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Consumer Preferences, Ecolabels, and the Effects of Negative Environmental Information

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Consumers prefer ecolabeled products. However, little is known about the effects of ecolabels when consumers are simultaneously exposed to negative environmental information. We conducted a stated choice experiment in France with eight fish products that were either ecolabeled or unlabeled. Four types of negative information concerning the potential negative environmental consequences of catching wild fish or producing farmed fish were randomly administered to the participants. The data were analyzed by a mixed logit model. Several results emerged. First, there are positive ecolabeling effects on the willingness to pay (WTP) for fish. Second, ecolabeling cannot fully mitigate the negative effects on WTP of negative environmental information. Third, there is a positive effect on the WTP for substitute fish produced with the same production technology as the type of fish that receives negative environmental information.

INTRODUCTION

Knowledge about a product is typically assembled from various sources of information, and each source can provide positive, neutral, or negative information. Labels are one source of information that is used to signal the presence or absence of specific attributes, and food labels can significantly change the purchasing behavior (e.g. Caswell and Anders 2011). Other types of information also affect preferences for food attributes as shown in studies in experimental economics (e.g., Fox et al 2002; Rousu et al 2004; Rousu et al 2007). However, the total effects of labeling, in combination with information from other sources, have received relatively little attention, and these effects are the focus of this paper.

Fish and fishery products are among the most traded food commodities worldwide and account for about 10 percent of total agricultural exports (FAO 2012). Ecolabeling is increasingly used by the seafood industry to meet consumers' concerns about the environmental impacts and sustainability of wild fisheries and aquaculture. Much of the focus on ecolabeling has been on the certification of wild fish products, such as the labeling activities of the Marine Stewardship Council (MSC). However, farmed fish has become increasingly important and ecolabels for farmed fish are in the process of gaining global influence.

Research that uses data from surveys, laboratory experiments, and the retail trade finds that consumers are willing to pay a premium for ecolabeled fish products (e.g. Wessells et al 1999; Jaffry et al 2004; Olesen et al 2010; Roheim et al 2011; Mauracher et al 2013). Consumers also receive information on wild fisheries and aquaculture from

newspapers, TV, and nongovernmental organizations. One example is the Eastern Baltic cod that was severely overexploited. This issue was widely covered in the Swedish media and the World Wildlife Fund (WWF) listed the Eastern Baltic cod on its blacklist and advised consumers against buying it. As a result, many Swedish consumers stopped buying not only Baltic cod but also cod from more healthy stocks.

We include four types of environmental information and two labels in our experiment. The labels are the MSC and the organic French AB labels. The information is related to the potential damages to the environment from cod farming, salmon farming, and wild cod fisheries. In the presence of labeling, the effects of these types of information are complex.

First, there are direct effects on the willingness to pay (WTP) for the target products of the information (e.g., farmed salmon). Since consumers are presented with both ecolabeled and unlabeled varieties of the target products, there are different direct effects for ecolabeled and unlabeled fish.

Second, there are indirect effects of information on the substitutes of the target product of the information. The indirect effects may depend both on the production method (wild versus farmed) and ecolabeled and unlabeled fish. If the negative information is about farmed salmon we can then differentiate between four types of indirect effects: (i) ecolabeled fish that is produced with the same production technology such as ecolabeled farmed cod; (ii) ecolabeled fish that is produced with another production technology such as ecolabeled wild cod; (iii) unlabeled fish that is produced

with the same technology such as unlabeled farmed cod; and (iv) unlabeled fish that is produced with another production technology such as unlabeled wild cod.

To our knowledge, the combined effects on willingness to pay of negative environmental information and ecolabels have not been previously investigated. Our objectives are to investigate: (i) the direct effects of negative information on the WTP for ecolabeled and unlabeled fish products; and (ii) the indirect effects of negative information on the WTP for substitutes. To investigate these objectives, we designed and carried out a stated choice experiment in France.

