Agriculture and Human Values
https://doi.org/10.1007/s10460-024-10548-5

Artifishial: naturalness and the CRISPR-salmon

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Accepted: 23 January 2024

Abstract
One of the reasons why GMOs have met public resistance in the past is that they are perceived as "unnatural". The basis for this claim has, in part, to do with crossing species boundaries, which is considered morally objectionable. The emergence of CRISPR is sometimes argued to be an ethical game-changer in this regard since it does not require the insertion of foreign genes. Based on an empirical bioethics study including individual interviews and focus groups with laypeople and other stakeholders, this article analyses the normative role of appeals to naturalness in discussions about the moral acceptability of using CRISPR in salmon farming. It discusses two dimensions of naturalness found in the material– living by species-specific nature and being unaffected by humans– and argues that these dimensions put down criteria for the application of CRISPR that lead to a conflict between our moral duties towards the farmed salmon and those we hold towards the wild salmon as a threatened species. It also points to a paradox which is likely to gain traction with further climate change and biodiversity loss, namely that while nature, understood as that which is unaffected by humans, is presented as an ideal, conserving nature in its pristine state may rely on technology and human intervention.

Keywords Genome editing · Animal ethics · Bioethics · Empirical ethics

Abbreviations

CRISPR	Clustered regularly interspaced short palindromic repeats.

From Frankenfish to CRISPR-salmon

In the 1980s, a large-scale research project that aimed to use genetic modification technologies on farmed salmon was set in motion in Norway in order to speed up the adaptation of this recently domesticated species for large-scale production. In 1984, the research leader, Harald Skjervold, announced that genes "from a mammal" had successfully been inserted into salmon and rainbow trout, promising a future in which genetic technologies could be used to fight diseases in fish as well as promoting growth (Finstad 2017, p. 108). When asked about the origin of the genes during the press conference, however, he avoided answering. But a few days later, a reveal was made on the evening news: The growth hormone genes which had been used in the experiment had been derived from humans. Public outrage and Frankenstein-syndrome accusations ensued (Nielsen et al. 2000, p. 239), with claims that meddling with nature and imagining ourselves to be architects of life in this manner leads us into an "ethical minefield" where we risk losing our humanity (Parmann 1985; Sætre and Østli 2021, p. 45). One researcher participating in the project commented that the research had been damaging to the industry– the public had to perceive the salmon as "natural" in order to accept it (Sætre and Østli 2021, p. 46). The negative public reaction led to the end of the research project, and in Norway, the climate for discussions about transgenic bioproduction was forever changed (Nielsen et al. 2000, p. 239).

This story serves as the backdrop for this article in three ways. First, it points to the central concept of this article, namely naturalness. That GMOs are perceived as "unnatural" has been an important reason for their past rejection (Bartkowski et al. 2018; Mielby et al. 2013; Shaw 2002). The sense of unnaturalness and human hubris in this context has often been described by invoking the Frankenstein myth– not all interventions in nature can be deemed morally

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Published online: 19 February 2024

acceptable, and we are rarely able to imagine the full scope of possible consequences (Devos et al. 2008). Second, it demonstrates how a technology can be rejected based on outrage and revulsion, commonly referred to as the "yuck factor". This gut feeling of rejection or wrongness tends to accompany objections to technologies as being "unnatural", but while it can impact how new products and technologies are received, it is rarely considered to have a normative importance. Finally, the story sets the stage for the particular concern here, namely the potential use of biotechnology in industrial salmon farming in Norway.

This article aims to assess the normative role of naturalness claims in stakeholders' views about conditions for morally acceptable use of CRISPR in the salmon farming industry. Does the use of CRISPR in salmon farming raise concerns about naturalness, and if so, how is the concept understood? Understanding naturalness arguments as normative (Bartkowski et al. 2018, p. 176), can reflecting on these conceptualisations guide which conditions have to be in place for CRISPR to be used in this context? The discussion is based on qualitative interviews with laypeople and other stakeholders, which are interpreted within an empirical bioethics framework.

In Norway, salmon hold a dual significance: Firstly, the wild salmon is an important cultural species, steeped in mystery and mythology, admired for travelling thousands of miles from the river to the oceans. Salmon fishing has a central role in both Norwegian and indigenous Sámi culture, and wild salmon is considered one of the most luxurious things to serve at a dinner table. Secondly, farmed salmon is a cornerstone of the aquaculture industry and a vital part of the new, blue economy. Here, the domesticated salmon swim around in crowded pens, far removed from the adventurous life of wild salmon.

Both wild and farmed salmon face challenges: Farmed salmon suffer from salmon lice infections and various diseases in the pens, the treatments of which cause suffering and pain (Sommerset et al. 2022). The wild salmon, on the other hand, is menaced by escaped farmed salmon, which compete with them for feed and breed, leading to genetic introgression and potential viability constraints (Bradbury et al. 2021; Grefsrud et al. 2022). Wild salmon was listed as a threatened species in Norway in 2021 (Hesthagen et al. 2021), and escapees are a major cause of this problem (Thorstad et al. 2021).

As one solution to these challenges, some point to CRISPR, the genome editing technology described as one of the most important scientific developments this century. There is ongoing research on how CRISPR can be used to induce sterility in farmed populations (Güralp et al. 2020; Wargelius et al. 2016) and make the farmed salmon resistant to parasites and diseases (Barrett et al. 2020; Nofima 2021). If a sterile salmon is put into production, it will prevent breeding with the wild salmon upon escape, solving one of the main environmental challenges in the industry.

One of the concerns that has been raised in debates about genetic modification in the past has to do with crossing species boundaries.[1] In Skjervold's research, the outrage was caused by the crossing of human and animal genes, a mix which stopped further research. But similar objections have been raised against any crossing of species. Along with similar arguments against "playing God" and "meddling with nature", such arguments tend to express the same concern: that we are illegitimately intervening in nature, committing an act of hubris (Lassen and Jamison 2006, p. 24; Myskja 2006, p. 228). As the then Prince of Wales (now King Charles III) put it, genetic modification strays "into realms which belong to God and God alone" (King Charles 1998).

