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# Labeling farmed seafood: A review

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## **ABSTRACT**

Food labels help consumers choose products in line with their food attitudes and preferences. As the market for farmed seafood grows, it is important for producers to meet consumer demand for credence characteristics like safety, nutrition, origin, and sustainability. Consumer preferences for credence characteristics are heterogeneous, and stakeholders in the farmed seafood industry can look to both agriculture and marine labels when they seek ways of positioning their products. In this article, we conduct a review of consumer studies related to mandatory and voluntary

labels used for farmed seafood. In most developed countries, mandatory seafood labels include information about species, farmed or wild, and area of origin. Voluntary labels include information regarding sustainability, organic production, animal welfare, traceability, and safety. We point to emerging research topics and possibilities. Challenges related to the labeling of farmed seafood are also discussed.

**KEYWORDS:** aquaculture; farmed seafood; mandatory label; product differentiation; voluntary label

## **Introduction**

Farmed seafood producers use product differentiation to meet consumer demands and maximize profits (e.g., Charles & Paquette, 1999; Grunert, 2005; Kinnucan et al., 2003; Roheim, 2005; Wessells, 2002). With increased international supply and trade in seafood, the importance of product differentiation is likely to increase (Kobayashi et al., 2015). Labeling is one way to differentiate products; modern consumers are accustomed to both mandatory and voluntary labels on food products. A large proportion of the research on seafood labels has focused on wild seafood (Bush et al., 2013). In this article, we review the literature on consumer preferences toward labeled farmed seafood products.

Consumer preferences affect all stakeholders in the value chain. For high-profile retailers and restaurant chains, certification for sustainability, organic production, and animal welfare fits well into their corporate social responsibility programs (Roheim, 2008; Alfinés, 2017). An example of such a company is IKEA. Their sustainability report stated that: “We remain committed to only sourcing Aquaculture Stewardship Council (ASC) or Marine Stewardship Council (MSC) certified fish and seafood” (IKEA, 2016, p. 31).

Food products can be thought of as bundles of search, experience, and credence attributes (Ahmad & Anders, 2012; Ward et al., 2008). Food labels typically provide signals of credence attributes, which are attributes that consumers cannot realize even after consumption (e.g., Caswell & Mojduszka, 1996; Sogn-Grundvåg et al., 2014; Wessells, 2002). Credence attributes

are frequently related to nutrition, area of origin, production method, animal welfare, fair trade, and sustainability. Search attributes are attributes that consumers can determine by searching, e.g., price, color, smell, texture, and fat content (Nelson, 1970, 1974; Wessells, 2002). Labels allow the consumers to evaluate credence attributes before purchase, and may transform a credence attribute into a search attribute (Wessells, 2002).

Depending on the ownership of a label, labels can be categorized as own labels, government labels, or third-party labels (Caswell & Anders, 2011). Government labels are usually mandatory and provide essential information on the main characteristics. For example, see the European Council (EC) regulation on the common organization of the European markets in fishery and aquaculture products (e.g., EC, 1999). Own labels and third-party labels are usually voluntary labels (Caswell & Anders, 2011), which often provide information related to production practices or some enhanced features of the product. Voluntary labels such as ecolabels are rewarded producers that follow sustainable practices (Roheim, 2009).

Since farming of seafood has many similarities to livestock production, farmed seafood can use labels similar to those used in agriculture (Teletchea & Fontaine, 2014). Organic is an example of a voluntary label already used by some aquaculture producers (Aarset et al., 2004; Ankamah-Yeboah et al., 2016), and country-of-origin labeling is an example of a mandatory label for both agriculture and aquaculture products. The origin for farmed seafood is usually a country, while the origin for most wild seafood is a specific area of water, e.g., cod from the

Northern Atlantic. Using well-established labels from agriculture, such as organic or country of origin, is likely to increase the recognition of the labels used on aquaculture products, and will reduce the time and resources needed to make the labels known among consumers.

In the next section, we will discuss the use of mandatory labels before we turn to the use of voluntary labels in Section 3. In Section 4, we look to the future and discuss some likely further labels for farmed seafood and some challenges. Section 5 concludes. Our selection of attributes is based on (1) the saliency of the labeling in the choice situation, (2) the literature discussing the effect of labeling on seafood consumer choices, (3) labeling that has received attention on agricultural or marine products that could also be used on farmed seafood, and (4) media coverage. Our selection is not a complete list of the potential labels that could be used on farmed seafood, but we tried to cover most groups of products, processes, and origin labels available to stakeholders in the farmed seafood value chain.

### **Mandatory labels**

The World Health Organization and the Food and Agriculture Organization of the United Nations (FAO) are jointly responsible for the Codex Alimentarius international food standards (FAO, 2012), which regulate the labeling of seafood products in international trade, while national laws stipulate which information should be on seafood products in stores. We review the mandatory labeling of eight groups of attributes in the following subsections.

