FISH WELFARE INITIATIVE

FISH WELFARE SCOPING REPORT: CHINA

By Isla Gibson, Tse Yip Fai, and Marco Cerqueira

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We welcome comments, questions, and feedback from all interested parties. To do that, please contact us.

Executive Summary

Aquaculture is the fastest growing food production sector,[1] with an estimated 73 to 180 billion farmed fish alive at any given moment.[2] In 2018, the Chinese domestic aquaculture industry was valued at nearly 900 billion yuan, with aquaculture representing almost 1% of total Chinese GDP.[3] Today, China accounts for nearly 70% of the world's total aquaculture production,[4] enabling the livelihoods of five million domestic workers.[5] Chinese aquaculture distinguishes itself by not only its contributions to global production, but also by its technical and scientific achievements in disease control, low-carbon farming systems, hatchery techniques, and commitment to its low-carbon, "green" development philosophy.[6] By 2030, China is likely to produce an additional 6-18 million tonnes of aquatic products - an increase of 9-27% - to satisfy projected domestic consumption.[7]

With global aquaculture still in its infancy, the opportunities that arise from considering the welfare interests of fish have yet to be capitalized upon. Fish are often kept in suboptimal environmental conditions and slaughtered using painful, stressful methods. As scientific methods for assessing welfare improve and practical incentives to implement welfare improvements become more salient, the concept of animal welfare is gaining traction in China, particularly through the efforts of organizations like the International Cooperation Committee of Animal Welfare (ICCAW). Moving beyond the scope of terrestrial animals, fish welfare is increasingly heralded as an intuitive next step for the agriculture of the future. Improvements in welfare increase efficiency along the production chain, strengthen business resiliency, reduce costs and risks for producers, and would safeguard the economic livelihoods of China's domestic fishery workers. Fish-friendly aquaculture is also correlated with reduced negative environmental impacts and greater food safety for the end-consumer.[8]

[1] Van Duren, L. (2020). Environmental impact of the fast growing aquaculture sector.
[2] Fishcount. (2019). Numbers of farmed fish slaughtered each year.
[3] Ibid.
[4] Li, X et al. (2020). Aquaculture Industry in China: Current State, Challenges, and Outlook.
[5] Godfrey, M. (2019). Massive shift underway in China's aquaculture, fisheries sectors.
[6] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.
[7] Crona, B et al. (2020). China at a Crossroads: An Analysis of China's Changing Seafood Production and Consumption.
[8] EFSA. (2009). Food Safety considerations concerning the species-specific welfare aspects of the main systems of stunning and killing of farmed fish.

This report aims to summarize the current welfare of farmed fish in China to better understand the world's leading producer, exporter, and consumer of aquaculture products.[9] In order to identify possible avenues for improving fish welfare, we conducted a detailed review of the relevant literature in both industry and academia, as well as a brief survey of the welfare conditions of a select number of species using internet-based anecdotal evidence. We also consulted a variety of experts from relevant organizations to deepen our qualitative understanding and produce the following conclusions:

- Of China's diverse aquaculture systems, pond culture dominates both freshwater and marine aquaculture and accounts for 72.7% of the world's freshwater systems.[10] In comparison with other major aquaculture-producing nations, there is a relatively low dominance of any one farmed finfish species.

- China is a particularly strong candidate to lead in operationalizing the welfare-minded aquaculture of the future due to the scale and diverse composition of the Chinese aquaculture sector, the latest fisheries policies as expressed by the Ministry of Agriculture and Rural Affairs (MARA), and the support scaffolding provided by government bodies and research institutions.

- Of the various welfare concerns associated with aquaculture in China, mitigating the stress connected to disease rates, water quality, inappropriate slaughter practices, and the high mortality rates associated with transport may all be effective in improving the lives of a large number of animals. These are areas in which the well-being of the fish and the financial interests of the farmer align.

- Animal welfare work in China has become an increasingly accessible space in recent years, particularly through the development of species-specific certification schemes. This presents a promising avenue for working with large to medium-scale producers willing to spearhead this new trend in corporate responsibility and sustainable aquaculture.

We conclude with a list of recommendations for future fish welfare work in China.

We encourage any organization or industry interested in engaging with fish welfare in China to contact us. We are able to offer formal partnership, consultation in the development of fish welfare improvements, and support in the form of training, endorsement, and overseas trips.

Lastly, we would like to thank all the people who made this report possible.

[9] FAO. (2017). Fishery and Aquaculture Country Profiles. China.
[10] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.

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1. Why Fish Welfare?

The concept of 同一健康 (One Health) expresses the interconnectedness and shared environment of human, animal, and planetary health. Using this expanded definition of health, better outcomes for fish are fundamentally tied to better outcomes in disease prevention, food safety, and sustainable fishery management. This not only means healthier aquaculture systems and nearby waters, but also healthier businesses and more resilient local economies. Looking to the future, the pursuit of higher welfare standards in aquaculture is a new domain for scientific, technological, and operational expertise within which corporations can excel and governments can steward.

1.1 Fish Sentience

A large body of research shows that fish have a qualitative experience of the world,[11] seek out pleasurable experiences,[12] can learn and remember,[13] anticipate future events,[14] and, like humans, are less negatively affected by the stressors that they can anticipate.[15] In aquaculture environments, fish are invariably subjected to highly stressful situations that can have negative effects on the animal's biological, cognitive, and psychological processes. The best available evidence, along with findings that detail the evolutionarily conserved neural substrate for the processing of emotional stimuli between fish and mammals,[16] indicates that fish are sentient beings that can undergo both positive and negative experiences.[17] Discussing welfare broaches not only the ethical considerations of rearing fishes in captivity, but also the variety of multi-sectoral benefits that can be achieved when welfare is brought into the conversation.

