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Grand challenges for global aquaculture

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The food challenge for the world to provide adequate nourishment for a rising population while reducing the environmental impacts of production and distribution systems is complex; aquaculture has hitherto been a marginal part of this big picture. Understanding where aquaculture currently and potentially “fits in”—how it can contribute to, or undermine, the UN Sustainable Development Goals (SDGs)—is becoming an issue of study and public policy. The frontiers between the aquatic food and terrestrial food systems are becoming more important to understand and increasingly integrated. Novel feed sources are used for both terrestrial and aquatic livestock, and as aquatic plants potentially contribute to, or compete with, land-grown crops in supply chains there are large implications for where and how aquaculture is practiced. The new revolution in cell-based foods and precision fermentation is likely to impact on conventional livestock—both terrestrial and aquatic—in ways yet to be seen. The increasing importance of vegetarian, vegan, or maybe non-meat-centric diets will pressure all forms of animal-sourced foods to highlight their cultural, nutritional, and environmental attributes.

Links to the wild

The uniqueness of aquaculture remaining strongly linked to wild sourcing of a diverse range of aquatic foods, with many hundreds of species currently cultivated, is another point of distinction from other terrestrial systems and is frequently ignored or minimized in dialog. There is increasing understanding that wild and farmed need to be considered together given cultural traditions and the range of opportunities to develop aquaculture. Frontiers in Aquaculture will ensure that aspects of fisheries relevant to aquaculture, whether in the area of consumer demand or in preserving aquatic biodiversity and ecosystems, are included as forthcoming Research Topics.

Complexity

The demands on commercial aquaculture enterprises are intense if they are to be both economically viable and also compliant with a whole range of societal expectations. They are pressured to be highly efficient users of water and good neighbors that retain and reuse nutrients rather than being sources of pollutants. In some places progress has been rapid, but this remains far from the norm. How research in technology and management can enhance productivity, maintain and enhance qualities such as animal welfare, and reduce

climate emissions remains a crucial area of research for improving productivity and relevance to the broader food system. Solutions to such challenges, however, may well reside outside the technical sphere and may require changes in individual and group behaviors, knowledge transfer, and local development. Governance approaches that work across value chains need to deal with a large range of different realities, species, systems, and geographies. Global trade of aquatic commodities is hugely valuable but, in places where aquatic foods are everyday food, sources often remain relatively local.

Value chains

Increasingly, research in the field of aquaculture is outside the production node but relates to innovation elsewhere in the value chain, connecting raw materials to consumption. *Frontiers in Aquaculture* will use this framing to ensure that relevant topics on challenges upstream and downstream of the farm gate are covered. So often it is elsewhere in the global value chain where innovations begin or are required for societal impact. This inevitably leads to a “whole fish” approach, in which research assessing roles of aquaculture within the circular economy and, increasingly, how non-food co-products are key parts of the marketable yield becomes prevalent. A core distinction of many traditional freshwater integrated systems, this approach is critical for the emergent seaweed sector that is expected to grow rapidly, signaling an era of zero waste in the sector. The boundaries around aquatic animals as food are becoming increasingly blurred and the importance of framing opportunities for the circular economy is becoming commonplace. Co-products from the aquaculture sector include biochemicals and feedstock valuable in other industries; incentives to remove waste from production and processing are becoming more urgent in this era of climate change.

Understanding demand

An assumption of endless growth has plagued the sector and the Blue Growth narrative in recent decades, and the importance of improving competitiveness with other types of food is often overlooked. The proportion of articles published in current journals that have no or limited relevance to impacts in the sector remains high. Demand for nutrition-sensitive “blue” food that is affordable and desired by a wide range of consumers remains largely unexplored. The unique nutritional properties of aquatic foods compared with competitive products are often undersold. A better understanding of how aquaculture value chains can be both efficient and ethical has come to the fore for many businesses, particularly in wealthy contexts, as consumers pivot toward informed choices and patterns of demand evolve. The potential role of aquaculture in underpinning nutritional security remains unresolved in many contexts, but has particular resonance as fisheries falter in fish-dependent cultures.

Reducing disease burden

A complex multifactorial interplay among the biology of aquatic organisms, the culture environment, social drivers, and the political landscape contribute to the significant array of diseases that negatively impact aquaculture practices. Disease susceptibility and poor animal welfare drive significant reductions in harvest, profit, overall food security, and the societal perception of aquaculture. The “one health” approach to aquaculture promises to take a nuanced approach to understanding disease, in which the impact of single pathogens, although fundamentally important, needs to be contextualised into the complex overarching set of factors mentioned above to improve health management and reduce the disease burden, particularly in local systems where food security is a pressing issue. Indeed, understanding the drivers that result in poor health outcomes requires a systems-based approach in which both reductionism and holistic approaches to health management have a platform from which to communicate. *Frontiers in Aquaculture* aims to provide such a place to develop, discuss, and test the myriad of approaches currently reported that aspire toward underpinning sustainability and improving animal welfare.

Aquatic organism resilience

Informing practice through research to improve organism health and welfare across the diverse range of aquatic environments and production systems in the face of the exceptional species diversity represents a huge undertaking. Selective breeding, from basic to gene editing approaches to manage diversity and improve trait selection, in combination with health management tools such as vaccines, has a fundamental role in disease reduction, which could lead to gains in productivity. Understanding how organisms respond to environmental challenges is a fundamental requirement for production from closed, highly intensive, biosecure production facilities to open systems. Here, the emergence of artificial intelligence is driving our ability to remotely monitor populations and analyze animals’ behavior in their environment, creating a fascinating backdrop and a fertile space for innovation across the aquaculture sector in which the future is bright.

Ambition

As a sector aquaculture still suffers from a limited academic base, particularly given its diversity of practice. *Frontiers in Aquaculture* sets out to bridge the divides between academic silos and the commercial world and invites contributions that will share best practice. Excellence of research that spans disciplines and cultures will be strongly encouraged, especially those linked to a dynamic commercial sector where knowledge so often remains unshared; the *Frontiers* journal aims to be a vehicle for improving the sharing of relevant, high-quality research that can make a clear case for impact in the sector.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

Conflict of interest

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

The authors SM and DL declared that they were editorial board members of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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