A risk scoring system for seafood supply chain breaches and examination of freshwater fish imported to Australia

Michelle Williams*, Marta Hernandez-Jover*, Thomas Williams* and Shokoofeh Shamsi

School of Animal and Veterinary Sciences & Graham Centre for Agricultural Innovation, Charles Sturt University, Wagga Wagga, NSW, Australia

*Correspondence to: Michelle Williams, C/O Albert Pugsley Pl, Charles Sturt University, Wagga Wagga, NSW 2678, Australia. E-mail: miwilliams@csu.edu.au

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Abstract

Legislative changes have altered the way imported edible seafood is inspected in Australia. Greater onus of responsibility has been placed on exporting countries to provide documentary evidence of adherence to internationally recognized food safety standards. According to global trade agreements, any additional safety tests applied to freshwater fish imported into Australia must be justified. Therefore, the aim of this study was to develop a risk scoring method to provide justification for identifying countries as ‘Freshwater fish high risk’ and to examine the seafood they export to Australia for seafood supply chain breaches. Scoring was conducted using six predictor variables, identified in the literature as important contributors to seafood supply chain breaches, to achieve the outcome variable, Country considered ‘Freshwater fish high risk’. Sixty-seven fish fillets (9.55 kg) of the same species were examined from the third highest scoring country (Country 20) and 562 (5.6 kg) whole fish from the sixth highest scoring country (Country 22). Country 20 had supply chain breaches of 28 macroscopic yellow cysts in one fillet. Two hundred and thirteen parasites and other supply chain breaches were identified in fish from Country 22, including retained liver (91 per cent), visible mud (11 per cent), a variety of debris (16 per cent) and, depending on the commodity code, these fish were imported to Australia under full intestine (90 per cent), retained gills (89 per cent), and partial intestine (9 per cent). Three serious physical hazards were recovered from the edible portion of three ‘consumer-ready’ fish and snails of Genus Lymnaea and Indoplanorbis were recovered from gill mud also from ‘consumer-ready’ fish. The study showed variable results from the scoring system and vast differences in seafood supply chain breaches between the third and sixth highest scoring countries.

Keywords: Imported seafood; supply chain breaches; parasites.

Introduction

In 2018, the Imported Food Control Amendment Act 2018 (Aust. Gov, 2018) entered into effect in Australia. This Act heralded a significant change in the way Australian biosecurity inspects imported edible foodstuff and reflects Australian solidarity with the Articles of the General Agreement on Sanitary and Phytosanitary Measures (SPS) (WTO, 1994). Articles of the SPS inferentially encourage recognition and acceptance of between-country equivalency in food production safety systems in order to facilitate international trade. The Act accords exporters with greater responsibility to demonstrate...
adherence to international health standards established by Codex Alimentarius (WTO, 1994). However, as Williams et al., (2020) identify, Article 3 of the SPS implies that if an exporting country is able to demonstrate compliance with a Codex international health standard, despite this compliance providing less food safety biocore than the importing nation may desire, then a ‘adjustment in compatibility’ of health standards may be unavoidable to expedite trade. It is unknown as yet if the Act augurs a positive step in Australian food safety biocore.

Seafood (‘fish in this study) is one of the most highly traded food vendibles world-wide. Aquaculture fish has surpassed wild-caught catch in meeting the consumption requirements of humans globally (FAO, 2016). In Australia, 70–75 per cent of all seafood consumed is imported (Senior and Stewardson, 2019). However, placing the onus of responsibility for food safety on exporters who financially benefit from the export of food may allow the introduction of products of uncertain safety into the Australian food chain. As food supply chains have increased in breadth, penetration, and complexity, the challenges to food safety have increased apace (Moore et al., 2012). Fox et al. (2018) identified four elements which threaten food integrity: ‘unintentional food quality’, ‘food safety’, ‘intentional food fraud’, and ‘defence’.

Intentional seafood fraud can take many guises, from fish/ package mislabelling (Ceruso et al., 2020), adulteration of ingredients (Power and Cozzolino, 2020), or forged declarations (Xiong et al., 2016). Spink and Moyer (2011) defined food fraud as an ‘intentional act for economic gain’ and comment that each fraudulent manipulation of the food chain can include multiple supply chain breaches. According to Moore et al. (2012), fraudulent practices associated with the global seafood supply chain are carried out to bypass quality assurance, quality control and Hazard Assessment Critical Control Point (HACCP) plans/procedures.

A significant challenge to Australian policy makers is how health standard equivalency can be adequately demonstrated when the environmental health safety standards of many exporting countries are contrary to those of Australia. According to scores in Wendling et al. (2018), a number of countries which export farmed fish to Australia have a country score of ‘0/100’ for ‘Wastewater Treatment’ and less than ‘50/100’ for ‘Water and Sanitation’. Wastewater treatment is fundamental to public health and provides a barrier between pathogenic organisms and contamination of water sources from human and animal faecal contamination (Hoefel et al., 2005). It has been demonstrated that water and sediment of fish-farming ponds influence bacterial composition of the fish intestine and gills (Al-Harbi and Uddin, 2005; Muziasari et al., 2017; Li et al., 2020). Fish raised in facially contaminated untreated waters are high risk for a number of pathogenic zoonotic parasites (Chaiputcha et al., 2015; Vinh et al., 2017). Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) stated, in the ‘Code of Practice for Fish and Fishery Products’, water used in fish processing should be ‘Potable water, freshwater suit fit for human consumption’ (FAO and WHO, 2020). Australia’s score for ‘Wastewater Treatment’ and ‘Water and Sanitation’ was 99/100 and 98/100, respectively (Wendling et al., 2018). It seems a downregulation of Australian health standards may have been necessary to accept fish from countries with very poor or nil scores for the corresponding categories.