1.2 Fish Welfare and Business Resiliency

Higher-welfare aquaculture is one way to safely restructure and transition the aquaculture sector while maintaining profitability and economic wellbeing for China's fishery workers and rural economies. Fish-friendly aquaculture translates to business resiliency for both small producers and larger operations looking to showcase their corporate responsibility. Chronically stressed fish have reduced growth rates,[18] increased mortality,[19] and inferior fillet quality.[20] Healthier fish have stronger

[11] Brown, C. (2014). Fish intelligence, sentience and ethics.
[12] Soares, M. (2011). Tactile stimulation lowers stress in fish.
[13] Millot, S. et al. (2014). Use of conditioned place preference/avoidance tests to assess affective states in fish.
[14] Cerqueira, M. et al. (2017). Cognitive appraisal of environmental stimuli induces emotion-like states in fish.
[15] Madaro, A. et al. (2016). Effect of predictability on the stress response to chasing in Atlantic salmon (Salmo salar L.) parr.
[16] O'Connell, L; Hofmann, H. (2011). The vertebrate mesolimbic reward system and social behavior network: a comparative synthesis.
[17] Braithwaite, V. (2010). Do fish feel pain?; Sneddon, L. (2013). Do painful sensations and fear exist in fish?; Cerqueira, M. et al. (2017) Cognitive appraisal in fish.; Balcombe, J. (2016). Cognitive evidence of fish sentience; Kohda, M. (2018). Implications of consciousness and self-awareness in fish; Brown, C. (2015). Fish intelligence, sentience and ethics; Low, P. (2012). The Cambridge Declaration of Consciousness.
[18] Van Weerd, J; Komen, J. (1998). Effects of chronic stress on growth.
[19] Wall, T. (2008) Disease and Medicines - the Welfare Implications.
[20] Anders N. et al. (2020). Effects of crowding stress on flesh quality.

immune responses,[21] meaning that there is a lowered risk of on-farm disease spread inducing financial hardship, food shortages, and even industry failure. Farmers who improve welfare measures note less aggression,[22] reduced fin damage,[23] fewer diseases and parasites,[24] and improved feed conversion ratios (FCRs).[25] Good animal health is, therefore, typically synonymous with less feed and drug inputs, lowered mortality rates, and less feed waste. One way this translates directly into higher profits for aquaculture operations is through a reduced risk of massive fish loss, which is brought on by the kind of disease outbreaks that cost the Chinese aquaculture industry estimated losses of over 10 billion RMB per year from 2008 to 2018.[26]

1.3 Fish Welfare and Sustainability Goals

In only a few years, China has emerged as a nation now vigorously promoting sustainable agricultural development as a basic tenant of its agricultural modernization with Chinese characteristics.[27] Among global aquaculture systems, Chinese aquaculture is one of those most vulnerable to the impacts of climate change.[28] This vulnerability poses a threat to fishery worker livelihoods, rural economies, and farmed fish alike, who may increasingly suffer from water quality degradation, the outbreak of virulent pathogens, and other hostile conditions such as rising water temperatures.[29]

Fish with higher welfare sustain a healthy ecosystem and environment. Under good welfare conditions, fish eat more efficiently, and so less feed is diffused. Excess feed in the water attracts larger predatory fish,[30] which are harmful to farm operations and prone to injuring themselves by becoming entangled in farm gear.[31] Fish with lower apparent stress levels appear to attempt fewer escapes,[32] lowering the risk of farmed fish interbreeding with wild species, competing for their resources, and transmitting diseases and parasites to wild populations, where they may endanger

[21] Stewart et al. (2012). The Bio-economic Impact Of Improving Fish Welfare Using Demand Feeders In Scottish Atlantic Salmon Smolt Production; Schneider et al. (2012). Welfare Interventions In Flatfish Recirculation Aquaculture Systems And Their Economical Implications.
[22] Martins, C. et al. (2012). Behavioural indicators of welfare in farmed fish.
[23] Animal Charity Evaluators (2020). Farmed fish welfare report.
[24] Aslesen et al. (2009). Multinational companies embedded in national innovation systems in developing countries: the case of Norwegian fish farming multinationals in Chile; McClure et al. (2005). Risk factors for outbreaks of infectious salmon anemia in farmed Atlantic salmon, Salmo salar.
[25] Stewart et al. (2012). The Bio-economic Impact Of Improving Fish Welfare Using Demand Feeders In Scottish Atlantic Salmon Smolt Production; Schneider et al. (2012). Welfare Interventions In Flatfish Recirculation Aquaculture Systems And Their Economical Implications.
[26] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.
[27] 农业部. (2015). 农业部：《全国农业可持续发展规划（2015—2030年）》发布.
[28] Elder, M. (2017). Aquaculture in China: Challenges and Opportunities.
[29] Crona, B et al. (2020). China at a Crossroads: An Analysis of China's Changing Seafood Production and Consumption.
[30] Miller, D; Semmens, K. (2002). Waste Management in Aquaculture.
[31] Barrett, L et al. (2018). Impacts of marine and freshwater aquaculture on wildlife: a global meta-analysis.
[32] Cerqueira, M. et al. (2017) Cognitive appraisal in fish; Cerqueira, M. et al. (2020). Cognitive appraisal in fish: stressor predictability modulates the physiological and neurobehavioural stress response in sea bass.

entire ecosystems.[33] Improved fish welfare also reduces harmful wastewater generation by improving feed conversion ratios (FCRs), by secreting less uneaten feeds into nearby waters,[34] and by improving immune functioning, decreasing the need for antimicrobials. Avoiding the overcrowding of fish increases production efficiency, and makes the maintenance of water quality easier by decreasing the proportion of waste to water.[35] Reducing reliance on fish meal fish oil (FMFO) feeds,[36] an industry associated with a whole host of environmental and welfare concerns, is just one policy highlighted under the government fishery offices' "Five Actions" campaign, which signifies a "win" for both fish and the planet.[37]

