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Eco-Certification in Aquaculture – Economic Incentives and Effects

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ABSTRACT

In recent years, eco-certification has become an important market feature for aquaculture products, with several labels available for producers who want to signal sustainable or responsible production practices. In this study, the literature on the economic effects of eco-certification of aquaculture is reviewed to summarize the current state of knowledge and identify research gaps. The literature to date primarily focuses on Europe, the Aquaculture Stewardship Council (ASC) certification scheme, and salmon products, but there are also insights into other markets and species. Consumer surveys indicate a preference for eco-labeled aquaculture products in most cases but with significant variation in the strength of the preference across markets and species. In addition, eco-labels for farmed products may decrease the preference gap often found between wild and farmed aquaculture for some species. Other factors like geographical origin influence perceived premiums more than eco-labeling. For producers, evidence of price premiums is inconclusive, suggesting non-monetary benefits like improved market access and production practices as motivators. Certification can be costly, particularly for smaller businesses and in developing countries.

KEYWORDS

Aquaculture; certification; economic effects; literature review; price premiums

Introduction

Rapid innovation, productivity growth and increasing global demand for aquatic products have made aquaculture an important part of seafood production (Asche et al. 2022: Naylor et al. 2023). The sector has now overtaken wild fisheries as a source of seafood for human consumption as it accounted for 57 per cent of global consumption in 2022, and its growth has fueled a significant increase in per capita seafood consumption from 9 kg in 1961 to 20.7 kg in 2022 (FAO 2024). There are also several environmental concerns associated with the sector (Naylor et al. 2021) impeding growth in some markets (Bronnmann and Asche 2017), and there is an increasing focus on sustainability also in the social dimension (Garlock et al. 2024). For firms with sustainable or responsible production practices, certification is a tool to overcome market challenges if consumers prefer sustainable products. Therefore, certification plays an important role in responding to the changing consumer landscape that increasingly emphasizes sustainable production practices (Belton et al. 2020).

Eco-certification and eco-labeling have emerged as significant tools for promoting sustainable aquaculture practices and ensuring the responsible management of aquatic resources (Bush et al. 2013; Vince and Haward 2017). An ecolabel provides a signal that products have been certified to be sustainable, thereby meeting the environmental and/or social standards necessary to obtain the label.[1] While the concept of sustainability is complex and not always clearly defined, leading to the availability of many different standards (Roheim et al. 2018; Osmundsen et al. 2020; Alfnes, Chen, and Rickertsen 2018), seafood buyers may still prefer sustainable options. When seafood buyers prefer sustainable seafood and choose labeled products, it increases the demand for sustainable products while decreasing the demand for non-certified and, presumably

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[1]For various reasons, including the numerous definitions of sustainability, most certification schemes currently use terms such as responsible rather than sustainable, and as they certify wider behaviors the term "eco-" is dropped from the eco-label. In this article the terms sustainability and eco-certification will be used as this is the common terminology in the academic literature.

unsustainable, ones (Roheim et al. 2018). This increased demand is expected to result in higher prices for sustainable products, and in some cases producers will have access to the highest-paying markets or outlets only if they can document sustainable production practices, creating a premium associated with market access. If the price premium consumers are willing to pay exceeds the additional costs of implementing more sustainable production methods, it serves as a strong motivation for adopting these production methods.

While ecolabeling may promote sustainable aquaculture production, its adoption faces several challenges. The cost and complexity of certification processes, the cost of compliance, and the potential for market fragmentation (e.g. numerous labels causing confusion among consumers) are hurdles that prevent the adoption of eco-certification by aquaculture producers, especially small-scale and developing country enterprises (Bush et al. 2013).

There is significant literature documenting the effects of eco-certified marine fisheries (see e.g., Ward and Phillips (2009) for an early example and Arton et al. (2020) for a more recent literature review of Marine Stewardship Council (MSC) certification). There is less documentation about the effects of eco-certified aquaculture, primarily because eco-certification became an important tool at a later stage. For instance, while the MSC label was introduced in 1997, the ASC (Aquaculture Stewardship Council)-label was not established until 2010 (Asche et al. 2021). Still, in recent years, there has been a growing interest as the number of certified aquaculture facilities has increased and certification of sustainable or responsible production practices has become more widely available.

In 2016, which is the year of the latest published global survey, approximately six percent of global aquaculture production (16% excluding China) was certified by the six main certification initiatives available at the time (Potts et al. 2016). At the time, the largest certifiers were Good Aquaculture Practices (GLOBAL G.A.P), which had certified around three percent of the production, and ASC, which had certified around one percent. In addition, Global Seafood Alliances Best Aquaculture Practices (GSA-BAP) and Friends Of the Sea (FOS) are important certifiers of aquaculture (Potts et al. 2016; Saha 2022). It is worth noting that GLOBAL G.A.P certification differs from other certifications since it is mainly a producer-to-producer certification, where labeling final products with information for consumers is not a significant component. As the use of certification schemes has increased there has also been interest from policymakers, e.g., in the European Union (Carlucci et al. 2017) to support sustainable aquaculture. The number of certified producers is increasing indicating that the share of the global aquaculture production that is certified in 2024 is higher than in 2016, but there are no published figures available.

