ENVIRONMENTAL COMMUNICATION

Environmental Communication

ISSN: (Print) (Online)Journal homepage: https://www.tandfonline.com/loi/renc20

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To cite this article: Laura N. Rickard, Cynthia L. Houston, Bridie McGreavy, Branden B. Johnson & Gabriella Gurney (2022): Fish Prisons and Bluehouses: Perceived Risks and Benefits of Land-based Aquaculture in Four US Communities, Environmental Communication, DOI: 10.1080/17524032.2022.2062020

To **link** to this article: https://doi.org/10.1080/17524032.2022.2062020

Published online: 20 Apr 2022.

ENVIRONMENTAL COMMUNICATION
https://doi.org/10.1080/17524032.2022.2062020

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

Fish Prisons and Bluehouses: Perceived Risks and Benefits of Land-based Aquaculture in Four US Communities

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ABSTRACT

The farming of aquatic species in water environments, aquaculture is presently the fastest-growing food producing sector worldwide yet is unfamiliar to many Americans. In this study, we examine perceptions of land-based recirculating aquaculture systems (RAS), a novel approach to raising fish. Through in-depth interviews (n= 71) with diverse stakeholders in four US communities, we explore how individuals make sense of the risks and benefits associated with proposed or existing RAS facilities and situate these judgments in the context of "naturalness." As a hybrid of fishing and industrial farming, land-based RAS can both support and undermine perceived naturalness, thus posing both perceived benefits and risks to local environments and economies. As a form of restoration, some RAS projects bring economic and environmental revitalization to communities; however, this restoration is understood in the context of a site's historical use. Findings contribute to emerging environmental scholarship on food systems communication, and offer practical applications for public communication surrounding aquaculture development.

ARTICLE HISTORY
Received 27 August 2021
Accepted 30 March 2022

KEYWORDS
Aquaculture; food technology; qualitative methods; perceived risk and benefit

Introduction

According to decades of consumer marketing research, public acceptance of food production often hinges on how individuals weigh perceived benefits against perceived risks, as well as how (un)natural a technology appears (Frewer et al., 2011; Siegrist & Hartmann, 2020). For example, discerning shoppers may eschew genetically modified (GM) strawberries yet reach for the grass-fed beef. Yet, our approval of food stems from more than cognitive assessment, just as communication about food is morethan persuasive labeling. Studying the environmental communication of food requires a systems-level perspective - one that accounts for community-level (and historical) relationships, power dynamics, and justice concerns (Gordon & Hunt, 2021). In this sense, avoiding GM fruit may be as much about the perceived risk of novel science to human health as opposition to the oppression of migrant farm workers. Depending on one's perspective, both risks - "risky" science or "risky" working conditions - could be construed as (un)natural and, by extension, (un)acceptable.

In this research, we extend this meaning making around benefits, risks, and the "naturalness" of food production - to date, mostly centered in production technology and terrestrial agriculture - to the context of aquaculture, the farming of aquatic species in water environments. Over the past few decades, aquaculture has been the fastest-growing food producing sector worldwide, with global aquaculture production now exceeding capture fisheries, with yields of 179 million tons in 2018

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and annual values over $250 billion (Food and Agriculture Association of the United Nations [FAO], 2020; Naylor et al., 2021; Tacon, 2020). Like terrestrial agriculture production, modem aquaculture is characterized by both traditional technologies (e.g. varietal species selection, specialized feed production) and innovations (e.g. genetic engineering of species, use of antibiotics and vaccines) (Rickard et al., 2018). Further, contemporary aquaculture has amassed critics and supporters based, in part, on publicperceptions of its production technologies' environmental and human health risks (e.g. producing toxic effluent) or environmental and economic benefits (e.g. reducing pressure on fisheries, creating jobs) (Hixson, 2014).

In recent decades, US domestic aquaculture production has been modest; yet, supported by Executive Order 13921 (Promoting American Seafood Competitiveness and Economic Growth, 2020), the industry is bringing the US a "Blue Revolution" in the form of innovative and/or expanded aquaculture facilities. Despite promise of a "vibrant and competitive" seafood industry to support the workforce and feed the nation, a growing literature suggests public opinion may not accord with sector growth. Recent studies have highlighted US audiences' limited familiarity with aquaculture (Rickard et al., 2020; Witzling et al., 2020) and potential precursors to opposition, including lack of trust in government or industry representatives (Rickard et al., 2020; Runge et al., 2021), perceived environmental risks (Hall & Amberg, 2013), or perceived threats to a locale's aesthetic qualities (e.g. Dalton et al., 2017; Hanes, 2018). As domestic and international corporations increasingly propose large-scale aquaculture development in communities across the US, how such individuals make sense of these food production systems is crucial to understand.

In this study, we examine a particular form of finfish aquaculture, land-based recirculating aquaculture systems (RAS): a suite of technologies allowing producers maximum control over inputs and outputs, from egg to harvest. In a RAS system, fish are raised in multiple, precisely calibrated tanks, with the size, shape, temperature, and construction dependent on the species' biological needs, including life stage. Filters remove solid waste through a mechanical filtration process (often repurposing it for plant fertilizer or other value-added products), while an additional biofiltration process removes dissolved wastes (e.g. ammonia, carbon dioxide) before the water is disinfected and reused. Producers constantly monitor system attributes, such as water quality, ensuring that the parameters are optimal for fish health (Recirculating Aquaculture Salmon Network [RAS-N], 2022). When successful, land-based RAS facilities optimize biosecurity - that is, fish are unlikely to escape and pathogens and predators unlikely to enter - thus addressing a limitation of ocean-based net pen aquaculture (RAS-N, 2022). Further, siting aquaculture on land allows communities previously unable to access local seafood a fresh option with fewer "food-miles" attached (Weber & Matthews, 2008). Thus, land-based RAS is novel not only because of its technological affordances (e.g. constant monitoring), but also because of its promise of environmental sustainability (e.g. repurposing some of the nutrients from effluent to grow other products, such as lettuce) (Tom et al., 2021) and food security (e.g. availability of local fish). While still a nascent approach, land-based RAS is gaining traction across the US and worldwide (Evans, 2019).

