Elsevier Editorial System(tm) for Food Control

Manuscript Draft

Manuscript Number: FOODCONT-D-16-00608R2

Title: DNA barcoding reveals substitution of Sablefish (Anoplopoma fimbria) with Patagonian and Antarctic Toothfish (Dissostichus eleginoides and D. mawsoni) in online market in China: how mislabeling opens door to IUU fishing

Article Type: Research Paper

Keywords: Sablefish, Anoplopoma fimbria, Toothfish, Dissostichus spp. Chinese E-commerce, Seafood frauds, DNA barcoding, Species identification, Illegal Unreported and Unregulated (IUU).

Corresponding Author: Dr. Andrea Armani,

Corresponding Author's Institution: University of Pisa

First Author: Xiong Xiong

Order of Authors: Xiong Xiong; Lisa Guardone; Cornax María José; Lara Tinacci; Alessandra Guidi; Daniela Gianfaldoni; Andrea Armani

Abstract: China's rapid economic development has determined profound changes in seafood consumption patterns, and nowadays besides the traditional luxury seafood, high-quality marine fish are consumed. Among these is Anoplopoma fimbria (Sablefish), a highly priced species on the Chinese market. A recent molecular survey on products sold online in China found that all the analyzed products sold as Yin Xue, used to indicate A. fimbria, were instead Dissostichus spp., a genus of fish extremely vulnerable to overfishing (Xiong et al. 2016). Considering this and the lack of a standardized naming system for seafood species in China, an initial search was conducted to identify all the possible Chinese names indicating A. fimbria. The aim of the present study was to assess the challenges of the online market with regards to frauds for fish species substitution. DNA barcoding was employed to verify the identity of 42 products sold on e-commerce platforms as Sablefish. Moreover, the information reported on the webpage and on the label was analyzed according to the Chinese regulation in force. All the PCR products gave readable sequences. By using the IDs analysis on BOLD and the BLAST analysis on GenBank all the samples were unambiguously identified at the species level. Of the 42 products sold as Sablefish, only 6 (14.3%) were molecularly identified as this species, while 32 (76.2%) were identified as Dissostichus eleginoides (Patagonian Toothfish) and 4 (9.5%) as D. mawsoni (Antarctic Toothfish), highlighting an alarming overall misrepresentation rate of 85.7% and implications for the management of these species' fisheries. The combined analysis of all the information of the webpages and the labels allowed us to hypothesize unintentional and intentional mislabeling. Our findings suggest the possible existence of a trade pattern enabling IUU fishing operators to launder illegal catches of Toothfish through mislabeling.

Dear Editor,

we would like to submit the following manuscript for possible publication:***"DNA barcoding reveals substitution of Sablefish (Anoplopoma fimbria) with Patagonian and Antarctic Toothfish (Dissostichus eleginoides and D. mawsoni) in online market in China: how mislabeling opens door to IUU fishing"***

The substitution of high-quality fish species with less expensive ones becomes quite easy in processed products due to the lack of the essential characteristics necessary for their morphological identification. In this context, the accurate labeling of seafood species plays an important role in protecting consumers. While in Western countries, and in particular in the European Union, seafood traceability has reached high standards level, China still has many shortcomings in the management of the fishery chain. In particular, it still lacks of specific mandatory provisions for the labeling and of an official reference list of seafood trade names.Moreover, processing countries, such as China, are at high risk for laundering of illegal catches into legitimate markets.

Nowadays, in China, marine fish are highly requested from the consumers. Among these ,a valuable species recently appreciated in China is *Anoplopoma fimbria*. Some of the Chinese names used to indicate this species often contains the term *Xue* that in China is used for Cod products, probably to make the products more appealing. In fact, the use of the term *Xue* creates the false impression of belonging to cod fish, which is highly appreciated. In addition, the chaotic use of these denominations could be further enhanced by the emerging online market, a novel business modelwhich is experiencing a very rapid growth in China.

A recent molecular survey on Cod products sold online in China (Xiong et al., 2016 Food Control, 60, 519-532), found out that all the analyzed products sold as *Yin Xue*, one of the term used to indicate *A. fimbria*, were in fact *Dissostichus* spp., a genus of Antarctic ground fish extremely vulnerable to overfishing. Then, also considering that recent reports on IUU fishing of *Dissostichus* spp. suspected of having China as its final market destination, we employed the DNA barcoding of a ~655bp region of the mitochondrial cytochrome c-oxidase I (*COI*) to verify the identity of 42 products sold on e-commerce platforms with different Chinese names used for *A. fimbria.*

Of these products only 14.3% were molecularly identified as *A. fimbria*, while 32 76.2% were identified as *Dissostichus eleginoides* (Patagonian Toothfish) and 9.5% as *D. mawsoni* (Antarctic Toothfish), highlighting an alarming overall misrepresentation rate of 85.7% and implications for the management of these species' fisheries.

Best regards

Andrea Armani

***Detailed Response to Reviewers**

Dear Editor,

We are sending you back the revised version of the manuscript entitled "*DNA barcoding reveals substitution of Sablefish (Anoplopoma fimbria) with Patagonian and Antarctic Toothfish (Dissostichus eleginoides and D. mawsoni) in online market in China: how mislabeling opens door to IUU fishing*".

Thank you for considering the manuscript for publication after minor revision. The manuscript has been revised accordion to the suggestion of reviewer 2. In particular, the section Results and Discussion has been shortened as possible (it was originally 4467 words while now it is 3455 words). We think that a further reduction of the section will negatively affect the clarity and the overall quality of the manuscript.

Reviewers' comments:

Reviewer #2: The authors have conducted a good review of their manuscript, incorporating most suggestions. However, I still think that their discussion is too long, therefore, I suggest they focus on the main point, avoiding themes not related with the main goals of their manuscript.

DNA barcoding reveals substitution of Sablefish (*Anoplopoma fimbria)* with Patagonian and Antarctic Toothfish (*Dissostichus eleginoides* and *D. mawsoni*) in online market in China: how mislabeling opens door to IUU fishing

Xiong Xiong[1,2°], Lisa Guardone [1°], María José Cornax [3], Lara Tinacci[1], Alessandra Guidi [1], Daniela Gianfaldoni[1], Andrea Armani[1]*.

[1]FishLab, Department of Veterinary Sciences, University of Pisa, Via delle Piagge 2, 56124, Pisa (Italy)

[2]College of Food Science and Technology, National Center of Meat Quality and Safety Control, Nanjing Agricultural University, Nanjing 210095, China

[3]Oceana. Gran Vía 59, 9, 28013 Madrid, (Spain)

°These authors have equally contributed to this work.

*corresponding author:

Postal address: *FishLab, (http://fishlab.vet.unipi.it/it/home/). Department of Veterinary Sciences, University of Pisa, Via delle Piagge 2, 56124, Pisa (Italy).*

Tel: +390502210207

Fax: +390502210213

Email: andrea.armani@unipi.it

Abstract

China's rapid economic development has determined profound changes in seafood consumption patterns, and nowadays besides the traditional luxury seafood, high-quality marine fish are consumed. Among these is *Anoplopoma fimbria* (Sablefish), a highly priced species on the Chinese market. A recent molecular survey on products sold online in China found that all the analyzed products sold as Yin Xue, used to indicate *A. fimbria*, were instead *Dissostichus* spp., a genus of fish extremely vulnerable to overfishing (Xiong et al. 2016). Considering this and the lack of a standardized naming system for seafood species in China, an initial search was conducted to identify all the possible Chinese names indicating *A. fimbria*. The aim of the present study was to assess the challenges of the online market with regards to frauds for fish species substitution. DNA barcoding was employed to verify the identity of 42 products sold on e-commerce platforms as Sablefish. Moreover, the information reported on the webpage and on the label was analyzed according to the Chinese regulation in force. All the PCR products gave readable sequences. By using the IDs analysis on BOLD and the BLAST analysis on GenBank all the samples were unambiguously identified at the species level. Of the 42 products sold as Sablefish, only 6 (14.3%) were molecularly identified as this species, while 32 (76.2%) were identified as *Dissostichus eleginoides* (Patagonian Toothfish) and 4 (9.5%) as *D. mawsoni* (Antarctic Toothfish), highlighting an alarming overall misrepresentation rate of 85.7% and implications for the management of these species' fisheries. The combined analysis of all the information of the webpages and the labels allowed us to hypothesize unintentional and intentional mislabeling. Our findings suggest the possible existence of a trade pattern enabling IUU fishing operators to launder illegal catches of Toothfish through mislabeling.

Keywords: Sablefish, *Anoplopoma fimbria*, Toothfish, *Dissostichus* spp. Chinese E-commerce, Seafood frauds, DNA barcoding, Species identification, Illegal Unreported and Unregulated (IUU).

1. Introduction

China's rapid economic development has determined profound changes in seafood consumption patterns, and nowadays besides the traditional luxury seafood (such as abalone, shark fin, sea cucumber and fish maw), also high-quality marine fish (such as salmon, cod and tuna) are consumed. However, the internal production of these species from aquaculture and catches is insufficient to cover their consumption (Xiong et al., 2016a), thus currently most of the demand is met by importation (Fabinyi, 2016; Fabinyi & Liu, 2014; Lindkvist, Trondsen & Xie, 2008).

Among the valuable marine fish species recently appreciated in China is *Anoplopoma fimbria*, a commercially important ground fish distributed in the Northeastern and Northwestern Pacific (Stewart, Thorson & Wetzel, 2011). Japan is the world's largest importer and consumer of this fish, with an average consumption of 26,900 metric tons per year during 1987-2012, which corresponds to 88% of the world's *A. fimbria* production in that period. *A. fimbria* has been recently appreciated also in China where, in 2013, 212 metric tons were imported from the USA, accounting for 2.5% of its total exportation (Sonu, 2014). China today ranks 7th among the top importing countries (Grilly, Reid, Lenel, & Jabour, 2015). The market appealing of this species is reflected by its high price that exceeds 100 euro per kg in Chinese supermarkets (author's note).

In the globalized seafood supply chain substitution of high-value species with less expensive ones, or abuse of vernacular seafood names to confuse consumers (Armani et al., 2015a; Cawthorn, Steinman, & Witthuhn, 2012; Khaksar et al., 2015) become

quite easy. This confusion is further enhanced by the difficulty in visual identification of processed seafood products (Armani et al., 2013) and by the complex pathways they follow to reach the final market destination (Bellmann, Tipping, & Sumaila, 2015).