Breaches may be associated with the lack of fish husbandry knowledge, inappropriate chemotherapy use, inexperienced employees, or poor water quality. Animal welfare and modern-day slavery were described by Fox et al. (2018) as factors contributing to the seafood supply chain vulnerability. Overcrowding has been demonstrated to have suppressive effects on fish immunity (Tort et al., 1996) in a variety of aquacultured or experimentally crowded species of fish (Rotllant et al., 1997; Montero et al., 1999; Orruño et al., 2001; Caipang et al., 2009). Crowding therefore creates conditions ideal for proliferation of zoonotic bacteria and parasites (FAWW, 2007). Unskilled labour inclusive of child or forced labour is considered an ongoing issue in the global aquaculture industry. Fisheries and aquaculture are the second and third highest industry abusers of child labour, respectively. A number of countries have been implicated in using child labour, some as young as 4 years old, in the fishery sector (Pearson et al., 2006; Srivastava, 2011; Zimmerman et al., 2014; IOM, 2019; Verité, 2019). A study conducted in a country of the Indian subcontinent identified 20.3 per cent of the labour force across five aquaculture facilities were child workers. The assigned duties of these children included the use of dangerous chemicals (Ferdousi and Faruk, 2016). By implication, chemotherapy management for control of parasites and other diseases in some aquaculture facilities may be managed by a young or inexperienced workforce. It is unclear how fish safety may be influenced by using unskilled or child labour; however, it seems logical that parasite mitigation strategies and appropriate chemotherapy controls may be inadequately supervised or applied.

The human health biosecurity risks of imported freshwater fish due to seafood supply chain breaches have so far been unexplored. Although it appears that after the early infections of coronavirus disease 2019 (COVID-19) occurred at a seafood market, the issue of supply chain breaches is one of escalating importance for global food security (Galanakis, 2020).

In 1994, Australia became signatory to three trade agreements at the Uruguay round of talks, collectively known as the Marrakesh Agreement. These agreements mandate Australia to justify any additional tests applied to imported seafood. Therefore, the aim of this study is to develop a risk-scoring method to provide justification for identifying countries as ‘Freshwater fish high risk’ and examining the seafood they export to Australia for seafood supply chain breaches. The secondary aim is to examine fish imported to Australia from any of the top 10 highest-scoring ‘Freshwater fish high risk’ countries, for supply chain breaches according to Australian importation policy for the selected seafood.

Materials and Methods

The study was conducted in three parts. In Part 1 and 2, a fishery supply chain risk scoring system was developed to identify a country as ‘Freshwater fish risk high’. In Part 3, fishery products from two of the top 10 ‘Freshwater fish high risk’-scoring countries were examined for supply chain breaches that may pose a threat to Australian biosecurity. Each species of fish examined in this study were identified with a letter (Species A–F) and each species described in Table 1.

The purpose of this study is to investigate the safety of the seafood product imported into Australia, not to disadvantage the aquaculture industry of any developing country. Therefore, any information that may lead to the identification of an included country has been omitted from the manuscript, auxiliary tables, and figures. This information includes country descriptions, fish species names, or citations. Any omissions in the manuscript for the stated reason is followed by (*).

Part 1

Six predictor variables were used to score the outcome variable ‘Freshwater fish high risk’. The predictor variables included social and environmental factors identified in published literature as
important within the forensics of seafood supply chain breaches. In Table 2, the four factors that affect food supply chain integrity from Fox et al., 2018), the predictor variables used in the present study and justification for the use of each predictor variable is included. Three predictor variables included in this study were based on the nine sins of seafood in Fox et al., 2018), and the titles modified as considered appropriate. Titles which were modified included (Fox study: This study) ‘Chain of custody abuse’; ‘Supply chain breaches’; ‘Modern day slavery’; ‘Unskilled labour’. The third predictor variable used in this study amalgamated ‘Economic deception’, which encompassed multiple fraudulent acts in Fox et al., 2018), into one predictor variable ‘Regulatory weakness’. This inclusion is supported by Sumaila et al., 2017 and Agnew et al., 2009 in which corruption was concluded as an important component of fish fraud. ‘Inspector coercion’ was also included based on Sumaila et al., 2017 and Agnew et al., 2009). The predictor variable ‘Australian import breach’, which tallied the amount of imported seafood deemed in breach of import conditions on entry to Australia, was novel to this study. However, Fox et al., 2018) details species adulteration, banned additives/contaminants, and chain of custody abuse as a threat to consumer rights/public health. Accurate labelling, origin of the product, additives and visual inspection for contaminants are requirements for entry of imported seafood into Australia. The predictor variable ‘Australian import breach’ is supported by Fox et al., 2018) and Australian requirements for imported edible seafood. The Predictor variable ‘Water, sanitation and wastewater treatment’ was also unique to this study; however, there is strong evidence to support contaminated water as an important influencer of zoosonic bacteria/parasites of seafood (Tendencia and de la Peña, 2001; Saha and Pal, 2002; Novotny et al., 2004; Miller et al., 2005; Sayasone et al., 2011; Chaiyachote et al., 2015; Vinh et al., 2017; Chaisiri et al., 2019). In addition, certain parasites have recently been identified as effective faecal bacteria in- diators (Lacerda et al., 2018; Amadi et al., 2020). As such, the inclusion of ‘Water, sanitation and wastewater treatment’ is valid for the purposes of this study.

Sources of information for each predictor variable

Predictor variable 1, ‘Supply chain breaches’
The scores for predictor Variable 1 were collated from published cases of fish mislabelling in which a labelled species of fish was substituted for another. A total of 60 publications were evaluated for cases of mislabelling from a review of published literature. The literature search included English text publications from 2000 until May 2019 and the sites used were Web of Science and Google Scholar. The search terms used for the literature search were: fish AND fraud odds ratio (OR) mislabelling/or mislabelling OR renaming OR DNA barcoding OR market substitution OR fraudulent renaming OR fraudulent labelling/or labeling. As it is impossible to know where the mislabelling occurred along the fishery supply chain both the country of origin included on the fish label, if known, and country where the substitution occurred were both included in scoring. High levels of fish mislabelling have been identified at both the production/supplier and end-user level (Warner et al., 2012b; Xiong et al., 2016; Xiong et al., 2018; Ceruso et al., 2020). It is considered that including both the country of origin where the mislabelling was identified and country on the label, although not perfect, was the most accurate way to score this variable.

Predictor variables 2 and 3, ‘Unskilled labour’ and ‘Inspector coercion’
Scoring for variables 2 and 3 included published literature, Government and media reports. Variable 2 included cases of child labour, restriction of liberty, sleep or food deprivation, and other human rights abuses described in published literature and other media reports. Scoring for variable 3 included cases which describe threats of personal harm, general harassment, sleep deprivation, money or alcohol offered as a bribe, tampering with official documentation and interfering with fish inspection procedures.