Through in-depth interviews ($n = 71$) with stakeholders across four US sites, we explore how these individuals make sense of perceived risks and benefits related to siting a local RAS facility. We attend to way(s) in which notions of naturalness and comparisons to terrestrial agriculture practices and productsshape, as well as complicate, these perceptions. Besides situating our findings in environmental and risk communication theory, we highlight implications of our results for communicating with public audiences about aquaculture development.

Understanding novel food technologies

Perceived risks and benefits

Among non-expert audiences, risk-benefit perceptions are critical in evaluating risks related to new technologies; often, such perceptions are inversely related- that is, technologies perceived as highly

beneficial are often rated low in risk - even when risks and benefits co-occur (e.g. Alhakami & Slovic, 1994; Gupta et al., 2012). Rather than a measured calculus of comparing pros and cons, risk-benefit perceptions may emerge heuristically among lay audiences: an "overall intuitive or affective impression" (Bearth & Siegrist, 2019, p. 21). Once established, these perceptions can influence various attitudes or behaviors, such as accepting fully automated driving technology (Liu et al., 2019). In the context of food-related technologies, risk-benefit perceptions can mediate between affective response (Bearth & Siegrist, 2019) or trust in institutions {Siegrist, 2000) on the one hand, and technology acceptance on the other.

A growing literature suggests that risk-benefit perceptions are also central to public opinion formation on aquaculture-related technologies. Information about aquaculture's purported benefits, such as producing affordable seafood, and risks, such as damaging community character or producing toxic effluent {Rickard et al., 2018), abounds in USprint news media, with attention to benefits increasing in recent years{Froehlich et al., 2017; Rickard et al., 2018; Rickard & Feldpausch-Parker, 2016). Despite low levels of both objective and self-reported knowledge among US audiences, knowing about aquaculture appears less important than how one perceives its risks and benefits in deciding to support its expansion or purchase farm-raised seafood (D'Anna & Murray, 2015; Hall & Amberg, 2013; Mazur & Curtis, 2006; Rickard et al., 2020). Risk-benefit perceptions can vary by stakeholder type as, for instance, representatives of Australian conservation groups weighed potential environmental, economic, and social risks of aquaculture more heavily than did individuals representing the aquaculture industry (Mazur & Curtis, 2006); thus, we expect that similar, if smaller, differences might occur across individuals living in communities considering a land-based RAS facility. Further, recent experimental studies show that risk-benefit judgments mediate the relationship between exposure to aquaculture narratives and intentions to support aquaculture products and policies among public audiences {Rickard et al., 2021; Yang et al., 2022).

Perceived naturalness

Researchers agree that support for a novel food technology often hinges on beliefs about its naturalness {Frewer et al., 2011; Siegrist & Hartmann, 2020); yet, how such perceptions develop requires further explanation. Lay connotations of"natural" range from safe to high quality to pure, whereas "unnatural" can signify artificial, poor quality, or contaminated (Rozin et al., 2004; Rozin et al., 2012). Psychologists posit that preference for the natural option may stem from instrumental {i.e. a belief based on an advantage of one version, such as reduced risk) or ideational {i.e. a belief based on no apparent objective advantage) reasons (Rozin et al., 2004), and that such reasons may be interconnected (Li & Chapman, 2012). In the case of food technology, the process applied to a product (e.g. genetic engineering) seems to matter more than its content (Rozin, 2005; 2006) in determining naturalness, though processing scale and product type are also influential (Etale & Siegrist, 2021). Regardless of how such perceptions develop, perceived naturalness often becomes a shortcut for assessing quality - a "natural is better" heuristic (Siegrist & Hartmann, 2020). In the case of sustainable agriculture, this heuristic may be especially problematic, as pop culture-informed consumer perceptions of natural (and conceivably, minimally managed) sustainable agriculture may be misaligned with the intensive management (e.g. irrigation, pest control) inherent in this food production system (Muller et al., 2017; see also Singer et al., 2020). By extension, fish that are bred, raised, and processed via input-intensive, technologically complex systems on land may appear to some consumers as less natural than - and thus inferior to - their wild counterparts. This perceived unnaturalness, paired with the technological novelty of land-based RAS, would also suggest the possibility of elevated risk perceptions among public audiences (Slovic, 1987).

From a communication perspective, naturalness is socially constructed, and thus its meaning is modifiable over space, time, and audience. In a recent study of Danish parents, for instance, Ditlevsen and Andersen (2021) apply anthropologist Mary Douglas (2002) foundational conceptualization to explain how purity has come to signify naturalness rather than hygiene; indeed, for

many contemporary parents whose rough-and-tumble children explore the playground and beyond, "dirt may sometimes signal purity more strongly than excessive cleanliness does" (Ditlevsen & Andersen, 2021, p. 180). Somewhat differently, naturalness can also be employed as an argumentative warrant to justify the claim that the unnatural represents elevated risk (Ditlevsen et al., 2020; see also Mielby et al., 2013}. In the case of a livestock vaccine developed using synthetic biology, scientific experts and lay citizens relied on distinct aspects of naturalness - e.g. as{un)predictable or as in harmony with the natural order - to make these claims, ultimately suggesting that differences in perceptions of naturalness may pose "potential for misunderstanding in public debate" {Ditlevsen et al., 2020, p. 302).

