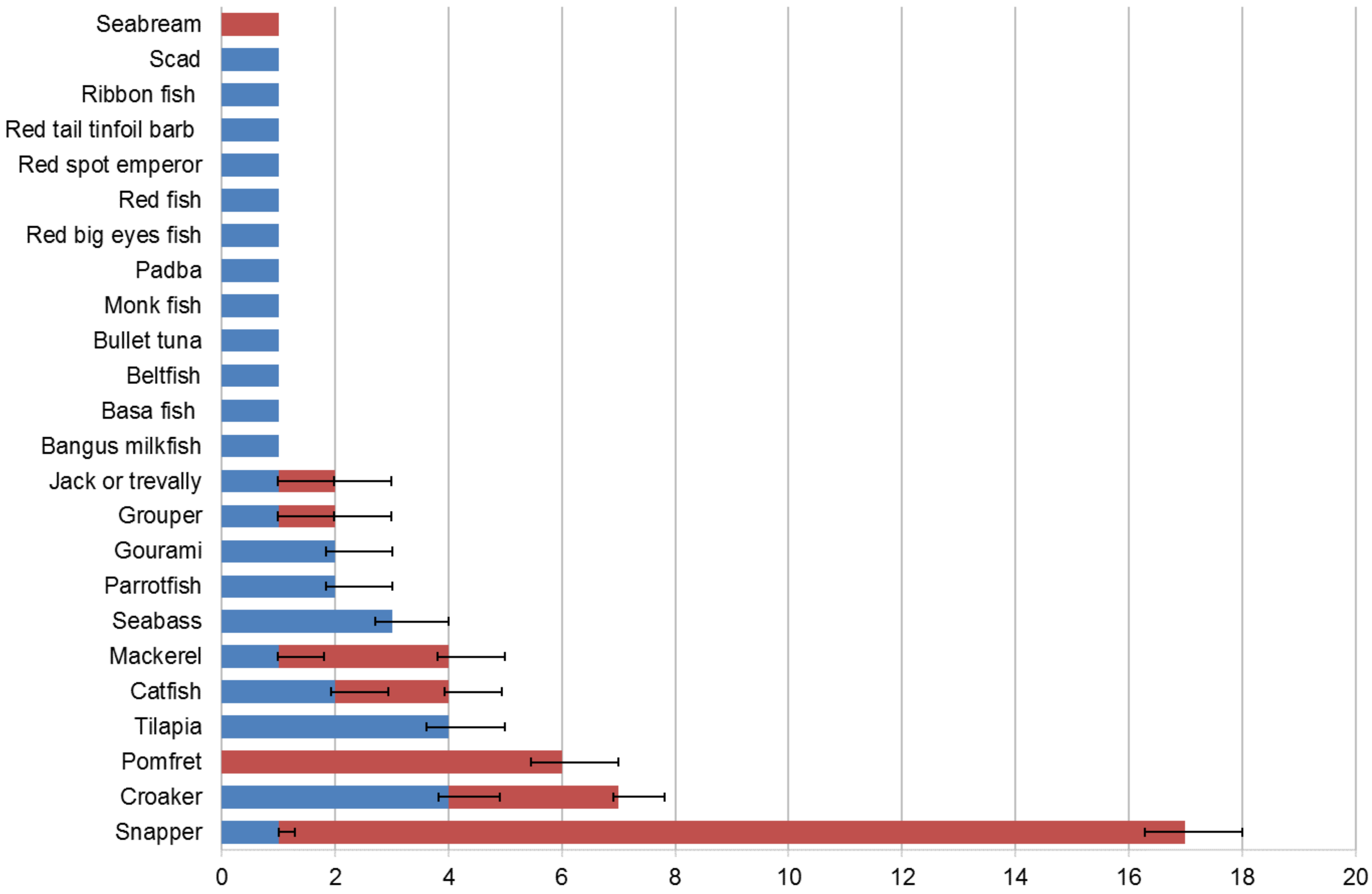

Figure 2. Mislabelling levels per product/taxon. The red part of the bar indicates the number of mislabelled specimens, while the blue part represents the correctly labelled ones. Error bars show 95% confidence intervals for species with “n” > 1.