The European Union (EU) has adopted a complex set of rules aimed at ensuring control of the fishing fleet and full traceability of fish and fish products, which are set out in two separate sections: the EU Control Regulation (CR) (Council Regulation (EC) No. 1224/2009) and the Common Organization of the Markets in Fishery and Aquaculture Products Regulation (COM) (Regulation (EU) No 1379/2013). Their common goal is to guarantee safe supply for processing enterprises and consumers, in spite of aggravated market conditions and an increasing scarcity of resources in the Community waters (UK Department for Environment, Food & Rural Affairs 2013). In particular, the CR regulates traceability and labelling for domestic fishing products to be disclosed in all the points of the supply chain. Complementarily, COM establishes the compulsory information (in particular the scientific name, the corresponding commercial denomination, the production method, the catch/farm area and the category of the fishing gear) that must be reported on the label of seafood products with the aim to inform final consumers and regardless from their origin (D'Amico et al., 2016).

In addition, in order to ensure that no Illegal, Unreported and Unregulated (IUU) fishing products enter the Community market or markets supplied from the Union, the EU introduced the IUU Regulation, which applies to all fishing vessels, under any flag

and in all maritime waters (Commission Regulation (EC) No 1010/2009; Council Regulation (EC) No 1005/2008). The Regulation seeks to ensure full traceability of all marine fishery products traded within the Community by means of a Catch Certification Scheme (CCS), mandatory for fishery products to be imported into the EU, declaring that the catch was made in accordance with applicable laws, regulations and international conservation and management measures (Leroy, Galletti, & Chaboud, 2016).

On the contrary, China is still in a development stage of seafood traceability (D'Amico et al., 2014) and the absence of a standardized seafood nomenclature as well as the unfamiliarity of Chinese consumers, Food Business Operators (FBOs) and Official Authorities with the new imported marine species can further foster mislabeling (Xiong et al., 2016b). Moreover, processing countries, such as China, are at high risk for laundering of illegal catches into legitimate markets (Clarke, 2010). Previous surveys conducted on Chinese products highlighted chaotic labeling (Armani et al., 2012; Armani et al., 2015b), with misrepresentation rates reaching 100% and substitution with potentially toxic species, such as *Lagocephalus* spp. (Armani et., 2015b; Shen et al., 2014; Xin-guang et al., 2013; Xiong et al., 2016b).

FAO 3-alpha code nomenclature for fish species sets the basis for species identification, global fisheries data collection and statistics, and seafood traceability (http://www.fao.org/fishery/collection/asfis/en). Nonetheless, the list of codes and relative names (commercial and/or scientific) is still incomplete at international level (Xiong et al., 2016a).

For *A. fimbria*, indicated as Sablefish in English, there is no equivalent nomenclature in pinyin while many Chinese names are used for this species (Table 1). Some of these names, which often contain the term *Xue* that in China is used for Cod products, are quite recognizable and appealing. In fact, the use of *Xue* creates the false impression of belonging to cod fish, which is highly appreciated by consumers (Xiong et al., 2016b).

The chaotic use of these denominations could be further enhanced by the emerging online market, a novel business model (Turban, King, Lee, Liang & Turban, 2015) which is experiencing a very rapid growth: in 2013, the Chinese online retail market became the biggest worldwide in terms of sale volume (China Internet Network Information Center 2014). Several e-commerce platforms in China can provide access to seafood and nowadays an Alaskan lobster is just a click-mouse away from Chinese consumers (Noble, 2015). On November 11th 2013 more than $1 million USD of USA seafood, including Sablefish, were sold on China's e-commerce website Tmall through Alibaba's Singles' Day Promotion (Peavey, 2013). However, when buying seafood online, customers do not have a chance to physically evaluate the product and the website serves to convey the information to the consumer (Rahimnia & Hassanzadeh, 2013). Thus, the peculiar characteristic of the e-market may foster frauds and misrepresentation (Xiao & Benbasat, 2011; Xiong et al., 2016b). A recent molecular survey on Cod products sold online in China (Xiong et al., 2016b), found out that all the analyzed products sold as *Yin Xue*, one of the term used to indicate *A. fimbria* (Table 1), were in fact *Dissostichus* spp., a genus of Antarctic ground fish

147 extremely vulnerable to overfishing (Norse et al., 2012). On the basis of these results,
148 supported also by the recent reports of Illegal, Unreported and Unregulated (IUU)
149 fishing of *Dissostichus* spp. suspected of having China as its final market destination
150 (Cornax pers. comm.; Pala, 2015;
151 http://oceana.org/press-center/press-releases/record-breaking-fines-imposed-beneficia
152 ries-illegal-fishing), the existence of a flux of illegally sourced fishes fraudulently sold
153 on the Chinese market was speculated. Connections between mislabeling and IUU
154 fishing have already been described (Pramod, Nakamura, Pitcher & Delagran, 2014).
155 In this study, the DNA barcoding of a ~655bp region of the mitochondrial
156 cytochrome c-oxidase I (*COI*) gene (Full DNA Barcoding, FDB), one of the most used
157 molecular approaches to verify the authenticity of seafood products (Armani et al.,
158 2015a; Cawthorn, et al., 2012; Zhang & Hanner, 2012), was employed to verify the
159 identity of the products sold on e-commerce platforms with different Chinese names
160 used for *A. fimbria* (Table 1) and to assess the challenges of the online market with
161 regards to frauds for fish species substitution. In particular, we speculated the causes
162 of mislabeling and we highlighted the need for the enforcement of a Chinese
163 traceability system, able to increase the trade transparency and close the markets to
164 IUU products. Finally, the potential impact of mislabeling for the conservation of
165 *Dissostichus* spp. was addressed.

166 **2. Materials and method**

167 ***2.1 Sampling***

168 Initially, a search to identify all the possible Chinese names used to indicate *A.*

fimbria was conducted (Table 1). The four Chinese names found were then used as the key words to search for products on the Business to Customer (B2C) platform. Forty-two samples were purchased from one of the largest B2C online platforms in China. The results of each search were displayed subdivided by online vendors, which were ranked on the basis of their overall monthly transaction volume (from large to small).

Thirty-three 银鳕 (Chinese pinyin *Yin Xue*) products from the top 23 vendors, 7 黑鳕鱼 (*Hei Xue Yu*) products from the top seven vendors and 2 裸盖鱼 (*Luo Gai Yu*) products from the only 2 vendors retrieved were selected (Table 2). No results were retrieved searching for 裸头鱼 (*Luo Tou Yu*). Once ordered, the products arrived in Nanjing (China) within the next two days by the express cold-chain logistics system. The received products consisted in frozen single or multiple slices (40) or heads (2) (Fig. 1). In the laboratory, all the 42 frozen products (Table 2) were registered, labeled with an internal code and stored at -20°C until further analysis.

2.2 Molecular analysis

2.2.1 DNA extraction. Total DNA extraction was performed following (Andrea et al., 2014). DNA quality and concentration were determined using a NanoDrop ND-2000C spectrophotometer (NanoDrop Technologies, Wilmington, DE, US). For each sample, a standard working concentration of 100 ng/µl was prepared. One thousand nanograms of the total DNA was electrophoresed on 1% agarose gel (Biowest Regular Agarose G-10, Shanghai, China) stained with ethidium bromide, and visualized via ultraviolet transillumination. DNA fragment size was estimated by

comparison with the standard 100 bp DNA Ladder (Vazyme, Nanjing, China) by visualizing on Molecular Imager® Gel Doc™ XR System (BIO-RAD, California, US).

2.2.2 Amplification and sequencing of the full-COI barcode (FDB). The DNA samples were amplified using the universal primers proposed by (Handy et al., 2011), for the amplification of a FDB of the *COI* gene. The PCR reactions were performed in a final reaction volume of 40 µl, containing 8 µl of a 5× buffer (Takara, Nanjing, China), 200 µM of each dNTP (Takara, Nanjing, China), 100 nM of each primer (Genscript, Nanjing, China), 0.5 U of PrimesSTAR® GXL DNA Polymerase (Takara, Nanjing, China), 200 ng of DNA and DNase free water. The amplification program involved an initial denaturation step at 94°C for 3 min, followed by 45 cycles at 94°C for 30s, 53°C for 30s and 72°C for 35s and final extension at 72°C for 10 min. The amplicons were then separated by electrophoresis on a 2% agarose gel (Biowest Regular Agarose G-10, Shanghai, China) stained with ethidium bromide. The presence of the expected amplicon was assessed by a comparison with the standard 100 bp DNA Ladder (Vazyme, Nanjing, China) by visualizing on Molecular Imager® Gel Doc™ XR System (BIO-RAD, California, US). PCR products were sent to the company GenScript (Nanjing, China) for purification and sequencing using ABI 3730 DNA sequencer (Applied Biosystems Division, Foster City, USA).

2.2.3 Post-sequencing data analysis and comparison of the molecular results with the databases. The sequences obtained were visualized, aligned and edited with BioEdit program version 7.0.9 (Hall, 1999). Fine adjustments were manually made

after visual examination. The generated *COI* sequences were analyzed using the Identification System (IDs) on BOLD (Species Level Barcode Records) (http://www.boldsystems.org/index.php/IDS_OpenIdEngine) and using the Basic Local Alignment Search Tool (BLASTn) on GenBank, (http://blast.ncbi.nlm.nih.gov/Blast.cgi). A top match with a sequence similarity of at least 98% was used to designate species identification. Since the *COI* sequences obtained in this study were not derived from voucher samples or expert-identified fish specimens, the sequences were not submitted to any international database.

2.3 Analysis of the information reported on the website and on the label and comparison with the molecular results

The information available on the website was assessed in the light of the requirements established by the selected B2C platform themselves. In particular, the heading of the product webpage and the information reported in the product description were analyzed. The label information reported on prepackaged products were assessed according to the Chinese general mandatory National Standard *General Rules for the labeling of prepackaged foods* (GB7718-2011), while those of in-bulk products were assessed according to the Law of the People's Republic of China on Quality and Safety of Agricultural Products (http://www.npc.gov.cn/englishnpc/Law/2008-01/02/content_1387986.htm).