## **Species**

In the US, the Food and Drug Administration (FDA) has released a list of acceptable market names for seafood (FDA, 2015). In the European Union (EU), member states are responsible for controlling the scientific names, the names in the official languages of the member state, and any other names accepted locally or regionally in the member state (EC, 1999).

The species of fish is a very important choice attribute for many consumers, and the name of the species is often written in large letters on the labels of the most popular seafood species. The likely reason for the importance of the species is that it is associated with the sensory quality of the product. For example, Rickertsen et al. (2017) reported significantly different hedonic taste scores for different species. Furthermore, taste has been found to be one of the most important food values (Lusk & Briggeman, 2009). Rickertsen et al. (2017) also found that both hedonic taste scores and species are highly correlated with willingness to pay (WTP) for fish.

Johnston and Roheim (2006) found that US consumers were reluctant to switch from their most-favored seafood species in terms of taste (cod, salmon, flounder, and swordfish) to a less-favored species bearing a “no overfishing” label. Furthermore, Roheim et al. (2007) found that species was among the most important determinates for retail fish prices. Loose et al. (2013) found that Australian consumers considered species as being more important than country of

origin, accompaniments, packaging methods, health claims, and environmental claim of zero carbon emissions.

With the increasing variation in farmed seafood species, the use of species names to signal quality can be problematic for some of the minor species. Most consumers in developed countries have sensory associations with well-known species such as salmon, but for many other species, the name of the species is not going to provide any information about its sensory qualities. Many of these less known species are likely to be mainly used in processed seafood products where the species name is less salient.

### **Farmed and wild**

With world production of wild and farmed seafood being of approximately equal size, consumers in most markets must choose between wild and farmed every time they buy seafood. The EU and the US require seafood products to be labeled with its production method (EC, 1999; FDA, 2005; USDA, 2017).

For a number of species such as catfish, tilapia, shrimp, salmon, oysters, and mussels, most of the supply in many markets are farmed. For these species, the differentiation between farmed and wild is less relevant since consumers can only choose among the farmed ones (Engle et al., 2017). The same argument applies for species with mainly wild caught supply.

Wirth et al. (2007) suggested that consumer preferences for wild versus farmed seafood seem to vary by location and species in the US. Early research provided mixed evidence on whether farmed or wild fish was preferred in the US market (Anderson & Bettencourt, 1993; Holland & Wessells, 1998). Most recent surveys indicate a clear preference for wild seafood among consumers who live in coastal areas of the US (Wirth et al., 2007; Roheim et al., 2012; Davidson et al., 2012; Hall and Amberg, 2013; Petrolia et al., 2016), while Wirth et al. (2007) and Quagraine et al. (2008) found that consumers prefer farmed fish in the central part of the US. It should also be noted that while there are ample populations of catfish in the US, almost all catfish sold in the US market are farmed.

In most European studies, consumers indicate a preference for wild seafood (e.g., Fernández-Polanco 2013; Rickertsen 2017). Interestingly, the preference for wild seems to be strongest among the oldest consumers. Verbeke et al. (2007) reported that the majority of consumers perceived no differences between farmed and wild fish. However, mean perception scores were slightly higher for wild fish on the attributes of taste, health, and nutritious value, particularly among consumers aged 55 years and older. Stronger preferences for wild fish among older consumers were also reported by Rickertsen et al. (2017), who investigated French consumer preferences.

Japanese consumers also preferred wild to farmed seafood. Aiji (2010) found that Japanese consumers were willing to pay more for wild than farmed bluefin tuna, and Uchida et al. (2014) found that Japanese consumers preferred wild to farmed salmon.

Even though consumers in most markets say they prefer wild seafood, farmed seafood is selling well in most markets. For example, Rickertsen et al. (2017) reported that French consumers stated that they preferred wild seafood, but farmed salmon was simultaneously the highest selling seafood species in the French market. Two aspects worth noting is that several popular species are now predominately sold as farmed, and consumers that grew up after the rise of farmed seafood may be less likely to differentiate between wild and farmed seafood.

### **Country of origin**

The EU and the US both require farmed seafood to be labeled with the country of origin (EC, 1999; USDA, 2017). The country-of-origin labeling makes it possible for producers in countries associated with high seafood quality to distinguish themselves from producers in countries with an inferior country image.

Many explanations for country-of-origin preferences have been suggested, including ethnocentrism, economic development, country image, and cultural distance (e.g., Balabanis & Diamantopoulos, 2004). The country-of-origin preferences for farmed seafood are in line with the typical findings from agricultural studies: domestic is preferred to imported, seafood from

developed countries is preferred to seafood from less developed countries, and seafood from countries strongly associated with seafood products is preferred to seafood from other countries (Ariji, 2010; Chen & Garcia, 2016; Davidson et al., 2012; Jaffry et al., 2004; Nguyen et al., 2015; Rickertsen et al., 2017; Salladarré et al., 2010; Sogn-Grundvåg et al., 2014; Uchida et al., 2014).