Predictor variable 4, ‘Regulatory weakness’
The Corruption Perceptions Index ( CPI, 2018) is published annually by Transparency International (TI). The index ranks public-sector corruption based on advice from business people and industry ex- perts and is intended as a tool to advance ‘accountability, integrity and transparency’ in the democratic foundations of each country. The scores awarded by TI are out of 100, with 100 representing the least corrupt.

Predictor variable 5, ‘Water, sanitation and wastewater treatment’
The Environmental Performance Index (EPI; Wendling et al., 2018) is a joint collaboration between the World Economic Forum and Columbia and Yale Universities. The EPI ranks countries on ‘en- vironmental health and ecosystem vitality’. There are 24 performance indicators used by the EPI to score each country. In the present study scores for two of the EPI performance indicators, ‘Water and Sanitation’ and ‘Wastewater Treatment’ in Wendling et al., 2018 were combined for Predictor variable 5.

Predictor variable 6, ‘Australian import breach’
The Department of Agriculture, Water and the Environment of Australia (Department of Agriculture, Water and the Environment, 2018)

Table 1. Description of Species A–F examined in this study

| Fish ID | Fish details |
|---------|--------------|
| Species A | Family Pangasiidae; a commercial freshwater aquaculture fish. Mostly fed on commercial pelleted high-protein feeds. However, integrated farming systems and variations of this system may be used during fish production |
| Species B | Family Cyprinidae; raised by local communities and considered a cash crop. It is found in slow-moving freshwater such as ponds and ditches. This bentholgic species feeds on algae, crustaceans, insects, and/or larvae and other organic debris |
| Species C | Family Channidae; primarily raised in freshwater aquaculture. This species feeds on worms and insects and is known as a voracious and predatory carnivore of other small fish. The preferred habitat is stagnant waters in muddy streams |
| Species D | Family Cyprinidae; a commercially cultured freshwater fish that is found in static freshwater ponds and is a herbivorous feeder |
| Species E | Family Bagridae; a commercial species that inhabits freshwater lowland rivers/basins and feeds on insects, crustaceans, and other plant matter |
| Species F | Family Cyprinidae; a freshwater aquacultured edible and ornamental fish species. It inhabits a variety of ponds, village lakes, floodplains, and back swamps. It is voracious feeder of freshwater aquatic plants and other floating organisms |
| Factors that influence food supply chain integrity in Fox et al., (2018) | Relevant ‘Predictor variable’ included in this study | Justification for inclusion as a ‘Predictor variable’ in this study |
|---|---|---|
| Food fraud | Corruption | Fraudulent seafood safety and inspection declaration from approved seafood inspection facility |
| Inspector coercion | Incorrect product labelling that misrepresents product contents |
| Supply chain breaches | Seafood not adequately inspected for parasites and other biosecurity risks |
| Australia import breach | Seafood safety declarations may be spurious |
| Food quality (unintentional) | Unskilled labour | Seafood that does not meet international food safety standards or highly parasitized seafood may be substituted for another |
| Water, sanitation and wastewater treatment | Illegally sourced seafood with dubious safety may be introduced into the food chain |
| Food safety | Unskilled labour | Inappropriate cold storage may increase the risk from bacteria or parasites |
| Corruption | Seafood safety declarations may be spurious |
| Inspector coercion | Seafood from a country frequently in breach of Australian food safety standards may have systemic failures in supply chain integrity |
| Supply chain breaches | Seafood not adequately inspected for parasites and other biosecurity risks |
| Australia import breach | Seafood that does not meet international food safety standards or highly parasitized seafood may be substituted for another |
| Food defence | Water, sanitation and wastewater treatment | Seafood safety declarations may be spurious |
| Corruption | Illegally sourced seafood with dubious safety may be introduced into the food chain |
| Inspector coercion | Inappropriate cold storage may increase the risk from bacteria or parasites |
| Supply chain breaches | Seafood that does not meet international food safety standards or highly parasitized seafood may be substituted for another |
| Australia import breach | Seafood from a country frequently in breach of Australian food safety standards may have systemic failures in supply chain integrity |
| Food quality (unintentional) | Water, sanitation and wastewater treatment | Seafood that may be a threat to human health may not be inspected on entry to Australia due to fraudulent documentation |
| Corruption | Seafood may be misrepresented on package label and consumers are unable to make informed choices |
| Inspector coercion | Seafood that may be a threat to human health may not be inspected on entry to Australia due to fraudulent documentation |
| Supply chain breaches | Seafood that may be a threat to human health may not be inspected on entry to Australia due to fraudulent documentation |
| Australia import breach | Seafood from a country frequently in breach of Australian food safety standards may have systemic failures in supply chain integrity |
| Water, sanitation and wastewater treatment | Clean potable water is not used during processing and increases the risk of zoonotic bacteria, parasites and multi-microbial-resistance bacterial contamination of seafood |
| Corruption | Australian seafood inspection procedures operate on a certain amount of good will. Fraudulent food safety declarations from the exporting country may introduce seafood of dubious safety into Australia |
| Inspector coercion | Incorrect importation commodity codes may increase the risk of seafood of a human health concern entering Australia uninspected |
| Supply chain breaches | Fraudulent product labelling may increase the risk of seafood of a human health concern entering Australia uninspected |
| Australia import breach | Inspectors may be coerced into accepting inadequate safety declarations in seafood to be exported |
| Water, sanitation and wastewater treatment | Inspectors may be coerced into allowing inadequately inspected seafood to be exported |
| Food defence | Inspector coercion | Inspectors may be coerced into allowing incorrect importation commodity codes; fraudulent food safety declarations and product labelling may increase the risk of seafood of a human health concern entering Australia uninspected |