Previous reviews of eco-certification and eco-labeling in aquaculture have focused on environmental effects (Rector et al. 2023; Jonell et al. 2013). Additionally, the economic effects of organic aquaculture (Gambelli et al. 2019) has been reviewed, revealing that organic aquaculture is costly, standards vary, and consumer knowledge of these standards is limited. Organic certification was initially used to offset the competitive advantage of eco-certified wild fish before eco-certification for aquaculture products became available (Asche et al. 2015; Saha 2022). It should be noted that there is no clear definition of what constitutes an eco-label, and that organic certification can also be considered as a type of eco-certification.[2] The approach of Saha (2022), who distinguish between organic and nonorganic aquaculture certification, is followed here and the focus is on the latter type of certification, while recognizing that there are other definitions. For instance, the EU reserve the word eco- in a food production context for organically produced food, while in the U.S. the organic labeling scheme does not encompass farmed fish. More generally, the definition of sustainability (or responsible production practices) differs between different certification schemes (Osmundsen et al. 2020). Moreover, eco-labels are increasingly providing information beyond environmental sustainability as they are extended to other desirable production practices. For example, ASC standards include criteria not only on environmental sustainability but also on food safety, community welfare and animal welfare (Bronnmann and Hoffmann 2018).

This study contributes to the literature by investigating the economic consequences of certification in aquaculture. The study begins by mapping the literature discussing the economic effects of eco-certification of aquaculture, adopting an approach influenced by Arton et al. (2020). Focus will be on exploring reported economic effects, at both the consumer and the producer levels. At the consumer level, preferences, and price premiums associated with eco-labeled

[2]The use of antibiotics and therapeutics is normally not allowed in organic aquaculture but is used in nonorganic aquaculture (Saha, 2022).

aquaculture products are discussed and related to various related topics. At the producer level, the focus will be on economic effects such as the costs of certification, producer price premiums, and other benefits.

Studies focusing on certification related to e.g., animal welfare, health issues or traceability are excluded. While organic certification may have been a precursor to the non-organic certification schemes, this is covered in Gambelli et al. (2019) and falls outside the scope of the current study. Nonorganic eco-certification schemes have become more important since the 1990s and have been supported by major international food retailers (Saha 2022). Finally, the review identifies gaps in the literature.

Literature review

The search and screening of literature is described in the Appendix, and Table A1 summarize the articles that this review is based upon.

Most studies investigating the economic impacts of ecolabels are quantitative (see Table A1 in Appendix A). Half of the quantitative studies, i.e., eleven studies, use Choice Experiments (CE), where data were collected by letting respondents pick their most preferred alternative among several discrete alternatives with different attributes. Other quantitative methods include demand analysis, expenditure analysis, and contingent valuation (CV). Only one study used revealed preference techniques to estimate price premiums, i.e., actual observed data on behavior are used, and in this case, a hedonic price function is estimated. Nine studies use a qualitative approach, but several studies mention qualitative pre-studies.

Most studies focus on eco-labeling targeted at consumers. ASC, a certification program that targets consumers, is the most studied certification scheme, despite GLOBAL G.A.P, a producer-to-producer certification scheme, covering a larger part of global production (Potts et al. 2016). Many studies do not focus on a specific scheme but use a hypothetical scheme (10 studies). This is because eco-certification for aquaculture products becoming available only recently, even though interest was significant due to the certification of wild fish (Roheim et al. 2018).

Studies covering Norwegian aquaculture are well represented, as well as those from the UK and Germany. Moreover, various other European countries, including Ireland, Italy, France, Denmark, Belgium, the Netherlands, Sweden, and Spain, have been the focus of research. In contrast, studies exploring certification outside of Europe are scarcer in the current body of literature. Studies that cover Asian countries include three from Japan and three from Vietnam. From North America, there are four from Canada and three from the US. All South American studies are from Chile.

Most research focuses on salmon, with all Norwegian studies exclusively centered on this species. This aligns with the farms certified, e.g., out of more than 1000 farms certified by ASC, 554 are producing Atlantic salmon (ASC 2023). Additionally, studies cover other species such as shrimp, trout, tilapia, sea bream, pangasius, and oysters. Notably, there is only one study about non-fed aquaculture (oysters), and six studies are about no specific aquaculture species. The studies seem to reflect where there is demand for eco-labeled products rather than where the production takes place, and it is notable that while around 90% of the global aquaculture production takes place in Asia (Garlock et al. 2023), there is little focus on eco-labeling in this region.

Topic categories

To frame the discussion of the literature, it is divided it into consumer and producer effects. Five topic categories are defined to explore consumer-related effects, namely, preferences for eco-labels (1), price premiums that consumers are willing to pay (2), price premiums of eco-labeled aquaculture products compared to other eco-labeled products (3), price premiums on eco-labels compared to other labels and attributes (e.g. size, freshness) (4), and consumer characteristics (e.g income, age, gender) and knowledge (5). The questions to answer are as follows:

1. Are eco-labeled aquaculture products preferred to non-labeled products?
2. How significant are the price premiums for eco-labeled aquaculture products?
3. How does the price premium associated with eco-labels compare to the price premiums of eco-labels on other products?
4. How does the price premium associated with eco-labels compare to the value of other attributes (including other labels)?
5. How do consumer attributes and consumer knowledge impact the value of the eco-label?

The first two questions explore how consumers perceive and value eco-certified aquaculture products. The third and fourth questions focus on how eco-labeled aquaculture products perform when compared to other product types and attributes. Eco-labeled

aquaculture products may be compared to eco-labeled wild-caught fish or alternate substitute products, such as eco-labeled meat. Additionally, the significance of eco-labels vis-à-vis other attributes like country of origin, package size, or product form is examined. Lastly, the final question investigates consumer disparities in the valuation of eco-labeled aquaculture products. This includes an exploration of the differential willingness to pay for eco-labels among various consumer segments and the influence of aquaculture production knowledge on valuation.

Subsequently, the economic implications at the producer level are investigated. This assessment focuses on three key topic categories: producer price premiums, additional economic benefits, and certification costs. While producers may realize direct benefits from price premiums in the primary market when certified, they will also incur certification costs. There may also be benefits other than price premiums that give producers incentives to pay for certification.

Impacts of eco-certification

This section first presents findings of consumer valuations of eco-labeled aquaculture products followed by producer-level effects.