Investigating consumers' associations with different origins of seafood, Rickertsen et al. (2017) found that consumers' origin preferences are related to the seafood's perceived safety, healthiness, and sustainability. Thus, when countries promote the origin of farmed seafood, it is important to consider these attributes. Furthermore, Verbeke and Roosen (2009) found that consumers in five EU countries stated that the country of origin for farmed seafood is significantly more important than the capture area for wild seafood.

### **Freshness**

In both the US and the EU, all prepacked seafood must be labeled with a best-before date. In the EU, the 2011 EU regulation on the provision of food information (Regulation (EU) No. 1169/2011) requires perishable foods, including seafood, to be labeled with a use-by date (EU, 2011).

Based on a survey conducted in five EU countries in 2004, Pieniak and Verbeke (2008) and Verbeke and Roosen (2009) found that the best-before date was the most important quality

cue for fish consumers. The price was the only package information that was more important. More than 80% of consumers thought the best-before date was very important.

### **Frozen**

Fish may be frozen once or several times in the distribution channel before it is sold as unfrozen. In both the EU and the US, previously frozen seafood that is sold unfrozen must be labeled as such. The results for frozen is conflicting. On one hand, Dey et al. (2014) present scanner data results showing that frozen fish sales in the U.S. supermarkets were growing. On the other hand, Davidson et al. (2012) found that Hawaiian consumers were willing to pay less than half for previously frozen salmon, tuna, and tilapia compared to their fresh counterparts. This latter results may explain why some stores do not follow the labeling regulation for thawed seafood (Burros, 2008).

### **Nutritional labeling**

Fish farmers have the potential to alter the nutritional value of their fish in a way wild seafood producers cannot. Prepacked seafood products must be labeled with nutritional content in both the EU and the US. A US study by Kumar et al. (2008), found that nutritional information was not a major driving factor for consumption. A study of French consumers by Rickertsen et al. (2017), showed that most of the French consumers were aware that salmon is a fatty fish and cod

is not, and most of them saw fish as healthy food. However, to our knowledge, there has been no consumer research related directly to the labels of the nutritional content of seafood.

### **Feed colorants**

It is common to use color additives such as canthaxanthin or astaxanthin in the feed of salmon and trout to impart color to the flesh of the fish. Without the use of these color additives, the flesh of the farmed salmon and trout would be paler. In the US, it is mandatory to label farmed salmon that has received these colorants with a “color-added” label (Upton, 2015), while in the EU it is not. The US color-added labeling requirement is one of very few feed additives labeling requirements on consumer food products.

Because such color additives are expensive (Forsberg & Guttormsen, 2006), knowledge about how color affects the WTP is important. Steine et al. (2005) and Alfnes et al. (2006) investigated the effects of flesh color and information about the origin of the color in farmed salmon. They found that Norwegian consumers had strong preferences for salmon redness both before and after informing the consumers that the redness was due to synthetic colorants in the feed. However, the uninformed participants preferred extreme redness to normal redness, while those informed about the origin of the color did not.

## **Voluntary labels**

The variety and number of voluntary labels used on farmed seafood are growing. They are used by producers to differentiate their products from their competitors' products. All producers emphasized the product or process attribute preferred by many consumers. Smith et al. (2010) noted that the success of voluntary labels requires consumers who are willing to pay a premium to cover the costs. We reviewed voluntary labeling related to seven attribute groups.

## **Sustainability**

According to Bush et al. (2013, p. 1067), voluntary sustainability certifications are market-based systems that are: "(i) setting standards for ecological and social interactions, (ii) auditing compliance with these standards, (iii) attaching labels to products and enterprises that meet the standards, and (iv) creating institutions to perform these functions".

The most successful voluntary seafood label is the MSC label for sustainable wild seafood. As of May 2017, MSC had certified 312 fisheries worldwide and MSC-labeled seafood is sold by leading retailers around the world. Studies of sustainability labels of wild seafood have found positive effects on consumer preferences worldwide (e.g., Constance & Bonanno, 1999; Gulbrandsen, 2009; Jacquet & Pauly, 2007; May et al., 2003; Pérez-Ramírez et al., 2015).