1.4 Fish Welfare and Human Health

In China, guarding the "bottom line" of food safety has become a staple of the government's aquaculture policies.[38] Along with government efforts to expand industry standards, the random sampling of agricultural products, and science awareness, fish-friendly aquaculture is essential to creating safer, more desirable food products for humans. When fish are injured due to crowding or rough handling, or when the fish's immune functioning has been compromised as a result of periods of prolonged stress, the animal is more susceptible to diseases, which can be ultimately transmitted to human populations.[39] Fish can contain bacteria, viruses, biotoxins, and parasites, all of which occur more frequently in poor-welfare environments.[40] To combat diseases, farmed fish are commonly treated with antimicrobials and antibiotics, whose indiscriminate use is increasingly a matter of public concern in China. Equally, stress before and during slaughter, which is correlated with inhumane slaughter practices and early-onset rigor mortis, has been directly linked to tastes and textures less palatable to the end-consumer.[41] Today, Chinese consumer notions of "high-quality" and "safe" fish generally include wild (as opposed to farmed), marine (as opposed to freshwater), and

[33] Wild fish collected near farms are sixteen times more likely to have diseases and parasites. These are easily spread between farmed and wild populations. Barrett, L et al. (2018). Impacts of marine and freshwater aquaculture on wildlife: a global meta-analysis; Naylor, R; Burke, M. (2005). Aquaculture And Ocean Resources: Raising Tigers of the Sea.

[34] Miller, D; Semmens, K. (2002). Waste Management in Aquaculture; d'Orbcastel, E et al. (2009). Towards environmentally sustainable aquaculture: Comparison between two trout farming systems using Life Cycle Assessment.

[35] For a review about the impact of stocking densities on the welfare of farmed fish, see Baldwin, L. (2011) The effects of stocking density on fish welfare.

[36] China uses only approximately 25% of the world's fishmeal, but accounts for more than 60% of global aquaculture production Han, D et al. (2016). A revisit to fishmeal usage and associated consequences in Chinese aquaculture.

[37] The "Five Actions" campaign, a term being used by government fishery offices across the country, includes reducing water pollution from aquaculture; reducing antibiotics use; improving genetics and seedlings quality; increasing the use of compound feeds; and reducing the use of juvenile fish as feed. Examples of other specific priorities laid out in recent State Council documents which bridge welfare and environmental concerns also include addressing utilizing domestic processing wastes more efficiently and promoting 'carbon-sink' fisheries, low-impact production systems like integrated rice-fish farming. Godfrey, M. (2020). China's government folding tourism into aquaculture, energy policies for domestic growth

[38] 农业部. (2020). 农业部：2020年农产品质量安全监管工作要点.

[39] EFSA. (2009). Food Safety considerations concerning the species-specific welfare aspects of the main systems of stunning and killing of farmed fish.

[40] Ibid; McClure, C et al. (2005). Risk factors for outbreaks of infectious salmon anemia in farmed Atlantic salmon, Salmo salar.

[41] Poli, B et al. (2005). Fish welfare quality as affected by pre-slaughter and slaughter management.

imported (as opposed to domestically produced) fish.[42] Higher-welfare aquaculture is therefore essential to ensure the supply of the safer, higher-quality products desired by domestic and foreign wholesale buyers alike.

1.5 Fish Welfare and Aquaculture Technology

Many of the most effective strategies for improving fish welfare invite technological solutions.[43] For example, pond aerators, water quality biosensors, automatic feeders, and stunning devices are all currently available, and may mitigate the welfare concerns associated with water quality monitoring and maintenance, suboptimal animal nutrition, and inhumane slaughter methods, respectively. Promoting higher fish welfare in aquaculture is, therefore, an opportunity to develop innovation in agriculture technology, showcase scientific expertise, and build a model of "best practices" in aquaculture for foreign export.[44]

2. About China

2.1 About China

China's relationship with aquaculture is a long one. Heralded as the earliest known monograph on aquaculture, Fan Li's *Yangyujing* 養魚經 [*Treatise on Pisciculture*] details, as early as 460 BCE, the commercial production of carp and turtles in what we now know as polyculture. China's aquaculture sector has led in supplying the country's massive production output since 1991. China has farmed more finfish - in both tonnage and total individuals - than the rest of the world combined.[45] Today, China accounts for nearly 70% of the world's aquaculture production.[46] Deputy Minister of the Ministry of Agriculture and Rural Affairs Yu Kangzhen states this succinctly: in China, "three of every four consumed fish are farmed. Globally, two of every three farmed fish are Chinese."[47]

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[42] Crona, B et al. (2020). China at a Crossroads: An Analysis of China's Changing Seafood Production and Consumption.

[43] Emerging technologies may entrench existing welfare concerns or even create new risks. For example, carp and tilapia species are recipients of the substantial funding channeled into the selective breeding of genetically improved fish. While these "improved species" may display, for example, enhanced disease resistance, the rapid domestication of genetically improved species may also bring about novel welfare infringements. Personal correspondence with Marco Cerqueira (2020).

[44] This is already recognized in the most recent high-level aquaculture policy. Policy documents specify disease diagnosis methods, wastewater management, smart fisheries, macrophytes intersection in aquaponics, and the development of novel, compound feed types as part of a comprehensive approach to strengthen innovation in "green" aquaculture technology both economically viable for the industry and also beneficial for human and environmental health. Upgrading the application of aquaculture technologies has also been highlighted from a foreign policy dimension, one Ministry of Agriculture and Rural Affairs (MARA) publication encouraging research institutes and universities to establish demonstration projects so as to promote China's aquaculture technology abroad. 郑州外资企业服务中心 (2019). 关于加快推进水产养殖业绿色发展的若干意见.

[45] FAO. (2017). Fishery and Aquaculture Country Profiles. China. China also farms more fish than the next nine top aquaculture producing nations combined. Mercy For Animals. (2020). Fish Farming in China - A Strategic Perspective.

[46] Li, X et al. (2020). Aquaculture Industry in China: Current State, Challenges, and Outlook.

[47] Xinhua. (2019). 我国水产养殖如何实现绿色发展：五千万吨产量背后的忧思.