Perceived naturalness will likely also influence how stakeholders view existing or proposed RAS facilities. Recent research has indicated that perceived unnaturalness is negatively related to support for aquaculture practices and policies among the USpublic{Rickard et al., 2020), and, relatedly, that sustainable aquaculture is associated with attributes such as "natural, traditional, local, and small-scale production systems with high animal welfare standards" among German consumers {Risius et al., 2017, p. 246}. In a different study of German lay publics, certain aquaculture production processes (e.g. raising fish in earth ponds) were judged more natural, and, by extension, viewed more favorably than more highly engineered systems, such as RAS (Feucht & Zander, 2015). Other work has pointed to a so-called "stigmatization by association" in the application of certain perceived unnatural scientific practices (e.g. genomics} to aquaculture (Tansey & Burgess, 2008). Lacking experience with new aquaculture technologies, members of the public may also rely on analogies to terrestrial agriculture to judge its acceptability. In this case, audiences may fixate on the risks to natural resources or animal welfare posed by agri-industry, extrapolating the same negative consequences to forms of industrial aquaculture (Aarset et al., 2004; Feucht & Zander, 2015; Rickard et al., 2018; Rickard et al., 2020; Schlag, 2010; Schlag & Ystgaard, 2013; Vanhonacker et al., 2011). In the context of RAS, Feucht and Zander (2015) explain how this inferential reasoning played out among focus groups of German consumers who were asked about various sustainable aquaculture techniques:

> As a result of their longing for naturalness and authenticity participants mainly approved near natural production methods, such as earth ponds and flow-through systems (if surroundings are vegetated), while simultaneously refusing more highly engineered systems, such as closed recirculation systems (RAS). The participants' expectations of sustainable aquaculture were mostly inferred from their understanding of sustainable and organic agriculture. Thus, RAS were put on one level with intensive farm systems, especially poultry farming, because of their high stocking rates and industrialized appearance (p. 157).

Whether US stakeholders express the same skepticism toward land-based RAS as artificial technology is an empirical question that this research explored in the context of four sites. While the perceived (un}naturalness of a given site may serve as a heuristic for opposition or acceptance (Siegrist & Hartmann, 2020), the multiple dimensions of naturalness (e.g. unaltered, familiar, pure} may also apply in distinct ways depending on the attributes and experiences of a given individual (Ditlevsen et al., 2020}. Further, perceptions of (un)naturalness may depend on the characteristics of the communities in which such sites would be housed, including their urban/rural context, history of agricultural or fisheries-related industries, and experiences of environmental injustice (Roberts, 2007). Thus, we ask: How do concepts of (a) perceived naturalness and (b) terrestrial agriculture inform stakeholder risk and benefit perceptions of land-based RAS?

Method

Study Sites

The data come from a mixed-methods study to understand acceptance of four proposed or existing US land-based RAS facilities producing Atlantic salmon *(Salmo salar}* in California (CA}, Florida (FL), and Maine (ME) at a scale not previously attempted in this country (Table 1):

- Samoa Peninsula, CA. Nordic Aquafarms (NAF), a Norwegian company, plans to build on the former Evergreen Pulp mill, currently leased from the Humboldt Bay Harbor District and about three miles northeast of Eureka. NAF recently (December 2021) produced a draft environmental impact report to examine potential impacts on Humboldt Bay, which houses eelgrass, marine mammals, fish, birds, invertebrates, and algae. The facility is projected to produce 22,700 tons head-on gutted (HOG) fish annually.
- Homestead, FL. A Norwegian company, Atlantic Sapphire operates in Homestead, FL, approximately 40 miles south of Miami on a former tomato farm. Using patented technology, the Florida site has a current production capacity of 9,500 tons HOG fish, with plans to expand to 220,000 tons HOG by 2031. Following three mass fish die-off events in 2020 and 2021, Animal Outlook filed a complaint with the Miami-Dade State Attorney's office; the investigation is ongoing.
- **Belfast, ME.** NAF's Belfast site will raise 33,000 tons HOG fish annually at the former Belfast Water District along the Little River, which discharges into Penobscot Bay. To date, NAF has received all necessary permissions for construction. Despite pending court disputes over ownership of the intertidal zone to house a wastewater outflow pipe, the city exercised eminent domain in August 2021 to allow construction to proceed; in December 2021, the ME Attorney General filed a civil action against the city and NAF, calling the eminent domain unlawful.
- **Bucksport, ME.** After purchasing the former Verso paper mill in 2019, US-based Whole Oceans proposed a RAS facility for the site which is located 16 miles north of Penobscot Bay. Most mill buildings have since been demolished, and the site is currently in "pre-construction," with all necessary permits. A ten-year, three-phase plan has been outlined; byphase 3 the facility is projected to produce 20,000 metric tons HOG fish annually.

Interviews

Between February 2020 and June 2021, the research team conducted interviews with a purposive sample of stakeholders associated with each site. Following maximum variation sampling (Creswell & Poth, 2016), we selected individuals from the following designations to represent a breadth of perspectives on these projects: (1) local government (e.g. city council); (2) state government (e.g. county-level district supervisor); (3) tribal; (4) corporate (e.g. associated with a for-profit aquaculture company, including as a producer); (5) local resident; (6) journalist; (7) advocacy and/or nonprofit group (e.g. environmental group, fishermen's association, aquaculture association); (8) university (n = 71 interviews).[1] Importantly, these categories were not mutually exclusive and many interviewees wore several "hats"; for the sake of simplicity, however, we assigned each individual one affiliation based on their more prominent role (Table 2). Due to travel restrictions imposed by COVID-19, all interviews were conducted via telephone or ZOOM, lasting 18 minutes to two

Table 1. Shared Attributes of the Four Study Sites.

	Samoa Peninsula, CA (Nordic Aquafarms)	Homestead, FL (Atlantic Sapphire)	Belfast, ME (Nordic Aquafarms)	Bucksport, ME (Whole Oceans)
Corporate ownership outside US	X	X	X	
Population < 10,000	X		X	X
Former agro-industrial site	X	X		X
Annual production= 35,000 metric tons or less	X		X	X
All operating permits secured		X	X	X
Animal rights groups opposition	X	X	X	
Former paper mill	X			X
Currently producing fish		X		

hours and thirty-eight minutes (M = 56 minutes). About 20% of the interviews involved two or more researchers, with one as primary interviewer and the other as note-taker.