Because the MSC label is used only for wild fisheries, aquaculture stakeholders have created their own sustainability labels. The MSC label is given to fish from specific origins such

as cod from the Barents Sea. The farmed seafood sustainability labels are given to producers. Two of the most widespread sustainability labels for farmed seafood are the Best Aquaculture Practices Certification (Best Aquaculture Practices, 2017) and ASC Certification (Aquaculture Stewardship Council, 2017). A few ecolabels, such as Friends of the Sea (Friends of the Sea, 2017), also certify both aquaculture and capture fisheries. In addition to these labels, a number of guides to responsible seafood are available, such as the consumer guide from the Monterey Bay Aquarium Seafood Watch program (Seafood Watch, 2017). For further discussion of the current programs for differentiating responsible aquaculture products, see Boyd and McNevin (2015).

The use of sustainability labels on farmed seafood is a relatively new practice; thus, there has been less research on this subject than on the sustainability of wild seafood. Roheim et al. (2012) found that northeast US consumers chose wild seafood products over farmed even when the farmed products were certified by an entity preferred by the consumer. Furthermore, existing aquaculture-specific labels for certified sustainable aquaculture were not well recognized, but had a small positive impact in the choice probability in a choice experiment. For more on consumer acceptance of sustainable production methods, see Barrington et al. (2010), who studied Canadians' acceptance of seafood products from integrated multitrophic aquaculture.

The few consumer studies on sustainable aquaculture indicate that aquaculture labels are far from getting the same recognition and positive attention as the MSC label; however,

sustainability labels for aquaculture may become as equally common over time as its wild seafood counterpart.

## **Organic**

To some consumers' surprise, organic seafood must be farmed. The EU introduced its regulation for organic aquaculture production on July 1, 2010. Before this date, organic seafood production was based on regulations in a few member states and some private initiatives. The EU regulation for organic aquaculture requires, among other things, that the feed is organically produced or derived from sustainably managed fisheries. The regulation also has lower limits for stock densities in fish cages, specify that biodiversity should be respected, and do not allow the use of induced spawning by artificial hormones (EC, 2009). Finally, there are many species-specific regulations. For example, astaxanthin, which is an important antioxidant for salmon and also gives the red color of the salmon, should be derived from natural sources, such as organic shrimp production, the yeast *Phaffia rhodozyma*, or certain bacteria (IFOAM, 2014). These sources of astaxanthin are more costly and less efficient than the synthetic sources used in conventional salmon farming.

The USDA National Organic Program is in the process of developing organic practice standards for aquaculture in the US. Specific labeling guidance will be detailed after these standards are implemented (Jalonick, 2015b). A specific labeling guidance was proposed in 2016

(USDA, 2016). The National Organic Program provides federal legislation regarding organic food in general, which is codified in the Code of Federal Regulations (National Organic Program, 2000). In 2012, the EU and the US agreed that any organic product produced in the EU or the US could be sold in each other's area (United States Mission to the European Union, 2015). However, the US has so far not had any certified organic seafood to sell because of the lack of organic labeling for seafood.

Aarset et al. (2004) reported that focus group participants in several European countries said they would buy organic seafood if available to avoid the negative aspects of conventional seafood. Olesen et al. (2010) studied Norwegian consumers' WTP for organic salmon, and found a WTP of less than half of the conventional salmon. They explained the low WTP for organic salmon was because of its much paler color. Comparing organic-labeled salmon with conventional, but equally pale, salmon, the consumers were willing to pay approximately 15% more for the organic salmon.

Organic regulations on feed and production processes make organic production considerably more expensive than convention aquaculture or wild harvest for many species. In addition, the price premiums consumers are willing to pay for organic seafood seems to be relatively modest compared to other attributes. Therefore, organic seafood will face tough competition from eco-labeled wild and farmed seafood, and will likely be a small niche product for most species in the years ahead.

## **Animal welfare**

Many consumers are concerned about animal welfare in food production; however, farmed seafood is not among the animals that most consumers worry about. In the special Eurobarometer survey on animal welfare in 2005, respondents in the EU ranked farmed seafood as the third least important of 12 farmed animal groups to receive improved welfare or protection (Eurobarometer, 2005).

Seafood animal welfare labeling is done by third-party organizations, such as the British animal welfare organization, the Royal Society for the Prevention of Cruelty to Animals (RSPCA). The RSPCA have a farm assurance and labeling scheme called Freedom Food, which certifies British producers of meat and farmed seafood (Royal Society for the Prevention of Cruelty to Animals, 2017). The organization has guidelines for farmed salmon (Freedom Food, 2017). Olesen et al. (2010) examined Norwegian consumers' WTP for Freedom Food-labeled salmon in an experimental market. They found that consumers were, on average, willing to pay approximately the same premium for the Freedom Food-labeled salmon as for organic salmon, when compared with conventional salmon of similar appearance.