Chinese aquaculture is distinguished from that of other major fishery nations by not only its scale, but also its high level of value chain partitioning according to product quality and end-market. Domestic consumers are generally motivated by freshness, taste, price, and food safety, and the literature generally indicates a low level of familiarity with the concept of farmed animal welfare within China.[48] Many aquaculture operations are contracted out to rural, small-scale farms that are either privately or collectively owned, and often employ family or part-time workers.[49] When small-scale operations are included, less than 1% of all aquaculture producers in China are certified.[50] Neither government-endorsed nor commercial certification schemes currently consider the positive welfare of fish.[51]

2.2 Animal Welfare in Legislation and Government

Although China has been a member of the OIE since 2007, "animal welfare" is not formally a part of the remit of any Ministry in China.[52] Despite this absence of stand-alone animal welfare legislation, animal welfare issues are addressed in several places in lower-level legislation, regulations, standards, and guidance.[53] There are other reasons to be optimistic, such as the presence of government representation in the first-ever conference on farmed animal welfare in China,[54] an increased reference to animal welfare by state media, and the inclusion of animal welfare in highschool biology curriculum.[55] Animal welfare work has become particularly accessible since 2017, specifically through the development of welfare-relevant standards schemes, which also address product quality and food safety. Aimed at granting awards to pig, sheep, and egg producers with

[48] A recent Faunalytics study of Chinese attitudes towards farmed animals found that only 38% of respondents agreed with the statements that "animals used for food have approximately the same ability to feel pain and discomfort as humans" and 46% that "it is important to me that animals used for food are well cared for." Anderson, J. (2018). Attitudes Toward Farmed Animals In The BRIC Countries. Another paper found that more than two thirds of survey participants have never heard of the term 'animal welfare'. You et. al. (2014). A Survey of Chinese Citizens' Perceptions on Farm Animal Welfare.

[49] China Fisheries Statistical Yearbook. (2019). 中国渔业统计年鉴.

[50] Ecovia Intelligence. (2020). China Sustainable Aquaculture Impacted by Coronavirus. National certification schemes promoted by government that include aquaculture products include ChinaGAP and the widely popular Green Food (绿色食品) standards. A small percentage of Chinese aquaculture producers have also signed onto various global certification schemes such as those provided by the Aquaculture Stewardship Council (ASC) and Global Aquaculture Alliance's Best Aquaculture Practices (GAA BAP). The Royal Society for the Prevention of Cruelty to Animals (RSPCA) offers a variety of species-specific, welfare-relevant standards and are generally regarded as the gold standard for current fish welfare certification schemes.

[51] Positive animal welfare is a relatively new dimension of animal welfare which addresses the welfare benefits of providing animals with greater opportunities for positive experiences, rather than a sole focus on minimising negative experiences. J, Yeates. Main, D. (2008). Assessment of positive welfare: A review.

[52] 'Animal welfare' (动物福利), translated from English, is not explicitly mentioned in any legislation.

[53] This legislation addresses specific species in select scenarios only. For example, both Interim Rules on Administration of Domestication, Breeding and Utilisation Technology of Fur-producing Wild Animals (2005) and Suggestions on Further Strengthening the Zoo Management (2010) refer to the humane treatment and reduction of suffering. Animal Protection Index. (2014). China Country Profile.

[54] The aforementioned Yu Kangzhen - responsible for fisheries at the Ministry of Agriculture and Rural Affairs - was the opening speaker at the World Conference on Farmed Animal Welfare (WCFAW) 2017, jointly co-hosted by FAO, ICCAW, and CAPIAC.

[55] This was included as an optional topic only. Ministry of Education. (2017). Biology Curriculum Standards (2017 edition) for Ordinary Senior High Schools.

higher welfare standards, the International Cooperation Committee of Animal Welfare (ICCAW) is the only domestic organization formally promoting the concept of farmed animal welfare in China.

2.3 Government Visions for Chinese Aquaculture

Pressures to increase production volume stand alongside government visions of a high-quality, "green," and market-driven aquaculture sector.[56] Prompted by a loss of access to value chains in various OECD countries, a production decline in many freshwater environments, negative publicity following a series of food safety incidents, and a growing list of environmental concerns,[57] demand for more stringent industry regulation in aquaculture is bolstered by China's "eco-civilization" policy, enshrined as one of the five pillars of "socialism with Chinese characteristics".[58] The knowledge and application of different aquaculture technologies varies significantly within China's diverse aquaculture sector.[59] Therefore, a 2019 Ministry of Agriculture and Rural Affairs (MARA) document emphasizes the strengthening of the employment of science and technology in aquaculture as one way to transition Chinese aquaculture towards a modern, quality-oriented sector, utilizing technology to bolster job security for rural fishery workers. Recent Ministry of Agriculture publications provide an overview of government targets to reduce total output volume, while increasing profits and improving quality and efficiency[60] by preventing disease, improving safety and quality monitoring, reducing illegal or improper drug use, and optimizing land use.[61] China's increasing reference to sustainable aquaculture is part and parcel of the state's much broader vision of environmental stewardship - Beijing's 生态文明 (Ecological Civilization).

3. System Types and Species

3.1 Systems Overview

Some two-thirds of the total aquatic animal and plant production in China now derive from aquaculture, the majority of which is for human consumption.[62] Freshwater, marine, and brackish water aquaculture are all practiced to maximize the use of China's diverse environments of shallow

[56] China's domestic market alone is set to put significant pressure on the demand for aquatic products. Additional demand will likely be fuelled by growing international export markets, as well as domestic income growth, urbanization, and dietary diversification. It is calculated that aquaculture production may double by 2050 in order for finfish and shellfish production to meet projected demand. Waite, R et al. (2014). Improving Productivity and Environmental Performance of Aquaculture.

[57] Ibid.

[58] The National People's Congress of the People's Republic of China. (2018). 中华人民共和国宪法 [Constitution of the People's Republic of China].