Consumer-level effects

When investigating consumer preferences for eco-labeled products, typically, the methodology relies on data collected from surveys or questionnaires. Commonly, choice experiments are conducted, where participants are exposed to products with different attributes and asked to choose their most preferred product. In these studies, labels are regarded as attributes of the products (e.g., Risius et al. 2017; Roheim et al. 2012; Xuan 2021; Uchida et al. 2014; Onozaka et al. 2023). There are also a few studies investigating price premiums using market data (Asche et al. 2021; Gulbrandsen et al. 2022).

Preferences for eco-labeled aquaculture products

In most cases, consumers are found to prefer eco-labeled over non-labeled aquaculture products. Risius et al. (2017) report that German consumers are likely to opt for eco-labeled farmed trout compared to unlabeled trout when presented with the two alternatives. Banovic et al. (2019) find an increased probability of a product being selected when the ASC label is present, based on surveys conducted across five European countries. Onozaka et al. (2023) report a general preference for ASC-labeled salmon among consumers in the USA, France, and Japan, and Uchida et al. (2014) find a significant rise in the likelihood of Japanese consumers purchasing eco-labeled salmon. In the Chinese context, Meng et al. (2023) reveal consumer intentions to increase purchases in response to aquaculture products attaining certification in Shanghai.

But, despite consumers revealing preferences for eco-labeled products over unlabeled ones in most cases the type of certification agency may matter. Roheim et al. (2012) reveal that informing US consumers about the certification of farmed shrimp and salmon does not increase their likelihood of choosing these products unless accompanied by the specific detail that the certification is endorsed by a government agency or an environmental organization. Merely stating that a product is certified without this additional context does not significantly impact consumer choices (Roheim et al. 2012). Similarly, Bronnmann and Hoffmann (2018) found no increase in the probability of purchase when an ASC label is added to a turbot in a study of consumers in two regions in northern Germany.

Price premiums on eco-labeled aquaculture products

Price premiums show how much consumers are willing to pay for eco-labeled aquaculture products compared to conventional products (i.e., price premiums). Table 1 presents price premiums for eco-labeled aquaculture products.

Most price premiums are for salmon (seven) and all calculations (except from Vietnam) use data from developed countries. Roheim et al. (2012) report that price premiums for certified salmon in the US ranged between $6.67 and $8.19 per pound (approximately between €2.80 and €3.50 per kg). This is in line with the price premiums calculated from information about the percentage price premiums from Hynes et al. (2019), and Uchida et al. (2014) reported in Table 1. Results in Bronnmann and Asche (2017) deviate somewhat from the other studies as they show that consumers in Germany would be willing to pay up to €4.60 more for ASC-labeled salmon in 250-gram packages (which corresponds to a kilo price of €18.40). The package size presented to the consumers is relevant, as smaller package sizes usually generate higher kilo prices in retailing (Asche et al. 2021).

Table 1. A summary of monetary or percentage premiums for eco-labeled products.

Study	Geographic Location	Species	Price premiums (€)
Bronnmann and Asche (2017)	Germany	Salmon	€3.71–€4.60 more per 250 g package
Hynes et al. (2019)	Ireland & Norway	Salmon	€3.52 more per kg in Ireland, €6.45 more per kg in Norway. Price premium of 22% in the Irish case and 41% in the Norwegian case.
Uchida et al. (2014)	Japan	Salmon	22%–44% price premium
van Osch (2017)	Ireland	Salmon	€1.72, €3.65, and €9.26 for 10%, 20% and 30% more sustainably produced salmon, respectively
van Osch (2019)	Ireland, UK, Italy, Israel, Norway	Salmon & Sea Bream	€2.45, €4.16, and €6.89 per kg of product that is 10%, 20% or 30% more sustainable, respectively
Roheim et al. (2012)	USA	Shrimp & Salmon	$6.67–$8.19 more per pound of salmon, (€2.80 and €3.50 per kg) $3.08–$3.18 more per pound (€1.08 and €1.11 per kg). of shrimp‡
Bronnmann and Hoffmann (2018)	Germany	Turbot	No significant effects
Xuan (2021)	Vietnam	Shrimp	6–51% price premium
Asche et al. (2021)†	Germany	Rainbow trout, Pangasius and Tilapia	9% price premium on rainbow trout, 6% on pangasius, 6% on tilapia

†Note that Asche et al. (2021) is the only study using revealed preference techniques, i.e. where actual market data are used to estimate price premiums.
‡Using exchange rates for 201.

While the studies indicate that price premiums differ across countries, the study by Hynes et al. (2019) reports higher price premiums for eco-labeled salmon in Norway compared to Ireland. Similarly, Uchida et al. (2014) reveal that Chilean eco-labeled salmon commands a higher price premium in the Japanese market compared to eco-labeled salmon from Japan, Alaska, or Norway.[3] Uchida et al. (2014) attribute this preference to Japanese consumers valuing the eco-labeling of Chilean salmon for perceived safety, possibly influenced by news of disease outbreaks in Chile and the perception of Chile having poorer production practices.[4] Despite potential negative perceptions, the study suggests, in line with Bronnmann and Asche (2017), that an eco-label can offset negative perceptions.

Although most price premiums estimates are for eco-labeled salmon, there are also some estimates for farmed shrimp (Roheim et al. 2012; Xuan 2021) and turbot (Bronnmann and Hoffmann 2018). Roheim et al. (2012) find that for certified shrimp in Rhode Island, US, willingness to pay range between $3.08 and $3.18 per pound (equivalent to approximately €1.08 and €1.11 per kg) and Xuan (2021) find that Vietnamese consumers are willing to pay 6 to 51% more for eco-labeled shrimp, depending on the type of label. Finally, Bronnmann and Hoffmann (2018) find that there is no price premium for "hypothetically" ASC-labeled turbot in Germany.