Schwedler and Johnson (1999, 2000) found that consumers paid attention to the health and well-being of farmed seafood, especially concerning proper farm planning and management. Grimsrud et al. (2013) found that Norwegian households were willing to accept tax increases for

animal welfare improvements in farmed seafood. Ellingsen et al. (2015) found that Norwegians cared about seafood welfare and were willing to pay a price premium for products made from welfare-assured seafood. Kole et al. (2008) found that although Dutch consumers were willing to pay a price premium for welfare-assured salmon, the purchased quantities were reduced when the price increased. In a US study, Swanson and Mench (2000) found that less than half of the respondents were prepared to pay a small premium for animal-friendly products. Solgaard and Yang (2011) found that about half of the Danish respondents were willing to pay a premium for farmed seafood with animal welfare traits.

However, generalizations about consumer behavior across markets should be made cautiously as demonstrated by the results obtained by Honkanen and Olsen (2009), who concluded that seafood welfare issues did not seem to be important among Spanish consumers. Other studies conclude that most consumers do not perceive animal welfare as their own responsibility (Te Velde et al., 2002). Instead, consumers considered it the responsibility of the retailers to secure animal-friendly production of their foods and that of governments to adopt appropriate animal welfare laws (Ellingsen et al., 2015; Te Velde et al., 2002).

### **Fair trade**

Recently social equity in fisheries has been the subject of increased concern with suggestions that seafood cannot be certified as sustainable if its production results in social harm, such as

unfair wages or the use of forced or child labor (McCleachan et al., 2016). Therefore, several ecolabels available for farmed seafood include “socially responsible” as part of their labeling regime. In addition, the fair trade label used in agriculture can also be used by seafood producers who want to signal that they produce in a socially responsible manner.

McCleachan et al. (2016) conducted a choice experiment with restaurants that were labeled with MSC sustainability label, local origin, and/or fair trade. They found that US respondents had a WTP for fair trade, but it was lower than the WTP for local origin and the MSC label. Brécard et al. (2012) studied ecolabels, fair trade, and health labels on seafood and found that French consumers’ preference for ecolabels were positively associated with fair trade labels.

Several reasons may explain why we are not likely to see many fair trade-labeled farmed seafood products. First, social responsibility is already covered by system-wide sustainability labels and these labels are likely good enough for the retailers. Second, consumers see other sustainability dimensions as more important. Third, consumers associate the fair trade label with products from developing countries; this makes it likely that the fair trade label would be a liability for seafood products.

## **Safety**

Food safety is one of the most crucial factors in explaining consumers’ choice of food (Lusk & Briggeman, 2009). Wessells and Anderson (1995) found that Rhode Island consumers were

willing to pay for inspection assurances regarding food safety for flounder. Pieniak and Verbeke (2008) found that consumers in five European countries considered labeling as an essential guarantee for safe seafood. They also found that consumers correlated information on product safety with information on product quality. Jan et al. (2006) found that Taiwanese consumers were willing to pay a high premium for Hazard Analysis Critical Control Point (HACCP)-certified safer seafood.

Consumers use labeling information, such as origin, as proxies for food safety information about the seafood. Rickertsen et al. (2017) found that farmed seafood from developing countries were perceived as less safe than seafood from Europe. Thus, food safety is likely an underlying factor for consumers' use of several other labels.

### **Traceability**

Traceability is implemented in the value chain of many farmed seafood products (e.g., Norwegian and Scottish salmon), but it is seldom used as labels on consumer products. Some quality labels, such as the French Label Rouge (2017), guarantee that seafood with their label is traceable, but they do not offer consumers an easy way of tracing the products. An example of a well-developed consumer label on traceability is the Canadian "ThisFish" label for wild fish (ThisFish, 2017). By entering a code on their webpage, the consumers can trace the seafood back to its origin.

Pieniak and Verbeke (2008) studied consumers in five European countries and found that consumers were less interested in labels with a batch number that can be used for tracing than in the other labels included in the study. They found that consumers with a high trust in fish information also had higher interest in traceability information.

According to Jiang (2010), traceability systems are also used for some farmed seafood products in Asia. According to a consumer survey conducted by Wang et al. (2009) in Beijing, Chinese consumers view traceability programs as an important trait. Seventy-nine percent of their respondents stated they were willing to pay a premium for fish from a traceability program. This is not surprising because fish are sometimes sold with misleading information about country or water of origin in the Chinese market. Chen and Garcia (2016) reported that salmon from other countries were typically marketed as Norwegian salmon in Chinese markets. Fish is also sometimes sold with misleading species information. For example, Chinese farmed trout has been sold as imported salmon (Chinese Food Technology Net, 2014).

China is not the only country where seafood is renamed or relabeled (Jacquet & Pauly, 2008), and the use of traceability labels is an effective way to counteract the practices of renaming and relabeling in seafood trade and retailing.