In the scientific debate, such concerns have usually been dismissed. "Naturalness" and "unnaturalness" are generally not considered relevant concepts by scientists (Myskja et al. 2015, p. 95). For instance, appeals to naturalness in the case of animals have been dismissed on the grounds that it rests on the mistaken view of species as fixed and immutable rather than dynamic and everchanging (Rollin 2003, p. 15). In scientific debates about genetic engineering, extrinsic concerns related to risk to human health and the environment as well as possible societal benefits and disadvantages tend to dominate the discourse, while intrinsic concerns are rarely given much attention (Myskja 2006, p. 226). One of the reasons is perhaps that such concerns can be difficult to get a grasp of: Because terms like "natural" and "unnatural" are open to more than one interpretation, different users can mean different things by them. Value-laden terms like these are often described as *essentially contested concepts*, which means that they can cause users to prefer different meanings, but where no meaning can be proven to be the right one (de Graeff et al. 2022, p. 8). The ambiguity of these terms make it difficult to know how we should understand them, and what significance, if any, they should have in these debates.

In practice, however, intrinsic concerns are difficult to disregard completely. Natural and moral orders have a long history of being linked, with nature having served as a pattern of values that can be invoked to settle controversies about gender, sexuality and cloning, to give just a few examples (Daston 2019). This issue may explain why ideas of naturalness have continued to play a role in the genetic

[1] Both the terms genome editing and genetic modification are used in this article, where the former refers to CRISPR specifically, while the latter is used to describe older generations of genomic techniques where species borders are commonly crossed. In the interview material that is discussed in this article, the participants were not always as familiar with the differences between these two technologies, and used the terms interchangeably to refer to human intervention in animal DNA.

modification debate, where the Eurobarometer survey from 2010, for example, found that three out of four respondents described GM food as unnatural (Gaskell et al. 2010, p. 50).

The emergence of CRISPR is sometimes argued to be able to change the scene for this debate. CRISPR is a powerful, efficient, and relatively inexpensive tool that enables rewriting of the genetic code, making it possible to modify and create novel genetic sequences, thus altering the capacities of nearly any organism. Since it does not rely on the introduction of foreign DNA, contrary to older genetic modification technologies, some argue that CRISPR might be deemed more acceptable (Bartkowski et al. 2018, p. 175; de Graeff et al. 2019, p. 6). As such, it can be understood as an attempt to have the technology itself accommodate concerns raised by the public (Mielby et al. 2013, p. 472). CRISPR is not the first genome editing technique: Other technologies, such as TALENs and Zinc Finger Nucleases (ZFN) have been in use since before CRISPR was invented. However, these technologies are more expensive and less precise than CRISPR (Stone 2017, p. 590). Since CRISPR changes the premises for the debate, it is sometimes argued to constitute an ethical game-changer (Bartkowski et al. 2018, p. 175; Schultz-Bergin 2018, p. 222).

While naturalness is often dismissed as an argument in the scientific debate about genetic modification, it frequently does play a central role in science communication about consumer acceptance. A testament to this is offered by Kevin Doxzen, a researcher who was engaged to help explain CRISPR technology to stakeholders and the public. Doxzen noticed how audiences presented concerns about CRISPR-edited organisms that were familiar from the GMO debates: That they are unsafe, unnatural, and present environmental risks (Doxzen and Henderson 2020, p. 866). He describes how he would come up with rhetoric strategies to intentionally distance the new technology from the older to avoid CRISPR being added to the familiar GMO narrative, describing how CRISPR-edited crops in fact are very different from GMOs and can arguably be seen as being more natural than them (Doxzen and Henderson 2020, p. 866). Other examples abound: Genome editing is described as a process of "draw[ing] inspiration from nature" (Hua 2023), as "what nature would have produced" (Chang 2017) or as "one of the most natural things there is" (Bratlie in Elnan 2022). Thus, the concept of naturalness continues to play a role in the discourse surrounding genome editing technologies. It is, therefore, important to consider how this concept plays into evaluations of the acceptability of them.

Farmed salmon is an interesting example for thinking about our understanding of naturalness. Salmon is one of the most recent species to be domesticated, a process which started in the late 1960s through a systematic breeding program which has ensured that different traits have been selected and cultivated to better adapt salmon to industrial production needs. Contrary to animals which were domesticated earlier in human history, farmed salmon is constantly inviting comparison with its wild counterpart. How is naturalness understood in the case of an animal which is the product of systematic design interventions? Before discussing the results, I will discuss the theoretical framework within which the data have been interpreted and present the methods used and the data collection process.

Theoretical framework: empirical bioethics

This analysis is situated within the field of empirical bioethics, which combines empirical research with philosophical analysis and reflection (Musschenga 2005, p. 468) and encompasses a wide variety of research endeavours, methodologies, and practices. Although there are different methodological approaches to empirical bioethics, they share a commitment to four assumptions, as identified by Strong: They hold that we can gain ethically meaningful information from studying people's expressed attitudes, moral beliefs, intuitions, reasoning, and behaviour; that methods from the social sciences and humanities can be used to gain access to this information; they aim at using these findings to inform ethical reflection and decision-making; and finally, they do not aim to generate moral truths or ethical norms, but to engage with particular ethical issues in a practical manner (Strong 2010, pp. 317–318). The aim is to offer a contextualised ethical analysis that is both grounded in lived experience and critically normative (Ives et al. 2017). Qualitative research methods are proposed as tools to achieve this, as they can provide insight into what people's opinions and values are and uncover the reasons and reflections behind them (Ives 2008). This article is committed to the four assumptions described above, and uses individual interviews and focus groups to examine both arguments and understandings that are given in conversations about using CRISPR on farmed salmon, using this data as a basis for normative reflection. The implication of this approach is that appeals to naturalness, which, as stated above, are frequently dismissed in scientific debates about biotechnologies, can in fact yield useful things to think with in ethical analysis. This idea has been aptly defended by Mary Midgley, who in her essay "Biotechnology and monstrosity: Why we should pay attention to the 'yuck factor'" warns us against dismissing emotional responses to biotechnology, such as rejecting uses of it on the basis that it is unnatural, as mere feeling. On the contrary, such feelings ought to be taken seriously because our emotions are part of what helps us find our way in the world (Midgley 2000, p. 7). While we often divide moral objections into concerns about probable

consequences on the one hand and intrinsic objections on the other, and consider the former legitimate while the latter is dismissed as subjective, in practice, concerns are usually difficult to divide into neat categories (Midgley 2000, p. 7). Because in practice, "[f]eelings always incorporate thoughts– often ones that are not yet fully articulated– and reasons are always found in response to particular sorts of feelings" (Midgley 2000, p. 8). Feelings and concerns may be rooted in legitimate objections, which we can spell out and then evaluate (Midgley 2000, p. 7). This is also an apt description of the role of philosophers working within empirical bioethics: They take as their point of departure concerns, feelings and values, which are systematically collected through qualitative research methods, and proceed to spell out and evaluate the arguments contained in them, using them in normative analysis of ethical questions.