In the next sections, we describe the current use of ecolabels in seafood markets. The experimental design and the econometric model are described, followed by the presentation and discussion of the results.

ECOLABELS IN SEAFOOD MARKETS

Fisheries management policy has focused on developing and enforcing management schemes related to the supply side of the seafood market. To a large extent, such schemes have been ineffective in conserving wild fish stocks (Beddington et al 2007). The Food and Agriculture Organization of the United Nations (FAO) estimated that almost 60% of the world's fish stocks were fully exploited in 2009, and almost 30% were overexploited (FAO 2011). A number of ecolabeling programs have been introduced following increased consumer concerns about overexploitation and related to seafood production issues such as: (i) safety (e.g. Wessells and Anderson 1995; Wessells et al 1996); (ii) quality (e.g. Verbeke et al 2007; Brécard et al 2009; Salladarré et al 2010a); (iii)

environmental effects (e.g. Jaffry, et al 2004; Verbeke, et al 2007); (iv) sustainability (e.g. Sogn-Grundvåg et al 2013); and (v) animal welfare (e.g. Teisl et al 2002; Aarset et al 2004; Verbeke, et al 2007). The long-term success of these ecolabeling schemes depends on firms' compliance with them. The most important success measure is that premium consumers are willing to pay for the labeled products (Thøgersen 2000; Nilsson et al 2004).

Although there is no French national ecolabeling scheme for wild fish, several labels are used by retailers. As early as the spring of 2004, Carrefour launched its own ecolabel for wild cod products. Other large retailers and processors of seafood followed with their own private labels (Salladarré et al 2010b). The certification program of the MSC is currently the most widely used and recognized sustainable wild fish labeling scheme in the world, and it is also used in France (Gulbrandsen 2009; Thrane et al 2009). As of 2013, 188 fisheries had been certified by the MSC program, and another 106 fisheries were being assessed (MSC 2013).

It is difficult for consumers to know which fish stocks are depleted, and it may be insufficient to know the species of the fish. In many cases, consumers need to know where and when the fish was caught. One example is Norwegian cod. Cod from the North Sea and the Norwegian coast is believed to be under considerable pressure and has not been granted the MSC label, whereas the cod fishery in the Barents Sea, which is currently generating record landings, does have the MSC label. To further increase the confusion, cod from the Barents Sea, which comes to the shores of Northern Norway during the winter months to spawn, can be caught during this period and MSC labeled.

For convenience, the environmentally concerned fish consumer can look for the MSC label to avoid buying wild fish from a depleted stock.

No ecolabeling program for farmed fish has so far gained international acceptance. The Aquaculture Stewardship Council (ASC) is the aquaculture version of the MSC. It was founded in 2009 by the WWF and the Dutch Sustainable Trade Initiative. The ASC aims to provide certification schemes for responsibly farmed fish. As of June 2013, only a few fish farms from six countries were certified, although Marine Harvest, which is the world's biggest producer of salmon, announced in May 2013 that it would seek company-wide ASC certification by 2020.

The Agriculture Biologique (AB) label is the most widely used ecolabel for food in France, and it certifies food products with an organic content of at least 95%. Farmed fish can be labeled as organic, whereas wild fish cannot. At the time of the experiment, we were unable to find any certified organic fish products in the French market. In the remainder of the paper, we refer to the AB label as the organic label.

Many studies of ecolabeling effects on wild and farmed fish suggest that labeling has a positive effect. Jaffry et al (2004) used a choice experiment and found that ecolabeled seafood from a sustainably managed fishery had up to a 7% higher probability of being chosen by participants. Roheim et al (2011) analyzed scanner data of MSC-certified frozen processed Alaskan pollock products and found that UK consumers were willing to pay a 14% premium for the label. Olesen et al (2011) conducted a nonhypothetical choice experiment and found that the average Norwegian participant was willing to pay a 15% premium for organic salmon. Mauracher et al (2013) found a significant price premium

for organically bred Mediterranean sea bass. For more information on ecolabels, see Consumer Reports (2013).