## **Geographic indication**

Several existing geographic labels can also be used for farmed seafood. The EU schemes for geographical indications and traditional specialties, known as protected designation of origin (PDO), protected geographical indication (PGI), and traditional specialties guaranteed (TSG), promote and protect names of quality food products including fish, mollusks, crustaceans, and derivative products. Two of the farmed seafood products that have received PGI status are Scottish farmed salmon and Marennes-Oléron oysters. The EU schemes come on the top of similar national schemes in several European countries. Long before the Marennes-Oléron oysters received the PGI status in 2009, Charles and Paquotte (1999) found that French consumers were willing to pay a price premium for oysters certified with a Marennes-Oléron label. To the best of our knowledge, no research is available on the effect of EU's PDO, PGI, and TSG schemes on consumer preferences or WTP for farmed seafood.

Another example of a geographic indicator is the "Seafood from Norway" label, which is owned by the Norwegian Seafood Council (NSC), and can be used on seafood from Norway. According to the NSC, "The country of origin mark 'Seafood from Norway' is a collective label that adds value across the Norwegian seafood industry" (Norwegian Seafood Council, 2017). However, no published research is available on consumers' perception of quality for seafood certified with the "Seafood from Norway" label.

## **Company brands and private labels**

Producers use company brands and retailers use private labels. The biggest retailers have private labels for several types of seafood. For example, the UK retailer Tesco sells many of its farmed seafood products under its own brand name, Tesco (Tesco, 2017). Several of the biggest producers have established company brands in different markets. For example, the world's biggest salmon producer, Marine Harvest, has a company brand called "Mei Wei" in the Chinese market.

To the best of our knowledge, no research is available on the effects of company brands and private labels focusing on farmed seafood. However, there are a few relevant studies of fish in general and wild seafood. For example, Wang et al. (2009) found that 78% of surveyed Beijing consumers said that brands affected their fish-purchasing decisions. Roheim et al. (2007), Sogn-Grundvåg et al. (2014), and Asche et al. (2015) found that seafood with national brands and upscale private labels were priced significantly higher than other products in the UK market. Consumer attitudes and WTP for company brands and private labels are likely to depend on the positioning of the producer and retailer, and also depend on how the specific products are marketed. Private labels such as Tesco Finest Salmon are likely to be significantly higher valued than company brands from less well-known producers.

### **Antibiotic-free**

The extensive usage of antibiotics in food production has sparked global concerns, particularly on the interplay between antibiotic-resistant bacteria in the food production and human medical sectors (Price et al., 2015). In April 2016, Norwegian salmon was labeled as antibiotic-free in the US market and US consumers were reported to prefer the more expensive antibiotic-free Norwegian salmon to other salmon (Mikalsen, 2016). However, no scientific research has been found on this topic.

### **The future of aquaculture labels**

In this section, we discuss some gaps in the knowledge and some emerging possibilities and challenges related to the labeling of farmed seafood.

### **Genetically modified feed and fish**

Genetic modification technologies are applied in two main areas of aquaculture. First, these technologies can be used to produce feed for fish. The EU and Norway are among the more restrictive regions on the use of genetically modified (GM) feed. In March 2013, there were 48 genetically modified organisms (GMOs) allowed for use in feed in the EU (Food Standards Agency, 2015). No countries have mandatory labeling requirements for meat or seafood coming from animals that have eaten GM feed (International Service for the Acquisition of Agri-Biotech

Applications, 2015). However, organic labeling schemes typically do not permit the use of GM feed.

Second, genetic modification technologies have been used to engineer GM salmon. To date, the AquaAdvantage salmon, which was developed by the US company, AquaBounty, is the only GM animal that has been approved for human consumption (Jalonick, 2015a). AquaBounty applied to the FDA for approval in 1995, and the FDA decided that the GM salmon was safe to eat in 2010 (Ledford, 2013). On November 19, 2015, the FDA decided that there was no biologically relevant difference in the nutritional profile when comparing the AquaAdvantage salmon with other farmed Atlantic salmon. For that reason, the FDA also decided that there was no requirement for the AquaAdvantage salmon to be labeled as GM in the US. However, even with US regulatory approval, the success of this GM salmon is questionable. According to Bloomberg Business (2014), 65 US supermarkets have signed a pledge not to sell it.

Studying consumers' WTP, Chern et al. (2002) reported premiums between 41% and 67% for conventional farmed salmon relative to GM-fed and GM salmon in the US and Norway. Several studies have also investigated attitudes toward labeling of transgenic salmon. Qin and Brown (2006) used focus groups in the US, Nep and O'Doherty (2013) used a deliberative public forum in Canada, Amin et al. (2014) surveyed Malaysian stakeholders, and Bremer et al. (2015) conducted workshops with aquaculture stakeholders in northern Europe. All found strong support for mandatory labeling to facilitate informed consumer choices.

