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Labelling accuracy in Tasmanian seafood: An investigation using DNA barcoding

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ABSTRACT

Mislabelling of seafood products has been documented in numerous countries for over three-quarters of a century. With a trend towards increased consumption of seafood, the informed consumer demands accurately labelled products that provide full disclosure of composition. DNA barcoding can be used to accurately identify a seafood product to species based on its genetic signature, and so provides a means to test the authenticity and accuracy of seafood labelling. This can be especially useful for products such as fillets which have few or no unambiguous identifying characters, and can easily be mislabelled. We investigated labelling accuracy in seafood retailers in Tasmania, Australia. Thirty-eight seafood products were obtained from seafood retailers, sequenced for the barcoding gene region cytochrome oxidase subunit 1(CO1), and subsequently identified to species level by querying GenBank and Barcode of Life Data Systems (BOLD) DNA sequence records. Results were compared with standard fish names (SFN) prescribed under the Australian Fish Names Standard (AFNS) and FishBase. Of the 38 samples, none were deemed to have been mislabelled under Australian regulation, although in some cases naming discrepancies and ambiguity may cause confusion for some consumers. Our work, while reflecting high standards in Tasmanian seafood, highlights the need for mandatory standard labelling across all seafood products so as to eliminate any possible misrepresentation.

1. Introduction

Numerous studies have shown that the mislabelling of products for human consumption is widespread and has been occurring for some time (e.g. Hanner, Becker, Ivanova, & Steinke, 2011; Jacquet & Pauly, 2008; Wong & Hanner, 2008). Meat products of high-market value are known targets for species substitution and adulteration. One study revealed that 68% of meat products sampled contained species not declared on the product's labelling (Cawthorn, Steinman & Hoffman, 2013). The 'horse meat scandal' of 2013, involving the adulteration of beef burgers in multiple European countries, is a prime example (Stoyke, Hamann, Rdeck & Gowick, 2013). Such reports highlight an issue fundamental to the problem of mislabelling: the inability of the consumer to accurately detect what it is they are about to eat. The ramifications are clear: at best mislabelling is the product of dishonest behaviour; at worst, it is fraud and may have serious financial, legal and health consequences (Jacquet & Pauly, 2008).

In the case of seafood, the absence of external morphological features, particularly in processed products such as fish fillets, hinders a person's ability to distinguish certain products or species from one another (Barbuto, Galimberti, Ferri, Labra & Malandra et al., 2010; Wong & Hanner, 2008). Various cooking and presentation methods add to this effect by masking the character, or edible qualities, of that which is being eaten. Seafood retailers may take advantage of the subtlety in fish fillet characteristics and contribute to what is now perceived as a growing form of economic adulteration (Hanner et al., 2011). Financial incentives are thought to provide the strongest motivation to mislabel fish – either with more appetising titles, or as higher-priced species (Jacquet & Pauly,

Abbreviations: FSANZ, Food Standards Australia New Zealand; ANZFSC, Australia New Zealand Food Standards Code; SSA, Seafood Service Australia; AFNS, Australian Fish Names Standard; SFN, Standard Fish Name; BOLD, Barcode of Life Data Systems; ABARES, Australian Bureau of Agricultural and Resource Economics and Sciences.

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2008). In doing so the fish benefits from an improved public image while the vendor benefits from increased sales and revenue. Ample evidence attests to the widespread nature of mislabelling in the seafood industry throughout the world (Table 1).

A lack of regulation and enforcement is also responsible for seafood mislabelling (Hanner et al., 2011; Miller & Mariani, 2010). In Ireland, where rates of mislabelling have been found to be high, such issues are dealt with by at least three government agencies. In this case, an excess of bureaucracy and conflicting interests impede successful enforcement of seafood labelling and traceability standards (Miller & Mariani, 2010). Of course, not all mislabelling may be deliberate. The often confusing repertoire of names applied to the same fish, reflecting the cultural, ethnic and geographic diversity of the peoples who caught and consume it (for example indigenous fishermen, European settlers, later immigrants etc.), may contribute to product misrepresentation. In Australia, the popular angling and food fish *Argyrosomus hololepidotus* is commonly known as either 'Jewfish', 'Mulloway', 'Butterfish' or 'Kingfish', depending on the state in which the animal is caught (NSW/Qld, Vic, SA, WA respectively): its Standard Fish Name for trade purposes Australia-wide is Jewfish (Australian Fish Names Standard AS SSA 5300).

