Horizon scanning for management of emerging parasitic infections in fishery products

María Llarena-Reino[1,2], Elvira Abollo[3], Marcos Regueira[1], Helena Rodríguez[3] and Santiago Pascual[1]

[1]Ecobiomar. Instituto de Investigaciones Marinas de Vigo. CSIC. Eduardo Cabello 6, 36208, Vigo, Spain.
[2]Present Address: CESAM & Dep. Biologia. Universidade de Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[3]Centro Tecnológico Del Mar (Fundación CETMAR). Eduardo Cabello s/n, 36208 Vigo, Spain.

Corresponding author: María Llarena-Reino[1,2]
Ecobiomar. Instituto de Investigaciones Marinas de Vigo. CSIC. Eduardo Cabello 6, 36208, Vigo, Spain. mariallarena@iim.csic.es. Phone: 0034986231930, Ext.182; Fax: 0034986 292762.

Abstract

Public organizations operating in health and food-safety sectors are increasingly realizing the advantages of the long-term view of risk uncertainties associated to biological hazards, served-up in the short-term to anticipate the problem and its handling. Thus, the horizon scanning is becoming a major strand in proactive risk management and patient-consumer protection continuity. This approach was recently explained in the scientific opinion on risk assessment of parasites in fishery products by the European Food Safety Authority, EFSA (2010), followed by the launching of a funding scheme for a specific EU Framework Program Project under the Knowledge Based Bio-Economy concept, KBBE (FP7-KBBE-2012-6), which drives the new EU 2020 strategy. The aim of this paper is to examine horizon scanning issues in relation to public health and industrial concern on the presence of parasites in fishery products recorded in the Rapid Alert System for Food and Feed (RASFF) System. We focus on specific threats, targets, methods and challenges as a means of acquiring management goals and future objectives. The proposed horizon scanning identifies emerging ideas/technologies for an early handling of parasitized fish stocks/products for priority setting to inform strategic planning of stakeholders, policy-makers and health services. In order to accomplish this, a set of risk GIS maps illustrating the state of art about the effect of the zoonotic *Anisakis* spp. on commercial fish stocks of the last 65 years was firstly developed. Secondly, a program of 108 surveys among fish sellers of Galicia (NW Spain) were carried out with the main objective of getting information about hazard recognition, fish product management practices, quality self-controls and corrective and preventive measures in use. Additionally, during the "I International Symposium on strategies for management of parasitized seafood products" (Vigo, Spain), groups of researchers, technologists, official inspectors and industries participated in roundtables with 3 different perspectives: market-industry, inspection and academia. All scanners agreed that the *status quo* to manage fish parasites in the production-to-consumption food pathway is unsatisfactory. The central message proposed a stable network performance based on collaborative software to provide multi-

level information for industrial management of parasite contaminants in fish products. The discussion group also proposed to invigorate collaborative translational research and professional training as key drivers to fuel technological innovations and tech transfer, which may help to minimize/eliminate the risk of parasites that have public health and economic impacts in fish products.

Keywords

Horizon scanning; fishery products; parasite; public health; commercial value; inspection

1. Introduction

Marine parasites constitute an important health and quality threat in fishery products (Sabater & Sabater, 2000). Since the middle 20th century, scientific evidences have confirmed the presence of a high and raising prevalence of a "dirty dozen" of parasites in wild stocks of fishery products of commercial interest around the world (Køie, 1993; Wharton, Hassall & Aalders, 1999; Mladineo, 2001; Quijada, Lima dos Santos & Avdalov, 2005; Valero, López-Cuello, Benítez & Adroher, 2006; Smith & Wootten, 1979; McClelland, Misra & Martell, 1985; Adams, Murrell & Ross, 1997; Abollo, Gestal & Pascual, 2001; Rello, Adroher, Benítez & Valero, 2009). Reasons for these emerging fish diseases in fishery products are diverse. Primarily, outbreaks depend on the nature and life-cycle strategy of the parasites, but mostly on an uncontrolled ecosystem management and on new consumers feeding habits. Well-know examples of ecosystem-based implications for parasites are the outbreak spreading of *Giardia* and *Cryptosporidium* protozoans around shellfish harvesting areas due to fecal contamination by river and waste waters (Freire-Santos et al., 2000; Gómez-Couso, Mendez-Hermida, Castro-Hermida & Ares-Mazas, 2005), or protectionist policies for marine mammals followed by several fishing practices that may increase the recruitment of zoonotic, allergenic anisakid nematodes at fishing grounds (McClelland, Misra & Martell, 1990; Abollo et al., 2001; Rodriguez et al., 2009). Furthermore, the new wave of increasingly eating raw or undercooked fishery products has also epidemiological implications in industrialized countries. Specifically, *Giardia*, *Cryptosporidium*, some species of anisakids and more recently *Kudoa* have been recognized as human health hazards responsible for emergent zoonoses, that causes from gastro-allergic disorders in consumers (Chen et al., 2008; Dick, Dixon & Choudhury, 1991; Smith & Wootten, 1978; Audicana, Ansotegui, Fernández de Corres & Kennedy, 2002; Vidacek, de las Heras & Tejada, 2009; Kawai et al., 2012) to occupathional-asma in fish-farming workers (Plessis, Lopata & Steinman, 2004; Nieuwenhuizen et al., 2006). Besides these detrimental effects on public health, the presence of parasites in fishery products may also hamper the commercial value of products reducing thus its marketability (Crowden & Boom, 1980; Brassard, Rau & Curtis, 1982; Arthur, Margolis, Whitaker & McDonald, 1982; Lom & Dykova, 1992; Williams & Jones, 1994; Kumaraguru, Beamish & Woo, 1995; Woo, 1995). As an example, the economic losses among fish processing industries caused by anisakid larvae in fish flesh have been estimated to reach several millions of dollars (Bonnell, 1994).

The “dirty dozen” genera that affect the quality and/or safety of fishery products comprise micro and macroparasites. Concerning microparasites (apart from waterborne *Giardia* and *Cryptosporidium*), the mixosporidians (*Kudoa* spp.) and the microsporidians (*Pleistophora* spp. and *Spraguea* spp.) are highly prevalent in the flesh of gadoid fish, mostly merluccidae and anglerfishes (Whipps & Diggles, 2006; Pascual & Abollo, 2008; Leiro, Ortega, Iglesias, Estévez & Sanmartín, 1996; Freeman, Yokoyama & Ogawa, 2004; Casal et al., 2012). Among the macroparasites, didymozoid trematodes occurring in scombrids (Pascual, Abollo & Azevedo, 2006), cestodes (*Gymnorhynchus* spp., *Molicola* spp.) present in pomfret fish and swordfish, the cosmopolitan anisakid nematodes (*Anisakis* spp, *Pseudoterranova* spp., *Contracaecum* spp.) and crustaceans of *Pennella* spp. in the swordfish, represent the relevant target parasites during veterinary inspections of fresh and frozen products in the European fish industry.