[59] Many small-scale producers may use farming modes similar to systems used decades ago and some may lack, for example, updated waste management facilities. The average education level of Chinese aquaculture practitioners is also relatively low, meaning that sufficient training and assistance needs to accompany any efforts to upgrade application of science and technology in rural areas. Li, X. et al. (2011). Aquaculture Industry in China: Current State, Challenges, and Outlook

[60] 郑州外资企业服务中心 (2019). 关于加快推进水产养殖业绿色发展的若干意见.

[61] Ministry of Agriculture and Rural Affairs. (2020). 农业农村部办公厅关于印发《2020年渔业渔政工作要点》的通知. Ministry of Agriculture. (2017). 农业部关于印发《"十三五"渔业科技发展规划》的通知. Ministry of Agriculture and Rural Affairs. (2017). 农业部关于印发《全国渔业发展第十三个五年规划》的通知.

[62] FAO. (2018). FishStatJ.

sea areas, tidal flats, ponds, rivers, lakes, reservoirs, paddy fields, and saline wastelands. Since the 1999 zero-growth plan for marine capture fishery, the stricter limitations placed on inshore fishing have led to a stronger emphasis on mariculture.[63] Nevertheless, the majority of systems are freshwater (Fig. 1).

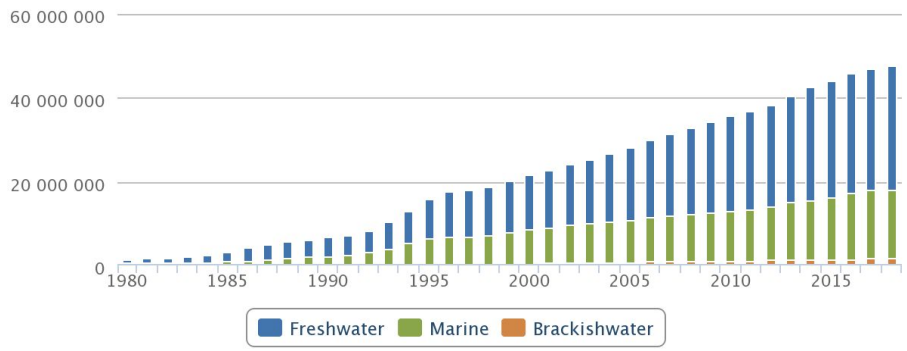

Fig. 1: Aquaculture production by culture environment 1980-2017 (unit: tonnes). Source: FishStatJ (2018).

While aquaculture is practiced throughout China, production is generally concentrated within the country's river basin regions and eastern seaboard.[64] Production in major aquaculture provinces can be broadly characterized by region:

- **Central River Basin Regions,** where aquaculture is largely freshwater polyculture pond culture systems, both extensive and semi-intensive. Overall, the Yangtze River and Pearl River basin regions account for the majority of inland aquaculture productivity.[65] Five of the eight leading freshwater aquaculture-producing provinces are in the Yangtze River basin.[66] In total, these five provinces account for 54.7% of China's freshwater aquaculture production.[67]
- **North and Northeast Regions,** where inland aquaculture typically comprises of freshwater pond culture systems. Here, Shandong is the most important mariculture province by output in tonnage.[68]
- **Coastal Regions,** where there is an emphasis on mariculture and imported fish species.[69]
- **Hainan Island Region,** where aquaculture is largely pond culture, either closed or semi-closed. [70]

[63] Chang, Y; Chen, J. (2008). The Status of Mariculture in Northern China.
[64] FAO. (2017). Fishery and Aquaculture Country Profiles The People's Republic of China.
[65] Ibid.
[66] Wang, Q; Cheng, L; Liu, J; Li, Z; Xie, S; Silva, S. (2015). Freshwater aquaculture in PR China: trends and prospects
[67] Ibid.
[68] Ibid.
[69] Lin, Y; Gao, Z; Zhan, A. (2013). Introduction and use of non-native species for aquaculture in China: status, risks and management solutions.
[70] Zhou, L. (2010). Nitrogen and phosphorus budget of intensive tilapia ponds in different culture models.

If we exclude the farming of molluscs and algae, freshwater aquaculture accounts for 90.8% of Chinese aquaculture production,[71] in which semi-intensive, small-scale pond cultures are the dominant system (Fig. 2). Due to the increasing regulation of multi-purpose public water bodies such as reservoirs, the number of cage and pen culture systems has been rapidly declining since 2011.[72]

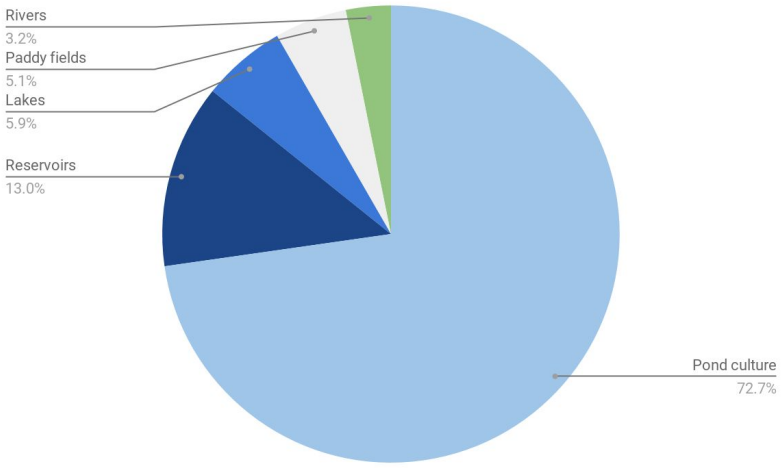

Fig. 2: Contribution of different freshwater aquaculture systems to total production. Source: Aquaculture in China: Success stories and modern trends (2018).

Despite the increasing popularity of intensive single-species systems since the 1970s, systems employed in freshwater aquaculture are relatively diverse.[73] Polyculture systems, particularly rice-cum-fish farming, have recently become increasingly attractive as an effective means of rationing water usage.

