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Seafood substitution and mislabeling in Brussels' restaurants and canteens

Henrik Christiansen [a], Nicolas Fournier [c], Bart Hellemans [a, b], Filip A.M. Volckaert [a, b, *]

[a] KU Leuven, Laboratory of Biodiversity and Evolutionary Genomics (LBEG), Charles de Bériotstraat 32 box 2439, B-3000 Leuven, Belgium
[b] KU Leuven, Biogenomics, Charles Deberiotstraat 32 box 2439, B-3000 Leuven, Belgium
[c] Oceana Europe, Montoyerstraat 39, B-1000 Brussels, Belgium

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ABSTRACT

A high demand for seafood in combination with overfishing threatens living marine resources worldwide. Sound regulation and enforcement is needed for sustainable management, yet the seafood business is characterized by high levels of uncertainty regarding product identity. Here, 280 fish dishes sold in commercial restaurants, canteens of the European Union and sushi bars throughout Brussels, Belgium were assessed for mislabeling using DNA barcoding. Overall 31.1% mislabeled samples were detected, with mislabeling present in all types of vendors. Cod and sole were the most frequently sampled and were also mislabeled regularly (13.1% and 11.1%). Bluefin tuna was substituted almost always (95% mislabeling), mostly by other tuna species. Results show that seafood labeling rules and controls are not sufficient, particularly in the food service industry, where for example commercial denominations can be ambiguous and scientific species denomination is not compulsory. Irrespective if negligent or fraudulent, mislabeling practices are detrimental for economical and sustainability goals and also consumers' trust.

1. Introduction

Seafood plays a dominant role in the diet of many people. Worldwide, 16.7% of animal protein intake per person stems from fish, with generally rising levels of fish consumption (world capita consumption on average in the 1960s: 9.9 kg, in 2013: 19.7 kg; FAO, 2016). Concomitantly rising with increasing human population is the number of people with access to seafood. Seafood demand remains thus unabated or is likely rising, yet production from capture fisheries has reached a plateau at a level of some 90 million tonnes per year (inland and marine fisheries, FAO, 2016), or – as some argue – is actually declining (Pauly & Zeller, 2016). Increasing aquaculture production (73.8 million tonnes in 2014, inland and marine aquaculture) is partially accommodating the demand, but pressure on capture fisheries remains high, particularly if demand continues to increase and technology continues to progress (Quaas, Reusch, Schmidt, Tahvonen, & Voss, 2015). As a result blatant overfishing and expanding fisheries towards previously spared systems (e.g., deep sea and polar regions) and previously non- or minor commercial species (e.g., Antarctic toothfish (*Dissostichus mawsoni*), Arctic char (*Salvelinus alpinus*) and Arctic cod (*Boreogadus saida* and *Arctogadus glacialis*)) threatens living marine resources worldwide (Morato, Watson, Pitcher, & Pauly, 2006; Roberts, 2002; Swartz, Sala, Tracey, Watson, & Pauly, 2010). While the importance of advanced conservation and management measures is now recognized by major governing bodies, for instance through the reformed European Common Fisheries Policy (Council of the European Union, 2013a), overfishing and mismanagement issues can be exacerbated by illegal, unreported, and unregulated (IUU) fishing (Agnew et al., 2009; Pauly & Zeller, 2016; Petrossian, 2014). Accurate seafood identification and traceability is imperative to combat IUU and overfishing and enforce sustainable management practices (Ogden, 2008), which is also recognized in European legislation (Council of the European Union, 2009; 2013b).

The seafood business, however, is characterized by high levels of uncertainty when it comes to the true nature of the product. This might be either due to lack of expertise for species identification (e.g., FAO, 2013), or impossibility to visually differentiate closely related species or stocks on site (Begg & Waldman, 1999), lack of unambiguous naming (Barendse & Francis, 2015), and the complex transformation through a long supply chain into various products and dishes (Leal, Pimentel, Ricardo, Rosa, & Calado,

* Corresponding author. Laboratory of Biodiversity and Evolutionary Genomics (LBEG), KU Leuven, Charles de Bériotstraat 32 box 2439, B-3000 Leuven, Belgium.
E-mail address: filip.volckaert@kuleuven.be (F.A.M. Volckaert).

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2015). Globalization of the seafood business, i.e., the high number of species from various origins that are traded worldwide, further complicates matters and renders sound regulation and enforcement indispensable for sustainable management (Berkes et al., 2006; Deutsch et al., 2007). Product uncertainty in wholesale, retail and catering can obscure scientific names (identification and origin), as well as sanitary and hygiene standards, or even pose health risks. Fish top predators for instance may contain high levels of heavy metals (Focardi, 2012; Hightower & Moore, 2003) or organic pollutants (Maes, Belpaire, & Goemans, 2008). Seafood mislabeling and fraud is an emerging risk that occurs through accidental or deliberate species substitution, the latter being economic fraud or adulteration, where usually high value species are replaced by lower value species for financial gain (Spink & Moyer, 2011). Seafood mislabeling may lead to financial loss for ethically honest businesses and confidence loss by customers, traders and retailers. Given the sheer diversity of traded species and seafood products, it is challenging for consumers to make informed choices. Mislabeling undermines efforts of (supra)national bodies to inform and regulate, as well as initiatives of conservation-oriented non-governmental organizations aiming at raising consumers awareness, for instance about endangered fish stocks (Logan, Alter, Haupt, Tomalty, & Palumbi, 2008).