The nematode *Anisakis* is a good candidate to be eligible as a sentinel model for targeting a horizon scanning for managing emerging parasites in fishery products. The reasons are: i) it is by far the most prevalent macroparasite in fish products from major stocks around the world, with significant demographic infection values regardless of the host species and fishing area. Especially of concern is the fact that during fish inspections anisakids are usually found in high amount on the gut cavity (Vidacek et al., 2009), in a lower quantity on the belly flaps (Abollo et al., 2001), and sometimes in the flesh (Smith, 1984; Wharton et al., 1999; Valero et al., 2006; Llarena-Reino, González, Vello, Outeiriño & Pascual, 2012); ii) in the last 20 years anisakids have been a trending topic within the scientific community, fish consumers and the industry dealing with biological risks in seafood products. This results from many social alarms in most southern European countries (Poli, 2005; León, Meacham & Cláudio, 2006) linked with the trending record of available medical literature concerning the public health implications of anisakids in general, and the genus *Anisakis* in particular; iii) besides the repercussion they have on seafood safety, quality aspects in parasitized fish decrease its commercial value by affecting the aesthetic of products (Fig. 1). This fact is hampering marketability of seafood products within a fair international trade and European consumer preferences which demand products with high standard quality (Vidacek et al., 2009; Pascual, Antonio, Cabo & Piñeiro, 2010); iv) because the parasite recruitment is successfully adapted to the marine trophic webs, alterations in the ecosystem reflect changes in the epidemiological status of this hazard in fish stocks and products (Deardorff, 1991; Slifko, Smith & Rose, 2000; Marcogliese, 2001; Pascual, González & Guerra, 2007; Wood, Lafferty & Micheli, 2010). This reinforces the idea of a management strategy enlarged from the net to the plates which also should include a study of viability of parasites in unprocessed marine fish waste used for feeding aquaculture fish, as juvenile wild fish on-grown in captivity; v) the risk assessment of this hazard demands a management strategy as the base of a fair international trade for products of different origin and production methods. In most cases neither the strategy is implemented nor available tools are integrated in the industry.

In relation to the discussion paper on the guide interpretation of Regulation (EC) 853/2004, recently the European Commission considered necessary to carry out a consultation to operators regarding the regulation of consumer information on such legislation. This work aimed to propose the elaboration of a detailed and complete horizon scanning of the situation resulting from the impact of the most relevant parasites on the value chain of commercial fishery products. To this end and following the mentioned example of the European Commission, authors decided to arrange a meticulous analysis and discussion by using the “consultation” method with fisheries stakeholders. Thus a triple strategy was put in practice:

(1) As a previous step it was considered the elaboration of risk GIS maps illustrating the state of the art concerning the condition of commercial fish stocks during the last 65 years, regarding the effect of the zoonotic parasite: *Anisakis* spp. Nowadays, there is an increasing interest on the use of GIS as an innovative technology to combine epidemiology, statistics and geographic information. This skill facilitates decision making, processing and analysis of information on several multidisciplinary areas.
(2) Secondly, it was planned a program of surveys to fishmongers. The consultative and anonymous character of this methodology, the potential amount of information available that offers this tool, the “consumer representation” made by fish sellers, and the “intermediary” role played by them within the fishing guild (exerts great influence on the extractive sector and on consumers), were important enough reasons to choose this methodology.
(3) Finally, it was carried out the organization of three round tables framed within an international symposium. Those panel discussions had the objective of agglutinating separately scientists, health inspectors and representatives of fishing companies, as the extractive sector, aquaculture businesses, restaurants, distributors, wholesalers and retailers of fish, etc. The main reason why horizon scanning was used as a suitable and useful method to identify key issues of concern and provide solutions to this biological hazard, is that the practice of horizon scanning is becoming a major strand in proactive risk management and business continuity.

2. Materials and Methods

EU legislation forces food market and industry to ensure, from the catch to the plate, that no contaminated fish reach the consumer. To that end stakeholders shall put in place, implement and maintain permanent procedures based on the HACCP principles (Regulations (EC) 852-854/2004; Commission Regulation (EC) 2074/2005). The European Hygiene Package (Council Directive 91/493/EEC; Commission Decision 93/140/EEC; Regulations (EC) 852-854/2004, Council Regulation (EC) 2406/96; Commission Regulation (EC) 2074/2005) and its modifications (Commission Regulations (EC) 1662-1664/2006), establishes that food business operators shall ensure that all stages of production, processing and distribution satisfy and comply with general and relevant hygiene requirements. Therefore fish industry has become responsible of the submission of fishery products for human consumption to visual inspection for the purpose of detecting visible parasites before being placed on the market. Considering the scientific literature to date and taking the European legislation in perspective, we defined the end-user prospect in a triple scheme:

2.1 Maps

In order to agglutinate available data illustrating the impact of parasitism by Anisakis spp. over fisheries, a literature search using the ISI Web of Knowledge databases was performed to compile articles published from 1947 to 2011 related to the keyword "*Anisakis*" in Atlantic Ocean. As a result a total of 929 publications were obtained and information from 104 selected papers with geo-referenced samples was extracted. The resulting 1287 registers were added to a computerized database. The retrieved information covered parasite and host species, sampling size, geographic location, date, anatomical site of infection, prevalence, mean intensity, mean abundance and density of infection, and the methods used for parasite detection. According to compiled information, overall infection parameters were calculated for each FAO fishing subzone. Geographic Information Systems (GIS) software ArcGIS 9.3. was used to link epidemiological information to FAO fishing areas´ vector layer. This map layer identified each fishing subzone by a unique ID polygon. A series of maps were produced to show the averages of the registered parameters of infection for each polygon in the Atlantic Area (Fig. 2). The cartography generated included a specific set of maps showing overall demographic infection values for *Anisakis* spp. for FAO subzones and also information relative to both host order and species of fishery importance.