The Predictor variable relevant to each of the four factors and justification for inclusion of each Predictor variable used in this study.
Part 2
Risk scoring: predictor variables 1–6
Each of the 84 countries that Australia imported seafood from during 2017, according to Fisheries Research and Development Corporation (FRDC) market trade data (FRDC, 2017), were randomly allocated a ‘Country’ number, which was used as an identifier for this study and will be used in subsequent publications. For scoring of variable 1, the country of origin included on fish packaging label and country where the fish mislabelling was identified, if known, and were each awarded a score of ‘1’ and scores combined for each country. For variables 2 and 3, a score of ‘1’ was awarded for each separate incident/number of people involved, which could be attributed to any of 84 countries from which Australia imports edible freshwater seafood. As publications or media reports often described multiple incidents or numerous individuals involved in incidents, a score of ‘1’ was awarded for each separate incident or for each individual involved in the incident. For example, if 15 individuals were reported exploited in the farmed prawn trade, ‘15’ was the score awarded to the country implicated. The scores included for variable 4, ‘Regulatory weakness’, were those awarded by TI (2018). The TI scores out of a possible 100 were reverse-scored to represent the lowest score as least likely to have weak regulatory processes. Scores for variable 5 were actual scores awarded out of 100 (100 being the best performers) by EPI for performance indicators ‘Water and Sanitation’ and ‘Wastewater Treatment’. The scores for each EPI indicator of ‘Water and Sanitation’ and ‘Wastewater Treatment’ were calculated based upon the recommendation of 2.50 g/1 kg sample of fish. The sample was then artificially digested in a physiological saline–pepsin solution (0.85 per cent sodium chloride with pepsin added to a concentration of 15 mg/L) (Bier et al., 2001). The pH of the solution was adjusted, after the fish was added to the solution, by adding HCl 6N (approximately 3 mL) to obtain a final value of pH 2.0. The pepsin solution was processed in an incubator orbital (run 37 °C; ~100–120 r/min 16–20 hours), then passed through a 1000-micron mesh strainer. The clarity of the fish digesta was adjusted with physiological saline and the remaining contents examined for parasites under a dissecting microscope (Leica EZ4 Stereo Microscope; 10x magnification).

Statistical analysis
Analyses were conducted using statistical software ‘R’ (R Core Team, 2020). Where breach data were available for individual fish products univariate logistic regression was employed to assess the association between breach type (i.e. debris present, gastrointestinal tract present) and fish species. Model fit was assessed using the Chi-square test. Where significant terms were present (at P<0.05), odds ratios and confidence intervals were calculated to quantify the strength of an association between fish species and breach type. Univariate logistic regression was also employed to identify associations between identified breaches (mud, debris, organs present) and the parasites present (list). Model fit was assessed, and odds ratios calculated where significant associations were observed. Pooled inspection data (limited to Species B only) were omitted from any statistical analysis due to the inability to interpret identified breach outcomes at an individual product level. Instead, these data are described descriptively.

Sample storage
Parasites were stored in 2.5 mL sterile Eppendorf® tubes containing 70 per cent ethanol. Other debris, foreign bodies, snails, or items of interest were either stored as for parasites or if intended for future
bacterial culture were stored in sterile Eppendorf® tubes containing sterile glycerol and frozen at −20 °C. Glycerol samples from each bottle used in this study were also stored for future bacterial culture.

Sterile swabs
Sterile swab samples were taken by swabbing the external surface of each fish using sterile culture swabs as per Saito et al. (2011) that had been pre-autoclaved at 121 °C for 60 minutes. Swab tips were immersed into sterile glycerol to preserve bacteria in 2.5 mL sterile Eppendorf® tubes and frozen at −20 °C for later microbial study.

Results
Figure 1 illustrates the contribution each predictor variable made to Country scores and Table 3 displays the top 10 scoring countries. Country 50 had the highest score, with a mean of 146.7, largely made up of high scores for Predictor variables ‘Unskilled labour’ and ‘Water, sanitation and wastewater treatment’. However, as Country 50 has a limited market penetration in Australia, imported fish from this country were not included for examination. There was a 32.4 per cent decrease between Country 50 and the second highest score, Country 9. The score of Country 9 was largely contributed by ‘Supply chain breaches’ and ‘Inspector coercion’. There was a 70 per cent decrease between Country 50 and the tenth-scoring country, Country 64. Countries 9, 20 and 30 incurred scores for all of the six predictor variables; Countries 99, 76 and 40 for five of the predictor variables; Country 22 for four; and Countries 64, 50 and 70, three and two, respectively.

There were 1.2 per cent of countries which scored over 80 for ‘Regulatory weakness’, 14.5 per cent over 70 and 22.6 per cent over 60 (100 indicating poorest score). For ‘Supply chain breaches’, 7.1 per cent of countries had over 50 breaches and 16.7 per cent had between 10 and 50. For ‘Inspector coercion’, 1.2 per cent of countries scored over 100 and there were 19.0 per cent that scored between 1 and 30. Five percent of countries scored over 100 for ‘Unskilled labour’ and 27.3 per cent scored between 1 and 10. For ‘Australian import breach’, 1.2 per cent scored over 100 breaches and 17.9 per cent over 10. There were 13.0 per cent of countries which scored over 150 and 100, and 33.3 per cent scored over 50 for ‘Water, sanitation and wastewater treatment’, which combined scores out of 100 for ‘Wastewater Treatment’ and ‘Water and Sanitation’, respectively. Within ‘Water, sanitation and wastewater treatment’, 10.0 per cent scored 100 for wastewater treatment, 18.0 per cent scored higher than 70, and 32.0 per cent higher than 50 for water and sanitation (high score indicates poor standard).