Midgley's remarks are mirrored by Henk Verhoog, who argues that the concept of (un)naturalness always has a normative component and provides prescriptions of what is morally right and wrong (Verhoog 2003, p. 295). In other words, if questions of naturalness and unnaturalness are treated as a question of consumer preference, as they have been in the past (Mielby et al. 2013, p. 472), we risk losing sight of what is morally at stake in situations where such notions are invoked. This article argues for the importance of taking such concerns seriously because they offer a valuable basis for reflection when assessing novel biotechnologies. Holding that society's morality is not an overarching and coherent system of beliefs, but rather "an interlocking whole of moralities embedded in particular practices", we can, in line with the empirical bioethics framework, understand qualitative research interviews as a genuine source of morality (Musschenga 2005, p. 478), something I here understand in the sense that they can provide a basis for normative reflection.

In the following, I first describe the study design. I then proceed to present the study's findings about participants' deliberation about the use of genome editing in salmon farming, with particular emphasis on how the notion of naturalness is used. In the final part of the article, I analyse key understandings of naturalness identified in the material and discuss the implications of these notions for the normative question of whether or not CRISPR should be taken into use. Finally, I indicate areas for further analysis.

Table 1 Individual interviews and focus groups

Category	Number of interviews
Scientists GE in fish	4
Trade union representatives	1
Salmon breeders	3
Fish health workers	5
NGO representatives	2
Advisory body representative	1
Sámi resource management	1
Wild salmon management	1
Focus group participant	24 (4 groups)

Data and method

The discussion below is based on qualitative interviews with stakeholders in the salmon farming industry. The interviews were conducted in collaboration with Torill Blix as part of an interdisciplinary research project on the use of CRISPR in salmon farming (https://www.ntnu.edu/crispr-salmon). 19 professionals were interviewed individually, and 24 lay people participated in four focus group interviews. To ensure a variety of different arguments and perspectives, we recruited people with different engagements in and views on salmon farming, in addition to laypeople. Table 1 shows the different participant groups and the number of participants from each group. The participants for the individual interviews were recruited through stakeholder mapping. We recruited people who work on the pens and on the administrative side of the salmon farming industry, scientists who use CRISPR on fish, and people who work for NGOs, wild salmon management, and governmental advisory bodies.

Focus group participants were recruited through the market analysis company IPSOS, and included participants from different regions and age groups in Norway (18–80), representing different genders and ethnicities. Each of the focus groups consisted of 6–7 participants. The individual interviews lasted about an hour, while the focus group interviews lasted up to 1 h and 40 min. The Norwegian Agency for Shared Services in Education and Research (Sikt) was notified before the sampling and use of personal information (Sikt reference number 707095). All stakeholder participants signed a declaration of consent. IPSOS AS arranged a standard declaration about GDPR and data management with focus group participants.

As the aim of this study, in accordance with the empirical bioethics methodology described above, was to uncover reflections and arguments relevant for a normative analysis, differences between professional stakeholders and focus group participants have not been considered relevant and have therefore not been analysed.

The interviews followed a semi-structured interview guide (Kvale and Brinkmann 2015). The questions included both open-ended questions that allowed the participant to bring up and reflect on topics of their own choosing, and more direct questions to probe for arguments and opinions. The aim was to extract a broad basis of arguments, emotions, opinions and descriptions to be used as a reflective basis for developing further arguments (Winther 2022). The topics and themes covered in the guides for individual and

focus group interviews were largely the same, and the overall structure of the guides was also the same. Three general topics were covered: Informants' personal experiences with salmon, their ethical reflections about the acceptability of using genome editing in the salmon industry, and sustainability issues related to the salmon industry. The flexibility of the semi-structured approach allowed us to pursue different topics brought up in conversation and ask follow-up questions, which made it easier to uncover reasonings and arguments. Since our interest precisely lay in establishing concerns and the reasons behind them, we asked open-ended questions about the participants' thoughts about using CRISPR, both based in specific examples, such as the sterile salmon or lice resistance, and on a general basis. This allowed the participant to bring up their own experiences and thoughts and reflect on them. Follow-up questions were sometimes asked in order to get thicker descriptions and clarifications, and sometimes to challenge certain views or ask the participant to justify them, in order to not merely elicit narratives, but to better examine normative justifications for beliefs (Brinkmann 2007). In this latter regard, we took an active, participatory role in the conversation, rather than serving as mere facilitators of dialogue (Myskja and Myklebust 2023; Skjervheim 1996).

All interviews were audio recorded and transcribed verbatim. In a first, preliminary round, the data were thematically organised in accordance with the themes of the research questions and the interview guide, such as "View on salmon"; "View on CRISPR"; and "View on GMO", with the aim of reducing data and organize them into meaningful categories (Coffey and Atkinson 1996, pp. 35–36). In a second, more inductive round, we focused on additional themes that emerged from the data during analysis, such as "naturalness", "intrinsic value", and "moral status". The theme of naturalness emerged as a central concept during this more inductive round, as this idea was found to be either implicitly or explicitly invoked in participants' reflections, although this concept was not a part of the interview guide. That finding motivated using this concept as a lens to examine how participants reflected about the acceptability of using CRISPR on farmed salmon. This material was then reviewed for descriptions, definitions and arguments about naturalness and conditions for the acceptability of using CRISPR in the salmon farming industry. As few participants present explicit moral arguments or definitions of naturalness in their reasoning, I have interpreted and developed them further in the analysis (Ives et al. 2008, p. 78) in line with the empirical bioethics methodology described above.

Results

From iconic species to swimming vegetable

Wild and farmed salmon are generally perceived differently, with the former being considered to be of higher value and holding an iconic status in Norwegian and Sámi culture. For one thing, the wild salmon is hunted and has the possibility of escape. It is "a fascinating animal that is part of a larger ecosystem, […] it is in the ocean and the rivers, and it interacts with so many incredible species", while the farmed salmon "has no such function […], it is merely produced to give us something to eat." Farmed salmon is easily accessible at the general store and is "something you can eat on any given Tuesday", whereas wild salmon is difficult to acquire and is reserved for festive occasions.

The concept of naturalness was occasionally invoked to express the difference between the wild and the farmed salmon, such as in this conversation with a scientist:

> Wild salmon is natural, but farmed salmon is not 100% natural. So it's still a fish, but it is not as natural as a wild salmon because it doesn't live like a wild salmon does, as it has lived for many years.