2.2 Inquiries

A program of 108 surveys to fish sellers from fish stands, whose main objective was to get information about (1) hazard recognition, (2) fish product management practices, (3) quality self-controls at points of distribution or sale, and (4) corrective/preventive measures in use. All those fish stands were placed in: 17 city market squares, 20 village market squares, 4 super/hypermarkets and 4 fish shops, all located in Galicia (NW Spain). A brief description of each type of establishment aims to achieve a better understanding:

- Market square: a place where different establishments sold daily food from agriculture, livestock and fishing.
- Super/hypermarkets: self-service expansive facilities offering a wide variety of food and household products. These establishments sells fish, meat, fresh produce, dairy, and baked goods, along with shelf space reserved for canned and packaged goods as well as for various non-food items.
- Fish shop: a shop that sells fish; a fishmonger's

The reason why there was an over-representation of market squares in the survey and an under-representation of super/hypermarkets and fish shops, is because the surveysclaimed to reflect the consumption habits of the population in the area studied. A total of 2 interviewers executed the surveys as individual and anonymous interviews composed of 8 questions. Selected queries for interviews were previously planned and described by a group of marine scientists, parasitologists and veterinarians whose lines of research are closely linked to parasites in commercial fish species. Those questionsdealt with the recognition and the presence of anisakids in fish, handling practicesand with improvements in sanitary conditions of the establishments.
Thequestionswere as follows:

1. Type of establishment interviewed (city market square, village market square, super/hypermarket, fish shop)
2. Which improvements do you consider essentialto ensure sanitary and quality conditions of fish at the point of sale: hot potable water, marine water, improved cleaning, better refrigerators, rain water system with timer, better illumination, flake ice machine, refrigerated desk, individual potable water, nothing?
3. Do you eviscerate any of the following fish species or remove the hypaxial muscle before placing fish for sale? *(Engraulisencrasicholus, MerlucciusMerluccius, Micromesistiuspoutassou,Conger conger, Lophius* spp., *Lepidorhombus*spp., *Sardinapilchardus*, *Zeus faber*, *Scomberscombrus*, *Trachurus* spp., other fish species)
4. Do you eviscerate any fish species at points of sale before keeping fish overnight? (yes, no, certain species)
5. Do you remove the hypaxial muscle at any fish species at points of sale before keeping fish overnight? (yes, no, certain species)
6. Do you know anisakids? (yes, no)
7. Do you usually reject fish species due to the presence of anisakids? (yes, no, which species)
8. Do you usually have claims from consumers due to the presence of anisakids in any fish species? (yes, no, which species)

The results from the surveys performed were compiled, submitted to a descriptive analysis, worked out, compared, matched when necessary, and then represented in graphics (Fig. 3). Furthermore, a Spearman Rank Order Correlation was carried out to test the statistical inference between sellers' rejections and consumers' claims due to fish infected by anisakids.

2.3 Round tables

The "I International Symposium on strategies for management of parasitized seafood products" gathered and organized in Vigo (Spain) in November 2010 (http:/www.iim.csic.es/parcode/), had a total of 200 participants from different countries and professional areas. Among them, 30% were fisheries industry agents (from more than 50 fishing companies) including representatives of the extractive sector, aquaculture, distributors, wholesalers and retailers of fish, restaurants, etc., 30% were veterinarians responsible of inspection services for the Administration, 22% of the assistants came from academic institutions, and 18% were consumers, students and independent professionals. This event have represented an important approach between scientific researchers involved in the presence of parasites in seafood, and all the agents that in any way are affected by this problem.

Parallel to the symposium, a set of round tables with 3 different groups of representative horizon scanners took place, by means of 3 different perspectives: academia, inspection and market-industry. Those 3 groups included (a) 12 scientific researchers, (b) 25 public health official inspectors and (c) 25 technologists from the fish industry. The round tables began with a series of individual and illustrative presentations which included oral explanations of the current situation. In the case of scientific researchers' round table, each participant presented his point of view of the *status quo* during around 10-15 minutes. In the cases of official inspectors' and fish industries' round tables, some representatives of each group presented their professional approach to this problem. Posteriorly the moderator opened a panel discussion, with a starting question which was focused on technology push vs. market pull as forces of innovation in this field. The central message was the need to progress on the use of the knowledge already generated with the aim of minimizing the repercussions that parasites in general have on consumers and seafood industry. More specifically, the matter that was discussed in more detail was "anisakids", firstly due to their recognition by the European Food Safety Authority as the only family of parasites that potentially causes allergic reactions in humans, and secondly by reason of the rejections caused in consumers since it can be sometimes easily detected macroscopically.

3. Results and Discussion

3.1 Maps

Epidemiological maps of Anisakis spp. created on the basis of the available scientific literature, shows a cosmopolitan distribution of this "species complex" spreading throughout the Atlantic Ocean, even though the sampling effort was not equitable in whole Atlantic area, neither for all species. However, a number of "hot spots" can be identified, particularly in the Northeast Atlantic, South Africa and South America. Furthermore, distribution of marine helminth parasites can be influenced by a wide range of abiotic factors, as well as by a trophic relationship between final, intermediate and transport hosts (Kuhn, García-Màrquez & Klimpel, 2011), a fact which may complicate the predictive mapping on infection parameters concerning commercial fish species. Despite this, the developed maps constitute a prospective valuable tool since they provide an overview of anisakids distribution and its incidence in major fish stocks. Although the impact of the epidemiological dynamics of *Anisakis* spp. on marine trophic structures and in fish populations are the subject of intensive studies, the spatial epidemiology of this re-emergent marine parasite with zoonotic and economic relevance have been disregarded so far. Nowadays, this useful tool brings important improvements to researches in the fields of medicine, health and environmental sciences. The creation of risk maps may help to underline hot-spot infection areas, as a pre-harvest control measure to reduce or minimize the risk of anisakids infection during the value chain of fishery products.