There were 67 fish fillets (Species A) of the same species (9.55 kg) examined from Country 20, which was the third-highest scoring country, and 562 whole fish (5.6 kg) of five different species (Species B–F) from Country 22, which was the sixth-highest scoring country for the outcome variable ‘Freshwater fish high risk’, examined for parasites (Table 4). No identifiable parasites were recovered from any of Species A. However, 28 macroscopic yellow cysts were observed embedded in one fillet. Many of the fillets of Species A from the same bag showed frequent holes, which may mean cysts had been removed along the processing line and one fillet was inadvertently missed. Yellow cysts will be sent for histology and results reported in a subsequent publication. No parasites were recovered from Species B or D; however, a total of 213 parasites were recovered from Species C, E, and F and were comprised of (number: Phylum) 46: Nematoda; 69: Platyhelminthes, 95: Acanthocephala, and three were unknown. Of the 562 fish examined from Country 22, 91 per cent had retained liver; 9 per cent retained intestine; 89 per cent retained gills; 92 per cent had not been purged and had retained food items; 16 per cent and 11 per cent had visible debris and mud, respectively. Nine percent had partially retained intestines (Figure 2A–2J). Three corroded barbed fish hooks with string attached were recovered from the edible portion of consumer-ready Species C (Figure 2A–2C). Two packets of Species B were in breach of Australian labelling requirements for imported fish. Both packets describe the contents as ‘gutted’; however, 360 fish were entire (Figure 2D). Eleven snails of Genus Lymnaea (N=10) and Indoplanorbis (N=1) were recovered from gill mud of Species D, which were also consumer-ready (Figure 2E).
Fish species was associated with several of the identified biosecurity concerns (P < 0.05) (Table 5). Species C was most likely to be infected with any parasite, then Species E (OR 0.177; confidence interval (CI) 0.031, 0.351), Species A and Species F (OR 0.007; CI 0, 0.332). In addition, Species F specimens were less likely (OR 0.044; CI 0.002, 0.214) to be affected by digenic parasites than Species C. Species E was significantly associated with the identification of parasitotother eggs (P < 0.05). Fish species was also associated with the recovery of whole gastrointestinal tracts (P < 0.001) and partial gastrointestinal tracts (P < 0.001). Whole gastrointestinal tracts were recovered from all Species B, Species E and Species F (100 per cent). Compared to Species C, whole gastrointestinal tracts were less likely to be recovered from Species D (OR 0.054; CI 0.003, 0.286), while partial gastrointestinal tracts were more likely to be recovered (OR 21; CI 3.9, 389.0) from Species D.

The presence of gastrointestinal tract (whole, partial, or no gastrointestinal tract) was significantly associated with the occurrence of some parasites (P < 0.05; Table 6). Little difference was observed in the occurrence of all parasite species when partial gastrointestinal tracts were present (OR 1.449; CI 0.758, 2.756) compared to whole gastrointestinal tracts, but the likelihood of parasite recovery was reduced when no intestinal tract was recovered (OR 0.106; CI 0.031, 0.274). Acanthocephalan and nematode parasites were more likely to be recovered from specimens where full gastrointestinal tracts were present (OR 1.627; CI 0.744, 3.443 and OR 1.842; CI 0.728, 4.448, respectively) compared to specimens where full gastrointestinal tracts were present. Full retained intestines were associated with the presence of digenic parasites (P < 0.05). Partial intestine and no intestine were 0.545 times and 0.22 times less likely to be associated with digenic parasite infection.

In each instance, mud (P < 0.05 Table 7) was associated with presence of parasites (OR 4.452; CI 2.458, 8.167), presence of digenecans (OR 4.217; CI 1.958, 9.118) and acanthocephalans (OR 3.4; CI 1.647, 6.97).}

### Discussion

The scoring system for visual inspection of seafood supply chain breaches returned mixed results between Countries 20 and 22. Country 20 scored highly for ‘Australian import breach’ (29.4 per cent of total). Country 20 would not have been one of the high-risk countries if the predictor variable ‘Australian import breach’ had not been included in this study. Country 22 had high scores for three predictor variables, ‘Water, sanitation and wastewater treatment’ (44.3 per cent), ‘Regulatory weakness’ (23.1 per cent), and ‘Unskilled labour’ (31.87 per cent), and these may be the most important factors that influence the seafood supply chain safety of freshwater fish imported into Australia. In future studies, weighting Predictor variables based on results of this study would be beneficial.

Wastewater treatment has been demonstrated to protect water sources from human and animal faecal contamination (Hoeft et al., 2005) but also from several pathogenic zoonotic parasites (Chaiputcha et al., 2015; Vinh et al., 2017). A high prevalence of parasites in fish from Country 22 may be due to poor water and sanitation coupled with an inexperienced labour force. It is possible that inspection procedures during processing to ensure compliance with Australian importation guidelines and other recommended parasite mitigation strategies are also poorly implemented.

Table 8 shows the Australian importation requirements for all fish examined in this study and the many breaches identified in this study that were inconsistent with Australian importation policy for edible fish. Edible fish imported into Australia must be accompanied by documentation from approved inspection facilities that declare the product as safety-compliant for a particular commodity code (Table 8). Country 22 scored highly for the variable ‘Regulatory weakness’. This is supported by the label breaches (Figure 2D), consumer-ready fish with full or partial intestine remaining (Figure 2F-2G), and unclear commodity code status of wild-caught versus farmed fish identified in this study.

‘Unskilled labour’ comprised 28.3 per cent of the total for Country 20; however, only 13.7 per cent of the total was ‘Regulatory weakness’.
Despite having 28 breaches from 67 fish, packaging was visually clean, fish appropriately glazed and no debris, mud, or other physical hazards were identified. The 28 macroscopic yellow cysts were observed in one fillet of a package of seven. As all fillets in the package showed visible signs that other imperfections had been removed it is clear that parasite mitigation strategies during processing (candling) are mostly effective and that regulation of safety inspection and the declarations accompanying the product is enforced. It is feasible that one fish fillet may be missed along the processing line. Therefore, unskilled labour may only be an influencer of imported seafood supply chain safety when verification of safety compliance is subject to regulatory weaknesses in the respective exporting country. Until identification has been made of the parasite/bacteria responsible for the macroscopic yellow cysts in Species A from Country 20, it will not be known if the supplier of this batch may have a farm-level safety issue at the aquaculture facility.