The consequences of mislabelling go beyond the economic. Should distributors, retailers or restaurants buy fish of lesser value and trade them as higher value substitutes, the consumer forfeits the price difference and vendors in turn secure increased profits (Jacquet & Pauly, 2008). Such practices serve to undermine consumer confidence in fish and seafood products (Hanner et al., 2011; Yearsley, Last, & Ward, 1999) and place honest suppliers or retailers at a disadvantage in a market where others may undercut them. On a broader scale, such acts nullify actions taken by the consumer to uphold conservation prohibitions (Hanner et al., 2011). The introduction of seafood awareness campaigns, certification programs (e.g. Marine Stewardship Council) and ecolabels (Jacquet & Pauly, 2007; Roheim & Sutinen, 2006) aim to persuade seafood consumers to select more sustainable or environmentally-friendly products (Von der Heyden, Barendse, Seebregts, & Matthee, 2010). Without accurate labels however, consumers are prevented from making such choices (Logan, Alter, Haupt, Tomalty, & Palumbi, 2008), and regardless of any good intentions, 'the "wrong" choice will inadvertently be made' (Von der Heyden et al., 2010). Marko et al., (2004) suggest that deliberate mislabelling not only defrauds consumers but also distorts the status of fish stocks as perceived by customers. This may be the case in Ireland, where a false perception of high availability of cod (a depleted species) suggests healthy stocks (Miller & Mariani, 2010).

Table 1
Examples of reported cases of mislabelling by country.

Country	Notes	Source
Australia	23.2% of seafood products mislabelled	Anonymous. Food Standards Australia New Zealand
Canada	41.2% of seafood products mislabelled	Hanner et al., 2011
Ireland	25% of cod and haddock products mislabelled;	Miller & Mariani, 2010
Ireland	28.2% of cod mislabelled	Miller et al., 2012
Italy	77% of 'palombo' shark products substituted;	Barbuto et al., 2010
Italy	32% seafood products mislabelled	Filonzi, Chiesa, Vaghi, & Marzano, 2010
Italy	79% jellyfish products mislabelled	Armani et al., 2013
South Africa	50% of seafood products mislabelled	Von der Heyden et al., 2010
South Africa	31% fish seafood mislabelled	Cawthorn et al., 2012
Spain	20% of hake sampled found to be mislabelled	Machado-Schiaffino, Martinez, & Garcia-Vazquez, 2008
United States	77% of red snapper mislabelled	Marko et al., 2004

As a means to authenticate animal meat products and bypass the inherent problems of morphology-based identification methods, a number of molecular diagnostic techniques have been developed (Wong & Hanner, 2008; Yamashita et al., 2008). Among them is DNA barcoding (Galimberti et al., 2013). Hebert, Cywinska, Ball, and deWaard (2003) established the idea that the DNA sequence of a specific mitochondrial gene could serve as the core of a system to unambiguously identify all animals across the globe. The target gene, cytochrome *c* oxidase unit 1 (CO1), approximately 650 base pairs in length, is responsible for encoding a portion of the terminal enzyme of the respiratory chain of mitochondria, and importantly, is known to possess low within-species compared to between-species variation (Ward, Hanner, & Hebert, 2009). Barcoding takes advantage of this gene to identify animals to the species level. Barcodes of unidentified specimens may be queried against reference sequences (linked to formally identified voucher specimens held in public collections) housed in the publicly-accessible Barcode of Life Data systems (BOLD) (Ratnasingham & Hebert, 2007; Wong & Hanner, 2008).

The barcoding process has proven successful in the identification of fish species including sharks (Holmes, Steinke, & Ward, 2009; Ward, Holmes, & Yearsley, 2008; Ward, Zemlak, Innes, Last, & Hebert, 2005). Importantly, it can be easily applied to seafood. Whole fish, fillets, fins, fragments, juveniles, larvae, eggs or any other properly preserved tissue may be used for identification (Becker, Hanner, & Steinke, 2011) and the technique can be applied to raw, smoked or cooked specimens (Hanner et al., 2011).

Although DNA barcoding is well established in Australia (see Ward et al., 2009; Ward, Holmes, White, Last, 2008; Ward et al., 2005), its application for the detection of mislabelling of seafood has rarely been attempted. Here, we use DNA barcoding to investigate the incidence of mislabelling specifically in Tasmanian seafood products. The state of Tasmania represents one of Australia's most valuable fisheries. In the 2009–10 period, Tasmanian fish represented a combined beach/farm gate value of $563.8 million and 25% of the country's total fisheries production. Tasmanian fish products are considered, locally and internationally, to be of high quality and this is linked to advanced technology and farming practices, combined with independent assessments of sustainability (TSIC 2013). The success of Tasmanian seafood is also attributed to the strong focus placed on marketing to domestic consumers and the use of certified and easily recognised labels that attest to the industry's 'clean' and 'green' credentials. Labelling accuracy on the part of vendors is therefore central to the continued success of Tasmanian fisheries, and given the high economic value of the industry, even conservative rates of mislabelling and substitution would compromise the environmentally-aware efforts made by both retailer and consumer.

2. Methods

2.1. Sample collection and DNA extraction

Fifty-one seafood products (fresh, uncooked and unprocessed fillets) were acquired anonymously from 15 fishmongers, markets or supermarkets across the Hobart (Tasmania) metropolitan area. From these products a small section of muscle tissue was removed and stored in plastic vials at −20 °C until processed. DNA was extracted from a 25 μg sub-sample of each fillet using the Qiagen DNeasy Blood and Tissue Kit (Qiagen, USA) according to