The assertion that farmed salmon is not *as* natural as wild salmon suggests the idea of naturalness as a gradient (Siipi 2008). The wild salmon is the benchmark against which farmed salmon is measured, and the farmed salmon finds itself on the lower end of the naturalness scale. The interviews suggested that its placement on this scale would be determined based on how far the farmed salmon was removed from the wild– features that "mimic the natural selection of the wild" are more acceptable than radical alterations in weight, size and colour, something which was vocalized by several participants. This idea, on my understanding, raises a fundamental question about where we should draw the line for what kind of breeding designs are considered acceptable, a question that is not new to the emergence of genetic modification, but which gains further traction with it. In the context of the GMO debate, this question has often had as its point of rotation the difference between transgenic and cisgenic edits and whether there is a moral difference between the two. In this material, however, I found that participants were more concerned with the features the farmed salmon are given rather than the methods by which these are brought about, and specifically with how these features impact fish welfare. For instance, a representative from the wild salmon management pointed to how the farmed salmon has a different heart shape than the wild, and how this impacts their welfare as an example of negative breeding, although this has nothing to do with

CRISPR, while another participant argued that using any means to make the farmed salmon resistant to salmon lice, including genome editing, would be extremely beneficial to the fish. Neither of these responses are specific to CRISPR; instead, when we discussed which conditions have to be in place for CRISPR to be considered acceptable, a univocal response was that applications should be beneficial to the welfare of the fish, where welfare was understood broadly as not just the absence of diseases, but as the ability to live in accordance with their species-specific nature. What "living naturally" means is, of course, difficult to operationalise and use consistently (Yeates 2018, p. 1). It was argued that it means that the fish should get to do what is natural for it as a species, but there was wide agreement that it is hard to say what a natural life means for farmed salmon– after all, swimming in circles in confined nets is not what comes to mind when we think about a natural fish life. When farmed and wild salmon were compared, the idea of naturalness was frequently put in connection with what kind of lives the fish lead, where the farmed salmon is measured against its wild counterpart, and where the farmed salmon has been bred to fit into what was described as "kind of like a barn". One interview participant, while stating that good treatment of farmed salmon consists in allowing it to live "as naturally as possible", continued by noting that "this is probably not realistic considering the kind of production volume the salmon farmers want in order to make a good profit." In other words, concerns were raised about how domestication impacts species norms, and how farmed salmon can live in accordance with their nature given that they lead their lives in pens. There are to aspects of this point: On the one hand, this is a matter of what kind of capacities the farmed salmon are bred to have, and on the other, it is a matter of the environment they live in. The history of the domestication of salmon has been a story of the mutual shaping of these two aspects, where the fish have been adapted to fit production facilities, and where the production facilities (admittedly to a lesser extent) have been adapted to fit the fish.

The above reflections are not concerned with genome editing specifically, but rather with domestication as such. Although our interest in the interview guide was to discuss the former, many of the concerns that were raised were applicable to domestication generally, and the participants would often realize this, and find themselves at a loss to explain the moral difference between breeding and genome editing in domestication processes. However, it was argued that that the use of genome editing for breeding purposes will amplify existing challenges. This was demonstrated in an interview with a person working on the administrative side of the salmon farming industry, where the question of when a salmon ceases to be a salmon arose:

> Some people say today that salmon is a swimming vegetable because it is fed with raw materials it was not originally intended to eat. […] Those claims will reach a new level if we start editing the hereditary material. When does it cease to be a salmon?

This raises an important question: How substantial can a human intervention in an animal's genes be before it loses its ontological identity card? Farmed salmon were described as "swimming vegetables" or "fish fingers"– metaphors that indicate artificiality and a disparaging judgment that designates farmed salmon as occupying a border position between animal and food. As Lien writes, "the word domestication enacts a detectable difference between life-forms that are 'pristine' and those that are somehow 'invented'" (Lien 2015, p. 9). Domestication has come to be used as a "sorting device" for distinguishing wild animals from species that are affected by human impact, which helps biologists specify which are "worth looking after", in the sense that they should be conserved, "and which ones are not" (Lien 2015, p. 9). Although domesticated salmon are not "worth looking after" in the sense that Lien describes here, we can argue that the fact that we have domesticated them gives rise to duties to treat them with care and ensure their well-being. As a focus group participant said, "The wild salmon is more natural, but either way, it [the farmed salmon] is a life, and when you first have created that life, you have to give it good opportunities." This point suggests that we have moral obligations towards farmed salmon as husbandry animals, as has been defended in care ethical approaches to animal ethics (Palmer 2010). Palmer argues that we have different duties towards husbandry and wild animals: While we have a moral duty to treat husbandry animals with care and sympathy, in the case of wild animals, we are morally required not to meddle in their lives (Palmer 2010, p. 2). In other words, the denaturalization of an animal may alter our moral responsibilities towards them. This point was acutely put by one of the scientists we interviewed: "We are responsible for ensuring their [the farmed salmon's] well-being because we have put them in confinement. But the wild fish– in that case, we have a responsibility to keep nature clean so that they can manage on their own." The stakeholder claim brings further nuance to Palmer's claim: Our responsibilities towards the wild salmon does not merely consist in a mere non-meddling, but also in taking active steps to ensure the thriving of the environments they live in. This is a point I will return to below.

The concerns discussed above, as already stated, are not new with CRISPR, but reaches a new level with it because of its precision and speed, as well as the scale and range of possible applications. Rather than pointing to a clear acceptability thresholds, it was suggested that possible applications

of CRISPR should be assessed on the basis of the following acceptability criteria: It must be consistent with a good and respectful treatment of the farmed salmon. This suggests that virtue ethical concepts like respect and care are core in the assessment of acceptable uses of CRISPR, but translating these virtues into an understanding of what they require in the specific context of salmon farming, which includes an understanding of which features it is acceptable to alter, remains an essential question. Additionally, whether CRISPR will prevent or enhance the farmed salmon's ability to live in accordance with their species-specific nature is an empirical question that requires further research. In the following, however, I aim to offer such an assessment, focusing on the case of the sterile salmon.

Conserving the wild: the sterile salmon as a paradigmatic case

The requirement that taking genome editing into use should be consistent with good and respectful treatment of the farmed salmon has to be balanced up against another condition which was put forth in the interviews, namely that genome editing must not lead to negative environmental impact, specifically that it must not negatively affect wild salmon populations. This became particularly clear in the discussions about the paradigmatic case for a CRISPRed salmon, namely the sterile salmon. There was broad agreement that a sterile salmon could be very beneficial. For example, a salmon farmer noted, "If the accident [that the farmed salmon escapes] happens, to have a sterile salmon, I would consider that to be positive. […] It could be incredibly important." Participants demonstrated a high awareness of the fact that the wild salmon populations are threatened on account of escapees, and stopping the "genetic pollution", as an advisory board participant put it, in order to protect the wild salmon from further decimation was seen as imperative. A trade union representative stated that "[Norway] has the world's largest population of wild salmon, and we have a responsibility to preserve it– we need to preserve it. Otherwise, we will never be forgiven."