EXPERIMENTAL DESIGN

The experiment was carried out in the sensory laboratory of l'Institut National de la Recherche Agronomique (INRA) in Dijon in December, 2008. Potential participants were randomly drawn from INRA's consumer panel.[1] In the recruitment process, they were asked to answer a short survey on their consumption and purchasing frequencies of fish products. Only those who ate fish at home more than once a month and bought fresh fish themselves at least every second month were recruited. Each participant was paid €25 to participate in the study.

Some of the participants had previously taken part in one or more similar experiments, and we refer to them as experienced participants while the remaining participants are referred to as new participants. New participants only answered the choice questions once while experienced participants answered them twice. For a new participant, we first randomly determined whether he or she would receive any information. If he or she received information, it was randomly determined which information set to provide before the participant answered the choice questions. In this way, we created between-subject variation among new participants. Experienced

[1] The consumer panel is a database of volunteers to participate in sensory experiments. The volunteers have been recruited in several ways: random selection of phone numbers in representative districts of all socioeconomic classes of Dijon and the suburbs, advertisements in the local press, and during exhibitions. Dijon is a city with about 150,000 inhabitants and is located 300 km southeast of Paris. The city is representative of France in terms of household disposable income and sociodemographic composition. Fresh fish consumption is slightly below the average consumption in France, but representative of the noncoastal regions.

participants were randomly given one of the four types of negative information between the first and the second rounds. In this way, we created within-subject variation among experienced participants. The total data set consisted of choices made by 78 new and 116 experienced participants. To obtain a reasonable sample size, we pooled data from both groups for estimating the econometric model.

To reduce the hypothetical nature of the experiment, the fish products were real and professionally packed 300 grams packages of fish products. No ecolabeled farmed fish products were available in France at the time of the experiment; therefore, unlabeled products were ecolabeled. To avoid selling these products to the participants, the stated choice format was chosen.

Since salmon and cod are the two most sold fish species in France, we focus on them. The environmental information was related to: (1) cod farming; (2) wild cod fisheries; (3) cod farming and wild cod fisheries; and (4) salmon farming. An English translation of the four information sets is included in the Appendix. Furthermore, both unlabeled and MSC-labeled wild cod and unlabeled and organic-labeled farmed cod and farmed salmon were included.

Altogether there were five unlabeled and three ecolabeled fish products included in the experiment (see Table 1). The products were labeled with species, origin, and price. In addition, some had ecolabels and the farmed fish were labeled as such. Most combinations of these factors would result in highly unlikely results such as pangasius produced in Norway or farmed monkfish. We therefore limited the fishes to the most common origin and production methods in the French market, and ecolabels to the most

sold products, salmon and cod. Monkfish was included as an expensive and pangasius as an inexpensive substitute for cod and salmon. Both were always unlabeled.

(Insert Table 1 about here)

A choice design with the eight products at varying prices was constructed by the SAS macro MktEx with zero priors, and the D-efficiency of the total design was 96.52. The design had 112 choice sets that were grouped into seven blocks. The order of the choice sets was randomized within each block. Each block of choice sets was used in two sessions, and each participant was randomly assigned to one of the sessions.

Each round of the stated choice experiment consisted of 16 choice sets. Each choice set included three alternatives that were presented in a Styrofoam box filled with ice. A none-of-these alternative was also included. To avoid systematic ordering effects, the participants could start at any of the 16 boxes.

ECONOMETRIC MODEL

The data are analyzed using the mixed logit model (McFadden and Train 2000). We let p denote price and group the dummy variables in three vectors. First, the vector **Fish** includes five dummy variables that correspond to the five fish types: wild cod, farmed cod, farmed salmon, wild monkfish, and farmed pangasius. These dummy variables are coded as 1 if we have the specified fish type and 0 otherwise. Second, the vector **Ecolabel** includes two dummy variables that are coded as 1 if the fish is labeled with the MSC and the organic label, respectively, and 0 otherwise. Third, the vector **Information** includes six information variables to take account of the direct and indirect information

effects. Two dummy variables take account of the direct effects for ecolabeled and unlabeled fish, respectively (coded as 1 if they are present and 0 otherwise), and four dummy variables take account of the indirect effects discussed above (coded as 1 if they are present and 0 otherwise).