All the information was translated to English by a native Chinese speaker, also with the use of multimedia translation tools (Google Translator; Word of Reference). Finally, the accuracy of the information reported on the website and on the received

product, paying particular attention to the commercial and scientific denominations and the geographical origin, was verified in the light of the molecular identification of the products, and the misrepresentation rate was calculated.

3. Results and discussion

3.1 Sampling

A preliminary survey was conducted to investigate the names used to indicate *A. fimbria*, and identify the key words to search for the products online. The Latin-Chinese Dictionary of Fish Names, , reports 银鳕 (Chinese pinyin *Yin Xue*) and 裸盖鱼 (*Luo Gai Yu*) as the Chinese names for *A. fimbria* (Latin-Chinese Dictionary of Fish Names, 2016). The Guideline of the Center for Food Safety of Hong Kong (Centre for Food Safety of Hong Kong, 2007) specifies *Yin Xue* as the Chinese common name in the market and *Luo Gai Yu* in scientific literature. In addition, the guideline specifies that *Yin Xue* can be used only if an additional term such as *A. fimbria*, *Luo Gai Yu* or Sablefish is reported (Centre for Food Safety of Hong Kong, 2007), considering that the term *Xue* would create the false impression of belonging to cod fish (Xiong et al., 2016b).

Fishbase (http://www.fishbase.org/) and Wikipedia (http://zh.wikipedia.org/wiki/Wikipedia) confirm these names and also provide 裸头鱼 (*Luo Tou Yu*) as another name for this species. Moreover, some online rumors claimed the acceptability of 黑鳕鱼 (*Hei Xue Yu*, which can be literally translated as Black Cod) for *A. fimbria* as well (http://blog.sina.com.cn/s/blog_546be44c0101ghm7.html).

257 Totally, the search for *Yin Xue* produced 193 results distributed in 107 online
258 vendors (accessed on 23th May 2015). These numbers decreased to 132 results in 50
259 vendors for *Hei Xue Yu* and 2 products in 2 vendors for *Luo Gai Yu*. As mentioned, no
260 results were found searching for *Luo Tou Yu*

261 The 42 frozen products analyzed in this study were selected ranking the monthly
262 transaction volume of the online vendors. Only the vendors with a monthly
263 transaction volume higher than 1 were selected for *Yin Xue* and *Hei Xue Yu*, while for
264 *Luo Gai Yu* only 2 vendors were found, so samples were purchased from both of them,
265 even though the monthly transaction volume of one of them was 0. The monthly
266 transaction volume (despite overstated sometimes) of the *Yin Xue* products ranged
267 from 2033 pieces to 1 piece (average 237). The price was also quite variable, from
268 78.8 to 11 Euro/kg (average 42.8 Euro/kg) (Table 2). *Hei Xue Yu* products presented
269 lower monthly transaction volumes (from 118 to 1, average 29) and were sold at
270 59.5-38.7 Euro/kg (average 47.1 Euro/kg). The price of one *Luo Gai Yu* product with
271 a monthly transaction volume of 42 pieces was 36.7 Euro/kg, while the other one
272 with a monthly transaction volume of 0 pieces had a higher price (58.2 Euro/kg)
273 (Table 2). The prices of the collected samples were very high and comparable with
274 those of the highest quality fish species such as Tuna, Grouper (Fabinyi & Liu, 2014)
275 and even Toothfish (Grilly et al., 2015). ***3.2 DNA extraction and amplification***

276 The total DNA was successfully extracted from all the samples and showed good
277 quality after spectrophotometric and electrophoretic analysis. In fact, a FDB was
278 amplified from all the 42 sampled products, giving an overall amplification success of

100%.

3.3 Sequences analysis and comparison with BOLD and GenBank databases

All the PCR products gave readable sequences. The sequence length and quality were analyzed first on the raw data and then after trimming at the 5’ and 3’ end, according to (Handy et al., 2011). The overall raw average length was 695bp (713-405bp), while the average length of the trimmed sequences was 628bp (655-318bp).

By using the IDs analysis on BOLD, a maximum species identity in the range of 98–100% was obtained for all 42 FDB sequences, which were unambiguously identified at the species level (Table 2). In particular, of the 33 *Yin Xue* products, 28 (85%) were identified as *D. eleginoides*, other 4 (12%) as *D. mawsoni* and only 1 (3%) as *A. fimbria*. Regarding the 7 *Hei Xue Yu* products, 5 (71.4%) were identified as *A. fimbria*, while 2 (28.6%) were identified as *D. eleginoides* as well as the only 2 *Luo Gai Yu* products (Fig. 2). Thus, of the 42 products sold as *A. fimbria*/Sablefish, only 6 (14.3%) were molecularly identified as this species, discovering an alarming overall misrepresentation rate of 85.7%.

All the FDB sequences returned the same result when analyzed by BLAST analysis.

3.4 General information reported on the webpage and on the label.

3.4.1. Webpage. B2C, together with Consumer to Consumer (C2C), are among the most common forms of e-commerce in China. Several large e-commerce platforms are available to market seafood products, particularly the imported ones..

301 The general rules for online food market have been taken into consideration in the
302 newly revised Food Safety Law (in force from 1st October 2015)
303 (http://news.xinhuanet.com/politics/2015-04/25/c_127731151.htm). However,
304 detailed requirements of the website preparation for online stores are not yet available,
305 thus prompting each online platform in China to place their own rules. Regarding the
306 selected B2C platform, the primary requirements for fresh seafood sold online are as
307 follows: *1) The heading of the product page must report at least the country of origin,*
308 *the name of the product and the net weight (the information must be displayed in this*
309 *order); 2) At least four photos of the product must be prepared, one of which must*
310 *present the label of the final product, if existing; 3) The real characteristics of the*
311 *product must be displayed.*

312 As shown in Table 2 and summarized in Table 1SM, the heading of the products
313 were prepared following the aforesaid requirements for all the samples, with
314 exceptions of 3 *Yin Xue* products. Regarding the product description, besides the
315 primary requirements, which were always present, voluntarily information such as
316 nutritional properties, the cooking method and the capture area was reported (see
317 Section 3.7).

318 Other information voluntarily presented included: the name of producer or
319 distributor (not specified), the sanitary certificate, the customs declaration and the
320 certification of origin (Table 2 and 1SM). In particular, the sanitary certificate was
321 available (even though not always readable) for 4 out of the 6 samples (66%)
322 identified as *A. fimbria* and for 10 out of 36 samples (28%) identified as *Dissostichus*

spp.

3.4.2. Labels. Regarding the received samples, 16 were prepackaged products (Table 2 and 1SM). Most of them (81.2%) were correctly prepared following the requirements of GB7718-2011 (GB7718-2011). Regarding the remaining 26 products sold in bulk, totally 84.6% of them reported the information mandatorily required by the Law of the People's Republic of China on Quality and Safety of Agricultural Products. A large amount of information was also illustrated voluntarily (Table 1SM).

Overall, 92.8% of the headings of the product page, 100% of the product descriptions and 83% of the labels of the final received products were prepared following the aforesaid rules of the selected B2C platform (Table 1SM).

3.5 Analysis of the denominations reported on the webpage and on the label

All the details regarding the denominations displayed on the webpage (heading and description) and on the label of the received products (product name and ingredient list) are reported in Table 2 and summarized in Table 2SM.

3.5.1. Webpage. Regarding the heading of the product page, in addition to *Yin Xue*, *Hei Xue Yu* and *Luo Gai Yu*, which were often found in combination, *Xue Yu* (Codfish) and *Xiao Lin Nan Ji Quan Ya Yu* (misspelling of Toothfish) were reported.

All the species denominations (scientific and commercial) found in the description of the product webpage were taken into consideration (Table 2 and 2SM). A great confusion was observed for *Yin Xue* products, since many other names were claimed for 16 samples. In addition to *Hei Xue Yu*, *Luo Gai Yu*, *Luo Tou Yu*, Sablefish, Silver cod and *A. fimbria*, incongruent names such as *Xue Yu*, *Xiao Lin Nan Ji Quan Ya Yu*,

345 Patagonian toothfish, Sea bass, Cod/codfish and *D. eleginoides* were found (see
346 Section 3.6).

347 *3.5.2. Label.* Regarding the label of the received products, the product name and,
348 for prepackaged products only, the ingredient list were evaluated (Table 2 and 2SM).
349 Similarly to what observed for the website description, 9 of the 33 *Yin Xue* products
350 reported other names. Moreover, two additional denominations were found: Chilean
351 seabass and Silver cod. Ten of the 11 prepackaged *Yin Xue* products presented an
352 ingredient list. Half of them reported only *Yin Xue*, while one reported only *Xiao Lin*
353 *Nan Ji Quan Ya Yu*. Regarding the residual 4 samples, in addition to *Yin Xue*, they
354 reported *Luo Gai Yu*, Chilean seabass and Toothfish.

355 On the *Hei Xue Yu* products (Table 2 and 2SM) 5 different denominations used for
356 *A. fimbria*. In particular, some of these products reported Black cod which is
357 sometimes used to indicate *A. fimbra*.Comparing the species denomination on the
358 product heading with the product description and with the label of the received
359 products, coherent species denominations (always referable to *A. fimbria*) were
360 observed only for 17 samples (40.5%, in grey in Table 2).

361 ***3.6. Comparison between denominations and molecular results.***

362 The molecular analysis herein performed identified *A. fimbria* only in 6 samples
363 (see Section 3.3) (Table 2). Therefore, 36 products were sold under a name not
364 consistent with the species declared on the label, giving an overall misrepresentation
365 rate of 85.7%, and specifically 97% for *Yin Xue*, 28.6% for *Hei Xue Yu* and 100% for
366 *Luo Gai Yu* products (Fig. 2). While the overall misrepresentation rate is significantly

higher than the values found in China for fish maws (53.3%) (Wen et al., 2015) and sea cucumber (63.6%) (Wen, Hu, Zhang & Fan, 2011), it is comparable to the results found analyzing cod products (100%) (Shen et al., 2014; Xin-guang et al., 2013).

In particular, it seems that the name *Yin Xue* (also reported online for both *Luo Gai Yu* products) is largely abusedprobably to promote their sale due to its high popularity (as indicated in Section 3.3.2) in China. The present results further support what already observed in our previous survey (Xiong et al., 2016b) in which 100% of the samples labeled as *Yin Xue* were mislabeled. Noteworthy is the fact that the lower misrepresentation rate (28.6%) was found for *Hei Xue Yu* products, although the utilization of this name for *A. fimbria* is not supported by official references (Table 1).