What emerged in the conversations is that there is actually a conflict between the responsibility and concern we have for the farmed salmon and the higher valued, "more natural" salmon in the wild. A sterile salmon was not considered unproblematic: As one NGO representative pointed out, it is not a solution that "goes to the root of the problem". Genome edited salmon can still escape; genetically editing it is only "symptom treatment". "It is a bit like shooting sparrows with cannons", a representative of Sámi resource management put it. However, given the dire state of wild salmon populations and the perceived urgent need to protect them, many seemed likely to consider it as an acceptable symptom treatment. While describing "meddling with genes" as "scary", one focus group participant noted that preventing farmed salmon from breeding in the wild seems smart and useful. A trade union representative noted that "you need strong reasons to do something– sterilising the salmon is done to protect the wild salmon." An NGO representative who, throughout our conversation, had objected to genome editing of animals agreed. This participant had ardently objected to using CRISPR on a general basis, but was willing to concede that given the current realities of salmon farming, the principle of protecting the wild salmon overrides misgivings against genome editing of the farmed salmon: The moral imperative is that wild salmon as a species should be preserved in its pristine state. As argued by a representative from Sámi resource management, an organisation that aims to protect natural resources central to the practise of Sámi culture and tradition: If we allow genome editing, we need to make sure that the phenotypes we create are not spread in nature, especially if they are genome edited.

The motivation for the sterile salmon is, of course, to minimise the impact of escapees on wild salmon populations. While the above section discussed an understanding of naturalness where it consists in the ability to live according to species-specific nature, we here find a different understanding, namely naturalness as that which is unaffected by humans. In other words, the wild salmon should be conserved in the sense that their genotype should not be affected by humans, while the mere fact that the genotype of farmed salmon is made by human design makes it less natural in this sense. As one salmon farming employee pointed out:

> The intrinsic value of an unaffected wild salmon underlies this idea that you don't want any [human] involvement. So there is an idea of a natural salmon and that when we intervene, we remove the invented salmon from that ideal.

They also noted that interventions in the intrinsic values of animals are not commonly discussed in agri- or aquaculture, since decisions are primarily made on the basis of what is safe for the environment and consistent with good fish health: "No one holds back because we should preserve the intrinsic value of that species– in that case, it must be the wild species you want to preserve the intrinsic value of." A sterile salmon is deemed a beneficial application of CRISPR because it will contribute to the conservation of wild salmon, and while it would be better not to have to sterilise the farmed salmon in the first place, this is considered an acceptable price to pay given the benefits. But while many of the participants were content to accept this conclusion, this dilemma raises further questions about our

role in nature and the implications of using CRISPR, as we will examine closely in what follows.

A bad gut feeling: Messing with nature

For many participants who voiced objections to various kinds of uses of CRISPR, it was often difficult to say exactly what they were objecting to. There was a wide gap between the participants regarding how well they understood the technology being discussed, from laypeople who had little familiarity with it to expert scientists who work with it daily. Participants from both groups expressed an "uneasiness" about CRISPR, even as they pointed to its many benefits. This uneasiness was often expressed as a question about where to "draw the line" on intervention in animal DNA. After all, humans have a long history of meddling with other species through breeding efforts. Even participants who held that genome editing is radically different from breeding found it difficult to pinpoint the principled difference between them: As one scientist put it, "Either way, you as a human have intervened and done something." This sentiment was echoed by a salmon farmer, who said that they thought it was "kind of the same because you change the genes regardless of whether it's a knockout or you put something in, it is still a change, so I wouldn't really separate those concepts [genetic modification and genome editing] that much, really, because it is still a change." On this understanding, the degree of (un)naturalness depends on human agency– both cisgenic and transgenic interventions are equally unnatural because they have come about through human interference (Mielby et al. 2013, p. 474; Siipi 2008, p. 80).

But even if CRISPR, on this account, is perceived as a continuation of human intervention through animal breeding, some participants expressed reluctance and misgivings about giving the green light for using this technology. Another scientist captured this uneasiness well:

> [W]ith breeding, you have more time […] to notice if something goes wrong. But if you do genome editing, it might go very fast and maybe a bit helter-skelter, and suddenly something happens very quickly that is more difficult to control in a way. […] I think that nature has done breeding for many, many, many years, so I think actually that with genome editing, humans are sort of coming in from the side lines and believing that we will play, well, God and start to mess with a system that has worked for very, very, very many years, and well, I don't think it is wrong that we are doing it, but I think maybe we need to take a step back and be humble in the face of nature, which has been doing this for a lot longer than we have. We are becoming a bit full of ourselves and think we can just go on without regard for the world, the Earth, the ecosystems, and everything.

The reflections presented here raise an important question: Considering the rapid pace with which CRISPR is developing, do we have sufficient time to stop and assess what we are doing? The participant implies that if a change takes more time, we are also given a better opportunity to observe and consider the consequences of our acts. This is also something Myskja reflects on. An ecosystem is in a continuous state of change. While slow and gradual alterations take a long time to spread and affect the environment, genetic modification technologies introduce altered traits over short periods, differing radically from the changes of evolution (Myskja 2006, p. 235). In other words, there is a higher risk of failing to respect the unique character of fragile ecosystems, which are seen as balanced (Mielby et al. 2013, p. 476).

Another person supported this view, using the metaphor of a ladder to explain the difference between breeding and genome editing: With breeding, we have to take one step at a time through each generation, whereas genome editing allows us to "sort of skip over steps of the ladder, making a much larger improvement". It is "a little bit like being steady and sure", they added– when we do selective breeding, we make smaller interventions, the effects of which we can observe over time. In light of this, we should remember that genome editing can have unintended consequences that we cannot foresee:

> Much can happen that we cannot control, and I think that's important to remember. […] If you want to make a salmon resistant to virus attacks, so many genes are upregulated and downregulated and signal paths that go here and there and crisscross, it's like taking a metro map of London and New York and shaking it together and putting it on the table, and you have closed a station. You think it just affects the green signal path, and then you notice that […] something is happening in the orange and purple line that we hadn't thought of.