When participant n chooses alternative j in choice situation t, the participant obtains utility U_{njt}:

$$U_{njt} = \alpha_n p_{njt} + \boldsymbol{\beta}_n \mathbf{Fish}_{njt} + \boldsymbol{\gamma}_n \mathbf{Ecolabel}_{njt} + \boldsymbol{\delta}_n \mathbf{Information}_{njt} + \grave{o}_{njt}, \tag{1}$$

where α_n is the individual-specific coefficient for price, $\boldsymbol{\beta}_n$, $\boldsymbol{\gamma}_n$ and $\boldsymbol{\delta}_n$ are individual-specific coefficient vectors, and $\grave{o}_{njt}$ is an error term that is assumed to have extreme value distribution and be independent and identically distributed for different observations.

The model was estimated by maximizing the simulated log likelihood function using NLOGIT 5 (Greene 2012). We specified 2,000 Halton draws per iteration, used the panel data structure of the data, and allowed for free correlation among the random coefficients. We estimated the WTP values by calculating the negative ratio between a nonprice variable's coefficient and the price coefficient. The standard errors of the WTP estimates were estimated by the delta method (e.g. Hole 2007).[2]

[2] The standard errors were also estimated by the Krinsky–Robb method (Krinsky and Robb 1986, 1990), and the standard errors of the two methods were close.

RESULTS AND DISCUSSION

The estimated coefficients, mean WTP estimates, and the 95% confidence intervals of WTP values are presented in Table 2. The McFadden pseudo R^2 (McFadden 1974) is 0.65, indicating a good model fit (see e.g. Louviere et al 2000, p. 54). The value of the log likelihood function at convergence and the Bayes Information Criterion (BIC) and Akaike Information Criterion (AIC) values are also provided in Table 2.

Participants were willing to pay €20.44 per kg of wild monkfish, €18.14 per kg of wild cod, €16.46 per kg of farmed cod, €17.78 per kg of farmed salmon, but only €0.29 per kg of farmed pangasius. For monkfish, salmon, and cod, these prices are reasonably well in line with the market prices at the time of the experiment. The WTP for pangasius is unrealistically low and not significantly different from zero. However, the low value is because few participants chose farmed pangasius in the experiment. The standard deviation for farmed pangasius is significant at the 1% level of significance, which indicates that preferences for pangasius are heterogeneous.

(Insert Table 2 about here)

The participants were willing to pay €0.80 per kg of MSC-labeled fish and €1.84 per kg of organic-labeled fish. The premium for the MSC label was about 4% for wild cod and that for the organic label was about 11% for farmed cod. These premiums are somewhat below the premiums found for Alaskan pollock in the UK (Roheim, et al 2011) and salmon in Norway (Olesen, et al 2011). The WTP values for the ecolabels are significant at the 5% level of significance. The higher premium for the organic label may be explained by a higher degree of familiarity with this label. While 61% and 32% of

participants claimed to have seen the organic label “often” and “sometimes”, respectively, only 10% and 30% of participants claimed to have seen the MSC label “often” or “sometimes”, respectively, before the experiment. Because of the large number of parameters, we do not estimate the effects of ecolabels for the different species of fish.

Using the mean WTP estimates provided in Table 2, Figure 1 shows the mean WTP for wild cod, farmed cod, and farmed salmon when the fish is unlabeled or ecolabeled and without or with the provision of negative information. There is a statistically significant and negative direct effect of about €2.2 per kg of fish of negative environmental information regardless of labeling. This value suggests that labeling cannot presently mitigate the direct negative effects on WTP of negative environmental information. Furthermore, the results indicate that the labeling organizations have yet to better inform consumers about their labels and their credibility.