3.2 Species Overview

While cyprinids continue to dominate freshwater aquaculture (Fig. 3),[74] there has been a gradual pivot since the 1990s towards the intensive farming of higher-value carnivorous species such as shrimp, grouper, and tuna. As a result, Chinese aquaculture is characterized by a high level of diversity and a relatively low dominance of any one species (Table 1).[75] The FAO names 43 freshwater fish species and 36 marine and brackish water culture fish species as commercially important in China.[76] In mariculture, non-fed species continue to be the most widely farmed finfish.[77]

[71] Elder, M. (2017). Aquaculture in China: Challenges and Opportunities.
[72] FAO. (2017). Fishery and Aquaculture Country Profiles The People's Republic of China.
[73] Zhang, W; Ma, X. (2019). China's aquaculture development trends since 2000 and future directions.
[74] The top 6 species (Grass carp, Silver carp, Bighead carp, Common carp, Crucian carp and Nile tilapia) yields accounted for 69.6% of total yields in freshwater aquaculture in 2014. China Fisheries Statistical Yearbook. (2019). 中国渔业统计年鉴.
[75] Out of China's top thirty six most farmed fish species, China's top five species, measured by the number of individuals alive at one point (AAOP), contributed 66% towards the total number of individuals. Mercy For Animals. (2020). Fish Farming in China - A Strategic Perspective.
[76] FAO. (2018). FishStatJ.
[77] Wang, Q; Cheng, L; Liu, J; Li, Z; Xie, S; Silva, S. (2015). Freshwater aquaculture in PR China: trends and prospects.

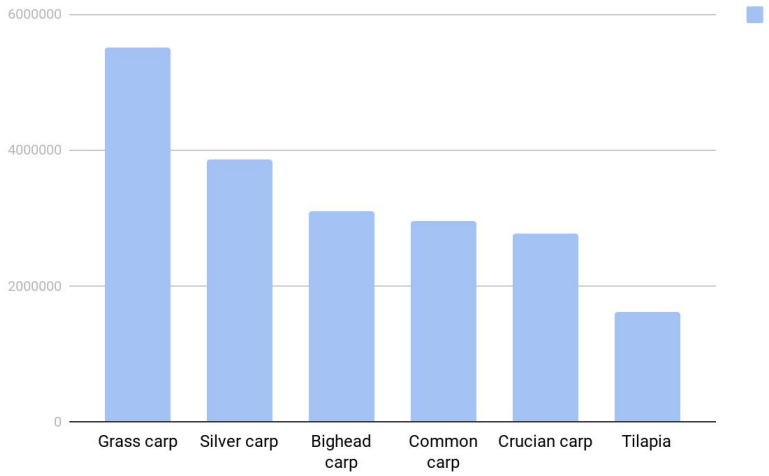

Fig. 3: Top five most farmed species in Chinese freshwater aquaculture production (units: tonnes). Source: FishStatJ (2018).

Major Species	Industry	Aquaculture Type	Major Culture System Type	Estimated Scale
Grass carp, *Ctenopharyngodon idella*	Human consumption	Freshwater aquaculture	Semi-intensive pond culture; integrated rice field aquaculture (IRFA); reservoir cage culture; high stocking density culture	5,504,301 tonnes (2018), 3,058,636,519 individuals (2016)
Yellow catfish, *Tachysurus fulvidraco*	Human consumption	Freshwater aquaculture	Semi-intensive pond culture; reservoir cage culture	~400 000 tonnes (2018), 1,717,109,756 individuals (2016)
Grouper nei, *Epinephelus coioides*	Human consumption	Mariculture	Traditional net-cage farming; large-scale	159,579 tonnes (2018), 424,493,378 individuals (2016)
Turbot, *Scophthalmus maximus*	Human consumption	Land-based brackish water aquaculture	Industrialized indoor-tank farming; intensive recirculating aquaculture system (RAS)	125,000 tonnes (2015), 48,878,425 individuals (2016)
Multiple species incl. Red crucian carp, *Carassius carassius;* Chinese goldfish, *Carassius auratus;* Asian arowana, *Scleropages formosus*	Aesthetic fish industry	Freshwater aquaculture	Unknown	3,925.07 million individuals (2019)[78]

Table 1: Diversity of aquaculture system type with exemplary species. Source: China Fisheries Statistical Yearbook (2019) and Aquaculture in China: Success stories and modern trends (2018).[79]

[78] Chyxx. (2020). 2019年中国观赏鱼养殖、进出口及前景分析[图]

[79] Scale given in tonnes sourced from Aquaculture in China: Success stories and modern trends (2018). All other information was taken from Aquaculture in China: Success stories and modern trends (2018).

4. Opportunities for Improving Welfare

4.1 Measuring Welfare

Contemporary definitions of welfare have advanced from the animal's ability to cope within its given environment to ones that consider quality of life as perceived by the animal. However, research for the development of welfare indicators (WIs) to monitor the welfare of fish is an ongoing project, and there is currently no unique or optimal system for welfare assessment.[80] A lack of species-specific, evidence-based prescriptions for farming parameters to improve farmed fish welfare, therefore, makes operationalizing welfare a challenge.[81] Small-scale farmers may not have the tools or knowledge necessary to measure the criteria critical to assessing welfare on-farm. In order to produce accurate welfare assessments, consistency and precision in data recording is crucial. Equally, trained evaluators should use assessment of multiple welfare indicators in combination. Any accurate assessment of welfare must also be specific to the given species, life stage, and prevailing farming system. In this sense, information about the basic biological requirements of the species must be available to fishery workers at all times.