Concerning the other names found in the webpage and on the label, the English names Sablefish and Black cod are also widely accepted for *A. fimbria*, even though the US seafood list suggests to avoid the use of Black cod (Table 3), while Silver cod, which is not used at international level, is a literal translation of the Chinese characters 银鳕 (*Yin Xue*) (author's note).

On the contrary, the other names found (Cod/Codfish, *Xue Yu*, Chilean seabass, Seabass, toothfish, *Xiao Lin Nan Ji Quan Ya Yu*, Patagonian toothfish and the Latin name *D. eleginoides*) refer to species distant from *A. fimbria* and are generally used for Codfish or Toothfish. The use of the term Cod/ *Xue* also for *A. fimbria* is probably due to the fact that at the international level this species is often referred as Black cod, Blue cod and Coal cod

(http://www.fishbase.org/comnames/CommonNamesList.php?ID=512&GenusName=Anoplopoma&SpeciesName=fimbria&StockCode=528). In fact, the name *Hei Xue Yu* is actually a literal translation of the English name Black cod (author's note). All the other names (Chilean seabass, Toothfish, Patagonian toothfish and *D. eleginoides*) refer to *Dissostichus* spp., according to the suggested names for this genus (Table 3). Finally, the name *Xiao Lin Nan Ji Quan Ya Yu* is actually a misspelling of *Xiao Lin Quan Ya Nan Ji Yu* and it also refers to *D. eleginoides* (Table 3).

3.7 Analysis of the geographical origin reported on the webpage and on the label

3.7.1 Webpage. As shown in Table 2, 1SM and 2SM, 39 samples (93%) reported the country of origin in the heading of the product webpage. Most of the *Yin Xue* products reported France (63.6%), while the rest claimed origin from other countries. All the *Hei Xue Yu* products were claimed from Alaska, while the two *Luo Gai Yu* products claimed France and Chile, respectively. As mentioned, voluntary information about the capture area could only be found in the heading of the product webpage of 6 *Yin Xue* products (Antarctic).

In the website description several countries of origin were reported for *Yin Xue* products: also in this case the most part reported France (67%). Twenty-nine (88%) *Yin Xue* products, all the *Hei Xue Yu* products and both *Luo Gai Yu* products reported the capture area (Table 2SM)..

3.7.2. Label. Of the total 42 samples, 34 (81%) reported the country of origin (Table 2, 1SM and 2SM). The *Yin Xue* products derived from 4 countries: France (51.5%), Chile (21.2%), New Zealand (3%) and US/Alaska (3%). All the *Hei Xue Yu*

411 products reported US/Alaska, while only 1 *Luo Gai Yu* presented the country origin
412 (France). Most of the products presented consistent information concerning the
413 country of origin on the webpage and on the label (Table 2).

414 Only 10 samples (8 *Yin Xue* products and 2 *Hei Xue Yu*) presented some
415 information about the capture area. Interestingly, of the different capture areas
416 reported (FAO 58, FAO 67, Kerguelen Islands, North Atlantic, North Pacific, South
417 Pacific and Arctic Ocean), only FAO 67 and North Pacific (30%) are coherent with
418 the distribution of *A. fimbria*, which is generally found in Northeastern Pacific from
419 Baja California, northward to the northern-central Bering Sea, and Northwestern
420 Pacific from Kamchatka peninsula, southward to northeastern coast of Japan (Stewart,
421 Thorson & Wetzel, 2011).

422 ***3.8. Comparison between geographical origin and molecular results.***

423 *"When a food undergoes processing in a second country which changes its nature,*
424 *the country in which the processing is performed shall be considered to be the*
425 *country of origin for the purposes of labeling"*
426 (http://www.fao.org/docrep/005/Y2770E/y2770e02.htm). Every subsequent transit
427 following the initial export after landing is defined by CCAMLR as a re-export
428 (Clarke, 2009).

429 On the basis of the available information, we assume that the 5 countries indicated
430 on the webpage and on the products (France, Chile, New Zealand, Argentina and
431 USA) have been responsible of the last processing step. It should be noted that for
432 Toothfish all processing generally happens on board

(https://www.ccamlr.org/fr/system/files/ID%20Guide%20PatToothFish_ENG_A4.pdf). Therefore the origin should match in theory with the vessel flag.

However, considering that Toothfish products have been recorded undergoing 8 transit before reaching the final destination (Clarke, 2010), it is very difficult to reconstruct the pathway followed by these products. Moreover, considering both the inconsistencies among the country of origin and the capture areas and between these data and the results of the molecular analysis, the truthfulness of all declarations is doubtful.

Overall, a capture area was available for 40 samples, ranging from Antarctic (15), North Atlantic (10), North Pacific/Alaska (8), France (4), Reunion Island (2), South Pacific (1) and English Channel (1) (Table 2 and 2SM). Comparing the declared catch areas and the range of the species molecularly identified, 16 out of 40 (40%) products presented completely inconsistent declarations. In fact, North Atlantic, English Channel and Alaska are inconsistent with the area of distribution of *Dissostichus* spp, suggesting intentional mislabeling (see Section 3.9). Congruent information was found for 21 products declaring North Pacific, Alaska or FAO area 67 and Antarctic, FAO area 58, France (most likely referred to the French Southern and Antarctic Lands) and South Pacific consistent with the distribution of *A. fimbria* and *Dissostichus* spp, respectively (Table 3SM).

3.9 Voluntary or involuntary mislabeling?

The seafood chain is one of the food sectors most affected by fraudulent practices. Over the last years, an alarming number of mislabeling cases have been reported

worldwide (Cawthorn, Duncan, Kastern, Francis, & Hoffman, 2015; Stiles et al., 2013). Mislabeling is usually committed by substituting high-price market species with less valuable ones. In some cases, mislabeling can allow the commercialization of toxic species banned from the market or recycle illegal fish products (Pramod et al., 2014; Xiong et al., 2016b).Thus, mislabeling is usually considered an intentional practice. In fact, the differentiation of fish species is often easily practicable by industry workers who handle these species on a daily basis (Miller, Jessel, & Mariani, 2012). However, in the case of processed products, accidental substitution could happen due to lack of the main essential morphological characteristics and can be further fostered by the absence of a detailed system for seafood labeling (Cawthorn et al., 2015; Xiong et al., 2016a).

China does not possess a legal framework for the management of the seafood traceability comparable to the one implemented by the EU. In particular, the lack of a specific regulation establishing the mandatory information that must be provided with the accompanying documents or the labels greatly affects the transparency of the seafood sector (Xiong et al., 2016a). In this context, the use of generic names can foster mislabeling. Although prices vary depending on fish preparation, the retail prices reported for Toothfish by Grilly et al., (2015) ($65/kg) and those found in this study for *A. fimbria* sold online are similar. Thus, the mislabeling of Toothfish as *A. fimbria* on the online Chinese market may be due to the fact that Chinese consumers are more acquainted to Sablefish. In addition, mislabeling would allow to market IUU products fished without authorization or over the catch quotas (see section 3.10).

Moreover, it has to be considered that prices for Sablefish in Chinese supermarkets can reach 100 euro/kg, thus it could happen that an IUU operator gets more economic benefit by selling the fish as Sablefish in China than by selling it as Toothfish in other markets. In these cases, products misdescription would be the result of a voluntary adulteration of the labels.

Interestingly, all the 11 products that reported additional names referring to *Dissostichus* spp. were molecularly identified as *D. eleginoides* (n=10) and *D. mawsoni* (n=1). In these specific cases, the label incongruities seem to be more likely due to the chaos affecting fish denominations and misspelling, rather than to a deliberate fraud. In fact, names referring to Toothfish were never found on the 6 samples identified as *A. fimbria* (Table 2).

Considering also the inconsistencies found in the analysis of the geographical origin, further detailed studies should be performed to exactly understand what products have been voluntarily commercialized under a false name. In fact, if not proper countered mislabeling opens door to IUU fishing and vanishes conservation efforts.

3.10 Potential impacts for conservation of Dissostichus spp.

Patagonian and Antarctic toothfish (*D. eleginoides* and *D. mawsoni*) are commercially important fish belonging to the Nototheniidae family. The long life span (up to 50 years) and late sexual maturity (10 years) make them exceptionally vulnerable to over-exploitation (Pala, 2015; Sovacool & Siman-Sovacool, 2008).

The commercial exploitation of Patagonian Toothfish began in the late 1980s

(Österblom, Bodin, Sumaila & Press, 2015). In the 1990s, as a consequence of the depletion of predatory fish stocks in the Northern hemisphere fishing effort moved southwards and *D. eleginoides* quickly became very popularin the USA and Japan (Österblom et al., 2015; Sovacool & Siman-Sovacool, 2008). The Antarctic toothfish fishery began later(http://www.colto.org/wp-content/uploads//2012/09/Ross_Sea_FAQ.pdf).

Most of Toothfish fisheries are managed by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR came into effect in the 1980's, has 25 member states and is the regional fisheries management organization for fisheries assessment, management and monitoring and marine conservation in the Southern Ocean (https://www.ccamlr.org/en/).

Patagonian toothfish is caught off the coasts of Chile, Argentina, Peru, Uruguay, Patagonia, and around sub-Antarctic islands and seamounts at depths of 500-1000 m. Antarctic toothfish is generally caught at higher latitudes in the circumpolar waters adjacent to Antarctica at depths of 2000 m (Roberts, Xavier & Agnew, 2011). In addition, Toothfish are caught outside CCAMLR's Convention Area, mostly taken from domestic fisheries around South America and landed in local ports (https://www.ccamlr.org/fr/system/files/ID%20Guide%20PatToothFish_ENG_A4.pdf).

Both species of *Dissostichus* are highly prized around the world, which is the main reason why they have caught the attention of IUU fishing vessels (https://www.ccamlr.org/en/fisheries/toothfish-fisheries). In order to combat this issue,

521 in the early 2000s CCAMLR developed a novel Catch Documentation Scheme
522 whereby all Toothfish unloaded or transported must be accompanied by a *Dissostichus*
523 catch document (DCD),
524 (https://www.ccamlr.org/en/compliance/illegal-unreported-and-unregulated-iuu-fishin
525 g).