The willingness to pay for labeled aquaculture products from Integrated Multi-Trophic Aquaculture (IMTA) systems, that are combining species like kelp, mussels, and salmon to reduce environmental impact, is also investigated (Barrington et al. 2010; Yip 2012; van Osch et al. 2017; van Osch et al. 2019). The products were not yet available for sale at the time of these studies. Barrington et al. (2010) conduct focus group discussions in Canada, revealing that 50% of the participants were willing to pay a 10% premium for labeled IMTA products (kelp, mussels, and salmon) compared to conventional ones. Yip (2012) finds a similar 10% price premium for eco-labeled salmon from IMTA in the US. Additionally, van Osch et al. (2019) demonstrate that there are price premiums for salmon farmed in IMTA systems, labeled as *sustainably produced*, not only in Ireland but also in the UK, Italy, Israel, and Norway, and extending to sea bream as well.

Comparing reported ex-ante price premiums to actual market prices is a limited field, with Asche et al. (2021) standing out. In cases like products from IMTA systems, where products are not sold, no market prices exist. Gulbrandsen et al. (2022) reveal that less than 15% of ASC-certified Norwegian salmon is sold with the ASC label, suggesting retailers doubt consumers' willingness to pay a price premium. Asche et al. (2021), employs retail data to estimate market price premiums for ASC-labeled rainbow trout,

[3]It should be noted that different species of salmon are produced in different countries, and targets different markets. While Atlantic salmon is produced in all countries with a significant salmon aquaculture industry (Pandy et al., 2023), several countries produce large, red-fleshed trout (Landazuri-Tveteras et al., 2021) and Chile also produce significant quantities of coho (Ceballos et al., 2025). The species is to a large extent targeting specific markets, and most of the Chilean coho is exported to Japan.

[4]Chilean salmon production is more impacted by diseases and other environmental challenges such as harmful algae blooms than other producer countries (Ceballos et al., 2025).

pangasius, and tilapia in Germany, finding an average premium of nearly nine percent for rainbow trout and six percent for pangasius and tilapia. Some retailers and brands show zero or minimal premiums, highlighting a decline with the average price level of the retail chain. In essence, while consumers express a willingness to pay premiums, the actual market situation may differ, with price premiums being more difficult to detect for high-end retailers.

Comparisons with eco-labels on other products

When eco-labeled products face close substitute products, the achievable price premium may be modest. Brécard et al. (2009) and Salladarré et al. (2010) suggest that consumers interested in eco-labeling often prefer wild-caught fish over farmed, potentially limiting the premium for eco-labeled farmed seafood.[5] Bronnmann and Asche (2017) propose that an eco-label could counteract negative perceptions associated with aquaculture. Comparisons of eco-labeled farmed salmon with wild-caught salmon in three studies (Bronnmann and Asche 2017; Roheim et al. 2012; Uchida et al. 2014) reveal a preference for wild-caught salmon in the absence of eco-labels, but the introduction of eco-labels increases consumer preferences for farmed salmon (Roheim et al. 2012) and raises its price premiums (Bronnmann and Asche 2017; Uchida et al. 2014). The ASC eco-label is also shown to compensate for the lower willingness to pay for non-labeled aquaculture compared to wild-caught salmon (Bronnmann and Asche 2017).

Beyond the context of salmon, there are few comparisons of price premiums of eco-labeled aquaculture products to other products. Roheim et al. (2012) find a preference for wild shrimp over farmed shrimp in the US, with consumer preferences for farmed shrimp increasing when eco-certified. Asche et al. (2021) note that price premiums for ASC-labeled pangasius, tilapia, and trout are lower than those reported for various MSC-labeled species. There is a lack of comparisons with eco-labeled non-seafood products from agriculture in the existing literature. Examining a broader range of products could provide insights into the relative willingness to pay for eco-labeled aquaculture products.

[5]In fact, many consumers are not aware that farmed salmon is the dominating product type in many markets. This is illustrated by the survey results from Fidra (2019) were half of the respondents thought that only 50 percent of the Scottish salmon sold in the UK was farmed (although the true rate was 100 percent).

Comparisons with other labels and attributes

While the primary focus is on eco-label premiums, it is crucial to recognize the significance of other attributes. Anderson and Bettencourt (1993) emphasize that attributes like freshness, product form, and package size, in addition to labels, impact pricing. Studies comparing various labels yield mixed results. Risius et al. (2017) find slight differences in German consumers probability to buy aquaculture products based on labels, with the organic label Naturland having the most significant effect. Xuan (2021) contrasts German and Vietnamese consumers, revealing a wide span of price premiums for different labels, from 6% for the Vietnamese label to 51% for the ASC-label.

Comparing ASC-labeling and MSC-labeling, Bronnmann and Asche (2017) report a willingness to pay one euro more for ASC-labeled salmon than for MSC-labeled salmon. Conversely, Bronnmann and Hoffmann (2018) find no price premium for ASC-labeled turbot but a €5 premium for MSC-labeled turbot. Overall, limited studies compare different labels, and existing findings are inconclusive. Varied results in Vietnam suggest substantial differences in label impact, while German studies indicate a lesser influence of labeling on consumer choices. When comparing ASC-labeling to MSC-labeling in Germany, results vary, possibly influenced by different species being considered.

Although price premiums associated with eco-labeling may be noteworthy, there may be many other attributes of a product that are important to consumers. Attributes such as country-of-origin, package size and product form (i.e., smoked, canned, fresh, or frozen) have been investigated in some of the studies selected. In the following, the valuation and price premiums for these attributes are discussed comparing them to the eco-labels under investigation.