## **Health**

It is possible to alter the nutritional composition of farmed fish through feeding practices. For example, the quantity of omega-3 in salmon depends on the feed. Recent research suggests that some farmed seafood is rich in long-chain omega-3 (Nichols et al., 2014; Nichols et al., 2002; Nichols et al., 2010; Tacon & Metian, 2008). Nichols et al. (2014) found that Australian farmed Atlantic salmon (*Salmo salar*) and barramundi (*Lates calcifer*) have higher long-chain omega-3 content than the same species from the wild. This provides an opportunity for the seafood industry to label some seafood with a nutrition label, for example, an omega-3 label.

## **Carbon footprint**

The carbon footprint of seafood depends on production method, transport, and consumption patterns. At the production level, the carbon footprint of farmed salmon is comparable to that of chicken, and only one-tenth of the footprint of beef (Ziegler et al., 2013). Many consumers are concerned about the environment, and differences in greenhouse gas emissions from seafood production are likely to affect consumers' preferences and attitudes toward different seafood. Preliminary research by Loose et al. (2013) found that a carbon zero claim has a negative impact, strangely, on Australian consumers' preference for oysters. Future research on this issue is of interest.

### **Total environmental impacts**

Labels have not been developed related to all the environmental impacts of seafood farming. For farmed seafood, labels only certify the production units that have produced the seafood; e.g., a specific farm or company. However, the aggregate impacts of multiple farms in one location have rarely been evaluated by labeling organizations (Belton et al., 2010). For example, these effects could be related to effects on the surrounding agricultural land or effects on mangrove conservation (Bush et al., 2010). Furthermore, seafood labels that certify at farm level typically do not consider the environmental impacts from seafood processing (Vandergeest, 2007). In addition, labels typically do not consider the environmental impacts of nonmarine feed inputs, including soy and wheat (Bush et al., 2013). Finally, the environmental effects of distribution and transportation of seafood are typically neither considered nor evaluated by labels for farmed seafood (Bush et al., 2013). Labels based on life cycle analysis from feed to table would give a better assessment of the total environmental impact of farmed seafood.

### **Interaction effects of labels**

Most of the research has been on the effects of a single label on consumer demand and WTP (Chen et al., 2015; Roheim et al., 2011; Roheim et al., 2012; Ward & Phillips, 2009; Wessells et

al., 1999). In the marketplace, multiple labels are frequently presented simultaneously, which is likely to create complex trade-offs for consumers.

Uchida et al. (2014) explored direct and interaction effects of seafood ecolabels with other commonly used seafood labels, and found moderate interaction effects between ecolabels and country of origin labels. In particular, they found the most positive effects of labeling on ecolabeled Chilean farmed salmon, suggesting that an ecolabel may be most effective when it is used on seafood from commonly perceived poor-practice countries. Chen et al. (2015) found significant interaction effects between negative environmental information and the labeling of farmed and wild fish. For example, negative environmental information about cod farming decreased the WTP for ecolabeled as well as unlabeled farmed salmon.

Interactions between various label types and between labels and other types of information available to the consumers are an important topic for future research.

### **The role of governments**

The development and implementation of new government labeling schemes, particularly balancing mandatory and voluntary approaches, are usually complex and often time consuming (Saner, 2008). Governments make important information available through mandatory labels. Given that voluntary labels tend to certify only positive attributes, there is still a demand for

mandatory labels that provide information regarding negative attributes, such as the content of heavy metals.

Governments can play an active role in building credibility and assurance for labels among the consumers (Uchida et al. 2014). As Wessells et al. (1999, p. 1084) noted, factors that affect consumer acceptance of ecolabels include: “(a) the credibility of the agency providing a label or certification, (b) consumers’ understanding and perception of the link(s) between product choices and environmental impact, and (c) an accurate and clearly understood meaning of the certification.” Governments supporting a label can help with the first of these items, the credibility of the agency providing the label.

The coexistence of multiple seafood guides and labels covering more or less the same attributes may confuse consumers if they do not use identical standards or come to different conclusions (Roheim, 2009). The confusion resulting from different standards can affect consumers’ trust in labels. There are mixed results concerning consumers’ current trust levels in seafood labels. For example, Chen et al. (2015) found that French consumers’ WTP for ecolabeled seafood declined after being informed about the negative environmental impacts of fisheries and aquaculture, while Arijji (2010) found that Japanese consumers’ WTP for ecolabeled seafood increased under similar conditions. Government-supported industry-wide standards would reduce this confusion, and would likely increase consumers’ trust in farmed seafood labels.

Finally, for some attributes, governments should also consider establishing credible voluntary certification schemes and labels across several countries. Examples of such schemes are the European organic label and the EU–US agreement to accept each other’s organic products (United States Mission to the European Union, 2015).

### **The role of international organizations**

Both the Global Aquaculture Alliance (GAA) and ASC certify producers that comply with their standards for responsible aquaculture. It is worth noting that while the MSC considers the entire stock of one specific species in one area, e.g., Barents Sea cod, the GAA and ASC certify specific producers. The certification of specific producers gives a potential for including producer-specific attributes in future criteria for these labels; e.g., a particular company’s organic aquaculture practice across its farms in different countries. No research has so far investigated the potential effects of such labels on consumer preferences.