After interviewing a key stakeholder in each community (e.g. mayor), we asked for recommendations of individuals whose job positions and/or community tenure would allowthem to comment on the project (i.e. snowball sampling; Lofland et al., 2006). The resulting sample represents a range of professions and levels of familiarity with the technical, social, and legal aspects of aquaculture production and permitting. Semi-structured in format, the interviews covered several topics including priorknowledge and perception of aquaculture and RASspecifically, sense ofplace and perception of community identity2, involvement in the siting process, and attention to the siting in news and other public discourse; however, our discussions remained flexible to allow for exploration of emergent topics. We obtained voluntary informed consent to record each interview, and interviews were professionally transcribed.

Analysis

Following a principle of the constant comparative method (Glaser & Strauss, 1967), the research team first identified several emergent concepts of interest from a primary review of our notes and interview transcripts.Weperiodically refined the interview guide in our subsequent interviews to further explore these emerging areas of interest and based on our initial understanding of the phenomena (Glaser & Strauss, 1967). Besides regular meetings, the research team also engaged in preliminary inductive coding of several transcripts, using a shared online document to catalogue emergent themes and significant quotations. With this document as a foundation, the first author continued line-by-line coding (Charmaz, 2001) in a more targeted fashion, focusing primarily on portions of the texts related to perceptions of aquaculture. As an informal reliability check, during this process, the first author periodically shared thematic development with the research team and solicited input. Using the software Dedoose (Salmona et al., 2019), which allows for merging and compiling of quotations as well as collaborative coding across multiple operating systems, related codes were combined and refined into a small number of codes in a second round of coding. Subsequently, each of these codes became the basis of the two overarching themes and five sub-themes discussed below.

Results

RAS as fishing-farming hybrid

Viewing land-based RAS as a hybrid of fishing and farming - an opinion expressed by some and implied by others - interviewees routinely drew upon examples from both terrestrial agriculture and the fishing industry to articulate the benefits and drawbacks (or risks) of existing or proposed RAS facilities. Importantly, various connotations of naturalness factored into the decision calculus

Table 2. Number of Interviews by Affiliation and Community (n = 71).

Primary Affiliation	Belfast, ME	Bucksport, ME	Homestead, FL	Samoa Peninsula, CA	Non-location specific"
Local government	1	5	1	3	0
State government	1	0	0	9	1
Tribal	0	2	0	3	0
Corporate	4	1	2	3	1
Citizen	3	2	0	0	0
Journalist	2	0	0	1	3
Advocacy or non-profit	7	1	1	6	2
University	0	0	2	2	2
Totals	18	11	6	27	9

"Interviewees with the background and/or expertise to speak about multiple land-based RAS sites.

of both RASsupporters and opponents (Ditlevsen et al., 2020). For instance, a RAS facility could be perceived as a "natural fit" in the sense of complementing a *traditional* fishing heritage or opposed because of perceived competition with this enshrined industry. Alternatively, a facility could be viewed as an unnatural addition to the landscape in terms of its potential to *contaminate* the local flora and fauna, or a natural choice in terms of its ability to produce *healthy, high-quality* fish. Below, we explore these juxtapositions of "natural" in further detail.

A natural fit. When specific to an existing or intended RAS site, a "natural fit" could reference the constellation of the site's available resources, including fresh- and saltwater reserves, access to existing transportation corridors, and a trainable workforce; existing together, these resources allowed one to construct an ideal, "natural habitat" for land-based RAS. Describing how Atlantic Sapphire chose their Homestead location, an executive noted:

> We studied 13 different states before coming to Florida, but the ideal conditions were here in this tropical weather, so again it was logical sense, the fact that there is no wild salmon down in Florida.There is also access to labor ... There is a lower cost of electricity than, for example, in Maine, and we found the perfect ground-water conditions for water intake and water discharge.

At first glance, raising Atlantic salmon, a cold-water fish, adjacent to mango plantations might appear far from '1ogical"; however, this individual suggests achieving a "natural fit"means weighing not solely environmental, but also economic conditions and consumer demand. In this vein, some saw land-based RAS as an opportunity to merge a community's fishing industry and agricultural heritage, providing a newemployment opportunity well-suited to the area and a "natural" extension of the local economy. Among RAS supporters in Maine, these projects represented an industry star on the rise, as they pointed to aquaculture's key role in the state's recent economic report (ME Department of Economic and Community Development, 2019), as well as a reassuring nod to a familiar, working waterfront past. As a pro-RAS advocate in Belfast commented, "This is a strong marine resources state and aquaculture is a hybrid between the two ... Maine wants to be the major, major US food producer it used to be and this is a totally natural fit in my opinion." When speaking more generally about aquaculture, such as the recent growth in marine shellfish and seaweed farming, several Maine interviewees also highlighted its ability to complement traditional natural resource sector activities - specifically, providing a natural "back-up plan" for a fishing community facing reduced catches, and ensuring long-term environmental and economic sustainability. Far from perpetuating an "environment versus economy" dualism, many supporters believed the RAS projects constituted a win-win for economic development and healthy ecosystems, as explained by one Bucksport official:

> Of course people want it to be environmentally friendly, which sounds weird, environmentally friendly and industrial valuation, but that's how the Whole Oceans project was seen.