526 Other efforts, such as the total allowable catch (TAC) limits, enforcement of
527 port/control inspection measures and a satellite linked vessel-monitoring system, have
528 also been made (Sovacool & Siman-Sovacool, 2008)
529 (http://www.colto.org/wp-content/uploads//2012/09/Ross_Sea_FAQ.pdf). Although
530 the implementation of these measures in the framework of international cooperation
531 claimed to succeeded to decrease IUU fishing substantially (Österblom et al., 2015), it
532 still remains a concern and has the potential to seriously undermine CCAMLR's
533 conservation objectives (Lack, 2008;
534 https://www.ccamlr.org/en/compliance/illegal-unreported-and-unregulated-iuu-fishin
535 g).

536 IUU fishing operators may find in the Chinese market open doors for laundering
537 their catches through mislabeling, suggesting the need for additional control and
538 enforcement measures. Previous surveys have already revealed that mislabeling
539 nullified the conservation efforts to promote the consumption of sustainably
540 harvested *D. eleginoides* by social marketing (Marko, Nance & Guynn, 2011; Marko,
541 Nance & van den Hurk, 2014).

542 **4. Conclusions**

China's leading role in the international seafood market, together with the booming demand for foreign seafood and the improved access by the emerging online seafood market, strengthen the importance of its role in the global initiatives for marine conservation (Fabinyi, 2016). In particular, the implementation of an accurate seafood naming and labeling is of pivotal importance (Helyar et al., 2014, Xiong et al., 2016a).

In this study, the substitution of *A. fimbria* with *Dissostichus* spp. in 86% of the products provides additional evidences of the possible existence of a collateral flow that most likely allows the recycling of illegal product on the Chinese market (Xiong et al., 2016b). This fraudulent conduct may represent a great issue for the conservation of *Dissostichus* spp.

Funding source

This project has been found by the University of Pisa.

Acknowledgments

We thank Doctor Yang Ying, from Nanjing Agricultural University, for her assistance in the preparation of DNA extraction and amplification.

Fig. 1 Presentation of the received products: single slice (a), multiple slices (b), head (c).

Fig. 2 Pie charts showing the species identified with the molecular analysis, divided according to the search term used.

References

Armani, A., D' Amico, P., Castigliego, L., Sheng, G., Gianfaldoni, D., & Guidi, A. (2012). Mislabeling of an "unlabelable" seafood sold on the European market: The jellyfish. *Food Control*, *26* (2), 247-251.

Armani, A., Tinacci, L., Giusti, A., Castigliego, L., Gianfaldoni, D., & 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 mislabeling in jellyfish food products. *Food Research International*, *54* (2), 1383-1393.

Armani, A., Tinacci, L., Xiong, X., Titarenko, E., Guidi, A., & Castigliego, L. (2014). Development of a simple and cost-effective bead-milling method for DNA extraction from fish muscles. *Food Analytical Methods*, *7* (4), 946-955.

Armani, A., Guardone, L., Castigliego, L., D'Amico, P., Messina, A., Malandra, R., Gianfaldoni, D., & Guidi, A. (2015)a. DNA and Mini-DNA barcoding for the identification of Porgies species (family Sparidae) of commercial interest on the international market. *Food Control*, *50*, 589-596.

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

Bellmann, C. Tipping, A., Sumaila, U.R. (2015) Global trade in fish and fishery products: An overview, *Marine Policy*, in press. http://dx.doi. org/10.1016/j.marpol.2015.12.019

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

Cawthorn, D. M., Duncan, J., Kastern, C., Francis, J., & Hoffman, L. C. (2015). Fish species substitution and misnaming in South Africa: an economic, safety and sustainability conundrum revisited. *Food chemistry*, *185*, 165-181.

Centre for Food Safety of Hong Kong (2007). Guidelines on identification and labeling of oilfish and cod. Available at: http://www.cfs.gov.hk/english/food_leg/files/oil_fish_guideline_070723.pdf Accessed 11 March 2016).

China Internet Network Information Center. (2014). China Internet network development state statistic report. https://www.cnnic.cn/hlwfzyj/hlwxzbg/hlwtjbg/201407/P020140721507223212132.pdf Accessed 11.03.2016.

Chinese National Standard GB 7718. General Rules for the Labeling of Prepackaged Food (GB7718-2011). Standard Press of China. 2011. In Chinese.

Clarke, S. (2009). Understanding China's fish trad and traceability systems. *TRAFFIC East Asia*

Clarke, S. (2010). Best Practice Study of Fish Catch Documentation Schemes, MRAG Asia Pacific,

Brisbane, Australia. Available at: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=C3A478A5359B01208579C553AF948BBE?doi=10.1.1.394.9744&rep=rep1&type=pdf. Accessed on 11 March 2016

Council Regulation (EC) No 1005/2008 of 29 September 2008 establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing (IUU Regulation) mending Regulations (EEC) No 2847/93, (EC) No 1936/2001 and (EC) No 601/2004 and repealing Regulations (EC) No 1093/94 and (EC) No 1447/1999. *OJEU, L286*

Commission Regulation (EC) No 1010/2009 of 22 October 2009 laying down detailed rules for the implementation of Council Regulation (EC) No 1005/2008 establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing. *OJEU 2009, L280*

Council Regulation (EC) No 1224/2009 of 20 November 2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, amending Regulations (EC) No 847/96, (EC) No 2371/2002, (EC) No 811/2004, (EC) No 768/2005, (EC) No 2115/2005, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007, (EC) No 676/2007, (EC) No 1098/2007, (EC) No 1300/2008, (EC) No 1342/2008 and repealing Regulations (EEC) No 2847/93, (EC) No 1627/94 and (EC) No 1966/2006. *OJEU, L343*

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

D'Amico P., Armani A., Gianfaldoni D., Guidi A. (2016). New provisions for the labelling of fishery and aquaculture products: difficulties in the implementation of Regulation (UE) n. 1379/2013. *Marine Policy*, 71, 147-156.

Fabinyi, M. (2016). Producing for Chinese luxury seafood value chains: Different outcomes for producers in the Philippines and North America. *Marine Policy*, *63*, 184-190.

Fabinyi, M., & Liu, N. (2014). Seafood Banquets in Beijing: Consumer Perspectives and Implications for Environmental Sustainability. *Conservation and Society*, *12* (2), 218-228.ù

Fishbase. (2016). http://www.fishbase.org/ Accessed 21.07.2015

Grilly, E., Reid, K., Lenel, S., & Jabour, J. (2015). The price of fish: A global trade analysis of Patagonian (*Dissostichus eleginoides*) and Antarctic toothfish (*Dissostichus mawsoni*). *Marine Policy*, *60*, 186-196.

Hall, T. A. (1999). BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. In *Nucleic acids symposium series*, *41*, 95-98.

Handy, S. M., Deeds, J. R., Ivanova, N. V., Hebert, P. D., Hanner, R. H., Ormos, A., Weigt, L. A., Moore, M. M., & Yancy, H. F. (2011). A single-laboratory validated method for the generation of DNA barcodes for the identification of fish for regulatory compliance. *Journal of Aoac International*, *94* (1), 201-210.

Helyar, S. J., Lloyd, H. A. D., de Bruyn, M., Leake, J., Bennett, N., & Carvalho, G. R. (2014). Fish Product Mislabelling: Failings of Traceability in the Production Chain and Implications for Illegal,

Unreported and Unregulated (IUU) Fishing. *PLoS One*, *9* (6), e98691.

~~Hsieh, M., & Tsao, W. (2014). Reducing perceived online shopping risk to enhance loyalty: a website quality perspective. *Journal of Risk Research*, *17* (2), 241-261.~~

Khaksar, R., Carlson, T., Schaffner, D. W., Ghorashi, M., Best, D., Jandhyala, S., Traverso, J., & Amini, S. (2015). Unmasking seafood mislabeling in U.S. markets: DNA barcoding as a unique technology for food authentication and quality control. *Food Control*, *56*, 71-76.

~~Kim, H., Xu, Y., & Gupta, S. (2012). Which is more important in Internet shopping, perceived price or trust? *Electronic Commerce Research and Applications*, *11* (3), 241-252.~~

Knetch, G. B. (2006) Hooked: pirates, poaching, and the perfect fish. Rodale.

Lack, M. (2008). Continuing CCAMLR's Fight against IUU Fishing for Toothfish. *WWF Australia and TRAFFIC International*

Latin-Chinese Dictionary of Fish Names. (2016). http://fishdb.sinica.edu.tw/chi/chinesequer1.php Accessed 11.03.2016

Lindkvist, K. B., Trondsen, T., & Xie, J. (2008). Restructuring the Chinese seafood industry, global challenges and policy implications. *Marine Policy*, *32* (3), 432-441.

Leroy, A., Galletti, F., & Chaboud, C. (2016). The EU restrictive trade measures against IUU fishing. *Marine Policy*, *64*, 82-90.

Marko, P. B., Nance, H. A., & Guynn, K. D. (2011). Genetic detection of mislabeled fish from a certified sustainable fishery. *Current Biology*, *21* (16), R621-R622.

Marko, P. B., Nance, H. A., & van den Hurk, P. (2014). Seafood substitutions obscure Patterns of Mercury Contamination in Patagonian Toothfish (*Dissostichus eleginoides*) or "Chilean Sea Bass". *PLoS One*, *9* (8), e104140.

~~McKnight, D. H., Choudhury, V., & Kacmar, C. (2002). Developing and Validating Trust Measures for e-Commerce: An Integrative Typology. *Information Systems Research*, *13* (3), 334-359.~~

Miller, D., Jessel, A., & Mariani, S. (2012). Seafood mislabelling: comparisons of two western European case studies assist in defining influencing factors, mechanisms and motives. *Fish and fisheries*, *13* (3), 345-358.

Noble, J. (2015). Alibaba and JD Online take fresh approach to China food shopping. http://www.ft.com/cms/s/bfaa55da-be4d-11e4-a341-00144feab7de,Authorised=false.html?siteedition=uk&_i_location=http%3A%2F%2Fwww.ft.com%2Fcms%2Fs%2F0%2Fbfaa55da-be4d-11e4-a341-00144feab7de.html%3Fsiteedition%3Duk&_i_referer=&classification=conditional_standard&iab=barrier-app#axzz3YTggeylZ, Accessed 28.02.2016.