3.2 Inquiries

Among the 108 total surveys, 98 were performed in market squares. From them, a total of 68 (60% from the total) were conducted in cities and other 30 interviews (28%) in villages (Fig. 3.1). With the aim of finding out the most important aspects of concern to fish sellers in order to improve sanitary and quality condition of seafood, we asked them about the changes they would apply at their workplaces. Around the 30% of the survey respondents considered that they have optimal conditions and no changes must be done, despite the lack of hot potable water for cleaning, flake ice machine, adequate refrigerators (in size and quality), or sometimes the need of an improved cleaning, which are essential aspects to ensure a proper management of commercial and sanitary quality of seafood. Furthermore, other less related or more commercial contributions like having a rain water system with timer, better illumination over the desk, improvements in the building and in the stands, or some advances in marketing and promotion (the last two improvements not reflected in the graphic) were proposed by them as some necessary changes in the points of sale (Fig. 3.2). Concerning the practice of evisceration or removing specific parts of certain fish species before placing them for sale, about 17% of the sellers confirmed the practice of evisceration in the case of *Pollachius pollachius,* and 6% in the case of *Trisopterus luscus*. For *Merluccius Merluccius*, 8% of the responders declared to eviscerate the fish and 3% said they removed the fish hypaxial muscle (Fig. 3.3), due to the fact that hypaxial muscle and viscera are the anatomical regions with higher amounts of larvae in parasitized fishes. Fish species with absence (*Sardina pilchardus*, *Zeus faber*, *Scomber scombrus, Lophius* spp., *Micromesistius poutassou* and *Engraulis encrasicholus*) or with lower (*Conger conger, Lepidorhombus* spp., *Trachurus* spp*., Gadus morhua* and *Thunnus* spp.) percentages of evisceration and/or hypaxial muscle removing were not represented in graphics. A similar question about eviscerating and removing the hypaxial muscle before keeping fishes overnight was made. About eviscerating 13% of the responders confirmed the practice, 28% performed evisceration only for certain species, and the remained 59% did not manipulate the fish. Moreover, no more than 9% of the sellers responded that sometimes remove the hypaxial muscle, depending on the species (Fig. 3.4). The majority answered "yes" to the question of whether they knew anisakids worms (94% of the responders) (Fig. 3.5).

Finally the two following questions dealt with fish rejections and claims caused by obvious and annoying presence of anisakids in fishes. The most remarkable data is that 50% of the sellers are currently rejecting fishes (of any species), and almost 50% of them are receiving complaints from customers due to an excessive presence of anisakids. Fish species involved in both type of incidences were represented in one single graphic, in order to compare them by descriptive analysis (Fig. 3.6). For *Merluccius* spp. and *Trigloporus lastoviza* almost the same number of rejections were made by consumers and sellers. For *Brama brama* the number of consumers' claims was higher than the amount of sellers' refusals. For *Micromesistius poutassou,* the quantity of both kind of refusals was exactly the same. For other species included in this point of the surveys there were no coincidence between rejections and claims; so they have not been represented in the graph. Moreover, as Table 1 shows, the results from Spearman Rank Order Correlations revealed that the relationship between refusals led by sellers and consumers' complaints in the species represented in Fig. 3.6, was evident ($r=0.2861$; $p=0.0026$). Specifically, for *Trigloporus lastoviza* r value was 0.699, for *Brama brama* r =0.292 and for *Micromesistius poutassou* the correlation between refusals and complaints was the highest, giving a significant value of r (0.864). However, for *Merluccius merluccius* the correlation was not significant. Despite this species gave the highest number of customers' claims due to the massive presence of anisakids, fish sellers believe that there are two types of Atlantic hake; the one which comes from nearby waters (“high quality” Hake), and other from distant waters (“very parasitized” Hake). From this point, they associate consumers’ claims to a distant origin, rather than the species.

After talking with respondents it could be established that: (1) the main reason why there is a positive relationship between these two variables is because sellers usually reject fish species that generate customers complaints due to an evident presence of anisakids; (2) the fact that a fish species is highly parasitized do not lead sellers to consider it as a product unfit for human consumption, if that species can be sold eviscerated or without specific parts of musculature (more parasitized). These facts suggests a lack of sanitary education among fish sellers. The need of a training to this guild is more important since sellers are representing the sector, and have the opportunity to sensitize consumers on good management and consumption practices.

3.3 Round tables

During the Symposium and round tables all horizon scanners agreed that the *status quo* to manage the parasite hazard in the production-to-consumption food pathway is clearly unsatisfactory. They also emphasized the advantages of the long-term view of risk uncertainties associated to biological hazards for anticipating the problem and its handling. As the European Food Safety Authority, EFSA (2010) recently explained in the scientific opinion on risk assessment of parasites in fishery products, the horizon scanning is becoming a major strand in proactive risk management and patient-consumer protection continuity.
Lastly, agents showed much concern for commercial rejections, their consequential economic losses and the increasing lack of confidence that anisakids and many other different types of parasites present in fishery products are currently producing.

Half a dozen of key issues to conduct research, to inform policy and to practice were specifically identified by scanners during the round tables:

3.3.1 Standardization

The lack of standardization is one of the most concerned bottleneck problems during parasite inspection in the fish industry. Improvement plans would require the development of more efficient, low cost, quick and accurate validated methods of parasite examination and detection during fish inspections. That lack of a golden standardization for fast and easy detection methods is hampering the consensus of parasite detection and diagnosis protocols at the fishing industry, thus reducing customer confidence in market transactions. The most debatable issue was the subjectivity and ambiguity of some concepts defined by legislation such as “visible parasite”, “clearly contaminated” and “obviously infested with parasites”, as specified in the European Hygiene Package (Council Directive 91/493/EEC; Commission Decision 93/140/EEC; Regulations (EC) 852-854/2004, Council Regulation (EC) 2406/96; Commission Regulation (EC) 2074/2005) and in its modifications (Commission Regulations (EC) 1662-1664/2006). These concepts evidence a lack of standard settings regarding the “*quantum satis*” conception, because no limit is defined between zero risk vs. tolerable risk. Therefore, a detection limit provided by sanitary authorities for an allowable number of larvae or amount of DNA-antigen traces in fresh fish musculature is desirable (Pascual et al., 2010). Furthermore, the accuracy of a "visual examination" scheme in the fish industry depends on the training and skills of inspectors (Levsen, Lunestad & Berland, 2005), but mostly on a well-tested statistical significance between the number of observable parasites in the abdominal cavity and surrounded organs, and the number of parasites in musculature (Llarena-Reino et al., 2012). Although this method does not guarantee a parasite-free edible part of fish, no other method as a golden standardization has been accepted as the international reference protocol accomplish with the industrial requirements. Moreover, the establishment of epidemiological monitoring programmes to standardize the methodology for fish inspections should comprise the definition of the concepts "sampling size" or "epidemiological unit" which are not defined by legislation. These issues represent a source for uncertainty in hazard analysis during fish safety and quality self controls.