Yet not all interview participants viewed land-based RAS as complementing existing industries and sustaining natural resources. Among Pacific salmon fishermen in Humboldt Bay, for instance, the availability of RAS-grown Atlantic salmon could pose a risk of direct competition for a finite pool of resources - both for attracting consumers and supporting state and local conservation efforts. As one fisherman explained:

> Every time you can figure out a way to avoid taking care of a natural system, sayfor instance the Sacramento and the San Joaquin salmon rivers in California, which were the third biggest salmon producers in the world at one time, any time you can figure out a way of nothaving to take care of that byhaving an artificial system, it makes it even harder and harder and harder to push politicians and othergroups that have no interest in preserving those natural systems into doing any of that stuff. We think that projects like the Nordic project ... do a great job of dragging our attention away from taking care of our natural systems.

Compared to those who saw aquaculture as poised to unite farming and fishing traditions, this zero-sum view saw investing money and attention in "artificial" land-based RAS as unfairly tipping the scales towards aquaculture and against the future of the wild fishery, and, by extension, current

and futurelivelihoods in the working waterfront. Said differently, investing in RAS is divesting in a fishery, threatening the significant environmental and cultural wealth associated with it.

(Un)natural production system. Comparisons between RAS and terrestrial agriculture also emerged in descriptions of a company's production system. Among a small but vocal group of RAS opponents in Belfast, these facilities were emblematic of the many risks posed by industrialized food production systems. Echoing Feucht and Zander (2015), they adopted terms like CAFO, or Concentrated Animal Feed Operation,3 a reference to federally regulated, large-scale farms raising livestock, as shorthand for unnatural, environmentally toxic conditions. For these individuals, land-based RAS was not a promising technology, but rather another harmful example in a long line of flawed protein-production systems. As a Belfast RAS opponent suggested:

> Whether it's a feedlot in the Midwest for cattle, or a huge catfish-raising operation in Alabama, or it's salmon raising on the Penobscot Bay, it's still an industrialized food production system.

Others highlighted animal welfare, perceived as diminished by unnatural living conditions, as reason to oppose the land-based RAS facility:

> No wild fish should be put in a tank and his whole life is swimming in circles, with no other lifeforms in the tank. That's torture. So I think they're torturing the salmon, and I don't want to eat torture.

Other interviewees across the sites viewed the terrestrial agriculture analogue as raising confidence in land-based RAS, whose increased control over all aspects of cultivation can maximize safe and "clean" products. In Maine and Florida, corporate representatives described this control as both similar to processes employed in terrestrial agriculture (e.g. monitoring water conditions as opposed to soil conditions) and superior to the uncertain provenance and diet of a wild-caught product. In Florida, where rearing Atlantic salmon requires cooling water piped into the facility to recreate an appropriate habitat, an Atlantic Sapphire representative applied an agricultural metaphor to describe the setting engineered to raise their product:

> ... What we call the Bluehouse is in reference to a greenhouse, so it's the place where you give the salmon ideal conditions for growth ... from egg to final product, including farming, freshwater farming and saltwater ….

Though non-native to thelocal environment, such fish are, like the tropical fruit fields surrounding thefacility, carefully cultivated, processed, and shipped. Similarly, referring to the superior quality of Nordic's salmon versus wild-caught fish, a Belfast corporate representative noted:

> Our fish have a nutritionist on staff. Wild fish don't. They definitely are eating stuff that is not nearly as healthy But also, because we treat, and disinfect, and clean the water so effectively, so efficiently, we don't need to use any antibiotics, any medications. It's a cleaner, healthier product. If you truly want a sushi-grade product, buy a land-based fish It's a truly premium fish.

The "premium" - in the sense of purity - quality ascribed to RAS fish and production systems also extended to the issue of ocean microplastics. Here, both interviewees quoted above pointed out that their systems contribute beneficially in two ways, byproviding a healthier product (i.e. fish that have not consumed microplastics), and by ensuring that plastic byproducts from their facilities do not end up in the sea (i.e. a healthier environment).

(Un)just extraction & (un)natural waste. Besides perceptions about the relative naturalness of theproduction system, diverse concerns arose about natural resource extraction and waste disposal, especially for how these processes can pose serious environmental impacts that may impede local industries (e.g. fishing), or other land uses (e.g. recreation). For instance, representatives of the Humboldt Bay and Belfast fishing communities both voiced concerns about possible impacts to the Dungeness crab and lobster harvests, respectively, in areas near the proposed facilities:

> Supposedly, nitrate levels are going to be 1,400 pounds a day, a phosphate level of 467 pounds a day. Then where is that going? I think that the local fishery is fearful that that's just going to go through an outflow tube that breaches the seafloor a mile and a half offshore. And if that stuff is going to be released there,

could that potentially impact the other primary fishery that operates out of there, which is Dungeness crab? Would that in turn create a domoic acid hotspot?

[Nordic Aquafarms is] yanking out 1.7 million gallons a day of freshwater, six million gallons a day of saltwater and they're spewing out 7.7 million gallons a day of wastewater. That sounds like a flow through system to me Sothey're damaging the salinity that impacts the fishery.

Other Maine interviewees saw the proposed project as treating their fresh- and saltwater resources as "a sewer," making it "black with sewage," and "too dirty for [wild] salmon to live in." For those who opposed the RAS facilities in Maine and California, concerns about natural resource extraction and waste were not limited to local settings, as these production systems were also viewed as inextricably linked to distant communities. As a Belfast activist explained, what NAF chooses to feed its Atlantic salmon can implicate a small town in Maine in global issues of social justice and equity:

There's a terrible thing happening in Chile where all of their small fish havebasically been netted out of their sea with huge ocean trawlers. And the same thingis happening on the coast of Africa right now where whole regions of people who havedepended on the small forage fish for their daily protein needs are now, instead, working for fish feed and chicken feed companies in order toget feed to these European white people's ideaof high-end sushi.