This suggest that we should proceed with precaution and care. The unknown possibilities of CRISPR give us special responsibilities, the scientist quoted above continued:

> It is important to take a step back and be humble too. […] About the CRISPR technology, I think it is very exciting, and I obviously see the opportunities, but can we just leap into it?– I think that asking for forgiveness rather than permission is not the best tool here

> because it can lead to unwanted consequences that we may not be able to return from. I'm kind of a precautionary person who thinks we need to take a break and ask where we are and what we want.

This is an expression of concern we found to be often articulated in different forms throughout the interviews and focus groups. In these contexts, some would refer to a general feeling of hesitancy about using CRISPR at all, such as the following quote by a salmon farmer: "I have kind of a bad gut feeling when it comes to everything that is about genome editing of the genetic material." This feeling was not related to safety: The participant explained that they felt that researchers and politicians can be trusted on this matter– if a project is set in motion, it must be because the researchers have deemed it safe to use. But still, it gives rise to fundamental moral question that must be addressed:

> You may have a far vaster area of use, and, well, rather scary areas of use you don't know if you want to contribute to. After all, CRISPR can be used on more than salmon or corn. I get a bad taste in my mouth when I say that it can be used on humans, too– the same technology can be used for anything, so it is not just the purely ethical assessments you are making of the specific adaptation of a production animal or a species, but a much larger discussion.

What this suggests, in my view, is that even as we discuss isolated cases of CRISPR applications, these discussions are embedded in a larger conversation about the radical potential of this technology. As a representative for a wild salmon management NGO told us, the generation growing up now faces challenges connected to gene manipulation and "nature-trickery" in a way that previous generations did not have to. Elaborating on this claim, we can also argue that we, therefore, must establish if and which kinds of "nature-trickery" are acceptable. Furthermore, there is an urgency to this demand since upholding ecosystems may rely on technological intervention, as I will discuss further below.

Discussion

The article started by asking whether the fact that CRISPR does not rely on the insertion of foreign DNA means that it can appropriately be thought of as an ethical game-changer in terms of moral and social acceptance. The findings presented above are non-conclusive in this regard, but suggest instead two notions of naturalness which are deemed crucial in discussions about the moral acceptability of genome-edited salmon. First, naturalness was seen as life under species-specific conditions, presenting the criteria that CRISPR cannot be considered acceptable unless it is used in a way that is coherent with this. Second, naturalness was understood as that which is unaffected by humans, indicating that wild salmon should be conserved in its pristine state.

One way of interpreting this is that once the crossing species boundary objection has been dealt with, the ethical discourse shifts to other concerns that must be addressed. But the requirement that farmed salmon should be able to live according to its nature raises the question of how this can be carried out in practice. According to Yeates, the benchmark for natural behaviour is set by "the behaviour of uninfluenced equivalent animals" (Yeates 2018, p. 5), but the central workings of salmon farming make it clear that this standard cannot be fully realised. Wild salmon do not swim around in pens, they are not fed and are not treated for their illnesses. The word "equivalent" presents the challenge here– the farmed salmon is far removed from its wild counterpart when it comes to living conditions and genetics. It precisely invites comparison because the domestication of salmon is fairly recent and because their environments, while intended to be kept apart, are continuously mixed.

On the one hand, a strong condition is put forth that using CRISPR must be consistent with salmon welfare and permit species-specific behaviour, but on the other, the conservation of wild salmon is considered an urgent demand. This creates a conflict between different concerns, where the latter is likely to weigh the heaviest. Using CRISPR to sterilise the farmed salmon to avoid genetic pollution of the wild populations is seen as acceptable, even by participants who initially either flatly rejected or were hesitant about sterilising the farmed salmon; they said that given the current state of the industry, this could be a potential solution to a dire problem– ensuring the wild salmon's continued existence.

There are obviously other ways the escapee problem could be solved, which do not include using CRISPR. Facilities could be moved on land, or, more idealistically, the industry could be minimised or abolished because of negative environmental impact. As a solution to challenges that industrial-farming conditions have brought about, CRISPR remains a symptom treatment, as some participants pointed out. However, my position here is that it makes moral sense to discuss possible non-ideal improvements within a practice that is unacceptable from an ideal position.

Both definitions of naturalness given above can be understood as raising the question of what kind of attitude we ought to have towards nature. This is seen in the emphasis on care, respect, and responsibility towards the farmed salmon as well as the wild salmon and its surrounding ecosystems. The requirement that CRISPR should be used in a way that is consistent with life under species-specific

conditions expresses virtues like care and respect, while the requirement that wild salmon should be preserved in its pristine state invokes respect and humility. Furthermore, a frequently raised claim in the discussion above was that potential applications of CRISPR should be approached with humility and temperance. The use of CRISPR on animals raise fundamental questions about what kind of attitude we ought to have towards lifeforms which are different from us. The statement that certain uses of genome editing is unnatural, then, can be understood as a critique of the lack of respect for "the otherness of nature as something that we cannot and should not attempt to control completely" (Myskja 2006, p. 231). The word "completely" is important here, as it indicates that there are situations and contexts in which altering the features of an animal may be consistent with the attitudes described above. The basis for the moral implications of both definitions above is the question of what it means for us to respect the otherness of nature, given the possibilities offered by genome editing technologies. Within the scope of this article, a definitive answer to this question cannot be given. However, an implication of the precaution that is urged for is that we should avoid using CRISPR in cases where other solutions could be sought. This means that even producing a sterile salmon, which has been the paradigmatic case in this article, is something that should be considered with wariness. Sterilizing farmed salmon to make it fit the production systems better– instead of changing the production system itself and asking what a production system that suited the life of this particular animal could look like– is instrumentalizing it further and is inconsistent with respecting its otherness, and cannot be acceptable.

While human intervention in nature has occurred for thousands of years, and in this sense is nothing new, emerging technologies such as CRISPR raise fundamental questions about our role in nature, where we both have responsibilities towards the animals we have created and the animals of the wild. When participants raise concerns about "playing God" and call for a "larger discussion" about how these technologies should be used, this can be understood as a call to stop and assess the power this technology gives us and how it may be used responsibly. As Midgley writes, "[p]laying God is actually a quite exact term for the sort of claim to omniscience and omnipotence that is being put forward" (Midgley 2000, p. 14). This kind of reasoning can be traced back to the very beginning of public debates on genetic modification. In a citizen panel in 1996 on genetically modified foods in Norway, a participant argued that "[r]espect for life and nature is part of our identity. If we uncritically take genetic technologies into use in food production, how does that affect us? Are we in danger of becoming stunted human beings?" (De nasjonale forskningsetiske komitéer 1996). In other words, using technologies like CRISPR raises fundamental questions about our role in nature that will only become more pressing in the years to come.