(Insert Figure 1 about here)

As discussed above, there are also indirect effects of labeling on the substitutes of the ecolabeled fish. These indirect effects may be different for ecolabeled and unlabeled fish so there are potentially different indirect effects for: (i) unlabeled fish that is produced with the same production technology; (ii) ecolabeled fish that is produced with the same technology; (iii) unlabeled fish that is produced with the other production technology; and (iv) ecolabeled fish that is produced with the other production technology.

As shown in Table 2, two of these effects are statistically significant at the 5% level of significance. First, there is a positive and significant effect on the WTP for substitutes produced by the same production technology as the fish type that received the negative

environmental information. The effect is about €1 per kg and the magnitude is independent of the labeling of the substitute fish. The effect is only significant at the 10% level of significance when the substitute is ecolabeled. For example, negative information about salmon farming results in an increase of the WTP for farmed cod, and negative information about cod farming results in an increase of the WTP for farmed salmon.

Second, quite surprisingly, there is a negative and significant effect on the WTP for substitutes produced with the other production technology when the substitute is unlabeled; however, this effect becomes insignificant when the substitute is ecolabeled. For example, the result suggests that negative environmental information about salmon farming reduces the WTP for unlabeled wild cod while there is no effect on ecolabeled wild cod.

CONCLUSIONS

Much of the focus concerning ecolabeling of fish is on the certification of wild fish products, such as the MSC label. However, ecolabeling of farmed fish products is as important as ecolabeling of wild fish products. We conducted a stated choice experiment including ecolabeled and unlabeled farmed and wild fish products. To investigate the effects of ecolabels when consumers are simultaneously exposed to negative information about the ecolabeled fish, negative environmental information was provided to some of the participants.

We found statistically significant WTP premiums for ecolabeled wild and farmed cod and ecolabeled farmed salmon. The average French participant is willing to pay a

premium of about 4% for MSC-labeled wild cod and a premium of about 11% for organic-labeled farmed cod, which are somewhat below the premiums found in Alaska pollock in the UK and salmon in Norway. Furthermore, since there is a cost associated with ecolabels, producers have to weigh the benefits against the costs.

Negative environmental information has a strong effect and results in a reduction in the WTP of about €2.2 per kg regardless of labeling. This result is in line with previous results, and the very low effect of labeling in the presence of negative information suggests that labeling organizations need to increase the awareness of their labels and their credibility.

There are also indirect effects of labeling on the substitutes of the ecolabeled fish. There is a positive and significant effect on the WTP for substitutes produced by the same production method as the fish type that receives negative environmental information. The effect is about €1 per kg and the magnitude is independent of the labeling of the substitute fish.

Our findings indicate that further research is needed on several topics. First, it is of interest to investigate the consistency of the findings of this experiment with the purchase behavior observed in scanner data. Second, we used information provided on sheets of paper to mimic information from newspapers, and it is of interest to study the effects of newspaper information on actual retail sales by using scanner data. Third, we find that the ecolabels have a rather low effect on the WTP as compared with the effects of negative information, and it is of interest to study how consumers' trust in ecolabels can be increased.

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Table 1. The products in the experiment

Species	Wild or farmed	Ecolabel	Area of origin[a]	Price range 300 g[b]
Salmon	Farmed	No	Norway	€1.95–5.45
Salmon	Farmed	Organic	Norway	€3.45–7.95
Cod	Farmed	No	Norway	€2.95–6.95
Cod	Farmed	Organic	Norway	€4.95–10.95
Cod	Wild	No	North Atlantic	€2.95–6.95
Cod	Wild	MSC	North Atlantic	€4.95–10.95
Monkfish	Wild	No	North Atlantic	€5.45–11.45
Pangasius	Farmed	No	Vietnam	€1.45–4.95

[a]The origins of the different products are the origins that are most common in the French market. For the organic cod and salmon, we use the same origin as for the nonorganic cod and salmon.

