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'Positive' animal welfare in aquaculture as a cardinal principle for sustainable development

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Introduction

A strong, albeit not always obvious, relationship exists between animal welfare and nearly every aspect of our physical lives. "One Health (Dar et al., 2022)" illustrates a unifying framework for coordinated action. Implementing a systemic, effective altruistic approach within this model could promote progress toward achieving the 2030 Sustainable Development Goals.

A food production system that is highly intensive and riddled with poor animal welfare considerations results in health deficiencies, disease outbreaks, rampant antibiotic use and subsequent resistance, ecosystem degradation, adverse impacts on biodiversity, and diminished resource efficiency (Keeling et al., 2019; OIE Aquatic Animal Health Strategy, 2021). Farmed animal welfare is a critical sector in need of improvement, in which aquatic animals have historically been overshadowed by their terrestrial counterparts. A holistic development plan that highlights animal welfare in aquaculture is paramount for protecting humans, animals, and the environment on an international scale.

There is a growing knowledge base for some of the world's most commonly farmed species in aquaculture (e.g., salmonids, carp, and tilapia). Considering there are hundreds of species farmed at different intensities around the world, there are numerous species that remain relatively understudied (e.g., shrimp, amberjack, and loach). Below, the links between animal welfare, the environment, and sustainability for Atlantic Salmon, an extensively farmed finfish, are highlighted. For each of these priority areas, explanations for how animal welfare advancements serve as a central theme in creating cross-cutting solutions are provided for many issues present in today's global dialogue such as food security, ecosystem resilience, carbon emissions, ocean pollution, overfishing, and threats to public health.

'Positive' points of convergence for sustainable development

Water quality

Inappropriately high stocking densities and wasteful feeding regimes can produce toxic wastewater in and around aquaculture facilities. Left untreated, it can deplete surrounding waters of oxygen, triggering algal blooms (NOAA, 2013) or dead zones (US Department of Commerce, National Oceanic and Atmospheric Administration, 2023). Aquaculture wastewater can often contain high-levels of contaminants and/or pollutants due to the prophylactic and therapeutic overuse of antibiotics (Pepi and Silvano, 2021). Offshore, salmon sea cages cause anthropogenic disturbance in benthic communities due to the release of large quantities of organic waste matter (Tomassetti et al., 2016). This could lead to biochemical fluctuations, advancing deoxygenation of the marine environment and exacerbating impacts to surrounding ecosystems.

Suitable stocking densities and curated feeding regimes can contribute to positive welfare in aquaculture as there is a decreased likelihood of aggression within the enclosures, increased feed efficiency from more spacious and less stressful conditions, and psychological variability that accompanies a dynamic feeding system (e.g., multiple dispensing points throughout the water column). High welfare feeding strategies that consider conspecific aggression, resource monopolization, and population access to food can also minimize excess aquafeed, all of which yields cleaner waterways.

Biosecurity and biodiversity

Disease outbreaks in aquaculture are often attributable to compromised immune systems from deficient animal health, nutrition, inadequate rearing conditions, and elevated stress levels (McClure et al., 2005). Maintaining a bio secure firewall between farmed animals and their wild counterparts is essential to prevent the transmission of these diseases.

Farmed aquatic animals reared in pond environments and sea pens are particularly vulnerable to predation. Aquafeed that accumulates in the water column in and around farms is a natural attraction for wild animals (Miller and Ken, 2002). The presence of birds or mammals around aquaculture farms can induce significant stress for farmed animals (European Inland Fisheries Advisory Commission, 1988). Stress can be manifested *via* behavioral changes or a reduction in feed efficiency, both of which could result in negative impacts on overall productivity (Huntingford et al., 2006). Furthermore, an increased presence of wild animals generates more frequent instances of entanglement, equipment damage, and farmed escapes (Fujita et al., 2023).

Salmon escapees create unnecessary resource competition for their wild cousins, dilute gene pools, and contribute to the depletion of lower trophic species. When it comes to mass escapes of farmed Atlantic salmon, many examples are available (Flatt and Ryan, 2017). Labeled as both a highly migratory and indicator species (NOAA Fisheries, 2009), Atlantic salmon are capable of negatively affecting cross-regional, marine ecosystems. Sea lice on salmon farms remains one of the most well-known biosecurity violations in aquaculture. Sea lice attach to, and feed on, both farmed and wild salmon, causing pain and physical injury.