Norse, E. A., Brooke, S., Cheung, W. W. L., Clark, M. R., Ekeland, I., Froese, R., Gjerde, K. M., Haedrich, R. L., Heppell, S. S., Morato, T., Morgan, L. E., Pauly, D., Sumaila, R., & Watson, R. (2012). Sustainability of deep-sea fisheries. *Marine Policy*, *36* (2), 307-320.

Österblom, H., Bodin, Ö., Sumaila, U. R., & Press, A. J. (2015). Reducing Illegal Fishing in the Southern Ocean: A Global Effort. *Solutions*, *4* (5), 72-79.

Pala, C. (2015). Forbidden catch. *New Zeland Geographic*, *135*, 66-81.

677 Peavey, S. (2013). Singles Day and China's Growing Love for eCommerce.
678 http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Singles%20Day%20and%20China's%2
679 0Growing%20Love%20for%20eCommerce%20_Shanghai%20ATO_China%20-%20Peoples%20
680 Republic%20of_12-4-2013.pdf, Accessed 11.03.2016.
681 Pramod, G., Nakamura, K., Pitcher, T. J., & Delagran, L. (2014). Estimates of illegal and unreported
682 fish in seafood imports to the USA. *Marine Policy*, *48*, 102-113.
683 Shen, Q., Jiang, T., Li, N., Wang, J., Han, C., Zhang, J., Xu, J., Zhang, D., & Li, F. (2014). Study on
684 tetrodotoxin detection and toxic puffer fish identification of roasted fish fillet at the retail in
685 Beijing and Qingdao. *Journal of hygiene research*, *43*(6), 944-952 [In Chinese].
686 Rahimnia, F., & Hassanzadeh, J. F. (2013). The impact of website content dimension and e-trust on
687 e-marketing effectiveness: The case of Iranian commercial saffron corporations. *Information &*
688 *Management*, *50* (5), 240-247.
689 Regulation (EU) No 1379/2013 Of The European Parliament And Of The Council of 11 December 2013
690 on the common organisation of the markets in fishery and aquaculture products, amending Council
691 Regulations (EC) No 1184/2006 and (EC) No 1224/2009 and repealing Council Regulation (EC)
692 No 104/2000. *OJEU, L/354*
693 Roberts, J., Xavier, J. C., & Agnew, D. J. (2011). The diet of toothfish species Dissostichus eleginoides
694 and Dissostichus mawsoni with overlapping distributions. *Journal of Fish Biology*, *79*(1), 138-154.
695 Sonu, S. C. (2014). Supply and market for Sablefish in Japan. NOAA Technical Memorandum NMFS.
696 Available at
697 https://www.st.nmfs.noaa.gov/Assets/commercial/market-news/sablefishSupplyMarket2014.pdf.
698 Accessed 10 March 2016
699 Sovacool, B. K., & Siman-Sovacool, K. E. (2008). Creating legal teeth for toothfish: using the market to
700 protect fish stocks in Antarctica. *Journal of Environmental Law*, *20* (1), 15-33.
701 Stewart, I. J., Thorson, J. T., & Wetzel, C. (2011). Status of the U.S. sablefish resource in 2011.
702 Available at http://www.pcouncil.org/wp-content/uploads/Sablefish_2011_Assessment.pdf.
703 Accessed 10 March 2016.
704 Stiles, M. L., Lahr, H., Lahey, W., Shaftel, E., Bethel, D., Falls, J., & Hirshfiel M. S. (2011). Bait and
705 switch: how seafood fraud hurts our oceans, our wallets and our health. *Oceana*. Available from:
706 http://oceana.org/en/news-media/publications/reports/baitand-switch-how-seafood-fraud-hurts-our
707 oceans-our-walletsand-our-health. Accessed 10 March 2016
708 Turban, E., King, D., Lee, J., Liang, T., & Turban, D. (2015). Overview of Electronic Commerce.
709 *Electronic Commerce* (pp. 3-49): Springer International Publishing.
710 UK Department for Environment, Food & Rural Affairs (2013). Guidance notes on Fish Labelling
711 legislation The Fish Labelling Regulations 2013. Available
712 at: https://www.gov.uk/government/publications/guidance-on-fish-labelling-regulations-2013.
713 ~~Vos, A., Marinagi, C., Trivellas, P., Eberhagen, N., Skourlas, C., & Giannakopoulos, G. (2014). Risk~~
714 ~~Reduction Strategies in Online Shopping: E-trust Perspective. *Procedia - Social and Behavioral*~~

~~*Sciences, 147*, 418-423.~~

Wen, J., Hu, C., Zhang, L., & Fan, S. (2011). Genetic identification of global commercial sea cucumber species on the basis of mitochondrial DNA sequences. *Food Control*, *22* (1), 72-77.

Wen, J., Zeng, L., Sun, Y., Chen, D., Xu, Y., Luo, P., Zhao, Z., Yu, Z., & Fan, S. (2015). Authentication and traceability of fish maw products from the market using DNA sequencing. *Food Control*, *55*, 185-189.

Wikipedia. (2016). https://zh.wikipedia.org/wiki/Wikipedia:首页 Accessed 22.02.2015.

Xiao, B., & Benbasat, I. (2011). Product-related deception in e-commerce: a theoretical perspective. *MIS Quarterly*, *35* (1), 169-196.

Xin-guang, L. I., Lu, W., Feng, Z., Li-ping, M. A., Yong, S., & De-qing, Z. (2013). Application of DNA Barcoding to Identify Commercial Fish and Fish Products (in Chinese). *Food Science*, *34* (18), 337-342.

Xiong X., D'Amico P., Guardone L., Castigliego L., Guidi A., Gianfaldoni D., Armani A., (2016)a The uncertainty of seafood labeling in China: a case study on cod, salmon and tuna. *Marine Policy*, *68C*, 123-135.

Xiong, X., Guardone, L., Giusti, A., Castigliego, L., Gianfaldoni, D., Guidi, A., & Armani, A. (2016)b. DNA barcoding reveals chaotic labeling and misrepresentation of cod (鳕, Xue) products sold on the Chinese market. *Food Control*, *60*, 519-532.

Zhang, J., & Hanner, R. (2012). Molecular Approach to the Identification of Fish in the South China Sea. *PLoS One*, *7* (2), e30621.

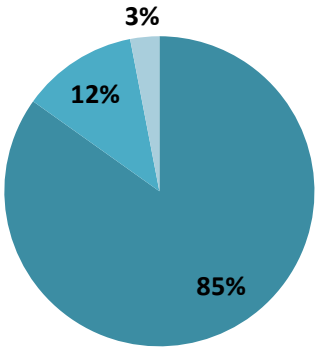
***Highlights (for review)**

- Products sold online as *Yin Xue* (Chinese pinyin for Sablefish) in China were collected
- DNA barcoding revealed an alarming overall misrepresentation rate of 85.7%
- Sablefish was found to be substituted with Patagonian and Antarctic Toothfish
- Voluntary and involuntary mislabeling have been hypothesized
- Implications for Toothfish conservation have been discussed

Figure

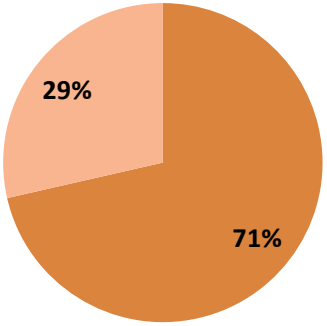
Click here to download high resolution image

Figure



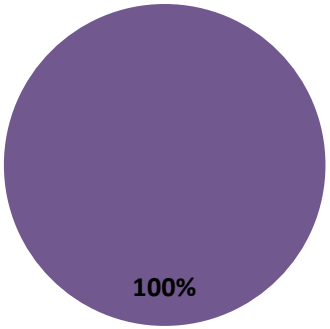
Yin Xue products

- *Dissostichus eleginoides*
- *Dissostichus mawsoni*
- *Anoplopoma fimbria*



Hei Xue products

- *Anoplopoma fimbria*
- *Dissostichus eleginoides*



Luo Gai Yu products

- *Dissostichus eleginoides*

Table 1 Chinese names for *Anoplopoma fimbria*

Scientific name	Chinese name	Chinese *Pin Yin*	References
Anoplopoma fimbria	银鳕	*Yin Xue*	Latin-Chinese Dictionary of Fish Names; Centre for Food Safety of Hong Kong (2007); Wikipedia
	裸盖鱼	*Luo Gai Yu*	Latin-Chinese Dictionary of Fish Names; Centre for Food Safety of Hong Kong (2007); Wikipedia; Fishbase
	裸头鱼	*Luo Tou Yu*	Wikipedia; Fishbase
	黑鳕鱼	*Hei Xue Yu*	Online rumors[a]

[a] http://blog.sina.com.cn/s/blog_546be44c0101ghm7.html Accessed 21.07.2015

Table

Table 2 Information on the sampled products and molecular results. Coherent species denominations, when comparing denominations found on the heading of the product webpage, in the product description in the product webpage and on the label of the received products, were observed only for 17 samples (40.5%, in grey in Table 2). NR: Not Reported