An unusual finding of the study was that visible mud was significantly associated with all parasites (OR 4.452; CI 2.456, 8.167), presence of digeneans (OR 4.21; CI 1.958, 9.118) and acanthocephalans (OR 3.4; CI 1.647, 6.97). Species C was the most highly parasitized fish in this study. Species C of family Channidae is a freshwater fish which feeds on worms and insects and predares other small fish. These fish are known as voracious and predatory carnivores in Country 22 (*). The preferred habitat for this species is stagnant waters in muddy streams (Froese and Pauly, 2018). Predatory fish have great potential to become highly infected with multihost
parasites acquired during feeding (Lafferty and Kuris, 1999; Hall et al., 2007). It may be that mud in this study was a confounder. Mud may have been associated with the fish habitat/carnivorous feeding, inexperienced labour during processing, poor processing standard operating procedures, and weak regulatory safety protocols and/or inspection procedures. However, many species of freshwater aquatic snails have a preference for lentic environments with stagnant water (Giovanelli et al., 2005).

| Table 5. Identified biosecurity breaches. Odds ratios calculated using the first level as a reference |
|------------------------------------------|
| Identified biosecurity breach           | Species | Occurrence (N) | Odds ratio (95% CI) | P value |
|------------------------------------------|
| Presence of any parasite                 | Species C | 69.5% (105) | | <0.001 |
|                                          | Species D | 0% (14) | | — |
|                                          | Species E | 21.1% (19) | 0.117 (0.031, 0.351) | |
|                                          | Species A | 1.5% (67) | 0.007 (0.0, 0.032) | |
|                                          | Species F | 1.5% (67) | 0.007 (0.0, 0.032) | |
| Presence of digenic parasites           | Species C | 25.7% (105) | | <0.001 |
|                                          | Species D | 0.0% (14) | | — |
|                                          | Species E | 21.1% (19) | 0.77 (0.206, 2.342) | |
|                                          | Species A | 0.0% (67) | | — |
|                                          | Species F | 1.5% (67) | 0.044 (0.002, 0.214) | |
| Identification of eggs                  | Species C | 1.0% (105) | | 0.008 |
|                                          | Species D | 0.0% (14) | | — |
|                                          | Species E | 15.8% (19) | 19.5 (2.339, 407.805) | |
|                                          | Species A | 0.0% (67) | | — |
|                                          | Species F | 0.0% (67) | | — |
| Recovery of whole gastrointestinal tract | Species C | 57.1% (105) | | <0.001 |
|                                          | Species D | 7.1% (14) | 0.054 (0.003, 0.286) | |
|                                          | Species E | 100.0% (19) | | — |
|                                          | Species A | 0.0% (67) | | — |
|                                          | Species F | 100.0% (67) | | — |
| Recovery of partial gastrointestinal tract | Species C | 37.1% (105) | | <0.001 |
|                                          | Species D | 92.9% (14) | 21 (3.949, 388.967) | |
|                                          | Species E | 0.0% (19) | | — |
|                                          | Species A | 0.0% (67) | | — |
|                                          | Species F | 0.0% (67) | | — |

Dashes denote levels where rational odds ratios could not be calculated. CI, confidence interval.

| Table 6. Presence of organs |
|----------------------------|
| Species | Presence of organs | Occurrence (N) | Odds ratio (95% CI) | P value |
|---------|
| Any parasite | Full intestinal tract | 35.4% (147) | 0.106 (0.031, 0.274) | <0.001 |
|          | No intestinal tract | 5.5% (73) | 1.449 (0.758, 2.756) | — |
|          | Partial intestinal tract | 44.2% (52) | 2.97 (0.78, 2.54) | — |
| Acanthocephala | Full intestinal tract | 17.0% (147) | 0.007 (0.0, 0.032) | — |
|          | No intestinal tract | 0.0% (73) | | — |
|          | Partial intestinal tract | 25.0% (52) | 1.627 (0.744, 3.434) | — |
| Nematode | Full intestinal tract | 10.2% (147) | 0.007 (0.0, 0.032) | — |
|          | No intestinal tract | 0.0% (73) | | — |
|          | Partial intestinal tract | 17.3% (52) | 1.842 (0.728, 4.448) | — |
| Digenea | Full intestinal tract | 16.3% (147) | 0.22 (0.051, 0.657) | — |
|          | No intestinal tract | 4.1% (73) | 0.545 (0.176, 1.408) | — |
|          | Partial intestinal tract | 9.6% (52) | 0.22 (0.051, 0.657) | — |

CI, confidence interval.

| Table 7. Presence of mud |
|---------------------------|
| Species | Presence of mud | Occurrence (N) | Odds ratio (95% CI) | P value |
|---------|
| Any parasite | No mud | 21.4% (210) | 4.452 (2.456, 8.167) | <0.001 |
|           | Mud present | 54.8% (62) | 1.41 (0.84, 2.33) | — |
| Acanthocephala | No mud | 10.0% (210) | 3.4 (1.647, 6.97) | 0.0011 |
|           | Mud present | 27.4% (62) | 1.41 (0.84, 2.33) | — |
| Digenea | No mud | 7.6% (210) | 3.4 (1.647, 6.97) | 0.0011 |
|           | Mud present | 25.8% (62) | 4.217 (1.958, 9.118) | — |