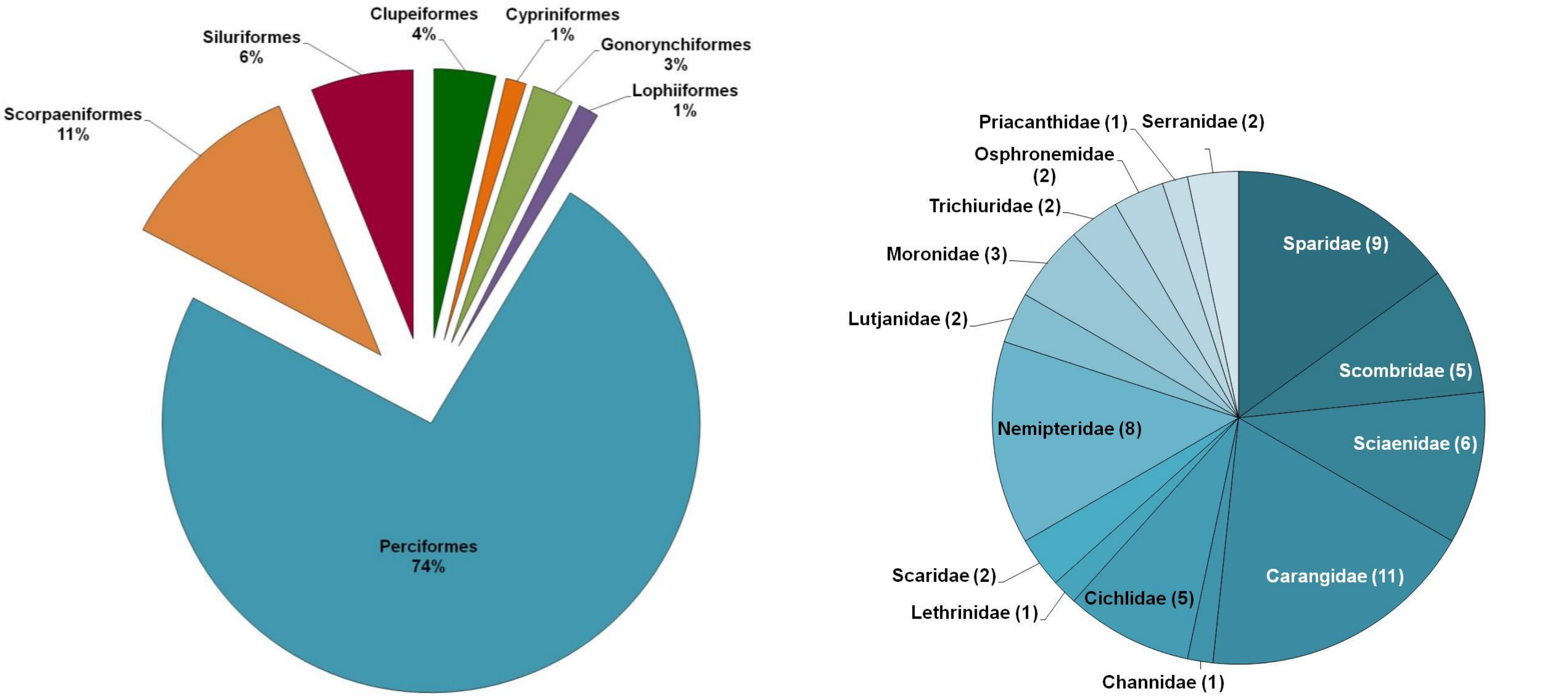

Figure 3. Taxonomical diversity of 81 samples by Order (left) and, for *Perciformes* specifically, by Family (right). Numbers in brackets refer to the number of species detected within each taxonomic group.