Consumers often prioritize the geographical origin of products over eco-labeling (Risius et al. 2017; Gulbrandsen et al. 2022; Uchida et al. 2014; Banovic et al. 2019; van Osch et al. 2019; Onozaka et al. 2023). For instance, Risius et al. (2017) find that consumers in Germany prefer trout from Germany or Denmark over Turkey, with country-of-origin influencing choices more than eco-labeling. In Norway, consumer trust in "Norwegian Salmon" surpass trust in the ASC-label (Gulbrandsen et al. 2022). Similarly, Uchida et al. (2014) observe that, for Japanese consumers, the price premium for an eco-labeled salmon (26%) is comparable to the premium for salmon being from Japan rather than from Chile (27%).

While few studies explore attributes beyond country-of-origin, Asche et al. (2021) find that price premiums for different product forms often exceed those for eco-labeling. For example, the premium for smoked and canned tilapia was 50%, and fresh trout instead of frozen, there is a price premium of 33%. This can be compared to the price premiums of the eco-label that is 6 and 9%, for tilapia and trout, respectively. Freshness (fresh compared to frozen) influences the probability of purchase more for salmon than the ASC-label in a study by Bronnmann and Asche (2017). Additionally, package size and the ASC label are considered more important than health and nutrition claims in Banovic et al. (2019). Furthermore, Onozaka et al. (2023) reveal that in Japan, the domestic origin of salmon holds greater importance than eco-labeling, while French consumers value eco-labeling more than domestic origin.

In summary, the studies underscore that attributes such as country-of-origin, product form, freshness, and package size can outweigh the influence of eco-labeling on consumer preferences and price premiums.

Knowledge and attributes of consumers

Some studies consider that consumers have varying knowledge about eco-labels (Bronnmann and Asche 2017; Bronnmann and Hoffmann 2018) and differing attitudes toward sustainably produced products, which influence their willingness to pay for eco-labeled products (Uchida et al. 2014; Hynes et al. 2019; Xuan 2021).

Bronnmann and Asche (2017) investigate how knowledge about the production practices required by the ASC certification scheme affects price premiums for eco-labeled salmon in Germany. The results indicate that after educating consumers about the production practices, the price premiums for ASC labeled salmon increased from €3.70 to €4.60 for a 250-gram package. For turbot, information about the ASC-label did influence consumers' willingness to pay (Bronnmann and Hoffmann 2018).

Xuan (2021) shows that consumers in Vietnam who believe that they can contribute to more sustainable aquaculture practices are willing to pay a price premium for eco-labeled shrimp. Similar findings are reported in Ireland and Norway by Hynes et al. (2019), where consumers who prioritize environmentally friendly salmon farming are more likely to pay a price premium for eco-labeled salmon (following the ASC standard). Hynes et al. (2019) also reveal that consumers who believe that there are aquaculture farms in their local area and who perceive sea lice from fish farms as having a negative impact on wild fish stocks are willing to pay more for eco-labeled salmon. Uchida et al. (2014) show that consumers are willing to pay price premiums for eco-labeling on the Japanese market only when consumers perceive information as credible or interesting. When consumers receive information that they do not find interesting or credible, the willingness to pay for eco-labeling decreases.

Lack of consumer knowledge about aquaculture production and eco-labeling is mentioned as an obstacle in many studies (Jonell et al. 2016; Gulbrandsen et al. 2022; Fidra 2019; Roheim et al. 2012; Risius et al. 2017). This lack of consumer knowledge poses a significant challenge in marketing ASC-certified salmon, contributing to non-labeled sales in the UK and Norway (Gulbrandsen et al. 2022).

Jonell et al. (2016) highlight the importance of consumer recognition and understanding of eco-labels, noting that consumers who recognize and understand these labels are more inclined to purchase eco-labeled seafood. Their study in Stockholm, Sweden, reveals that only 23% of respondents recognized the ASC-label. In addition, Fidra (2019) shows widespread unawareness regarding the farming of Scottish salmon and a lack of understanding about various eco-labels. For instance, 21% of consumers expressed disinterest in certification schemes, and 38% were content with any scheme without a specific preference. Furthermore, Roheim et al. (2012) find that consumers lacking knowledge about aquaculture production are more likely to purchase farmed salmon products but less inclined to choose certified farmed salmon products. Roheim et al. (2012) also find that simply stating that the product meets the standards of an eco-label does not affect the probability of buying salmon or shrimp in the US. Indicating that certification is either by a government agency or an environmental organization increases the probability.

As mentioned above, some studies use a hypothetical label to see how consumers react and value it compared to labels available at the market. In many cases, consumers state that they recognize the hypothetical label. In Risius et al. (2017), 60% of consumers acknowledge recognizing the hypothetical label used in the study. This can be compared to the 17% of consumers in Jonell et al. (2016) who state that they recognize a hypothetical label presented to them.

Wakamatsu and Miyata (2021) find that consumers are willing to pay more for ASC-certified oysters when they feared that oysters might be radioactively contaminated. Thus, ASC is seen as guaranteeing safety of the oysters although its wider purpose is to minimize the negative impact on the environment.

Some studies acknowledge that consumers are heterogeneous, and that average preferences or price premiums may disguise differences between consumers. The willingness to pay for eco-labeling could e.g., differ depending on characteristics such as age, gender, education, or family situation. Few studies investigate how consumer characteristics affect willingness to pay for eco-labeled aquaculture products.

Hynes et al. (2019) show that being a student, having few members in the household, eating fish at least once a week, partaking in coastal recreation, and having a high income positively affect the price premium for eco-labeled salmon in Ireland and Norway. In the Norwegian case, it is also found that women are willing to pay more for eco-labeled salmon, which contradicts the results in Roheim et al. (2012), who find that women and households having children younger than 8 years old are less likely to buy certified farmed salmon products. On the other hand, Jonell et al. (2016) find that demographic variables (age, gender, education, and number of children in the household) have little effect on the intention to buy eco-labeled wild and farmed seafood in Sweden.