3.3.2 Monitoring

As most of scanners stated the industry as responsible of food security and quality, needs tools to detect parasites, sanitize seafood products and develop effective management strategies. They proposed that proactive self-inspections carried out by fish operators could provide a chance to transform the parataxonomic inspection carried out by the industry into a zoosanitary vigilance program by networking an industrial upgrading of national sanitary defense associations, as it is the case in aquaculture production. Furthermore, it also would be advisable to take into account samples from oceanographic and evaluation resource campaigns financed by national governments and international funds, which periodically are operated by research entities.

3.3.3 Innovation

With the increasing demand for ready-to-eat, fresh, and minimally processed fish, new ecology routes for parasite survival have emerged as it was demonstrated in modified atmosphere packaging (Pascual et al, 2010). In order to minimize the loss of quality and to control parasite hazard, hurdle technology was suggested in the design of preservation systems for minimally processed foods at various stages of the food chain. However these new and other emergent technologies such as ultrasounds, electrolyzed oxidizing water, etc…, should be specifically evaluated for parasite hazards. Group discussion proposed to invigorate collaborative translational research and professional training as key drivers to fuel technological innovations and tech transfer, which may help to minimize or eliminate the risk of parasites with public health and/or economic concerns in fish products. Additionally, the proportionality of innovations that take into account the weight up of cost-benefit ratios for different interventions in the food chain was also stressed by industrial scanners. Finally, they also identified technological and economic benefits in outsourcing R&D in an open innovation strategy for component improvements, design and new process/product innovations.

3.3.4 Training

In general all fish food industry employees in Europe are educated and trained in relevant food safety practices, beyond basic food handler training. Some available guidebooks describe the good manufacturing practices and safe fish handling procedures that help fishermen, fish processors, truckers and retailers to assure and maintain the food safety and fish products quality from the boat to the retail counter. Nevertheless, educational seminars for relevant emerging topics like parasite hazards are needed and are still absent in many European regions.As surveys revealed, there is lack of sanitary education concerning parasites among fish sellers; they confuse basic notions and are not able to differentiate those parasites which can cause zoonotic disease, from those innocuous to public health.

3.3.5 Risk assessment

Among the surveys' findings, it was noted that fish sellers' rejections due to excessive parasitism matched in amount and fish species with consumers' complaints. Repeatedly, sellers' criteria seems to be conditioned by consumers' reactions to parasites. That absence of a proactive behaviour at points of sale implies that prevention is not being applied. Much more risk assessment information, both in fish products and for consumers and sellers has been a relevant plea throughout horizon scanning roundtables. A friendly SMART (self-monitoring and intelligence reporting technology) platform has been suggested to generate pre-harvest control tools (e.g., risk maps and epidemiological reporting). The creation of methodologies of categorization or staging which should include the parasite identity, the spread of parasites in the edible part of fish, and the food quality and safety implications of this biological hazard, was also recommended. The development of this kind of risk-based metrics (point and probabilistic estimates) should be incorporated, implemented and monitored in HACCP plans. Risk assessment from a public health perspective demands attending natural variability and scientific uncertainty through statistical inference for relationships between catch origin, fish species, fish stock structure and parasite quantitative descriptors in different "what-if" and simulations scenarios for parasite animals, traces and antigens. Mapping of *Anisakis* allergens in seafood and a deeper understanding of immune response to the parasite antigens were noted as important tasks for research. Furthermore, integration of epidemiological information on infectivity and inactivation of parasites taking the whole production-to-consumption food pathway, and the incidence of this zoonotic infection in humans, will aid to analyze, predict and prevent the probability of illness, complaints and fish rejections, thus enhancing public awareness and the effectiveness of control measures. As one of the more strong initiatives, scanners also proposed to create and develop a thematic network performance based on collaborative software to provide multi-level information (on-site and at-line) for industrial management of parasite contaminants in fish products. The ultimate goal for all implicated horizon scanners during this event was the collaboration and the creation of common spaces between agents, industries and scientists, getting thereby better advances in the strategies and technologies to fight against this important hazard. Only by achieving this purpose the international competitiveness of fish products could be enhanced.

3.3.6 Risk communication

Risk communication was determined by scanners as a matter of concern to manage alerts instead of alarms. It was suggested to elaborate a risk profile for each emergent parasite species with the aim of sharing multi-level information and to aid technology-knowledge transfer. Each “parasite array” will assure communication with public regulatory authorities and the industry, thus reinforcing the industry’s competitiveness by implementing added-value strategies to guarantee a high standard quality in healthy fishery products. Similarly to the above knowledge-based bio-economic approach, it would be of high priority to spread the knowledge to the broader society to ensure consumer protection within an open public access plan.

To be relevant and useful the participants agreed to bring horizon scanning under a QCA perspective by repeating the process and collation annually, and to include the topic and the information in the working groups of the European Fish Technology Platform.

4. Conclusions

The data collected from the maps, inquiries and during the round tables, contains valuable suggestions orienting current and future strategies, identifying key problems with the existing procedures and providing advices that could improve public health policy and reduce economic losses. These ideas have been summarized and compiled around six key issues conforming a very constructive horizon scanning effort for managing emerging parasites in fishery products, as follows:

- The lack of standardization during parasite inspection in the fish industry is the main reason why the industry demands that the transfer of food safety co-responsibility from governs to companies should be led by a tough and progressive program of unified standards more closely monitored by governs. This lack of consensus and standardization concerning self-control, makes easier a free criteria and heterogeneity when internal inspection of batches, manufacturing facilities or processes take place. FAO protocols, facto standards by CODEX, military standards or statistical standards are some examples of quality criteria in use for internal controls by food companies.

- Supervised proactive self-inspections at industries could lead to set up stable zoosanitary vigilance programs. The monitoring of demographic values of infection by parasites in fishes could be integrated for its study as a part of the evaluation programs during oceanographic campaigns.

- The setting of innovations based in positive weight up of cost-benefit ratios as labeling requirements for parasite-free trademarks, could provide a chance for enable commercial blister beneficiaries of process monitoring programs, for periodic analysis of products and for preventive and corrective measures for parasites with public health and economic implications. Furthermore, the elaboration of an innovation guide directory with the portfolio of services was suggested as a key drive to help identify organizations which do outsourcing R&D work for fish companies.

- Educational seminars concerning relevant emerging topics like parasite hazards, for industry employees and retailers should be implemented in all European regions, especially the establishment of proof-of-concepts and demos linked to GMP and SOP programs within the legal scenarios to monitor into real-life. Fish sellers represent a critical point that must be conscientiously trained and instructed, since they are the target vehicle to reach the consumer in an immediate, inexpensive, effective, continuous and conservative way.