Finally, considering the value ascribed to naturalness as nature that is unaffected by humans leads us to a paradox which is likely to gain traction as genome editing is pointed to as a possible solution to save the wilderness through adapting animals to changing climates and as part of rewilding-strategies: While the understanding of naturalness at stake is nature as being unaffected by human activity, keeping nature pristine may rely upon human intervention. Furthermore, there is no meaningful way in which we can say that any part of the planet is completely unaffected by human activity. What do "wilderness" and "wild animals" mean when human impact on the planet extends to virtually everywhere? (Vetlesen 2023, p. 11). Though this article has offered no conclusive answer to the question of whether CRISPR is an ethical game-changer in terms of its acceptance compared with older generations of genetic modification technologies, this paradox can be understood as a game-changer for discussions on whether and under which conditions CRISPR and similar technologies ought to be taken into use, as it constitutes a novel context for the assessment of acceptable uses of this technology.

Conclusion

While concerns about naturalness are frequently dismissed in the scientific debate, this article has argued that if taken seriously, such concerns can unveil objections that shed light on the moral problems presented by emerging biotechnologies. I have also argued that empirical bioethics may present an appropriate methodology for doing so. Empirical bioethics is a growing field with many ongoing discussions on how empirical data can inform normative reflection in a meaningful way (Ives et al. 2017). Here, I have taken data from focus groups and individual interviews to form a basis for normative reflection, using reflections, emotions, and opinions that arose in conversation as a departure for developing my own arguments about normative dimensions of the naturalness concept. Elaboration of the methodological framework for doing this, however, remains a topic for further research.

The article has found two definitions of naturalness to be at stake in the question of using CRISPR in the salmon farming industry. Each definition presents a moral requirement for how we should consider its application. In the case of farmed and wild salmon, this means allowing salmon to live according to its species-specific nature and ensuring that it is unaffected by human activity respectively. Both of these definitions are interpreted as being concerned with

what attitudes we demonstrate when facing the otherness of nature. There is a variety of research projects on potential applications on CRISPR in the salmon farming industry already, with further development likely on the way. The article has not been able to provide an assessment of all these potential uses, but has focused rather on the use of CRISPR to make farmed salmon sterile, which was found to be inconsistent with respecting the otherness of nature. A paradox is pointed to but remains unresolved, namely that the imperative to conserve nature in an unaffected state may only be realised through technological measures. This dilemma will likely become more pressing as climate change and loss of biodiversity accelerate.

Table.

Acknowledgements I am grateful to Bjørn Myskja, Lotte Holm, and the reviewers for helpful comments and advice, which greatly improved the article. I would also like to thank Torill Blix, with whom I did the data collection and initial analysis. Finally, I would like to thank Wageningen Academic Publishers for allowing me to develop my extended Eursafe abstract, "From iconic species to swimming vegetable: CRISPR as the new frontier in the domestication of salmon", into a full article.

Funding Open access funding provided by NTNU Norwegian University of Science and Technology (incl St. Olavs Hospital - Trondheim University Hospital)

References

Barrett, L. T., F. Oppedal, N. Robinson, and T. Dempster. 2020. Prevention not cure: a review of methods to avoid sea lice infestations in salmon aquaculture. *Reviews in Aquaculture*, *12*(4).

Bartkowski, B., I. Theesfeld, F. Pirscher, and J. Timaeus. 2018. Snipping around for food: Economic, ethical and policy implications of CRISPR/Cas genome editing. *Geoforum* 96(August): 172–180.

Bradbury, I. R., I. Burgetz, M. W. Coulson, E. Verspoor, J. Gilbey, S. J. Lehnert, T. Kess, T. F. Cross, A. Vasemagi, M. F. Solberg, I. A. Fleming, and P. McGinnity. 2021. Beyond hybridization: the genetic impacts of non-reproductive ecological interactions of salmon aquaculture on wild populations. *Aquaculture Environment Interactions* 12: 429–445.

Brinkmann, S. 2007. Could interviews be epistemic? An alternative to qualitative opinion polling. *Qualitative Inquiry* 13(8): 1116–1138.

Chang, K. 2017. These foods aren't genetically modified but they are edited. *The New York Times*, 9 January. https://www.nytimes.com/2017/01/09/science/genetically-edited-foods-crispr.html. Accessed 16 Jan 2024.

Coffey, A., and P. Atkinson. 1996. *Making sense of qualitative data. Complementary research strategies*. Sage.

Daston, L. 2019. *Against nature*. Cambridge, MA: The MIT.

De nasjonale forskningsetiske komitéer. 1996. *Kvikklaks og teknoburger. Sluttrapport fra Lekfolkskonferansen om genmodifisert mat, 18.-21. oktober 1996*.

de Graeff, N., K. R. Jongsma, J. Johnston, S. Hartley, and A. L. Bredenoord. 2019. The ethics of genome editing in non-human animals: a systematic review of reasons reported in the academic literature. *Philosophical Transactions B* 374(20180106): 1–25.

de Graeff, N., M. Buijsen, and A. Bredenoord. 2022. *On the nature of nature. A study on the use and meaning of nature and (Un)naturalness in the literature on genetic modification*. CGM 2022-01. Onderzoeksrapport.

Devos, Y., P. Maeseele, D. Reheul, L. Speybroeck, and D. Waele. 2008. Ethics in the societal debate on genetically modified organisms: a (re)quest for sense and sensibility. *Journal of Agricultural and Environmental Ethics* 21(1): 29–61.

Doxzen, K., and H. Henderson. 2020. Is this safe? Addressing societal concerns about CRISPR-edited foods without reinforcing GMO framing. *Environmental Communication* 14(7): 865–871.

Elnan, T. 2022. Kyr uten horn og gladere laks: Nå fødes fremtidsdyrene. *Morgenbladet*. 11 February. https://www.morgenbladet.no/aktuelt/reportasje/2022/02/11/kyr-uten-horn-og-gladere-laks-na-fodes-fremtidsdyrene/. Accessed 16 Jan 2024.

Finstad, T. 2017. Naked gene salmon: debating fish, genes, and the politics of science in the age of publics. *Technology and Culture* 58(1): 97–120.

Gaskell, G., S. Stares, A. Allansdottir, N. Allum, P. Castro, Y. Esmer, C. Fischler, J. Jackson, N. Kronberger, J. Hampel, N. Mejlgaard, A. Quintanilha, A. Rammer, G. Revuelta, P. Stoneman, H. Torgersen, and W. Wagner. 2010. *Europeans and Biotechnology in 2010 - Winds of change?* European Commission.