Disease and antimicrobial resistance

The under-regulated, chronic use of antibiotics in aquaculture is cause for extreme concern regarding antimicrobial resistance. Insufficient animal welfare practices raise the need for antimicrobials to treat viruses, parasites, and pathogens. Farmers have no method for tracking individual animals; therefore, they do not have precise health plans. As a result, treatments are applied as a prophylactic to the entire farmed population. This can swiftly lead to the emergence of antibiotic-resistant strains of bacteria (Pepi and Silvano, 2021).

A 2020 study estimates the aggregate global antimicrobial use in 2030 will be 236,757 tons. Aquaculture would constitute 5.7% of this value, but carries the highest use intensity per kilogram of biomass (164.8 mg kg−1). This study suggests that antimicrobial use for some farmed aquatic species can be more intense than levels used in terrestrial agriculture and human treatments (Schar et al., 2020). Antibiotic resistance in animals translates to antibiotic resistance in humans. In 2019, 4.95 million people died of an antibiotic-resistant infection, 1.27 million of which were attributable to antibiotic resistance of the infection (World animal protection, alliance to save our antibiotics, bureau of investigative journalism, 2022). Positive welfare practices in aquaculture produce healthier animals that are less susceptible to disease, and less reliant on antibiotics.

Industrialized obstacles vs. artisanal advantages

Commercial aquaculture has been marketed as a solution to overfishing. Farming carnivorous species simply accelerates the extractivism of marine species sourced from strained fisheries using inhumane fishing practices. This process contributes to a further decrease in already declining populations, just to acquire the marine ingredients necessary to sustain the dietary needs of these farmed animals.

Responsible aquaculture explicitly considers vulnerable social groups, with coordinated and coherent actions for development throughout the entire value chain. Overfishing sardines or anchovies, and the overuse of fishmeal and fish oil as feed components for farmed species, deprives lower-income communities that would otherwise utilize these "reduction" fisheries as a direct protein source, promoting food insecurity. Carnivorous species are not being farmed to sustain coastal communities that will bear the primary burdens of climate change. They are premium products meant for tourists and higher income populations.

A recent study (Willer et al., 2022) found that 4 million tons of wild fish could remain in the sea if they were not caught for the

purpose of feeding other fish on farms. The authors demonstrate how reducing marine feeds in salmon production, and allocating wild-caught feed fish for human consumption, could result in more nutritious products for seafood consumers, and allow 66–82% of 'feed' fish to remain in the ocean. 'Feed' is also the main source of carbon emissions in most aquaculture systems. Emissions arising from fishmeal production, feed blending, and transport are all industrialized externalities that tend to be difficult to quantify and could be variably inaccurate.

Coastal communities rely on seafood for nutrition, employment, and economic development. Mismanagement and unsustainable practices further exacerbate many of the issues previously discussed. Human trafficking, human rights violations, and occupational hazards are all present in both capture fisheries and aquaculture. By working with the private sector and certification bodies to promote animal welfare, fair and equitable treatment of seafood production workers can be promoted. Shifting aquaculture development towards a more localized, holistic approach that considers species requiring little or no feed could yield overarching benefits for the animals, people, and environment.

An emerging setback

While aquaculture production inevitably continues to accelerate, new species are being considered for farming as the latest industrial development. However, there is growing interest in farming a class of invertebrates in which no commercial experience or information currently exists: cephalopods. Each concern discussed above is only amplified if cephalopod (chiefly, octopus) farms are approved for operation.

Octopus would be produced in land-based farming facilities that require a constant water quality monitoring system and backup system to be in place, both of which require a considerable amount of energy and resources to function. Octopus are well-known escape artists. The introduction of even one farmed octopus into any adjacent waterway has the potential to become the next serious public health risk, as captive cephalopods can be vectors of multiple unknown pathogens and zoonotic diseases such as cholera. There are no historic examples of *farmed* octopus escapes; however, invasive species are major drivers of global change, and studies demonstrate how they can alter biodiversity and ecosystem functioning (Linders et al., 2019). Taking note of antimicrobial resistance trends in extant aquaculture, octopus farms are also likely to foster entirely novel disease strains that will demand aggressive and harmful prescriptions. No farm-level treatment plans, prevention strategies, or risk assessments have been developed as of this writing. Therefore, farm-wide experimentation related to disease management could yield costly and catastrophic results.