Emerging technologies may grant us new capabilities to better monitor fish behavior and aquaculture environments. The emergence of 智慧渔业 (smart fishery) in China signals the accelerated ability of the Chinese aquaculture sector to leverage new technologies to improve on-farm animal welfare assessments.[82] Particularly exciting are the developing uses of precision fish farming, AI, open data, biosensors, and smart fishery cloud platforms, which may enable improved ecological modeling, satellite and mapping capabilities, and monitoring of pH, DO levels, and stocking densities. Smart fishery may not only enable vast improvements in fish health outcomes, but also reduce the operating costs for producers and the costs associated with monitoring and supervision for local governments. These technologies may also allow workers to forego some of the heavy physical labor associated with fishery work.[83]

4.2 Current Welfare Conditions and Concerns

Often, the welfare issues that aquatic animals face are not intuitive to us, as they live in an environment that is both vastly different to ours and difficult to observe with the naked eye. The following list of welfare concerns is by no means exhaustive, and represents only a brief overview of

[80] Welfare indicators are observations or measurements that provide information about the extent to which the animals' welfare needs are met

[81] A welfare assessment of farmed fishes is publicly available at FishEthoBase. This database provides updated information on the welfare requirements of several cultured species for stakeholders interested in comparing and safeguarding various commonly farmed aquatic species (continuously updated) and provides scientific recommendations for specific welfare improvements. Such contributions increase the likelihood of evidence-based standards being developed for many of the top farmed species globally in the near-future.

[82] 'Smart fishery' refers to emerging technologies and the digitalisation of aquaculture to revolutionise a highly efficient, green aquaculture. China Fisheries Association. (2019). 智慧渔业，来了!

[83] Emerging technologies may, for example, allow fishery workers to distribute feed and adjust water quality via their mobile device. Ibid.

the data we were able to review. Other critical measures include stocking density, feed quality and management, handling practices, levels of environmental enrichment (EE), and the indiscriminate and erroneous use of antimicrobials.

Poor Water Quality

Fish are constantly in contact with their environment through their gills and skin. Therefore, water quality, water flow, and exchange rates are considered to be some of the most important factors affecting fish welfare.[84] Poor water quality is clearly linked to slower growth, disease, and higher mortality rates,[85] and encompasses a range of metrics, including dissolved oxygen (DO), pH, suspended solids, carbon dioxide, ammonia, nitrite levels, temperature, and intensity of light, noise, and vibration, all of which should be monitored regularly. Dissolved oxygen levels are of particular importance for achieving adequate welfare. When mismanaged, inappropriate DO levels cause tissue hypoxia[86] and revenue loss.[87] The water pollution linked to the heavy feed and chemical inputs employed in high-density Grass carp farming is similarly cited as a direct cause of disease and "huge" economic losses in the aquaculture industry.[88]

High Levels of Disease

Continuous exposure to health-threatening situations such as poor water quality or nutritional imbalances increases fishes' susceptibility to diseases due to the compromising of their immune functioning.[89] In China, fish diseases are largely caused by parasitic and bacterial pathogens.[90] Reports of disease in Large yellow croaker, for example, include over twenty different diseases, the most serious of which is parasitic infestation.[91] Infectious diseases are a major constraint on aquaculture efficiency,[92] and major disease outbreaks can wreak havoc on local economies. In 2007, for example, an infection of *Cryptocaryon irritans* in croakers led to the loss of 20,000 sea cages of marketable-sized fish in Gangyu, Fujian Province.[93] Aquatic animal disease directly caused an economic loss of approximately 14 billion RMB in 2014 alone.[94] Many of the most prominent infectious finfish diseases can now be controlled by vaccination. Some, however, lack available

[84] FAWC. (2014). Opinion on the Welfare of Farmed Fish.
[85] Macintyere, C. (2008). The influence of water quality on farmed fish welfare.
[86] 水产养殖网. (2014). 越冬鱼养殖后期如何防止缺氧死亡的发生; Ministry of Agriculture and Rural Affairs (MARA). (2003).养殖鱼类缺氧的原因分析及对策.
[87] Anon. (2017). 高密度养殖、缺氧死鱼、养户损失惨重，这样的惨剧为什么年年有.
[88] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.
[89] Raposo de Magalhães, C. et al. (2018). A Proteomics and other Omics approach in the context of farmed fish welfare and biomarker discovery.
[90] For example, rates of bacterial hemorrhagic septicemia are higher in freshwater cultured species and those of parasites higher in industrial-scale systems. Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.
[91] Wang, Y et al. (2012). Diagnosis and prevention treatment of cryptocaryon irritants of pseudosciaena crocea in marine cages.
[92] Austin, B. (2012). Infectious Disease in Aquaculture: Prevention and Control.
[93] Economic Information Daily. (2007). Introspection on an outbreak of white spot disease in Linjiang district.
[94] China Fishery Statistical Yearbook. (2014.) 中国渔业统计年鉴.

treatment. Still more diseases require treatments that are aversive, have significant side effects, or are restricted by environmental standards.

Mortality And Inefficiency Associated with the Fish feed Industry

The use of low-value fish for the production of fish feeds has been estimated by the FAO at five to six million tonnes globally, and poses a variety of concerns for fish welfare, sustainable fishery management, and broader sector efficiency.[95] 25 to 30% of this total has reportedly been used by China, typically for marine cage culture.[96] Fish meal fish oil (FMFO) fish feed products are largely derived from catch-fishery bycatch, pelagic "trash fish" either too small or too diverse to be edible. The FMFO feed industry is not only associated with a whole host of welfare concerns, it also contributes to the depletion of wild fishery resources, high levels of mortality, waste, and poor value chain traceability.[97] In comparison with local feed ingredients, FMFO feeds are also costly for small-scale farmers.[98]

Long-Distance Transport

Transportation is as taxing for fish as for any other animal. It involves physical handling, crowding, netting or pumping,[99] starvation prior to and during transport,[100] and keeping fish in an artificial, ill-suited environment. Due to China's geographical scale, the welfare concerns associated with the long-distance, live transport of fish are significant. Carp, for example, may frequently travel up to 2500 km before slaughter.[101] The deterioration of water quality is the most significant animal welfare issue present in the transportation of live fish, especially the depletion of oxygen or accumulation of carbon dioxide and ammonia. Improving fish welfare during transport represents an opportunity to significantly reduce overall mortality rates, hence preventing the value loss of all the economic inputs invested in better on-farm aquaculture practices.