Selected products	General information				Heading of the product webpage		Product description in the product webpage			Label of the received products				Molecular results		
					Geographical origin			Geographical origin			Species denomination		Geographical origin				
	Code of online vendor	Code of sample	Monthly transaction volume (Pieces)	Price (Euro/kg)	Species denomination	Country of origin	Capture area	Species denomination	Country of origin	Capture area	Product status	Species denomination in the product name	Species denomination in the ingredient list	Country of origin	Capture area	Sequence length (bp)	BLAST NCBI	BOLD IDsystem
Yin Xue products	F1	ON1	2033	44.06	*Yin Xue*	France	NR	*Yin Xue* and *Luo Gai Yu*	France	North Atlantic Ocean	In bulk	*Yin Xue*	NR	France	NR	622	*D.eleginoides* 99-100%	*D.eleginoides* 100%-98.92%
		ON2	42	45.88	*Yin Xue*	France	NR	*Yin Xue* and *Luo Gai Yu*	France	North Atlantic Ocean	In bulk	*Yin Xue*	NR	France	NR	624	*D.eleginoides* 99%	*D.eleginoides* 99.83%-98.72%
	F2	ON3	1351	43.38	*Yin Xue*	Chile	NR	*Yin Xue* and silver cod	Chile	Ross Sea (Antarctic Ocean)	Prepackaged	*Yin Xue*, Patagonia toothfish and *D.eleginoides*	*Yin Xue*	Chile	NR	610	*D.eleginoides* 99%	*D.eleginoides* 98.72%-99.65%
	F3	ON4	768	42.94	*Yin Xue*	France	NR	*Yin Xue*	France	Grown in North Pacific Captured in Réunion Island	In bulk	*Yin Xue*	NR	France	NR	642	*D.eleginoides* 99-100%	*D.eleginoides* 98.78%-100%
		ON5	54	50.00	*Yin Xue*	France	NR	*Yin Xue*	France	Grown in North Pacific Captured in Réunion Island	In bulk	*Yin Xue*	NR	France	NR	620	*D.eleginoides* 99-100%	*D.eleginoides* 98.92%-100%
	F4	ON6	1244	61.28	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue* and Patagonian toothfish	France	deep sea of France	Prepackaged	*Yin Xue*, Patagonia toothfish and *D.eleginoides*	NR	France	FAO 58	318	*D.eleginoides* 99-100%	*D.eleginoides* 99-100%
		ON7	76	28.43	*Yin Xue*	France	NR	*Yin Xue*, *Luo Gai Yu*, *Luo Tou Yu*, *Hei Xue Yu* and *A. fimbria*	France	deep sea of France	Prepackaged	*Yin Xue*	*Yin Xue*	France	NR	648	*D.eleginoides* 99-100%	D. eleginoides 98.79-100%
	F5	ON8	236	29.04	*Yin Xue*	France	NR	*Yin Xue* and cod fish; *Yin Xue* belonging to *Bei Da Xi Yang Yu Ke*[a];	France	North Atlantic Ocean	Prepackaged	*Yin Xue* and toothfish	*Yin Xue* and toothfish	NR	NR	619	*D.eleginoides* 99-100%	*D.eleginoides* 99.09%-100%
		ON9	25	12.65	*Yin Xue* and *Xue Yu*	Chile	NR	*Yin Xue*	Chile	Antarctic deep sea	Prepackaged	*Yin Xue*	*Yin Xue*	Chile	NR	648	*D.eleginoides* 99-100%	*D.eleginoides* 98.96%-100%
		ON10	30	47.00	*Yin Xue* and *Xue Yu*	Chile	Antarctic	*Yin Xue*	Chile	Antarctic deep sea	Prepackaged	*Yin Xue* and toothfish	*Yin Xue* and toothfish	Chile	NR	646	*D.eleginoides* 99-100%	*D.eleginoides* 98.78%-100%
	F6	ON11	371	40.44	*Yin Xue*	France	NR	*Yin Xue*, *Luo Gai Yu*, *Luo Tou Yu*, *Hei Xue Yu* and *A. fimbria*	France	NR	In bulk	*Yin Xue*	NR	France	NR	612	*D.eleginoides* 99-100%	*D.eleginoides* 98.89%-100%
	F7	ON12	346	44.04	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue* and *D.eleginoides*	France	FAO 58	In bulk	*Yin Xue*	NR	France	Kerguelen Islands	618	*D.eleginoides* 99-100%	*D.eleginoides* 99.09%-100%
		ON13	12	11.03	*Yin Xue* and *Xue Yu*	New Zealand	NR	*Yin Xue* and cod	New Zealand	North Atlantic Ocean	In bulk	*Yin Xue*	NR	New Zealand	NR	616	*D.eleginoides* 99-100%	*D.eleginoides* 98.94%-100%

F8	ON14	232	46.32	*Yin Xue*	NR	Antarctic	*Yin Xue*, silver cod, sablefish and *A. fimbria*	Chile and France	Grown and captured in North Atlantic Ocean; Captured in Antarctic	In bulk	*Yin Xue*	NR	Chile	NR	649	*D.eleginoides* 99-100%	*D.eleginoides* 98.95%-100%
	ON15	28	24.01	*Yin Xue*	NR	Antarctic	*Yin Xue*	France	NR	In bulk	*Yin Xue*	NR	Chile	NR	647	*D.eleginoides* 99-100%	*D.eleginoides* 98.78%-100%
F9	ON16	221	39.56	*Yin Xue*	France	NR	*Yin Xue* and silver cod	France	North Atlantic Ocean	In bulk	*Yin Xue*	NR	France	NR	547	*D.eleginoides* 99-100%	*D.eleginoides* 98.89%-100%
F10	ON17	119	40.59	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue*	France	North Atlantic Ocean	In bulk	*Yin Xue*	NR	France	NR	654	*D.mawsoni* 99-100%	*D.mawsoni* 99.84%-100%
F11	ON18	116	78.82	*Yin Xue* and *Xiao Lin Nan Ji Quan Ya Yu*	Argentina	Antarctic	*Yin Xue* and *Xiao Lin Nan Ji Quan Ya Yu*	Argentina	Antarctic Ocean	Prepackaged	*Yin Xue*, Patagonia toothfish and *Xiao Lin Nan Ji Quan Ya Yu*	*Xiao Lin Nan Ji Quan Ya Yu*	NR	NR	647	*D.eleginoides* 99-100%	*D.eleginoides* 98.94%-100%
F12	ON19	67	43.82	*Yin Xue*	France	NR	*Yin Xue* and silver cod	France	Antarctic Ocean	In bulk	*Yin Xue*	NR	France	NR	648	*D.eleginoides* 99-100%	*D.eleginoides* 98.94%-100%
	ON20	5	48.04	*Yin Xue*	Chile	NR	*Yin Xue*	Chile	Antarctic Ocean	In bulk	*Yin Xue*	NR	Chile	NR	650	*D.mawsoni* 99%-100%	*D.mawsoni* 99.84%-100%
	ON29	5	48.19	*Yin Xue*	Chile	NR	*Yin Xue*	Chile	Antarctic Ocean	In bulk	*Yin Xue*	NR	Chile	NR	635	*D.mawsoni* 99%-100%	*D.mawsoni* 99.83%-100%
F13	ON21	84	57.35	*Yin Xue*	France	NR	*Yin Xue*	France	Captured in deep sea of France	In bulk	*Yin Xue*	NR	France	NR	650	*D.eleginoides* 99-100%	*D.eleginoides* 98.96%-100%
F14	ON22	67	42.06	*Yin Xue*	France	Antarctic	*Yin Xue*	France	Captured in Antarctic	In bulk	*Yin Xue* and *Luo Gai Yu*	NR	France	North Atlantic Ocean	640	*D.eleginoides* 99%	*D.eleginoides* 98.6%-99.84%
F15	ON23	64	47.12	*Yin Xue* and *Xue Yu*	NR	NR	*Yin Xue*	Chile	Captured in South Pacific Ocean	Prepackaged	*Yin Xue* and Chilean seabass	*Yin Xue* and Chilean seabass	NR	South Pacific Ocean	652	*D.eleginoides* 99-100%	*D.eleginoides* 99.12%-100%
F16	ON24	53	40.59	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue* and Patagonian toothfish	France	North Atlantic Ocean;	In bulk	*Yin Xue* and silver cod	NR	France	FAO 58	609	*D.eleginoides* 99-100%	*D.eleginoides* 99.09%-100%
F17	ON25	35	40.59	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue* and cod	France	North Atlantic Ocean; *Yin Xue* is always produced in Antarctic; Our *Yin Xue* is captured in Reunion Island	In bulk	*Yin Xue*	NR	France	NR	653	*D.eleginoides* 99-100%	*D.eleginoides* 98.78%-100%
F18	ON26	24	38.43	*Yin Xue* and *Xue Yu*	USA	NR	*Yin Xue* and *Hei Xue Yu*	USA	Alaska	Prepackaged	*Yin Xue*, *Luo Gai Yu* and *A.fimbria*	*Yin Xue* and *Luo Gai Yu*	USA	FAO 67	651	***A.fimbria* 99%-100%**	***A.fimbria* 98.85%-100%**
F19	ON27	22	45.88	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue* and seabass	France	NR	Prepackaged	*Yin Xue*	*Yin Xue*	NR	Arctic Ocean	645	*D.eleginoides* 99-100%	*D.eleginoides* 98.78%-100%
	ON31	22	45.88	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue* and seabass	France	NR	Prepackaged	*Yin Xue*	*Yin Xue*	NR	Arctic Ocean	610	*D. mawsoni* 99-100%	*D. mawsoni* 99.83%-100%
F20	ON28	28	39.96	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue*	France	Antarctic Ocean	In bulk	*Yin Xue*	NR	NR	NR	645	*D.eleginoides* 99-100%	*D.eleginoides* 99.09%-100%
F21	ON32	13	35.29	*Yin Xue* and *Xue Yu*	France	NR	*Yin Xue*	France	NR	In bulk	*Yin Xue*	NR	France	NR	652	*D.eleginoides* 99-100%	*D.eleginoides* 99.12%-100%
F22	ON33	1	61.28	*Yin Xue*	Chile	Antarctic	*Yin Xue*	Chile	Antarctic Ocean	In bulk	*Yin Xue*	NR	France	NR	653	*D.eleginoides* 99-100%	*D.eleginoides* 98.8%-100%
F23	ON34	28	50.00	*Yin Xue*	France	NR	*Yin Xue*	France	deep sea of France	In bulk	*Yin Xue*	NR	France	NR	648	*D.eleginoides* 99-100%	*D.eleginoides* *98.96%-100%*