Onozaka et al. (2023) show that salmon consumers are heterogeneous within the USA, France, and Japan. In the US, consumers valuing eco-labeling (ASC) the most (19% of their sample) are characterized by high environmental consciousness and low interest in food pleasure, measured through consumers valuing different statements about their eating habits on a Likert scale. Age and income levels do not significantly impact these US consumers. In France, consumers valuing eco-labeling the most (68% of the sample) are not environmentally conscious and have a low interest in food pleasure, but they are frequent buyers. Age and income levels do not significantly matter for these French consumers. Finally, in Japan, consumers who prioritize the ASC-label have higher incomes and are more frequent buyers. Environmental consciousness, food pleasure and age do not significantly influence this group in Japan.

Producer-level effects

While there may be price premiums at the consumer level for eco-labeled aquaculture products, it is uncertain if primary producers that are certified get a price premium. Since primary producers, in most cases, must pay to be certified, the benefits of certification must at least cover the costs of certification to be economically interesting. Therefore, it is important to investigate what the literature has to say about price premiums, other benefits, and costs of certification at the producer level.

Price premiums at the producer level

There is no study that uses producer prices to estimate potential price premiums obtained by certified aquaculture producers. The few studies addressing this topic are based on interviews with farmers and other stakeholders at different parts of the market. Ishihara et al. (2022) report that producers in Japan are unlikely to receive a price premium for ASC-certified products, with retailers not charging higher prices at the consumer level as the main explanation. For Norwegian salmon, producers that are interviewed express uncertainty regarding the existence of price premiums for certified Norwegian salmon (Olsen et al. 2021) and, in general, producers do not expect price premiums in the short run (Vormedal and Gulbrandsen (2020); Olsen et al. 2021)).

Thi et al. (2020) report that retailers pay a price premium of $ 0.1 per kg of shrimp produced by farms belonging to a cooperative in Vietnam. This is lower than stated in the contracts with the buyers, where a minimum price premium of 15% of the market price was stipulated. Another study from Vietnam find that ASC-farms charge higher prices for their products than similar non-certified farms, although it was unclear if the price premium was caused by the certification or if the higher prices had other explanations (WWF Austria et al. 2017).

Other economic benefits

Market access is mentioned in some studies as a benefit of being certified (Ishihara et al. 2022; Olsen et al. 2021; Weitzman and Bailey 2018), although this can be linked to a price premium if it entails access to better paying markets. For example, finfish aquaculture farms in Nova Scotia, Canada, expressed the belief that certification would increasingly become a pre-requisite for entering certain markets (Weitzman and Bailey 2018). In Norway, producers report experiencing pressure to be certified not only from their customers, but also from NGOs and other stakeholders (Amundsen and Osmundsen 2020).

Ishihara et al. (2022) describe that ASC-certification has opened up new and more stable distribution channels for Japanese certified products.[6] Gulbrandsen et al. (2022) find that many leading retailers require their salmon to be certified. Amundsen and Osmundsen (2020) argue that certification has become

[6]Similarly, Sogn-Grundvåg et al. (2019) report that MSC-certified whitefish has longer duration and therefore lower menu costs than unlabeled fish.

mandatory for many producers, not only to access markets but to obtain predictable contracts for high volumes of fresh produce. Thus, revenues may increase even if there are no price premiums since larger quantities can be sold when certified.

Olsen et al. (2021) report that, by obtaining ASC-certification, producers argue that they benefit from access to new markets and distribution channels. The benefits may also materialize in the future as increases in market shares for certified aquaculture products. Many aquaculture company representatives emphasize the importance of obtaining ASC or other certifications early to avoid missing out on the possibility to meet future consumer demands and gain market shares (Olsen et al. 2021). ASC certification thus serves as a learning opportunity to prepare the organization and production processes for stricter regulations in the future.

Some studies highlight the use of eco-certification to improve the reputation of aquaculture (Ishihara et al. 2022; Vormedal and Gulbrandsen 2020; Gulbrandsen et al. 2022; Olsen et al. 2021). Vormedal and Gulbrandsen (2020) suggest collective motives, emphasizing the improvement of the industry reputation and the safeguarding of common-pool resources. Gulbrandsen et al. (2022) note that ASC certification in Norway and the UK primarily serves business-to-business relations, demonstrating sustainable practices to retailers. Olsen et al. (2021) argue that ASC certification allows producers to demonstrate sustainability compliance to key stakeholders, such as the World Wildlife Fund (WWF), thereby improving their overall reputation.

Amundsen and Osmundsen (2020) report that additional benefits from becoming certified are improved routines and procedures, through how documentation is systematized, standardized and structured, and through creating better and more efficient systems and practices. According to the majority of their respondents this leads to significant changes, such as improved waste management, risk assessments and management, and mitigation plans and measures, and constitute a different path through which certification improves production practices. These are features that over time are expected to reduce operation costs.

Costs of certification

Certification incurs significant costs (Amundsen and Osmundsen 2020), including expenses for documentation, conformity to standards, certification and auditor fees, travel expenses for certification meetings, and increased staff costs. Many companies allocate full-time staff to certification matters, emphasizing the advantage of larger firms. While ASC certification is noted as the most expensive standard, companies may pursue multiple certifications to address diverse production aspects and customer demands. Davis and Boyd (2021) highlight that certified shrimp farms, particularly ASC-certified ones, are larger and more productive in Asia and Latin America. Certified farms in Asia produce ten times more than non-certified counterparts, emphasizing the profitability for larger operations. Size is crucial for spreading fixed certification costs across more units, as noted by Samerwong et al. (2018), who find that the majority of Thai shrimp farmers prefer the cheapest certification standard due to perceived low economic benefits from three investigated standards.