In a contrasting view, other participants described how extraction and waste associated with land-based RAS are not unique to this production system, but rather a natural part of any agricultural or natural resource-basedsystem. As oneMaine environmental advocate suggested, "So [land-based RAS] haswaste and so on. It has the challenges any agribusiness has, and so let's start treating it just like one more business, not a magic thing that can't pollute " AnAtlantic Sapphire representative pointed out that their company's system of injecting wastewater into deep, underground wells is common practice among surrounding agricultural farms:"It's a well-established regulation for the wastewater disposal." Some suggested that RAS not only limited the damaging effects of other aquaculture production systems (e.g. ocean net pens) on natural habitats, but also could *improve* the quality of these environments. Responding to concerns of anti-RAS activists in Belfast, a corporate representative countered:

The total suspended solids in Belfast is actually less than the background level in the bay. So the water that comes out of the facility is cleaner than in the bay And ammonia as well, and the nitrogen is lower than the background level for our discharge.[4]

RAS as relative restoration

RAS projects may bring much-needed economic (e.g. jobs) and environmental (e.g. cleaning contaminated sites) revitalization to communities; however, this restoration was relative, in that it was understood (e.g. as a "natural fit" or not, as explored above) in the context of the site's former use, and the community's historical aquaculture and agriculture production. Thus, interviewees' assessments of RAS facilities were often less a summation ofpros and cons than a comparison to past land or ocean-use archetypes. Below, we explain how both RAS supporters and opponents applied this accounting in the context of two examples: net pen aquaculture and former industrial sites.

(Not) a net pen. For many interviewees, judging the value of a proposed RAS project meant grappling with the complex legacy of other aquaculture production in both nearby and far-flung communities. As one corporate RAS representative from Bucksport put it, "bad memories of bad actors and bad practices in aquaculture" had occurred as recently as the 1990s in Maine; others pointed to more mediated encounters with aquaculture. Describing her initial reaction to the facility plan, a Bucksport local official explained:

I think Iwatched like a PBS documentary I swear like 20 years ago that was about like fish farming in Southeast Asia and it was pretty horrificbecause it just stayed with me and that was what I thought aquaculture was and I was like I will never eat those fish.

While she would later become a project supporter, her comments are telling in illustrating the importance of indirect encounters with aquaculture, often through media channels and covering foreign countries, in shaping perceptions of local projects (Rickard et al., 2018). Whether in Southeast Asia or Eastern Maine, such "bad" fish farms become archetypes: proof of aquaculture's past follies and, critically for RAS, standards by which new aquaculture ventures can (and should) be judged. For many stakeholders, especially those most familiar with local aquaculture production, the prospect of changing from net pen to land-based RAS was a step toward a less risky, more controllable, and environmentally sustainable aquaculture. A local official in Bucksport described the proposed facility as:

> ... Heading in the right direction. We're not going to have the fish escaping from pens in the bay. You're not going to have the massive pollution or disease that those scenarios seems to bringwith them, the pen fishing. It would seem to be a good evolution.

Similarly, as corporate representatives in Belfast suggested, " ... Thetechnology we're working with here is something that has a relatively sustainable profile that's a step in the right direction for the aquaculture industry ... it's a net win, I think, from a sustainability standpoint."

Yet not all interviewees applied the net pen metric with the same optimism about the future; a few people in Belfast, for instance, compared the present "excitement" and "political will"surrounding RAS development in Maine to the urgency to expand net pen aquaculture over thirty years ago. With trepidation, they asked whether RAS would pose familiar risks, albeit in different constellations. Using the example of sea lice, crustaceans that feed on salmon and cause physical damage and adversely affect growth, an anti-RAS activist explained:

> [A RAS facility] is worse than net pens, because all the problemsof net pens are in the tailpipe of this thing ... Of course, their fish won't get the lice. [Nordic Aquafarms is] trying to protect their fish from the lice, but they're not protecting the wildlife from the lice, because the lice are going to all congregate around that pipe.

In this view, RAS facilities do not eliminate the risk of sea lice, but rather displace it - i.e. from affecting farmed fish to affecting native wildlife -yielding uncertainty about the facility's net benefit.

(Not) a Brownfield. Interviewees also judged the acceptability of a RAS facility by the site's land usehistory. As the evolution from net pen to RAS was understood by many as environmentallybeneficial, RAS facilities slated for former industrial sites evoked similar praise. That such "sacrifice zones" (Lerner, 2012) could be repurposed to support a more environmentally benign industry seemed to dampen perceived risks. The proposed Bucksport and Samoa Peninsula sites would occupy land formerly used by paper mills, in local economies originally built on natural resource extraction and associated industry. In both locations, the prior sacrifice and its associated environmental risks (e.g. hazardous waste deposits) created an urgency for repurposing, and, like the net pens, a metric for success. As a local official in Bucksport said:

> So when you talk about clean and renewable and better for the property, it's gone from a tannery, which is probably one of the worst things to have; to a paper mill, which was better; to land-based - it's gotten better.

Stakeholders in Samoa expressed support for the proposed sitedue to its industrial legacy, as one individual associated with the Wiyot tribe explained:

> [The proposed location is] one of the only really *wned* industrial areas on the immediate coast of California ... And so this area was already severely impacted by industry over the last century or more, with shipyards and pulp mills and logging yards. While there still are some amazing dunal - pristine dune habitats on the Samoa Peninsula, this site is not one of them.

Land zoning and pre-existing infrastructure from previous tenants, such as outfall pipes, also made these sites desirable logistically. Designation as toxic landscapes meant reduced prospects for development, yet increased urgency for clean-up, especially for the Samoa Peninsula, a former Superfund site where federal cleanup efforts are ongoing and would be continued by Nordic Aquafarms, according to a recent (December 2021) draft environmental impact report. For many

Bucksport and CA stakeholders, restoring such sites symbolized both environmental and economic progress - as one local official in CA put it, "the rebirth of the Peninsula" - and a catalyst for beneficial change.