- Regardless of the method used for fish inspection, it is essential to design methodologies of categorization or staging which should be incorporated, implemented and monitored in HACCP plans. Integration of epidemiological information of parasites will aid to study, predict and avoid fish rejections and zoonoses, and will enhance public consciousness and the success of control measures.

- With the aim of improving risk communication to the broader society it would be indispensable to spread the knowledge to ensure consumer protection within an open public access plan.

5. Acknowledgements

We thank Xunta de Galicia for financial support under Projects Parcode (10TAL033E), Anitech (10TAL001CT) and IN841C. Authors would like to thanks the excellent bibliographic work to Miguel Bao (ECOBIOMAR), and to Carlos Vello/Luis Outeiriño (Comercial Hospitalaria Grupo 3 S.L.) and also to Rosa Fernández (CETMAR) for their help in the organization of the I International Symposium on strategies for management of parasitized seafood products. M. Llarena-Reino and M. Regueira thanks Fundação para a Ciência e a Tecnologia and European Social Fund for financial support under grants SFRH / BD / 45398 / 2008 and SFRH / BD / 51038 / 2010 respectively.

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Table

Fish species	***N***	***r***	***t (N-2)***	***p-level***
Merluccius merluccius	108	0.166583	1.60274	0.112495
Brama brama	108	0.292306	2.89971	0.004693
Trigloporus lastoviza	108	0.699164	9.27722	0.000000
Micromesistius poutassou	108	0.864426	16.31130	0.000000

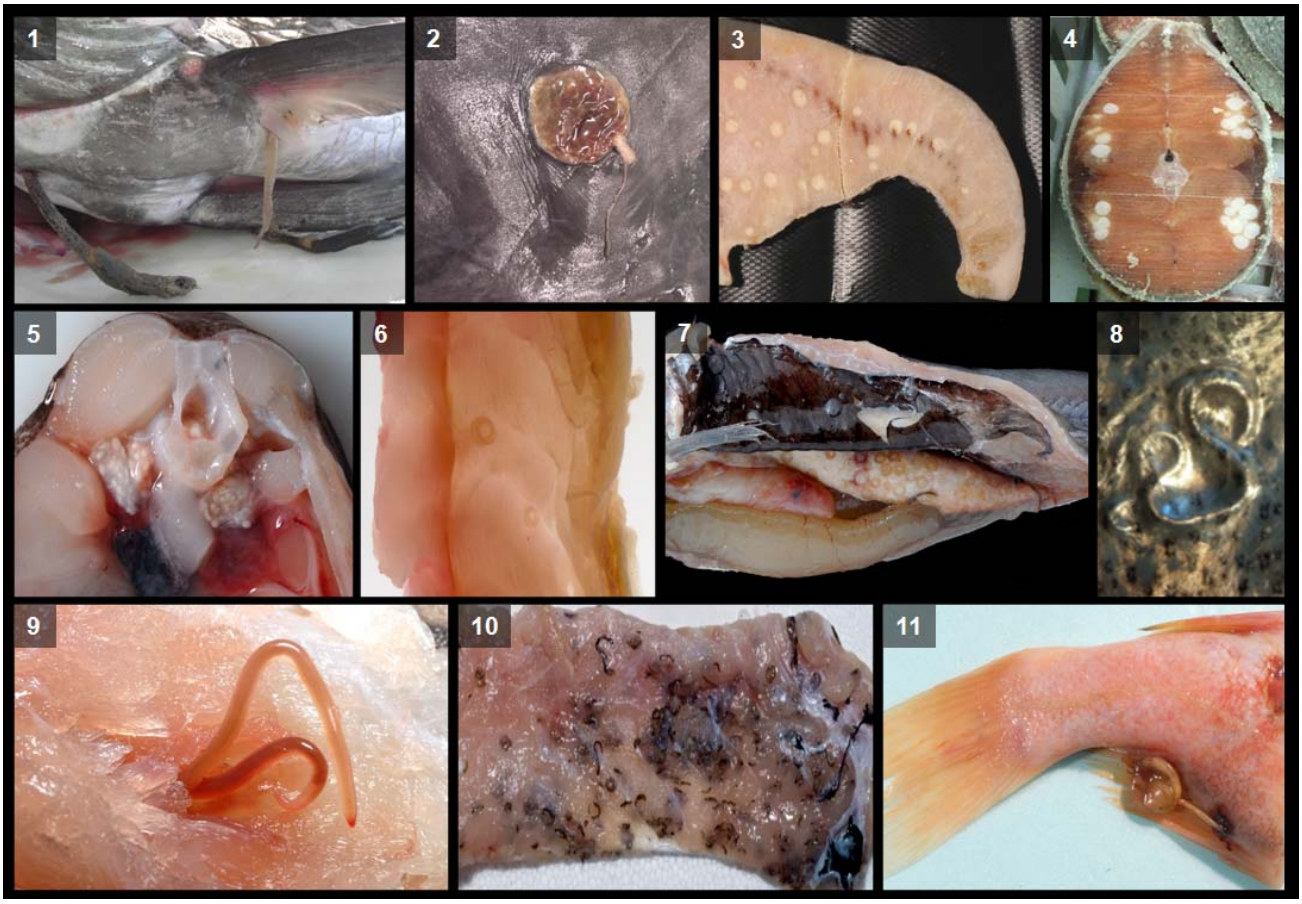
Table 1 Spearman Rank Order Correlations between sellers' rejections and consumers' claims due to commercial fish infected by anisakids.