CI, confidence interval.
| Species | Country | Heading code and classification | Import HS code Australia or CI code | Class entry or BICON conditions | BICON | Biosecurity breaches |
|---------|---------|---------------------------------|-------------------------------------|---------------------------------|-------|---------------------|
| Sp. A   | 20      | 0304 (fresh) FISH FILLETS AND OTHER FISH MEAT (WHETHER OR NOT MINCED), FRESH, CHILLED OR FROZEN | 030432 HS 03043 CI | 19.2 | Included in the automatic entry for approved commodities | • 28 yellow cysts |
| Sp. A   | 20      | 0304 (frozen) | 03046 HI 03046 CI | 19.2 | Included in the automatic entry for approved commodities | |
| Sp. B   | 22      | 0302 (entire) FISH, FRESH OR CHILLED, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 030279 HS 03028 CI | 19.2 | CR fish liver, intestines, head and gills must be removed and internal and external surfaces thoroughly washed. If NCR must have liver removed and be either from approved country for farmed fish or fish must be wild-caught Country 22 Nonapproved for unviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) |
| Sp. B   | 22      | 0303 (entire) FISH, FROZEN, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 030329 HS 03038 CI | 19.2 | CR fish liver, intestines, head and gills must be removed and internal and external surfaces thoroughly washed. If NCR must have liver removed and be either from approved country for farmed fish or fish must be wild-caught Country 22 Nonapproved for unviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) |
| Sp. C   | 22      | 0302 (entire) FISH, FRESH OR CHILLED, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 03027 HS 03027 CI | 19.2 | Country 22 Nonapproved for unviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies • Fish hooks (CR & NCR) • Parasites • Mud (CR & NCR) • Entire snails (CR & NCR) |
| Sp. C   | 22      | 0303 (entire) FISH, FROZEN, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 03032 HS 03032 CI | 19.2 | Country 22 Nonapproved for unviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies • Fish hooks (CR & NCR) • Parasites • Mud (CR & NCR) • Entire snails (CR & NCR) |
| Sp. D   | 22      | 0302 (entire) FISH, FRESH OR CHILLED, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 03027 HS 03028 CI | 19.2 | Country 22 Nonapproved for unviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies (CR & NCR) • Mud (CR & NCR) • Entire snails (CR & NCR) |
| Species | Country | Heading code and classification | Import HS code or CI code | Class entry or BICON conditions | BICON | Biosecurity breaches |
|---------|---------|---------------------------------|---------------------------|---------------------------------|-------|---------------------|
| Sp. D   | 22      | 0303 (entire) FISH, FROZEN, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 03032 HS 03038 CI | 19.2 | Country 22 Nonapproved for uneviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies (CR & NCR) • Mud (CR & NCR) • Entire snails (CR & NCR) • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies (CR & NCR) • Parasites |
| Sp. E   | 22      | 0302 (entire) FISH, FRESH OR CHILLED, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 03027 HS 03028 CI | 19.2 | Country 22 Nonapproved for uneviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies (CR & NCR) • Parasites |
| Sp. E   | 22      | 0303 (entire) FISH, FROZEN, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 030329 HS 03038 CI | 19.2 | Country 22 Nonapproved for uneviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Foreign bodies (CR & NCR) • Parasites |
| Sp. F   | 22      | 0302 (entire) FISH, FRESH OR CHILLED, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 03027 HS 03028 CI | 19.2 | Country 22 Nonapproved for uneviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Parasites |
| Sp. F   | 22      | 0303 (entire) FISH, FROZEN, EXCLUDING FISH FILLETS AND OTHER FISH MEAT OF 0304 | 030329 HS 03038 CI | 19.2 | Country 22 Nonapproved for uneviscerated farmed fish | • Uneviscerated (CR) • Livers retained (CR & NCR) • Head and gills retained (CR) • Parasites |

The HS code is the current Australian export commodity code classification and CI are the import codes for entry arrangement class 19.2. Class entry conditions or those additionally applied by BICON have been included in column 5. CI, confidence interval; BICON, Australian Biosecurity Import Conditions; CR, consumer-ready; NCR, non-consumer-ready.
**Indoplanorh**is spp. are recognized intermediate hosts for zoonotic/nonzoonotic digenean and trematode parasites (Britz et al., 1985; Singh et al., 2012; Chontananarth and Wongsawad, 2013; Suanyuk et al., 2013; Nyindo and Lukambagire, 2015; Shareef and Abidi, 2015) and a heavy burden of digested shells of these gastropod species were identified in Species C and E, both of which were infected with digenean parasites. In this instance mud may be significant for digenean infection in some fish from Country 22. Controlling snail populations is essential to reducing digenean/trematode infection (Singh et al., 2014) and the use of synthetic molluscicides is the most effective control for gastropods (Yang et al., 2010; WHO, 2017). The snails identified in the stomach contents of Species C/E and in the gill mud of Species D indicate that chemotherapy to control the snail intermediate hosts may not be adequately controlled by producers at the farm level in Country 22. This may be a reflection of the high score for the predictor variable ‘Unskilled labour’.

The 67 fillets examined in this study from Country 20 were frozen; however, as can be seen in Table 8 under import code 030432HS, Species A from Country 20 may also be imported fresh or chilled, and providing all importation documentation is compliant, for this country and fishery product automatic entry into Australia is permitted. The products examined in this study appear compliant with the importation requirements for this commodity code apart from the 28 macroscopic yellow cysts in one fillet.

The commodity code and safety compliance status of all fish from Country 22 was unclear and/or poor when compared with Australian importation requirements. Table 8 shows Country 22 may import whole fish, fresh or frozen, under commodity codes 0302HS and 0303HS (Australian Bureau of Statistics, 2019). However, according to information at Australian Biosecurity Import Conditions (BICON), fish of these codes from Country 22 must be either ‘consumer-ready’ (head and gills removed and eviscerated) or wild-caught nonconsumer-ready (livers must be removed; Department of Agriculture, Water and the Environment, 2020). Farmed, whole nonconsumer-ready fish are only accepted from Taiwan and the Philippines. Species C and D were consumer-ready fish; however, Species C was statistically demonstrated to have high retained full and partial intestines and gills (Figure 2F–2G). The presence of entire and partial gastrointestinal tract was significantly associated with the occurrence of parasites. Only two parasites were recovered after digestion of Species C musculature. It is therefore considered that lack of compliance with Australian importation regulations for consumer-ready fish from Country 22 has the potential to introduce parasites of human health concern into the nation’s food supply chain. It is also considered that upskilling workers involved in processing fish from Country 22 will largely eliminate the parasite and other risks in the exported fish. A number of new host records globally, for parasites infecting edible and ornamental freshwater fish (Acosta et al., 2020; Al-Jawda and Ah, 2020; Chanda et al., 2020; Morozova et al., 2020; Guardone et al., 2021), may signal a need for greater emphasis to be placed on fish parasites in imported fish.

The processing standard between consumer-ready species of fish from Country 22 was highly variable (Figure 21-2J) and it is considered that processing by inexperienced labour must have played a large part in this variability. In addition, consumer-ready fish imported into Australia must be accompanied by a declaration from an official inspection facility in Country 22 that fish have been processed to compliance. Consumer-ready fish from Country 22 (Figure 3) are not inspected on arrival into Australia providing valid documentation accompanies the product. It seems clear that ‘Unskilled labour’ at the farm level/during processing and ‘Regulatory weakness’ has the potential to introduce safety uncertainty in consumer-ready fish of Species C and D that are imported into Australia from Country 22. In addition, two packets of Species B clearly stated the fish were gutted (Figure 2B) and 360 fish were entire. Species E and F were also entire.