Among RAS opponents in Belfast, however, the facility's proposed location was not a sacrifice zone, but rather *sacrificing* a parcel ofland valued by adjoining private landowners and the general public alike for recreation and wildlife habitat. As one activist described it, "a greenfield site with forest that has not been cut for more than 50 years." Beyond concerns about violating a "pristine" natural setting in a picturesque coastal community, anti-RAS activists also took a longer view to contextualize the proposed facility in Belfast's agricultural (chicken farming) and industrial (shipbuilding, sardine canning) past. Rather than viewing this natural value as stable over time, activists emphasized that positive changes in Belfast's environmental quality could be attributed, at least partly, to their advocacy. One activist's reaction to hearing about NAF's interest in their community was:

> ... We've had to fight long and hard for a pristine environment, because the Department of Environmental Protection let those chicken factory wastes go on forever, and they let the HoltraChem mercury dump go on forever and ever and ever.

In this view, the current environmental quality in Belfast cannot be taken for granted, but rather is precarious and must (continue to) be guarded. The HoltraChem reference is to a chemical manufacturing production facility that resulted in a massive lawsuit and subsequent clean-up and ongoing fishing restrictions in Penobscot Bay due to mercury contamination, providing another yardstick by which to measure the value of NAP's proposal. Yet, like RAS advocates in Bucksport and Samoa, corporate representatives in Belfast invoked these past land uses as a metric by which to elevate the status of their proposed activity and *minimize* its environmental risk: "We're not going to be dumping things into the bay, like the poultry farm did, or the sardine farm did. Those were just zero filtration and total dumping."

Discussion

Through qualitative interviews, this study explored how stakeholders interpret the risks and benefits associated with four land-based RAS facilities. In assessing these facilities, as in past research (e.g. Feucht & Zander, 2015) interviewees invoked their perceptions of naturalness and comparisons to terrestrial agriculture. Emergent themes reveal how individual-level perceptions may interact with community-level factors unique to each site, providing a richer understanding of how diverse publics evaluate a novel food technology. A complementary industry to farming and fishing, land-based RAS was viewed by some as a "natural fit" in their community. Yet, the large-scale production systems, considerable natural resource extraction, and waste streams - while like those employed in terrestrial agriculture - could also produce unease. Whereas land-based RAS sites could mean restoring industrial waste sites, such valuations seemed contingent on howinterviewees understood the past - and projected the future - identity of their communities. Below, we explore how these seemingly conflicting perceptions may be illustrative oflarger tensions inherent in contemporary food production systems, and how this intersects with environmental and risk communication research.

Land-based RAS and environmental tensions

In her exploration of the toxic sublime in Edward Burtynsky's photographs of contaminated industrial sites, Peeples (2011, p. 381) suggests that such images invoke tensions that "reflect our own complicity with pollutants." While our wants, including accessible food sources, implicate us in the creation of such sites, we are simultaneously repulsed by the visual aftermath of our consumerism. In another form of environmental tension, though not necessarily visually-based,[5] our results

suggest that what renders land-based RAS appealing - i.e. mass production of fish - can also exemplify its repugnance - i.e. large-scale waste - and both opinions can appear in a single community, or even be acknowledged by a single individual. Overall, complicating straightforward support or opposition, stakeholders voiced significant environmental tensions (Peeples, 2011) in their perceptions of these projects:

- RAS can complement a traditional fishing industry (e.g. alternative income for fishermen) *and* threaten it (e.g. economic competition with local salmon).
- The unnatural character of RAS production systems renders them unsafe/harmful(e.g. a CAFO producing large-scale waste) *and* safe/beneficial (e.g. a method to minimize microplastics consumption in fish and ocean waste).
- Extraction and waste inherent in RAS is a familiar/natural part of any local agricultural system *and* an unprecedented/novel environmental justice problem with global implications.

Tensions explored above were especially apparent at sites where facilities could be viewed as providing a second life for community "sacrifice zones" (Lerner, 2012) or, alternatively, as sacrificing locally important landscapes. While land-based RAS for some represented progress, others warned such facilities would lead a community towards environmental risk and inevitable loss.To this end, we find the tensions in land-based RAS perceptions reminiscent of what Gordon and Hunt (2021) call "the normatively 'environmental' contradictions of food systems" - namely:

> ... the material impacts of food production on local environments and environmental quality, uneven consumption and waste patterns, and its intersections with energy sectors, global and local economies, and climate change mitigation and adaptation (p. 16).

In the case of land-based RAS, while such contradictions may not be immediately resolved on the community level, acknowledging them as worthy of further reflection may be an important step in ongoing community decision-making processes.

Our results also suggest that stakeholders approached land-based RAS not with a blank ledger, but rather weighted by, and relative to, their own - and their community's - salient experiences. Thus, many interviewees seemed to "anchor" their assessments of land-based RAS on these examples, "adjusting" subsequent evaluation of risk and benefit from this foundation (Tversky & Kahneman, 1974; see also Moscovici, 2001). As much risk communication scholarship has pointed out, such experiences shape risk perceptions (Bodemer & Gaissmaier, 2015; Masuda & Garvin, 2006), and, in this case, help inform whether land-based RAS represents a net benefit or risk to a given community. From an environmental and economic risk perspective, a community's land use history, and, by extension, their desired future, was instructive in whether developing a particular location would prove restorative or destructive; comparisons to the same history could support arguments for or against a given facility. For example, a facility could be an improvement from a poultry farm, or a threat to return a gentrifying community to its agro-industrial roots. Likewise, land-based RAS could represent an environmentally sustainable improvement on aquaculture production, or potential for irreparable environmental harm, often in Maine both referring to the state's net pen aquaculture legacy. Our latter findings mirror a recent Q methodology study of attitudes toward aquaculture development in Maine among industry stakeholders,[6] finding that the "aquaculture historian" perspective is skeptical of further aquaculture development in the state, since net pen development failed to fulfill its promise of diversifying fishing businesses and the state economy {Britsch et al., 2021). Scholars interested in community perceptions of energy development transitions have reported similar themes, relying on social representations theory and the concept of "anchoring" to explain howcitizens may interpret local projects as "place-enhancing" or "place-threatening" depending on their interpretation of project impacts, past experiences, and the meaning of the place itself (Bergquist et al., 2020; Bugden et al., 2017).