Hei Xue Yu products	F5	ON35	10	51.76	*Hei Xue Yu* and *Xue Yu*	Alaska	NR	Hei *Xue Yu*	USA	Alaska	Prepackaged	*Hei Xue Yu* and black cod	Hei *Xue Yu*	USA	NR	653	***A.fimbria* 99%**	***A.fimbria* 98.7%-99.84%**
	F4	ON36	118	48.47	*Hei Xue Yu* and *Xue Yu*	Alaska	NR	Hei *Xue Yu*	Alaska	Alaska	Prepackaged	*Hei Xue Yu* and *Luo Gai Yu*	NR	USA	NR	649	***A.fimbria* 99%-100%**	***A.fimbria* 98.8%-100%**
	F15	ON37	45	59.49	*Hei Xue Yu* and *Xue Yu*	Alaska	NR	*Hei Xue Yu*	Alaska	North Pacific	Prepackaged	*Hei Xue Yu* and black cod	*Hei Xue Yu* and black cod	NR	North Pacific Ocean	655	***A.fimbria* 99%-100%**	***A.fimbria* 98.86%-100%**
	F8	ON38	18	38.76	*Hei Xue Yu* and *Xue Yu*	Alaska	NR	*Hei Xue Yu* and *Luo Gai Yu*	Alaska	Alaska	In bulk	Hei *Xue Yu*	NR	USA	NR	653	***A.fimbria* 99%-100%**	***A.fimbria* 98.86%-100%**
	F24	ON39	1	48.53	*Hei Xue Yu* and *Xue Yu*	Alaska	NR	Hei *Xue Yu*	USA	Alaska	Prepackaged	*Hei Xue Yu* and black cod	*Hei Xue Yu* and black cod	USA	NR	647	***A.fimbria* 99%-100%**	***A.fimbria* 98.82%-100%**
	F12	ON40	10	40.59	*Hei Xue Yu* and *Xue Yu*	Alaska	NR	*Hei Xue Yu* and *Luo Gai Yu*	Alaska	Alaska	In bulk	Hei *Xue Yu*	NR	Alaska	NR	625	*D.eleginoides* 99%-100%	*D.eleginoides* 98.94%-100%
	F18	ON41	4	42.21	*Hei Xue Yu* and *Yin Xue*	Alaska	NR	*Hei Xue Yu* and *Yin Xue*	USA	Alaska	Prepackaged	Black cod, *Yin Xue*, *Luo Gai Yu* and *A.fimbria*	*Yin Xue* and *Luo Gai Yu*	USA	FAO 67	560	*D.eleginoides* 99%	*D.eleginoides* 98.51%-99.64%
Luo Gai Yu products	F25	ON30	42	36.69	*Yin Xue* and *Luo Gai Yu*	Chile	NR	*Yin Xue*	France	North Atlantic Ocean	In bulk	*Yin Xue*	NR	France	NR	650	*D.eleginoides* 99-100%	*D.eleginoides* 98.79%-100%
	F26	ON42	0	58.18	*Yin Xue*, *Xue Yu* and *Luo Gai Yu*	France	NR	*Yin Xue*	France	English Channel	In bulk	NR	NR	NR	NR	646	*D.eleginoides* 99-100%	*D.eleginoides* 98.78%-100%

The products highlighted in grey are those reporting congruent denominations in the product page (heading and description) and on the label. The BLAST NCBI and BOLD ID system results in bold are those showing identity with *Anoplopoma fimbria*: only for these 6 products the species declared on the webpage and on the label corresponded to the species molecularly identified.

[a]*Bei Da Xi Yang Yu Ke* does not exist.

Table

Table 3 Common names of *Anoplopoma fimbria*, *Dissostichus eleginoides* and *Dissostichus mawsoni* in different countries and international lists

Species	FAO ASFIS list[a]		USA[b]		Canada[c]	UK[d]	France[e]	Spain[f]	Italy[g]	Australia[h]		China[i]
	English name	Accepted market name	Common name	Vernacular name	Accepted market name	Accepted market name	Accepted market name	Accepted market name	Accepted market name	Accepted market name	Obsolete name	Accepted market name
Anoplopoma fimbria	Sablefish	Sablefish	Sablefish	Black cod, Butterfish, Skil, Skilfish, Beshow, Coalfish	Sablefish, Black cod	Sablefish	NR	Bacalao negro de Alaska	Carbonaro dell'Alaska	NR	NR	裸盖鱼 (*Luo Gai Yu*) 银鳕 (*Yin Xue*) 黑鳕鱼(Hei Xue Yu) 裸头鱼(*Luo Tou Yu*)
Dissostichus eleginoides	Antarctic toothfish	Chilean seabass/toothfish	Patagonia toothfish	Antarctic cod, Icefish, Mero, Sea bass, Snapper	Patagonian toothfish	Icefish, Toothfish	Légine antarctique, Ccolin antarctique	Robalo de fondo, Robalos de profundidad	Moro antartico	Patagonian toothfish	Australian sea bass, Sea bass, Toothfish	小鳞犬牙南极鱼 (*Xiao Lin Quan Ya Nan Ji Yu*)
Dissostichus mawsoni			Antarctic toothfish	NR	Antarctic toothfish		NR	Robalos de profundidad	NR	NR	NR	鳞头犬牙南极鱼 *(Lin Tou Quan Ya Nan Ji Yu)*

[a]FAO Fisheries and Aquaculture Statistics and Information Service. ASFIS List of Species for Fishery Statistics Purposes. Fishery Fact Sheets Collections, 2015 http://www.fao.org/fishery/collection/asfis/en; [b]http://www.accessdata.fda.gov/scripts/fdcc/?set=seafoodlist; [c]http://www.inspection.gc.ca/active/scripts/fssa/fispoi/fplist/fplist.asp?lang=e; [d]https://www.gov.uk/government/publications/commercial-designations-of-fish-united-kingdom; [e]http://www.economie.gouv.fr/dgccrf/Consommation/Etiquetage-des-produits/Produits-de-la-mer-et-d-eau-douce/Listes-des-denominations-commerciales; [f]Resolución de 22 Marzo 2011 de la Secretaría General del Mar; [g]Ministerial Decree of the Italian Minister of Agriculture, Food and Forestry (MIPAAF) of 27th March 2002 and subsequent integrations; [h]http://www.fishnames.com.au/; [i]The references for the Chinese names of *A. fimbria* are listed in Table 1; The references for *D. eleginoides* and *D. mawsoni* are the Latin-Chinese Dictionary of Fish Names (2016) and the Centre for Food Safety of Hong Kong (2007).

e-component

Click here to download e-component: Table 1SM.doc

e-component

Click here to download e-component: Table 2SM.doc

e-component

Click here to download e-component: Table 3SM.doc

***Detailed Response to Reviewers**

Reviewer #1: It is an interesting work that identified the valuable fish species from e-commerce platforms. Indeed, China lacks the standardized seafood nomenclature and measures for seafood traceability. Chaotic labeling and mislabeling of seafood is a problem to food safety and species conservation.

There are some revisions suggesting:

Page 3, line 64: changes "reef fish" to "fish maw", abalone, shark fin, sea cucumber and fish maw are in the list of the four treasures from the sea in Chinese cuisine.

This change has been done

Page 8, lines 171-172: exchange "B2C" with "Business to Customer (B2C)".

Business to Customer (B2C) has now been inserted the first time the term appears (line 169).

Table 2 and Page 18, lines 400-402: "Consistent species denominations are in grey." is confused, which are consistent species denominations? Yin Xue?

With consistent species denominations we meant that the species denominations found on the heading of the product webpage, in the product description in the product webpage and on the label of the received products were coherent. This means that they were always referable to *A. fimbria*. For example, when denominations such as Yin Xue (used for *A. fimbria*) and toothfish were found on the same product, they were considered inconsistent. The heading of Table 2 and the text (line 399) have been amended hoping that the meaning is clearer now.

What is NR, maybe "no record"?

NR means Not Reported. It has been now reported in the caption of the table.

Page 8, line 187: 100 ng/ml or 100 ng/<mu>l?

It was a mistake. The correct concentration is 100 ng/µl. The text has been amended.

Page 13, line 301: Why the lengths of FDB sequences of same species D.eleginoides were significantly different (318, 547and 648 bp in Table 2)?

On the basis of our experience we can state that it is normal to obtain sequences of different length even using the same primers for the amplification of the DNA. In fact, the length of the sequences depends on the quality of the raw data obtained from the sequencing service. Anyhow, the average length of the sequences obtained in this work was ~628bp that corresponds to 95% of the expected length (655bp).

Page 14, line 309 and Page 19, line 412: Where is Fig. 1?

It was a mistake. Fig 1 has been now uploaded on the system but it is now named Fig. 2 since we have also produced another figure (Fig. 1) illustrating the kind of products analyzed in the study.

Page 15, lines 415-416: "Qing et al., 2014" is the research on puffer fish identification, not cod. You can compare with "Xiong et al., 2016".

In the work of Qing et al. 2014 7 products sold as cod were in fact *Lagocephalus*.

Table 3: Illustrate "ASFIS".

ASFIS has been explained.

Reviewer #2: Xiong et al conducted a molecular identification of seafood from Chinese on-line market. They have analysed 42 seafood products and found 85.7% of mislabeling. The manuscript results are very interesting, but their results and discussion is to long making it hard to read and understand. I suggest the

authors to simplify the results and discussion section focusing on their results and not in consumer's preferences and on-line platforms. See below more detailed suggestions:

Line 71-74 - This sentence needs a citation.

The citation related to this sentence is Sonu, 2014, which is cited after the following sentence.

Results and discussion

279-283 - Where is your correlation data? Moreover, you are discussing consumers on-line preferences? I believe you should discuss results of your molecular data, and not Chinese on-line consumers preferences.

We agree that the term correlation could have been misleading and we removed the part.

Line 289-296 - I don't think you need to show in the results and discussion details of DNA extraction and amplification. If you got the COI barcodes from all samples, it means you extracted and amplified well all your samples.

Considering that we did not encountered any problem and all the DNA samples have been extracted and amplified without problems, this section has been structured reporting only the essential data. In fact, it only takes 7 lines. This section has been shortened but, in our opinion, it must be reported in the manuscript.

Line 316-317 - B2C is a delivery service, which is not a webstore. So their responsibility is to deliver, but not to guarantee the quality of produtcs they sell. Could you make this clear? I believe the brand or industry producing or processing the seafood product are responsible for the seafood quality and certification.

This is a complex and still debated issue. According to the amended Food Safety Law of China (2015):

"*Third-party platform providers for online food trade shall implement real-name registration of admitted food distributors, specify their food safety management responsibilities and, if they have lawfully obtained licensing, inspect their licenses*"

"*Upon finding any activity in breach of this Law, they shall immediately stop the activity and report to the food and drug administration of the competent people's government at the county level; in case of a serious breach, they shall immediately stop providing online trading platform services*"

"*Any consumer whose lawful rights and interests are damaged due to purchase of food via any third-party platform of online food trading may claim indemnification against the distributor or producer of such admitted food*"

In fact it appears a shared responsibilities and platforms can manage this aspect establishing internal rules. See for example: https://compliancecloud.selerant.com/latestnews/food-e-commerce2.aspx?CompID=&q=

However, according to your suggestion and considering that the topic is complicated and under discussion, we decided not to add any new part regarding this aspect.

Line 344-349 - You are discussing data not related to your work here. This makes your discussion to long.

The discussion between lines 344-349 has been deleted.