Molecular methods are now readily applicable and affordable for identification purposes of traded seafood. DNA barcoding is a powerful system to rapidly determine the taxonomic group of a given organism (Hebert, Cywinska, Ball, & DeWaard, 2003). In fish fragments of the mitochondrial cytochrome *c* oxidase I subunit gene (COI) are useful for identification to species level in many cases and DNA barcoding campaigns of fishes have been conducted worldwide (Ward, Hanner, & Hebert, 2009; Ward, Zemlak, Innes, Last, & Hebert, 2005). COI as a marker is comparatively robust, allowing amplification of suitable DNA fragments from not only fresh, but also degraded, processed or cooked material.

Mislabeling and seafood substitution has accordingly received much attention through studies utilizing DNA-based identification approaches to varying scope and extent (reviewed by Pardo, Jiménez, & Pérez-Villarreal, 2016). Technological advances enable the use of DNA barcoding at a large scale and for seafood authentication in general (Hanner, Becker, Ivanova, & Steinke, 2011; Wong & Hanner, 2008), and to identify species composition of convenience food (Huxley-Jones, Shaw, Fletcher, Parnell, & Watts, 2012) and other highly processed (e.g., canned) fish products (Shokralla, Hellberg, Handy, King, & Hajibabaei, 2015). Mislabeling rates have recently been assessed *inter alia* in Portuguese supermarkets (Harris, Rosado, & Xavier, 2016), European retail (Mariani et al., 2015), English sushi restaurants (Vandamme et al., 2016), Brazilian market places (Carvalho, Palhares, Drummond, & Frigo, 2015), South African restaurants and retailers (Cawthorn, Duncan, Kastern, Francis, & Hoffman, 2015), Chinese online markets (Xiong et al., 2016) and Malaysian markets and sushi bars (Chin, Adibah, Danial Hariz, & Siti Azizah, 2016). Overall, species labeling throughout retail was found to be relatively good (Shokralla et al., 2015; Pardo et al., 2016). However, few studies targeted restaurants, where guidelines and regulations regarding seafood identity and origin are less stringent and hence elevated levels of mislabeling and substitution might be expected (Bénard-Capelle et al., 2015; Kappel & Schröder, 2016; Pardo et al., 2016; Vandamme et al., 2016). Seafood dishes served at restaurants are processed food items that exhibit none or few recognizable characters for species identification. Thus, as a consumer it is virtually impossible to verify species identity (or origin) of the purchased product at a given restaurant. Kappel and Schröder (2016) have shown that at least common sole in German restaurants is highly prone to substitution (50%). Albeit reporting a lower rate of 14.8% mislabeling in restaurants, Khaksar et al. (2015) confirmed that this rate was indeed significantly higher than in retail. Nevertheless, overall only 10% of all samples analyzed for seafood mislabeling in the past five years stem from restaurants or takeaways, and therefore additional research specifically targeting restaurants should be conducted (Pardo et al., 2016).

The Belgian seafood market is supplied by a small fishery (18,377 tonnes landed in 2015 by 79 vessels; Van Liefferinge, 2016) of which flatfish are the economically most important species. By far the most important species in value is common sole (*Solea solea*), representing 67% of the total landing value in 2015, yet only one third of the landing volume. Plaice (*Pleuronectes platessa*), in contrast, contributed 54% by volume but only 18% of the total in value (European Commission, 2016). Other important species landed by Belgian vessels are turbot (*Scophthalmus maximus*) and Atlantic cod (*Gadus morhua*). As in the European Union (EU) in general, the degree of self-sufficiency in fisheries products (domestic supply over domestic demand) of Belgium is very low (0.13) and its market is a net importer of fisheries and aquaculture products (New Economics Foundation, 2017). In 2015 Belgian imports of seafood were over six times the actual landings (approximately 110,000 tonnes; European Commission, 2016). The main imported species in volume are tropical shrimps and prawns, striped catfish and Nile perch, followed by tuna species. In 2015, the annual per capita consumption of fisheries products in Belgium was 24.9 kg, just below the EU average of 25.5 kg (European Commission, 2016). Belgian consumers largely make similar choices as average EU consumers regarding fishery and aquaculture products (European Commission, 2017). “Product and species names” are very relevant information for 87% of Belgians, and it is notable that, on average, Belgian consumers care more than the EU average about environmental, social and ethical information on labels (European Commission, 2017). Given the relevance of species name for consumer choice it is imperative that products are labeled correctly.

The objective of the present study is to assess levels of mislabeling or substitution through molecular identification of seafood obtained from restaurants, sushi bars or takeaways, and canteens embedded in offices of the European Union in Brussels, Belgium. No large scale study to date has been conducted in Belgium in general and in Brussels in particular. The latter is used here as an exemplary target area with a high density and broad range of prepared seafood dishes available to consumers.

2. Material and methods

2.1. Sampling survey

Samples of raw and cooked fish dishes were collected at catering facilities (216 from restaurants, 42 from canteens in premises of the European Union (EU) institutions and 22 from sushi bars) in the Brussels agglomeration between March and June 2015 (Fig. 1). Addresses were chosen non-randomly to give a fair representation of the landscape of restaurants in Brussel based on prices (e.g., low-end to high-end restaurants), locations (e.g., central, European and surrounding quarters) as well as species commonly served (e.g., cod (*Gadus* spp.), sole (*Solea* spp.), bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), and rays (*Raja* spp.)). Five staff were trained and involved in tissue collection; following the protocol used by Oceana in the USA they posed as normal customers and sampled as unobtrusively as possible. They identified the served seafood dish based on the menu and an oral request to the waiting personnel. Small tissue pieces were collected and immediately stored in cryotubes filled with 100% ethanol.