In sum, while our data consists of individual perceptions, our findings nonetheless underline the significance of a food systems communication perspective to understanding perceived risks and benefits associated with a novel food technology and the siting of a local production facility - that is, "the matrices of power, history, and ongoing forms of domination that affect food systems and how communities may transgress them" (Gordon & Hunt, 2021, p. 11). In this sense, while the (un)naturalness interviewees associated with land-based RAS may stem from a universal cognitive heuristic and a familiarity with terrestrial agriculture, such meanings are also grounded in hyper-local, personal, and shared histories of power, environmental justice, and place associated with food production in each community (Gordon & Hunt, 2021). As land-based RAS facilities proliferate worldwide, we encourage future research to further account for such micro-, meso-, and macro-level influences may interact to shape public responses to these innovative seafood production systems.

Umitations

Due to the COVID-19 pandemic, we were unable to visit all but one of the study sites. Pending public health concerns, future research should include observation at public events (e.g. community meetings), as well as an analysis of other forms of public discourse (e.g. written public comments to regulatory decisions) to better contextualize interview data. Relatedly, our inability to be "on the ground" in some cases limited our access to interviewees, especially those not identified as community leaders, yet who resided near a site. This was especially true in Homestead, the most metropolitan of the communities, where our attempts to reach even county-level officials were largely unsuccessful. While our research also included an address-based questionnaire mailed to residents surrounding each site, future research should access a wider range of residents. Further, while these siting processes are evolving in real time, our interviews captured a snapshot of interviewees' attitudes and perceptions (e.g. before a major development, such as a permit approval). Ideally, research considering emergent issues should involve multiple opportunities to gauge public opinion over time.

Future research

From an applied perspective, while relating land-based RAS to terrestrial agricultural production may enhance its familiarity for consumers, such framing may tow considerable baggage (Siegrist & Hartmann, 2020). Merely telling people unfamiliar with the technology that land-based RAS is "farming fish on land," for instance, is unlikely to form favorable public opinion, just as listing the technology's benefits may fall flat if such benefits are associated with other unacceptable "old" food production systems (e.g. CAFOs) (Siegrist et al., 2016; Siegrist & Siitterlin, 2017). To this end, raising salmon in a "Bluehouse" may not necessarily convey environmental friendliness if commercial greenhouses suggest excessive plastics and pesticide use and, more problematically, could be construed as a form of corporate greenwashing (Torelli et al., 2020).

As Peeples (2011) suggests regarding the toxic sublime, however, highlighting tensions underlying the production method may represent another route to persuasion, as encountering such contradiction may change attitudes. Future research should extend this rhetorical line of reasoning to social psychological approaches, considering, for instance, how framing of visual narratives about aquaculture (Rickard et al., 2021; Schroter & Mergenthaler, 2019; Yang et al., 2022) can incorporate these tensions to influence systematic information processing, and, by extension, influence attitudes toward land-based RAS. Following recent work in perceptions of novel food technology, we also recommend that future research distinguish between perceptions of land-based RAS production (e.g. technologies to treat effluent) and RAS products (i.e. salmon), as well as the role of affect (Bearth & Siegrist, 2019; Rickard et al., 2021; Witzling et al., 2020). Uncovering these grounded meanings is critical when shaping public communication about - and in service of - aquaculture production. Finally, though beyond the scope of this study, our ongoing analysis of survey data will further account for how such community-related perceptions (Boyd, 2017) may influence

acceptance of land-based RAS facilities, including sense of place (Bergquist et al., 2020; Lewicka, 2011), community change over time, and trust in government and corporate stakeholders.

Notes

1. In four cases,given scheduling and time constraints, researchers conducted a second interview with the same individual to complete questioning. Three interviews included two individuals from the same organization.
2. The relationship between aquaculture perceptions, sense of place, and community identity is further explored in [our in-progress work], which draws upon quantitative survey data collected in three out of the four communities (Samoa Peninsula, CA; Homestead, FL; and Belfast, ME).
3. U.S. federal law includes a separate designation for "Concentrated Aquatic Animal Production Facilities (CAAP)" (see 40 CFR Part 122.24).
4. Since the Belfast site is not yet operational, this comparison of effluent waste to water quality in Penobscot Bay is based on modeling, as well as on specific definitions and limits of what constitutes acceptable levels of pollutants. That Nordic Aquafarms has received all necessary permits from state environmental agencies to construct their facility shows that this information has cleared the necessarylegal bar; however, we cannot know the true environmental impact of the operation until regular water testing begins.
5. While beyond the scope of this study, visual aesthetics are an important component to understanding individual and community-level perceptions of aquaculture development and are often central to understanding the social context for aquaculture in a locale (e.g., Dalton et al., 2017; Weitzman & Filgueira, 2020).
6. Using qualitative dominant mixed-methods, Q methodology reveals the diversityof viewpoints about a given issue (e.g., aquaculture development) by asking participants to rank a "concourse» of statements about the issue, then answer questions about this ranking (Ramlo, 2016).

Acknowledgements

The authors wish to thank the individuals who graciously agreed to be interviewed for this research.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the U.S. National Oceanic and Atmospheric Administration (NOAA) Sea Grant College under grant #NA190AR4170327. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of the National Sea Grant College Program, National Oceanic and Atmospheric Administration, the U.S. Department of Commerce, nor any of the other listed organizations. This material is also based upon work supported by the National Science Foundation under Grant No. 1828466.

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