Grefsrud, E. S., L. B. Andersen, P. A. Bjørn, B. E. Grøsvik, P. K. Hansen, V. Husa, Ø. Karlsen, B. O. Kvamme, O. Samuelsen, N. Sandlund, M. F. Solberg, and L. H. Stien. 2022. *Risikorapport norsk fiskeoppdrett 2022 - risikovurdering - Effekter på miljø og dyrevelferd i norsk fiskeoppdrett*. Havforskningsinstituttet.

Güralp, H., K. O. Skaftnesmo, E. Kjærner-Semb, A. H. Straume, L. Kleppe, R. W. Schulz, R. B. Edvardsen, and A. Wargelius. 2020. Rescue of germ cells in dnd crispant embryos opens the possibility to produce inherited sterility in Atlantic salmon. *Scientific Reports*, *10*(1).

Hesthagen, T., R. Wienerroither, O. Bjelland, I. Byrkjedal, P. Fiske, A. Lynghammar, K. Nedreaas, and N. Straube. 2021. *Fisk: Vurdering av laks salmo salar fra Norge. Rødlista for arter 2021*. Artsdatabanken. https://www.artsdatabanken.no/lister/rodlisteforarter/2021/8149.

Hua, H. 2023. CRISPR inspirations from nature. *Nature Methods* 20(1): 37.

Ives, J. 2008. Encounters with experience: empirical bioethics and the future. *Health Care Analysis* 16: 1–6.

Ives, J., H. Draper, H. Pattison, and C. Williams. 2008. Becoming a father/refusing fatherhood: an empirical bioethics approach to paternal responsibilities and rights. *Clinical Ethics* 3(2): 75–84.

Ives, J., M. Dunn, and A. Cribb. 2017. *Empirical bioethics: theoretical and practical perspectives*. Cambridge University Press. https://doi.org/10.1017/9781139939829.

King Charles, I. I. I. 1998. An article by The Prince of Wales titled The Seeds of Disaster, The Daily Telegraph. Royal.uk. https://www.royal.uk/clarencehouse/speech/article-prince-wales-titled-seeds-disaster-daily-telegraph. Accessed 16 Jan 2024.

Kvale, S., and S. Brinkmann. 2015. *InterViews*. *Learning the Craft of Qualitative Research Interviewing* SAGE Publications Inc.
Lassen, J., and A. Jamison. 2006. Genetic technologies meet the public: the discourses of concern. *Science Technology and Human Values* 31(1): 8–28.
Lien, M. E. 2015. *Becoming salmon: aquaculture and the domestication of a fish*. Oakland, CA: University of California Press.
Midgley, M. 2000. Biotechnology and monstrosity. Why we should pay attention to the yuk factor. *Hastings Center Report* 30(5): 7–15.
Mielby, H., P. Sandøe, and J. Lassen. 2013. *Multiple aspects of unnaturalness: are cisgenic crops perceived as being more natural and more acceptable than transgenic crops*? 471–480.
Musschenga, A. W. 2005. Empirical ethics, context-sensitivity, and contextualism. *Journal of Medicine and Philosophy* 30: 467–490.
Myskja, B. 2006. The moral difference between intragenic and transgenic modification of plants. *Journal of Agricultural and Environmental Ethics* 19(3): 225–238.
Myskja, B. K., and A. Myklebust. 2023. Socratic dialogue on responsible innovation– a methodological experiment in empirical ethics. *Etikk i Praksis* 17(1): 29–44.
Myskja, B., H. J. Schouten, and M. Gjerris. 2015. Ethical distinctions between different kinds of plant breeding. In *Know your food: Food ethics and innovation*, ed. D. E. Dumitras. & S. Aerts. Wageningen Academic Publishers: I. M. Jitea.
Nielsen, T. H., A. Monsen, and T. Tennøe. 2000. *Livets tre og kodenes kode. Fra genetikk til bioteknologi Norge 1900–2000*. Oslo: Gyldendal.
Nofima. 2021. *CMSEdit - Genome editing for CMS resistance in salmon*. https://nofima.com/projects/cmsedit. Accessed 16 Jan 2024.
Palmer, C. 2010. *Animal ethics in context*. New York: Columbia University.
Parmann, G. 1985. Bioteknologien skaper etiske problemer. *Aftenposten*, 30 May.
Rollin, B. E. 2003. Ethics and species integrity. *American Journal of Bioethics* 3(3): 15–17.
Sætre, S., and K. Østli. 2021. *Den Nye Fisken. Om temmingen av laksen Og alt det forunderlige som fulgte*. Oslo: Spartacus.
Schultz-Bergin, M. 2018. Is CRISPR an ethical game changer? *Journal of Agricultural and Environmental Ethics* 31(2): 219–238.
Shaw, A. 2002. It just goes against the grain. Public understandings of genetically modified (GM) food in the UK. *Public Understanding of Science* 11(3): 273–291.
Siipi, H. 2008. Dimensions of naturalness. *Ethics & the Environment* 13(1): 71–103.
Skjervheim, H. 1996. *Deltakar Og Tilskodar Og andre essays*. Oslo: Aschehoug.
Sommerset, I., C. S. Walde, B. B. Jensen, J. Wiik-Nielsen, B. Bornø, V. H. S. de Oliveira, A. Haukaas, and E. Brun. 2022. *Fiskehelserapporten 2021*. Norwegian Veterinary Institute.
Stone, G. D. 2017. Dreading CRISPR: GMOs, honest brokers, and Mertonian transgressions. *Geographical Review* 107(4): 584–591.
Strong, K. L. W. K. I. 2010. The strengths and limitations of empirical bioethics. *Journal of Law and Medicine* 18(2): 316–319.
Thorstad, E. B., T. Forseth, and P. Fiske. 2021. *Status of wild Atlantic salmon in Norway 2021*. Vitenskapeleg råd for lakseforvaltning.
Verhoog, H. 2003. Naturalness and the genetic modification of animals. *Trends in Biotechnology* 21(7): 294–297.
Vetlesen, A. J. 2023. *Animal lives and why they matter*. New York: Routledge.
Wargelius, A., S. Leininger, K. O. Skaftnesmo, L. Kleppe, E. Andersson, G. L. Taranger, R. W. Schulz, and R. B. Edvardsen. 2016. Dnd knockout ablates germ cells and demonstrates germ cell independent sex differentiation in Atlantic salmon. *Scientific Reports* 6(5817): 1–8.
Winther, H. 2022. Reflective empiricism and empirical animal ethics. *Animals* 12(16).
Yeates, J. 2018. Naturalness or animal welfare. *Animals* 8(53).

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