Costs associated with adhering to standards vary across countries. Luthman et al. (2019) point out that the ASC standard for salmon is more stringent in Chile than in Norway compared to the existent national regulation, thus potentially making certification less costly for producers in countries with more stringent regulations. This can pose a significant burden for producers in less regulated countries, especially in the developing world. Thi et al. (2020) analyze ASC certification outcomes for Vietnamese shrimp farms, revealing substantial costs. Many certified farms and cooperatives received external financial support to cover certification-related expenses. Despite the costs, the total price incentive for ASC certification averaged US$312 per household annually. This amount can be compared to the average household income in Vietnam of around US$ 15,000 (calculated as GDP per capita in 2021 (US$3750) times the average household size (four) (IMF 2023). In contrast, Xuan (2021) notes that implementing domestic aquaculture certification standards in Vietnam is less expensive than international certification, with government subsidies. The limited international recognition diminishes its value on the global market.

Conclusions and discussion

This review of the economic effects of eco-labeling and eco-certification of aquaculture producers reveals that most studies on this topic are empirical studies primarily focused on Europe. The ASC (Aquaculture Stewardship Council) scheme, particularly for salmon, stands out as the most extensively investigated scheme. Consequently, studies from other parts of the world, especially in developing countries, and regarding other species, especially non-fed species, are highly limited. This may also be interpreted as less interest in

eco-labeling in these countries. It suggests that it is mainly producers aiming for the European market who need to prioritize eco-certification.

Most consumer preference studies report that consumers favor eco-labeled aquaculture products over similar non-labeled products. Similarly, most studies indicate that consumers are willing to pay a price premium for eco-labeled products. Findings from a systematic review by Cantillo et al. (2020) examining the fin-fish market and specific studies, like Asche et al. (2021) in Germany, cast doubt on the extent to which these stated preferences translate into actual market behavior. Notably, Gulbrandsen et al. (2022) report that most Norwegian ASC-certified salmon is sold without labeling, as a price premium is not anticipated. The existence of producer-to-producer certification schemes such as Global G.A.P. also suggest that there are other benefits associated with certification.

There is also evidence that, when they exist, price premiums vary by retail outlet and the premium declines with the average price level of the retail chain (Asche et al. 2021). This is a result that is also reported for wild and organic labeled salmon (not included in this review) by Asche et al. (2015) and suggest that there are important market nuances. High-end retailers often have no premium, suggesting that they treat sustainably produced seafood as one of the quality attributes the chain provides. Low price retailers charge the highest premiums, which may lead to a lower market share for eco-labeled products.

Several studies compare eco-labeled aquaculture products with other products, particularly focusing on salmon. These studies reveal that eco-labels can mitigate the general preference of wild to farmed salmon. For other species, the price premium associated with eco-labeling may be lower compared to wild-caught alternatives.

Besides eco-labels, other attributes, notably the product origin, play a significant role in consumer preferences. Many consumers express a higher willingness to pay for products from their local area or home country than for eco-labeled products. This aligns with the broader literature, such as Cantillo et al. (2020), emphasizing the importance of origin attributes in consumer decision-making. Interpreting the origin attribute can be complex, as consumers often use it as an indicator of product quality. For instance, Onozaka et al. (2023) find that Japanese consumers associate domestic origin with positive qualities like freshness, healthiness, safety, taste, naturalness, convenience, and sustainability, while French consumers have negative associations.

Comparisons between eco-labeling and other attributes beyond country-of-origin are limited. Exploring how information about genetic modification in the supply chain, for example, compares to eco-labels could provide valuable insights. Weir et al. (2021) investigate the impact of genetic modification of salmon products, particularly genetically modified feed, and find a negative consumer preference for such ingredients. Understanding how these preferences compare to preferences for ecolabelling would be interesting.

Several studies highlight the importance of consumer knowledge about eco-labeling and aquaculture production in shaping preferences. Recognizing hypothetical labels is a common challenge, reflecting broader issues of misinterpretation in sustainability-related food labels (McLeod et al. 2024). Informed consumers, educated about aquaculture and certification standards, consistently demonstrate a positive willingness to pay for eco-labeled products.

There is a lack of studies estimating price premiums for eco-certification at the producer level and whether price premiums at the retail level move upstream through the supply chain to the producers. This may be important as the literature on wild fisheries extensively examines price premiums at the producer (fisher) level. Recent studies by Andersson and Hammarlund (2023) and Bronnmann et al. (2023) contribute to this discourse. As price premiums are often found to be absent, this raises questions about how much the observed price premiums at the retail level encourage more sustainable production practices in aquaculture.

Beyond price premiums, there may be additional economic benefits associated with eco-certification. Interviews with producers reveal diverse motives for certification, including accessing new markets, establishing stable distribution channels, securing predictable contracts, and anticipating growing market shares. It is important to note that market access and price premiums may be interconnected. Certified producers accessing higher-paying markets inherently experience a premium in more attractive market settings, whether in a specific country or retail chain (Roheim et al. 2018).

Growing demand for sustainable seafood in developed countries has prompted retailers, such as Tesco, Lidl, and Walmart, to commit to sourcing only sustainable seafood (Roheim et al. 2018). In aquaculture, ASC certification is embraced by companies like IKEA (Olsen et al. 2021) and has become a prerequisite for accessing specific retailers. Retailers are motivated by the desire to safeguard their brand reputations,

avoiding associations with environmental problems in fisheries and aquaculture that could impact public perception. Notably, there are no quantitative studies investigating how eco-certification affects distribution channels for aquaculture products. As for organic salmon, Asche et al. (2021) find no evidence of increased stability compared to non-organic salmon, attributing this to the much higher supply reliability for salmon than for other species. For cod and haddock, Sogn-Grundvåg et al. (2019) demonstrate that eco-labels contribute to more stable distribution channels in the UK, arguing that this may benefit producers in terms of cost reductions.