[b]An eight-point price scale was used for each product. The price range of the unlabeled fish was based on market prices in the area at the time of the experiment. In the market, the prices varied quite considerably, reflecting factors such as size, cut, outlet, day, and promotions. The price ranges used in the experiment covered the minimum and maximum prices in the market. For the ecolabeled products, the price ranges were set €1.5–2.0 above the price ranges of the corresponding unlabeled products.

Table 2. Mixed logit results and willingness to pay (WTP) estimates

	Mixed logit		WTP estimation	
Attribute	Coefficient	Std. Dev.	Mean WTP (€)	95% CI (€)
Wild cod	7.34***	3.80***	18.14***	[17.43, 18.86]
	(0.28)	(0.24)	(0.36)	
Farmed cod	6.66***	4.14***	16.46***	[15.76, 17.16]
	(0.28)	(0.23)	(0.36)	
Farmed salmon	7.19***	4.29***	17.78***	[17.17, 18.39]
	(0.26)	(0.17)	(0.31)	
Wild monkfish	8.26***	4.08***	20.44***	[19.63, 21.25]
	(0.31)	(0.23)	(0.41)	
Farmed pangasius	0.12	5.84***	0.29	[–1.63, 2.22]
	(0.40)	(0.44)	(0.98)	
MSC label	0.32	1.40***	0.80*	[–0.03, 1.62]
	(0.17)	(0.16)	(0.42)	
Organic label	0.74***	0.94***	1.84***	[1.30, 2.24]
	(0.11)	(0.12)	(0.28)	
Direct effect unlabeled fish	–0.87***	1.36***	–2.16***	[–3.15, –1.18]
	(0.20)	(0.23)	(0.50)	
Direct effect labeled fish	–0.94***	0.94***	–2.32***	[–3.31, –1.33]
	(0.20)	(0.12)	(0.50)	
Indirect effect unlabeled fish and	0.40**	1.17***	0.98**	[0.20, 1.76]
same production method	(0.16)	(0.19)	(0.40)	
Indirect effect labeled fish and	0.38*	1.16***	0.95*	[–0.05, 1.95]
same production method	(0.21)	(0.22)	(0.51)	
Indirect effect unlabeled fish and	–0.31**	0.94***	–0.77**	[–1.53, –0.02]

different production method	(0.15)	(0.17)	(0.38)	
Indirect effect labeled fish and	–0.17	1.00***	–0.41	[–1.32, 0.51]
different production method	(0.19)	(0.16)	(0.47)	
Price (€ per kg)	–0.40***	0.24***	NA	NA
	(0.01)	(0.01)	NA	
Log likelihood function		–3786.05		
Bayes information criterion		8584.60		
Akaike information criterion		7810.10		
McFadden pseudo R^2		0.65		

[a]The numbers in parentheses are standard errors. Coefficients that are significant at the 10%, 5%, or 1% level of significance are marked with *, **, or ***, respectively.

[b]CI, Confidence interval.

[c]The production methods are wild fisheries and aquaculture. For example, when the environmental information concerns farmed salmon, then the indirect effect of the information on ecolabeled wild cod is modeled as "indirect effect with label (different production method)", whereas the indirect effect of the information on unlabeled farmed pangasius is modeled as "indirect effect without label (same production method)".