Wild-caught whole nonconsumer-ready fish from Country 22 must be accompanied by an ‘Import permit’ and declaration that fish have been verified wild-caught. In addition, Country 22 must demonstrate compliance with all of BICON importation categories for each fish species with an ‘Official Government Certificate’ from an approved facility, for categories as follows:

For low-risk fish species, the following evidence must be provided:

1. The genus and species of fish contained in the consignment.
2. A statement that the fish were wild-caught.
3. A statement that the fish were not grown or harvested in an aquaculture system at any stage.
4. A statement that the consignment does not contain fish species other than those listed above.
5. A statement that the fish were processed in premises (including vessels/refrigerated warehouses) approved by and under the control of the competent authority.
6. A statement that the fish were inspected under the supervision of the competent authority and/or systems approved by the competent authority.
7. A statement that the fish are free from visible lesions associated with infectious disease.

In a 2011 study it was estimated that over 70 per cent of households in rural areas of Country 22 were involved in some form of aquaculture on freshwater floodplains (*). Species E, according to Froese and Pauly (2018), is listed as a ‘commercial; aquaculture’ species for this country. Species B is raised by local communities and considered a cash crop (*) and Species F is raised in polyculture aquaculture (*). Clarification is required regarding how wild stocks in Country 22 are able to fulfil reliable, continuous and steady export demand. If Species B, E and F and are ‘Wild-caught whole nonconsumer-ready’ then BICON condition E states ‘Each consignment must be packed in clean and new packaging and must be free of live insects, seeds, soil, mud, clay, animal material (such as faeces), plant material (such as straw, twigs, leaves, roots, bark) and other debris prior to arrival into Australian territory’ (Department of Agriculture, Water and the Environment, 2020) and in Health and Safety commodity codes that livers shall be removed (Department of Agriculture, Water and the Environment, 2017). According to the heading codes and classification that the fish examined in this study were imported under (Table 8) there were multiple breaches identified in fish from Country 22. These include retained intestines, gills, livers, mud, physical hazards (fish hooks), foreign bodies (twigs, vegetation, crustaceas), and snails.

Country 22 had a score of ‘0’ for Wastewater Treatment, under ‘30’ for Water and Sanitation, and a high prevalence of mud in the gills and abdomen of fish. It is considered that the microbiological content present in the water and sediment of culture ponds where fish are raised reflect the microbiological ecology on fish pre-harvest, post-harvest and at packaging (Orban et al., 2008). In a study of bacteria along the fish processing line, 174 isolates and 38 species of zoonotic bacteria were identified; the genera represented by Aeromonas, Acinetobacter, Lactococcus, and Enterococcus and isolates Providencia, Shigella, Klebsiella, Enterobacter, Serratia, and Wautersiella (Tong Thi et al., 2013).
The greater part of global aquaculture production takes place in countries with no or few effective regulations for antibiotic use (Defoirdt et al., 2011). In terms of resistant strains of bacteria, it is likely that human health threats may arise from products from these regions. The potential of mud in fish from Country 22 to harbour zoonotic multi-antibiotic-resistant bacteria is of concern.

Fish hooks found in the edible portion of a small consumer-ready Species C (Figure 2A-2C) were covered in mud, had sharp barbs and string attached. Although fish hook consumption in humans most often impacts the oesophagus or throat (Agbomhekhe et al., 2014; Cermele, 2014) all hooks in this study were of a suitable size according to Akenroye and Osukoya (2012) to pass through the adult oesophagus and into the gastrointestinal tract (GIT). Perforation of the GIT is a life-threatening condition and any delays in diagnosis may result in poor clinical outcomes including death (Webb, 1995; Coulier, 1997; Choi et al., 2014). As these fish were consumer-ready, small and likely to be cooked by consumers without further processing, it is considered that the fish hooks pose a danger to human health.

Conclusion

In conclusion, the scoring system which was developed to justify examination of fish imported into Australia for supply chain breaches yielded mixed results. Statistical analysis of the breaches identified appear to support the predictor variables of ‘Unskilled labour’, ‘Regulatory weakness’, and ‘Water, sanitation and wastewater treatment’ as the greatest influencers of seafood supply chain breaches in fish imported into Australia. However, an obvious limitation of the study is that fish from only two countries were examined. Therefore, no concrete conclusions can be made in regard to the scoring system as an accurate predictor of seafood supply chain breaches until a larger sample size from other high-risk countries is examined. When the study and scoring system was designed the intention was to include imported seafood from more of the ‘high-risk’ countries. However, lack of fish availability and limitations on laboratory access during 2020 due to COVID-19 restrictions hampered this endeavour.

The study showed vast difference in quality control between fish from Countries 20 and 22. Country 20 represents a long-standing aquaculture-producing country. Certainly, in the past there were concerns raised regarding the safety of fish produced by Country 20. However, in the last decade the country has taken a proactive approach to fish safety and inspection (*) and this appears to be reflected in the consistent standard of fish processing observed in the present study.

Fish from Country 22 were of concern, with many supply chain breaches identified which were inconsistent with Australian importation policy. The findings of this study support a conclusion that more support is required for Country 22 to reach edible fish safety compliance at the farm level, and during processing and inspection which should include upskilling workers. In addition, it is concluded that greater support and scrutiny of the exportation regulatory processes of Country 22 should be considered. Of particular concern is Species C, D and F packaged labelled as HACCP and production quality-controlled. The HACCP system should control the introduction of any chemical, biological, and physical hazard into the food chain (FAO and WHO, 2020). Both Species C and D had high breaches.

The Australian HACCP process has determined farmed, whole nonconsumer-ready fish from Country 22 are unsuitable for importation. It is unquestionable that Species B–F are raised as aquaculture species in Country 22 and given the many breaches identified in Species B–F and such low scores for ‘Water, sanitation and wastewater treatment’ it may be of benefit to scrutinize this importation arrangement and inspection of these imported products more closely.

The results of this study will be shared with the Australian Government so appropriate support strategies can be developed for Country 22 to reach fish safety compliance.

Author Contributions

Study conception and design: Michelle Williams, Marta Hernandez-Jover, Shokooeh Shamsi; Analysis and interpretation of data: Michelle Williams, Marta Hernandez-Jover, Thomas Williams; Drafting of manuscript: Michelle Williams, Marta Hernandez-Jover, Thomas Williams, Shokooeh Shamsi; Critical revision: Michelle Williams, Marta Hernandez-Jover, Thomas Williams, Shokooeh Shamsi.

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Conflict of Interest

The authors declare no conflict of interest.

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