Based on decades of study in both industrial agriculture and aquaculture, there is substantial evidence to suggest that similar issues can, and will, translate over to octopus farming if it is allowed to persist. Not only is this latest development an animal welfare tragedy waiting to happen, but it is a blatant demonstration of simply expediting unsustainable practices. Due to the scale of animal welfare, sustainability, and environmental threats this endeavor could generate, it is worth discussing here in an attempt to cease development before there is international adoption of yet another industrialized, unsustainable component that is added to the global food system.

Discussion

Consistent with the interconnections outlined above, a regulatory analysis on existing international frameworks was performed and suggestions for relevant stakeholders in crafting political strategies aimed at enhancing the institutional linkage of animal welfare, environmental, and sustainability policies are highlighted.

In alignment with their "Blue Transformation" approach, recognizing the importance of aquatic food systems as drivers of employment, economic growth, social development and environmental recovery (Fao and Hogsholt, 2022), the Food and Agriculture Organization (FAO) successfully held The Global Conference on Aquaculture Millennium +20 in September 2021. The Shanghai Declaration, a key output from the GCA +20, represents a road map to optimize the role that aquaculture can play in achieving the 2030 Agenda for Sustainable Development (FAO, 2021).

An important provision that was added based on feedback provided by registered participants such as the Aquatic Life Institute, directly relates to the bond between positive animal welfare and sustainable development in aquaculture:

•Page 4: #11 "Recognizing that developing aquaculture sustainably and equitably requires a holistic approach that values both human and animal health and welfare and further recognizing that aquaculture activities should be conducted in a manner that assures the health and welfare of farmed aquatic animals, by optimizing health through minimizing stress, reducing aquatic animal disease risks and maintaining a healthy culture environment at all phases of the production cycle."

The FAO lists several stakeholder implementation suggestions for constructing regional based approaches to aquaculture throughout the Shanghai Declaration. One relevant approach pertains to:

•Page 15 #4: Stakeholders may support this strategic priority by…

○"Working with the private sector and certification bodies to promote and enshrine fair and equitable treatment of aquaculture workers".

Many consumers turn to seafood certification bodies for guidance on how to avoid purchasing species that were produced using unsustainable and low welfare practices. With more than 100 certifications and ratings programs in use by the seafood industry, they are now a permanent component in the welfare landscape. This shift means that 40% of all farmed seafood (including seaweed) is rated or certified (Sustainable seafood: a global benchmark, 2019), and volumes of certified farmed fish and shellfish constitute around 8% of global aquaculture production (Jonell et al., 2019). The amount of certified aquatic animal products is only expected to increase. There is no evidence that certification will be phased out in view of consumers' increasing demand for sustainable seafood, and

the absence of a better alternative (FAO, 2020). A large number of these labels lack considerations for positive animal welfare, or fail to provide adequate welfare protections. Certifications rely on the premium consumers place on eco-friendly products, but in reality fail to meet sustainable expectations. Products labeled as "sustainable" or "environmentally responsible" should, and must, include the most robust, positive animal welfare regulations.

Pushing for the development of consistently high standards among different certification bodies can serve as a catalyst to advance funding for species-specific research, novel on-farm trials, and proactive approaches to farmed aquatic animal welfare innovation. A cohesive, multi-pronged approach built around a shared blueprint is the most strategic way to move forward. Certification bodies have the power to drastically improve conditions for billions of animals, while simultaneously promoting aquaculture resilience to climate change through policies encompassing positive welfare principles, environmental conservation, and an open exchange of information.

Exerting a permanent "One Health" approach to development will facilitate the design of food systems capable of separating human benefits of consuming seafood from negative environmental, animal welfare, and societal impacts that have been historically observed in this sector (Stentiford et al., 2020). Interaction and integration of independent certification schemes' standards and traditional regulation could amplify the positive evolution of our seafood industry (Vince and Haward, 2019). Combining seafood certification with international regulation and regional implementation may serve as a key step towards truly sustainable development in aquaculture.

Author contributions

TG conceptualized, drafted, revised, and approved the submitted version of the manuscript. The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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