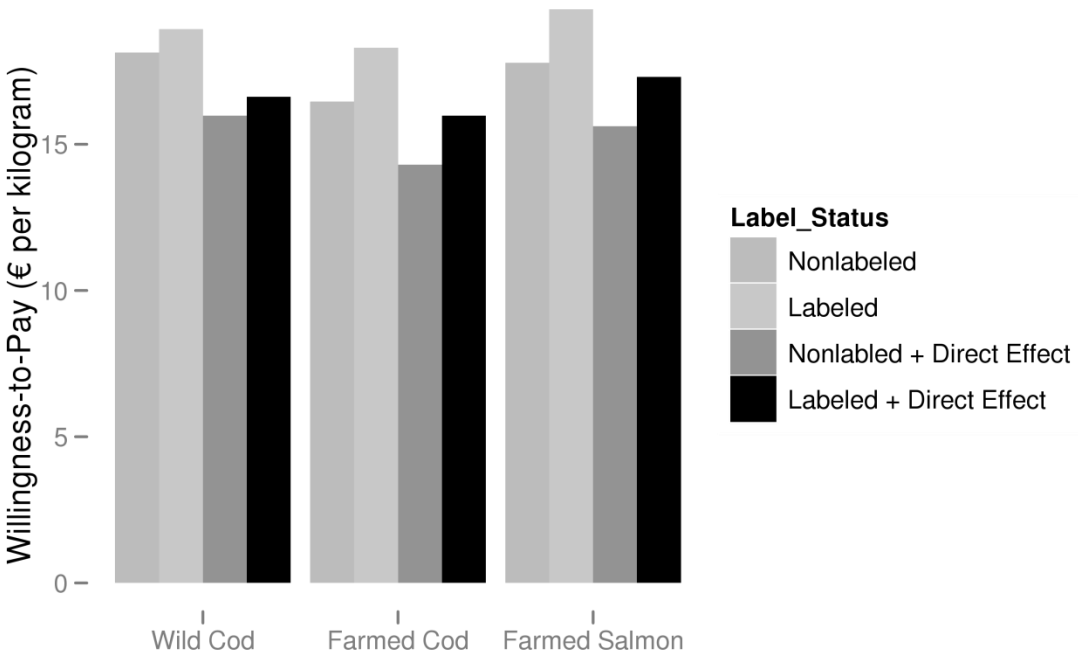

Figure 1. Direct effect of negative information

APPENDIX: ENVIRONMENTAL INFORMATION GIVEN TO THE PARTICIPANTS

An English translation of the environmental information that was provided to some participants in the experiment is given below. The original transcript was written in French.

Type 1: Negative information about fish farming that is relevant for farmed cod (264 words in French)

Cod is a favorite fish among French consumers. The high demand for and value of cod have led to intense exploitation; catches exceeded the renewal rates and the stocks of cod declined severely in the late 1990s. Cod farming (aquaculture) appears as a possible solution to some of these problems. Nevertheless, cod farming conducted in its natural surroundings may have negative impacts on the environment and can lead to:

- Pollution of the sea and the seabed. This pollution can be caused by waste from farming, uneaten feed, parasites, diseases, and injuries that are a consequence of overpopulation in the breeding cages, and by therapeutic chemicals used to treat diseases.
- A risk of breeding of the farmed cod that have escaped from the cages with the wild cod. This may lead to uncontrolled genetic modifications of the wild cod with unknown consequences.
- Overexploitation of other species of fish. The feed of farmed cod is primarily made from small fishes. Three to five kg of fish are needed to produce one kg of cod. The species used for feed were considered to be inexhaustible; however, the strong growth of fish farming may put the sustainability of these species at risk.

- Damage to other species. Some fish farming is protected from birds and other predators by nets, but these nets can also capture protected species.
- Damage to the seabed. Farming can particularly damage the flora close to production sites.

Type 2: Negative information about wild fisheries that is relevant for wild cod (244 words in French)

Cod is a favorite fish among French consumers. The high demand for and value of cod have led to intense exploitation; catches exceeded the renewal rates and the stocks of cod declined severely in the late 1990s. Even though recent scientific observations of the stocks of cod are encouraging, industrial fisheries may have negative impacts on the environment and can lead to:

- A decrease of the fish resources. Industrial cod fisheries lead to the capture of other nontargeted (sometimes protected) species and of undersized fishes. These captures, without any market value, are often discarded (dead) at sea.
- The death of other animals. “Secondary” captures of mammals and sea birds (including dolphins, albatross, etc.) occur. These animals die trapped in the nets or on lines with fishhooks.
- An imbalance of the marine ecosystem caused by the decrease of other marine species.
- Damage to the seabed. Some fishing techniques damage the flora (including seaweeds and corals), disturb the seabed, and destroy habitats.