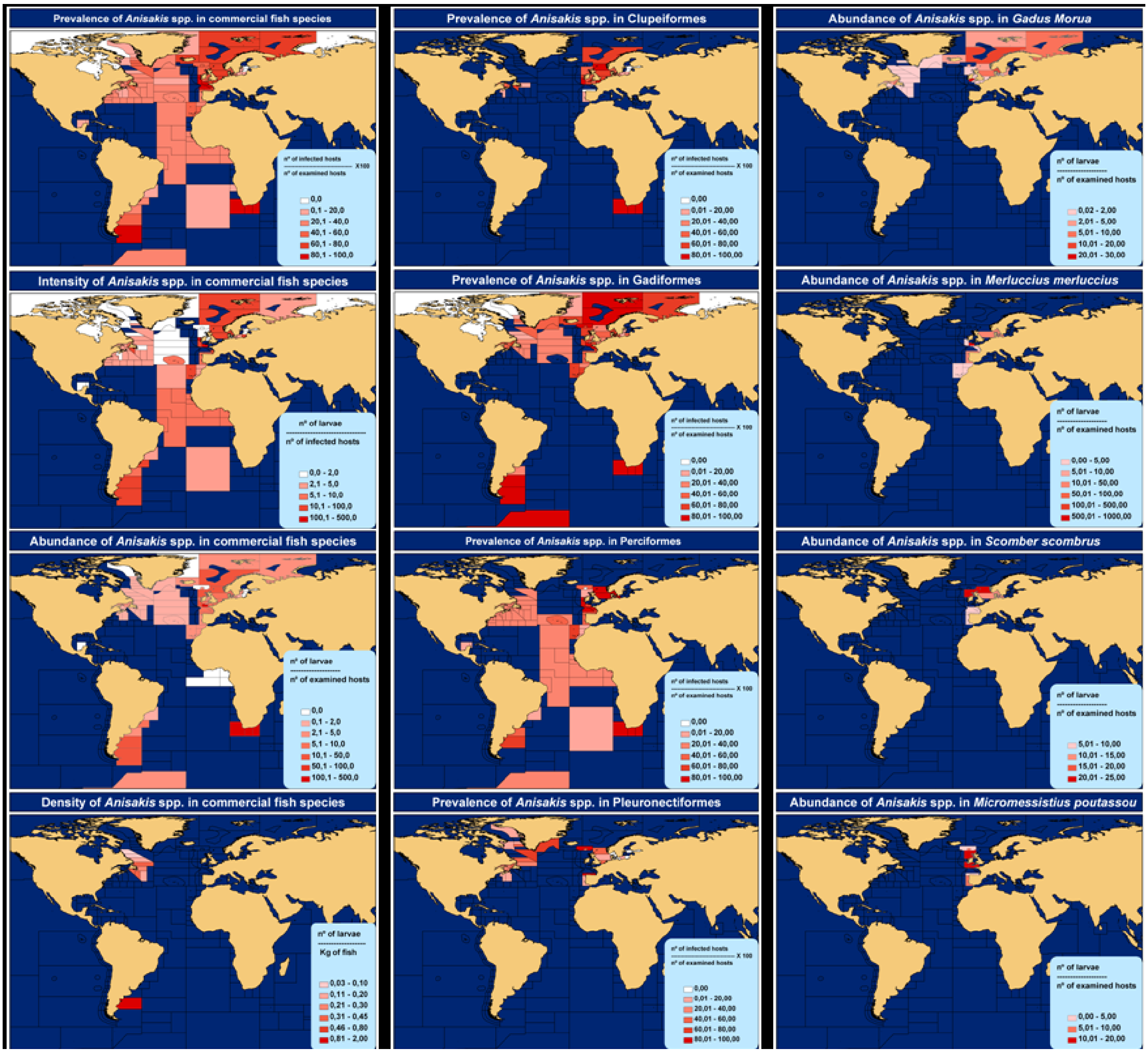
Figures Captions

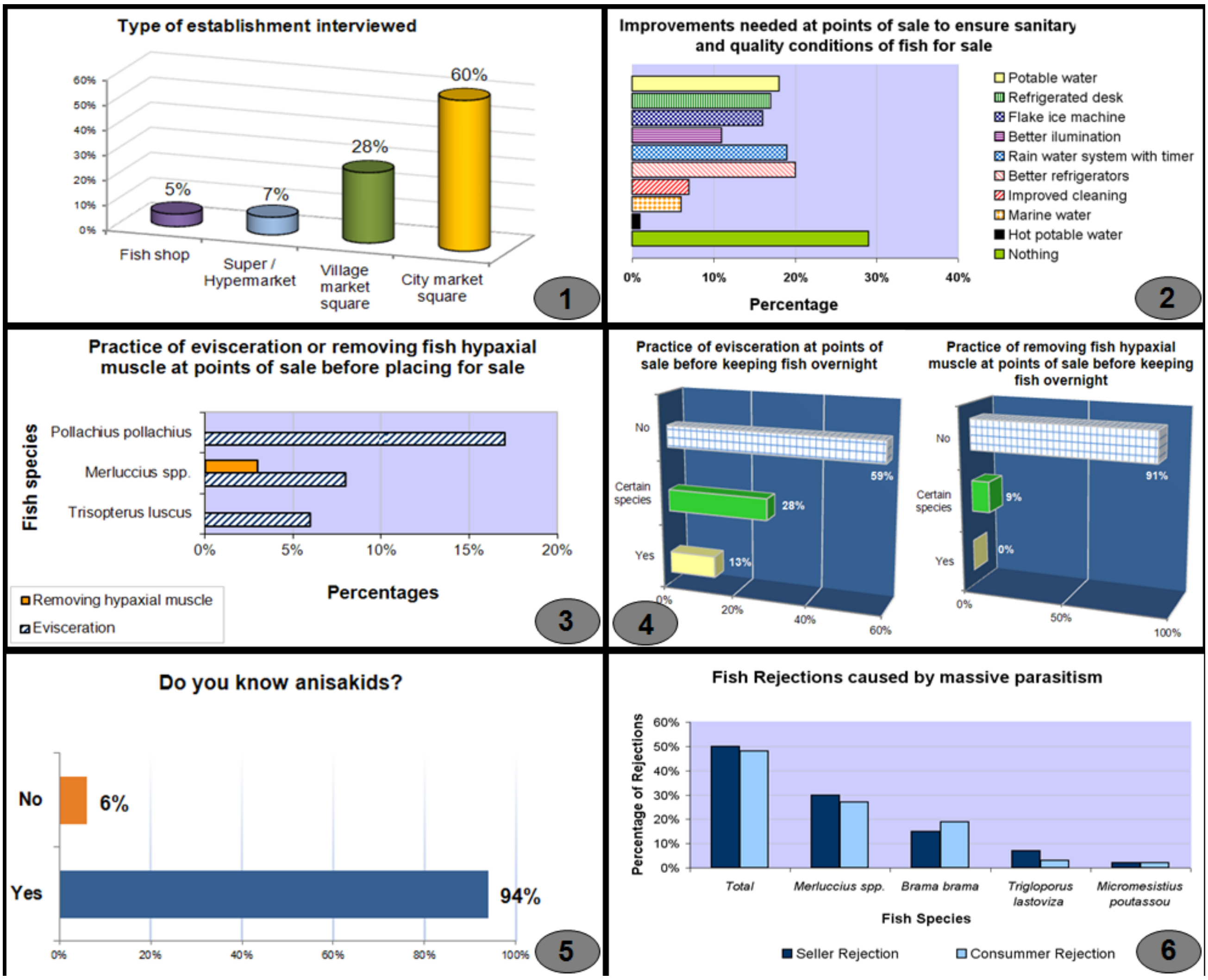
Fig. 1 The unaesthetic figures that many parasites produce on seafood products represent a serious problem that has a significant impact on consumer's preferences by decreasing enormously the commercial value of affected products. Regardless of the concern for the public health, the effects that parasites causes on marketability forces seafood industry to discard large quantities of fish and to intensify quality inspection protocols on seafood products. At this point, the most valuable goals of the industry are increasing the quality of parasitized products and the consumer's confidence. A-H. Macrophotographs showing unaesthetic problems associated to visible parasites found in commercial fish lots. 1. Up to 3 copepods belonging to *Pennella* sp. with the anterior end anchored internally in the musculature of *Xiphias gladius*. 2. *Pennella* sp causing inflammatory and ulcerous wounds around the entrance hole followed by abscesses in host musculature. 3. Large number of *Molicola* sp. within the flesh of *X. gladius*. 4. Pseudocysts of *Kudoa* sp. in the flesh of *Salmo salar*, at times associated to post-mortem myoliquefaction ("milky flesh syndrome"). 5. Microsporidian xenomas of *Spraguea lophii* infecting nervous tissues of *Lophius budegassa*, usually located along the length of the vertebral column (body), and on the medulla oblongata of the hind brain (head). 6. Encysted larval of *Anisakis* sp. in the flesh of *Micromesistius poutassou*. 7. Encysted larvae of *Anisakis* sp. in the gut cavity and belly flap of *M. poutassou*. 8. Larval of *Anisakis* sp. migrating under the skin of *M. poutassou*. 9. Larval of *Pseudoterranova decipiens* in the flesh of *Lophius piscatorius*. 10. Old encysted (melanin capsules) larvae of *Anisakis* sp. embedded in the flesh of *Merluccius merluccius*. 11. Copepod belonging to the family Lernaeopodidae in *Sebastes mentella*, anchored internally in the musculature surrounding fins.