Certification costs typically paid by producers, need to be justified by benefits, especially when perceived price premiums are viewed as future promises rather than immediate gains. Existing studies on certification costs predominantly focus on developing countries, where challenges may arise due to stricter standards than national regulations and difficulties faced by smaller firms in covering these costs. Future studies on certification costs are essential in both developing and developed countries.

While price premiums may exist in certain market segments, expanding sales to a larger market can be challenging. Ankamah-Yeboah et al. (2019) illustrate that as the market for organic salmon in Denmark grows, price premiums are estimated to decline by 25%. This reduction may arise from a saturation of the market for organic products, a topic that remains underexplored in studies on eco-labeled aquaculture products.

Several challenges impeding the wider adoption of eco-certification in aquaculture remain underexplored in the literature. These include insufficient research on consumer reactions to the multitude of available eco-labels and the comparison of price premiums for eco-labels against those for other attributes. Additionally, there is a gap in studies examining how producers prioritize between labels and investigating price premiums using data from retailers and producers. Furthermore, the literature provides limited insights into the costs of eco-certification, particularly whether these costs outweigh the benefits for producers.

Author contributions

Cecilia Hammarlund: Conceptualization, Funding acquisition, Supervision, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. Kevin Svensson: Investigation, Writing – original draft. Frank Asche: Validation, Writing – Review & Editing. Julia Bronnmann: Validation, Writing - Review & Editing. Tonje Osmundsen: Validation, Writing - Review & Editing. Rasmus Nielsen: Conceptualization, Supervision, Validation, Writing – original draft, Writing – Review & Editing.

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Appendix A

Searching for articles

To investigate economic effects of eco-certification and eco-labeling on consumers and producers, we commenced with a literature search. We initiated the literature search by adopting the method in Arton et al. (2020), modifying the terms "marine" and "fisheries" to "aquaculture." The resulting search string is as follows:

TITLE-ABS-KEY ("Aquaculture Stewardship Council" OR "aquacult* eco-label" OR "aquacult* ecolabel" OR "aquacult* eco label" OR "aquacult* certif*" OR "certif* aquacult*").

Abstracts, titles and key words were searched using this search string, covering all available years and document types. The search was restricted to texts in English and performed across the following online databases:

1. Elsevier SCOPUS database: https://www.elsevier.com/solutions/scopus
2. Clarivate Analytics Web of ScienceTM Core Collection: https://www.webofscience.com/wos/woscc/basic-search

To access additional texts and grey literature, the same search terms were applied to Google Scholar (https://scholar.google.com/). For these texts, the initial 50 entries were extracted for screening and analysis. The following search results were obtained:

a. Via Elsevier SCOPUS database: 69 documents
b. Via Clarivate Analytics Web of Science Core Collection: 53 documents
c. Via Google Scholar, the same search string gives a total of 1960 results, where we extract the first 50 results for further screening.

A total of 172 articles and documents were potentially eligible for inclusion in the literature review and analysis. The date for the search was September 2, 2022 (and was repeated in Scopus and Web-of-Science October 27, 2023 without finding any new relevant articles).

All documents were sorted and organized separately per database/source. The documents retrieved from various databases were merged, and articles that appeared in duplicate, either through multiple sources or multiple instances within a single database, were systematically removed. From the initial Web-of-Science search 49 duplicates found in SCOPUS were eliminated. Moreover, 19 documents sourced from Google Scholar had already been identified in the Web of Science or SCOPUS databases, leading to their exclusion. Additionally, two duplicates were removed as they appeared twice within the same database. Following this initial screening process, the refined list comprised a total of 102 documents.

Table A1. Summary and some basic facts about the literature.

Type of Study	Type of Certification/ Labeling	Geographic Area	Species
Quantitative (22)	ASC (20)	Norway (8)	Salmon (14)
Qualitative (9)	No specific scheme (10)	UK (6)	Shrimp (6)
	Global G.A.P. (3)	Germany (5)	Other species (10)
	GAA (2)	Other European countries (12)	No specific species (6)
		Asia (10)	
		North America (8)	
		South America (3)	
		Global studies (2)	

Note: One article can be classified in more than one category. ASC: Aquaculture Stewardship Council; G.A.P: Good Agricultural Practices; GAA: Global Aquaculture Alliance.

Next, the articles were screened, and irrelevant articles were removed. The exclusion criteria were:

1. Articles not focused on aquaculture (5).
2. Articles not specifically addressing eco-certification or eco-labeling (19).
3. Articles that did not present the effects stemming from certification or labeling (37).
4. Articles not composed in the English language (8).
5. Articles excluded based on various other specific reasons (11).

The final exclusion criteria included articles that were not accessible to through electronic library subscriptions (8 records). After the initial screening, 22 records remained for further analysis and classification. Subsequently, a full-text screening of these records was conducted, resulting in the exclusion of another five documents due to reasons stated in the previously presented exclusion list.

We also examined whether the articles covered economic effects (such as price premiums or revenues and costs of certification for producers). Three articles were excluded as they did not discuss any economic aspects. At this stage, we identified additional relevant literature (16 articles) referenced in the selected literature. Many of these records had titles, keywords and abstracts with words and terms not captured by the search string, such as *environmental credentials*, *sustainable products*, *preferences*, and *willingness-to-pay*.

Finally, we added one article, published after September 22, 2022, which we found to be highly relevant. Thus, the final list comprised 31 articles, which discuss economic effects of eco-labeling aquaculture products or eco-certification of aquaculture production.