- Social and economic effects. Due to the decrease of marine resources, the number of people employed in fishing activities is continuously decreasing. Increasingly public subsidies try to support fishing activities, since some of the fishing activities are unprofitable.

Type 3: Negative information about fish farming and wild fisheries that is relevant for cod (457 words in French)

Cod is a favorite fish among French consumers. The high demand for and value of cod have led to intense exploitation; catches exceeded the renewal rates and the stocks of cod declined severely in the late 1990s. Even though recent scientific observations of the stocks of cod are encouraging, industrial fisheries may have negative impacts on the environment and can lead to:

- A decrease of the fish resources. Industrial cod fisheries lead to the capture of other nontargeted (sometimes protected) species and of undersized fishes. These captures, without any market value, are often discarded (dead) at sea.
- The death of other animals. “Secondary” captures of mammals and sea birds (including dolphins, albatross, etc.) occur. These animals may die trapped in the nets or on lines with fishhooks.
- An imbalance of the marine ecosystem caused by the decrease of other marine species.
- Damage to the seabed. Some fishing techniques damage the flora (including seaweeds and corals), disturb the seabed, and destroy habitats.

- Social and economic effects. Because of the decrease of marine resources, the number of people employed in fishing activities is continuously decreasing. Increasingly public subsidies try to support fishing activities, since some of the fishing activities are unprofitable.

Cod farming (aquaculture) appears as a possible solution to some of these problems. Nevertheless, cod farming conducted in its natural surroundings may have negative impacts on the environment and can lead to:

- Pollution of the sea and the seabed. This pollution can be caused by waste from farming, uneaten feed, parasites, diseases, and injuries that are a consequence of the overpopulation in the breeding cages and the therapeutic chemicals used to treat diseases.
- A risk of breeding of the farmed cod that have escaped from the cages with the wild cod. This may lead to uncontrolled genetic modifications of the wild cod with unknown consequences.
- Overexploitation of other species of fish. The feed of farmed cod is primarily made from small fishes. Three to five kg of fish are needed to produce one kg of cod. The species used for feed were considered to be inexhaustible; however, the strong growth of fish farming may put the sustainability of these species at risk
- Damage to other species. Some fish farming is protected from birds and other predators by nets, but these nets can also capture protected species.
- Damage to the seabed. Farming can particularly damage the flora close to production sites.

Type 4: Negative information about fish farming that is relevant for farmed salmon (283 words in French)

Salmon is a favorite among French consumers. The stocks of wild salmon collapsed in the late 1980s after catches exceeding the renewal rates. Then, fishing was dramatically reduced and present catches are among the lowest ever registered. Salmon farming (aquaculture) appears as a possible solution to some of these problems. Nevertheless, salmon farming conducted in its natural surroundings may have negative impacts on the environment and can lead to:

- Pollution of the sea and the seabed. This pollution can be caused by waste from farming, uneaten feed, parasites, diseases, and injuries that are a consequence of overpopulation in the breeding cages and the therapeutic chemicals used to treat diseases.
- A risk of breeding of the farmed salmon that have escaped from the cages with the wild salmon. This may lead to uncontrolled genetic modifications of the wild cod with unknown consequences.
- Overexploitation of other species of fish. The feed of farmed salmon is primarily made from small fishes. Three to five kg of fish are needed to produce one kg of salmon. The species used for feed were considered to be inexhaustible; however, the strong growth of fish farming may put the sustainability of these species at risk.
- Damage to other species. Some fish farming is protected from birds and other predators by nets, but these nets can also capture protected species.

- Damage to the seabed. Farming can particularly damage the flora close to production sites.