Fig. 2 Cartography that includes specific set of maps illustrating the averages of demographic infection values for *Anisakis* spp. in each Atlantic FAO fishing subarea (1st row), and related to both host order (2nd row) and species of fishery importance (3rd row).

Fig. 3 Graphical representation of the results obtained after carrying out a total of 108 surveys among fish sellers in Galicia, NW Spain.




Prevalence of Anisakis spp. in commercial fish species
nº of infected hosts / nº of examined hosts X100
0,0
0,1 - 20,0
20,1 - 40,0
40,1 - 60,0
60,1 - 80,0
80,1 - 100,0
Prevalence of Anisakis spp. in Clupeiformes
nº of infected hosts / nº of examined hosts X 100
0,00
0,01 - 20,00
20,01 - 40,00
40,01 - 60,00
60,01 - 80,00
80,01 - 100,00
Abundance of Anisakis spp. in Gadus Morua
nº of larvae / nº of examined hosts
0,02 - 2,00
2,01 - 5,00
5,01 - 10,00
10,01 - 20,00
20,01 - 30,00
Intensity of Anisakis spp. in commercial fish species
nº of larvae / nº of infected hosts
0,0 - 2,0
2,1 - 5,0
5,1 - 10,0
10,1 - 100,0
100,1 - 500,0
Prevalence of Anisakis spp. in Gadiformes
nº of infected hosts / nº of examined hosts X 100
0,00
0,01 - 20,00
20,01 - 40,00
40,01 - 60,00
60,01 - 80,00
80,01 - 100,00
Abundance of Anisakis spp. in Merluccius merluccius
nº of larvae / nº of examined hosts
0,00 - 5,00
5,01 - 10,00
10,01 - 50,00
50,01 - 100,00
100,01 - 500,00
500,01 - 1000,00
Abundance of Anisakis spp. in commercial fish species
nº of larvae / nº of examined hosts
0,0
0,1 - 2,0
2,1 - 5,0
5,1 - 10,0
10,1 - 50,0
50,1 - 100,0
100,1 - 500,0
Prevalence of Anisakis spp. in Perciformes
nº of infected hosts / nº of examined hosts X 100
0,00
0,01 - 20,00
20,01 - 40,00
40,01 - 60,00
60,01 - 80,00
80,01 - 100,00
Abundance of Anisakis spp. in Scomber scombrus
nº of larvae / nº of examined hosts
5,01 - 10,00
10,01 - 15,00
15,01 - 20,00
20,01 - 25,00
Density of Anisakis spp. in commercial fish species
nº of larvae / Kg of fish
0,03 - 0,10
0,11 - 0,20
0,21 - 0,30
0,31 - 0,45
0,46 - 0,80
0,81 - 2,00
Prevalence of Anisakis spp. in Pleuronectiformes
nº of infected hosts / nº of examined hosts X 100
0,00
0,01 - 20,00
20,01 - 40,00
40,01 - 60,00
60,01 - 80,00
80,01 - 100,00
Abundance of Anisakis spp. in Micromessistius poutassou
nº of larvae / nº of examined hosts
0,00 - 5,00
5,01 - 10,00
10,01 - 20,00


Type of establishment interviewed
5%
7%
28%
60%
Fish shop
Super / Hypermarket
Village market square
City market square
1
Improvements needed at points of sale to ensure sanitary and quality conditions of fish for sale
Potable water
Refrigerated desk
Flake ice machine
Better ilumination
Rain water system with timer
Better refrigerators
Improved cleaning
Marine water
Hot potable water
Nothing
Percentage
2
Practice of evisceration or removing fish hypaxial muscle at points of sale before placing for sale
Fish species
Pollachius pollachius
Merluccius spp.
Trisopterus luscus
Percentages
Removing hypaxial muscle
Evisceration
3
Practice of evisceration at points of sale before keeping fish overnight
Practice of removing fish hypaxial muscle at points of sale before keeping fish overnight
No
Certain species
Yes
59%
28%
13%
91%
9%
0%
4
Do you know anisakids?
No
6%
Yes
94%
5
Fish Rejections caused by massive parasitism
Percentage of Rejections
Total
Merluccius spp.
Brama brama
Trigloporus lastoviza
Micromesistius poutassou
Fish Species
Seller Rejection
Consummer Rejection
6