### **Fraud**

NOAA Fisheries’ FishWatch points to three types of common seafood fraud. Seafood substitution, seafood mislabeling, and seafood short-weighting (FishWatch, 2015). The first two types of fraud are related to the labeling issues discussed in this paper.

Once the fish is filleted and skinned, its species can be difficult to determine. Sellers can take advantage of this and substitute a low-valued species for a more expensive one (Maxwell, 2015). In a study by the ocean conservation group Oceana, this type of seafood fraud was found in one-third of the 1,215 samples taken in 21 US states. Typically cheap fish species like tilapia were sold as more expensive but similar-looking fish species like red snapper (Warner et al., 2013). Such fraud makes it difficult for consumers to avoid eating fish species that for some reason they would like to avoid; e.g., due to farming practices associated with one type of fish.

The second type of fraud that is relevant for this paper is mislabeling of other attributes of the seafood (Jacquet & Pauly, 2008). Many of the discussed labels represent credence attributes, where consumers are not able to detect whether they have obtained what is claimed on the label. Examples include changing the country of origin to avoid taxes or to increase consumers' WTP, or selling farmed as wild fish to increase profits. For a review and discussion, see Jacquet and Pauly (2008).

A more recent version of fraud is misuse of sustainability labels. There has been extensive media coverage since the Guardian (2014) reported on the use of Asian slave labor in the production of prawns for supermarkets in the US and UK. Much of these prawns were sold with the GAA Best Aquaculture Practices certification. Media coverage of negative aspects of farmed seafood production such as use of slave labor, contamination of the seafood, animal welfare

problems due to lice and environmental problems can erode the confidence of buyers' in sustainability labels (Chen et al, 2015).

Better international tractability systems for seafood are required to reduce the level of seafood fraud. Furthermore, stakeholders in the seafood value chain must start requiring traceability documentation.

### **Inclusion of stakeholders in developing countries**

The exclusion of smallholders, particularly in developing countries, needs to be addressed from two perspectives. First, stakeholders from developing countries are typically excluded when labeling standards are established because of problems related to, e.g., language, access, cost, time, or resources (Bush et al., 2013). Consequently, local understanding of agroecology and the social dimensions of environmental equity and justice have not been considered (Vandergeest, 2007). Second, because of the complexity and substantial costs of certification, smallholders in developing countries cannot establish new labels or obtain the rights to use existing ones without external support. Consequently, these smallholders are excluded from lucrative markets in developed countries that require certain labels and certifications (Bush et al., 2013). The affected stakeholders include small aquaculture farms and enterprises, collectors, small-scale traders, brokers, and input suppliers (Bush et al., 2013).

Developing support networks that allow aquaculture smallholders, especially in developing countries, to obtain the necessary certification for labeling will improve their business opportunities and economic viability. Both governments and international organizations can play a role in developing these support networks.

### **Concluding remarks**

Labeling differentiates farmed seafood products in an increasingly international and competitive seafood market. Labels that are well perceived by the consumers are likely to increase the profitability of the labeled seafood, while labels that are not appreciated by the consumers will incur costs to producers that cannot be recompensed in monetary terms.

Most recent research is related to the effects of voluntary rather than mandatory labels. This focus on voluntary labels does not indicate that mandatory labels are less important or less useful. On the contrary, a number of studies have found that consumers use information provided by mandatory labels related to species, country of origin, or production method (farmed or wild-caught) to infer the unobserved levels of product quality.

The role of mandatory labels is to ensure that essential information is provided to the consumers. Voluntary labels supplement mandatory labels and provide information on attributes that some consumers desire but cannot be observed without a label. Important examples include organic and animal welfare. By providing information on desirable attributes, voluntary labels

influence consumers to the extent that producers and retailers can obtain price premiums. However, because voluntary labels are largely driven by the self-interest of the industry, voluntary labels only certify attributes that have a positive impact on consumer preference. Attributes with a negative impact, e.g., heavy metal content in seafood, will not be labeled voluntarily.

Aquaculture producers can use successful labels from agriculture, such as country-of-origin and organic labeling, and copy successful labels from wild fisheries, such as the MSC label. The voluntary labels appreciated by large consumer groups will prevail over time and set the industry standards, while other labels will only be found on niche products.

To the best of our knowledge, several important topics related to farmed seafood labeling have not been investigated in any detail. These topics include WTP for an antibiotic-free label, usage of a nutritional label, a carbon footprint label, a total environmental impact label, interaction effects of labels, and labels related to the contents of negative attributes such as heavy metals in farmed seafood. Future researches on these topics are encouraged.

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