Slaughter Practices

Fishes are commercially killed in many ways, some of which may include prior stunning, but may more commonly involve asphyxiation by air or live chilling in ice slurries without stunning. For example, approximately half of China's Tilapia are sold live in either wet markets or restaurants, where they may die of asphyxia or manual percussive stunning.[102] Pond loaches are often killed by

[95] FAO. (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in action.
[96] Han, D et al. (2016). A revisit to fishmeal usage and associated consequences in Chinese aquaculture.
[97] Global Reporting Program. (2019). Fishmeal.
[98] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.
[99] Some fish also may endure long periods inside transport tanks which have been pumped with hydrogen peroxide, a cost-effective way of ensuring sufficient oxygen levels during transport. This practice can be extremely toxic for the animals involved and may prove hazardous to the end consumer. CNHNB. (2016). 提高草鱼运输成活率要点.
[100] Anon. (2019). https://zhidao.baidu.com/question/589241431709579685.html.
[101] Anon. (2020). https://wenku.baidu.com/view/dd44e841094c2e3f5727a5e9856a561252d32183.html
[102] Total annual consumption of fresh Tilapia is above 60,0000 tonnes accounting for nearly 50% of China's annual production. Chen, L. (2011). Policy recommendations on sustainable development of tilapia industry in China.

salt[103] or wine,[104] cooked alive,[105] or directly beheaded.[106] Salting was the slaughter method most frequently referenced in our research. It is also potentially the most painful.[107] The animal may also undergo stressful operations prior to slaughter, including fasting periods, crowding, removal and handling procedures, and transport to the place of slaughter. These procedures are highly stressful if performed improperly, and can cause injury through contact with other fishes, nets, or other hard surfaces.[108] The late onset of rigor mortis triggered by highly stressful slaughter practices typically results in products less desirable to the consumer, characterised by reduced firmness, color, and shelf-life.[109]

4.3 Recommendations and Promising Approaches

When approaching work in China, it should be noted that some species,[110] system types, regions,[111] and welfare concerns will present fewer logistical barriers than others. For a more comprehensive review of our technical recommendations on implementing welfare interventions, please see our report: Fish Welfare Improvements in Aquaculture.

Collaborate with Domestic Bodies

Due to China's unique requirements, domestic organizations are the best suited for leading work in the region. The role of Fish Welfare Initiative could be, therefore, to assist local groups, either in an advisory capacity or through providing funds. Potential partners include domestic groups working on certification or sustainability in aquaculture, local governments, and higher education or research institutions. It could also be particularly helpful to support prominent aquaculture producers so as to allow domestic actors full reign to spearhead fish welfare improvements in China.

Collaborating with certification bodies already awarding welfare or sustainability-relevant schemes has become an increasingly accessible and effective strategy for animal welfare work in China since 2017. As middle-class demand for safer, imported,[112] and/or potentially certified aquaculture products increases, aquaculture producers in China may pivot to produce and standardize along

[103] Anon. (2020). https://haokan.baidu.com/v?pd=wisenatural&vid=5067169594504881862.
[104] Anon. (2020). https://haokan.baidu.com/v?vid=15784838475945534752&pd=bjh&fr=bjhauthor&type=video.
[105] TOMIKKUNET. (2019). https://www.youtube.com/watch?v=w39XLLoyLwU.
[106] Anon. (2019). https://haokan.baidu.com/v?vid=2115799424175051359&pd=bjh&fr=bjhauthor&type=video.
[107] Personal correspondence with Tse Yip Fai (2020).
[108] Lines, J; Spence,, J. (2012). Safeguarding the welfare of farmed fish at harvest.
[109] Poli, B et al. (2005). Fish welfare quality as affected by pre-slaughter and slaughter management.
[110] For example, we suspect working on welfare issues associated with the raising of the popular cyprinid species, Nile tilapia, Large yellow croaker, and Pond loach, may be particularly effective. These have been selected on the basis of scale - in both output tonnage and number of individuals - as well as the tractability of enacting species-specific welfare improvements, species' sensitivity to negative stimuli, and actual conditions during rearing, transport, and slaughter.
[111] For example, Hainan island is granted more free market-oriented economic policies and flexible governmental measures by its status as a Special Economic Zone (经济特区).
[112] China's seafood imports surged 39% from 2018 to 2019, and China now ranks as the world's second-largest single-country seafood importer after the US. Harkell, L. (2020). Trade insights: Breakdown of China's $16bn in seafood imports.

these lines. As competition appears from aquaculture producers in neighboring countries such as Vietnam, Chinese firms may also want an opportunity to distinguish their export products. This may be a particularly tractable approach for working with large to medium-scale operations, which have the capacity to invest in the auditing process, technology, and accessing export markets.[113] In order for welfare certifications to be meaningful, they must usually be species-specific.[114] Examples of potential future collaboration include developing a "Good Fish" Award with the International Cooperation Committee of Animal Welfare (ICCAW) and Compassion in World Farming (CIWF).

Due to the overlap between the goals of sustainable aquaculture and positive outcomes for fish welfare, partnering with experienced sustainability advocates may create a strong mutually beneficial relationship. Many measures highlighted in state publications, such as more efficient feed use, are as important for fish welfare as they are for sustainable development.[115] Examples of potential future collaboration include working with the Hainan Tilapia Sustainability Alliance to integrate welfare strategies into their training programs.

As a result of the growing number of successful partnerships between government-backed aquaculture projects and European aquaculture experts and technology providers in China, collaborating with local governments on projects where fish welfare and economic interests clearly align may be increasingly tractable.[116] This may be an excellent opportunity to not only build trust, but also to potentially have an extremely significant impact. Examples of potential future collaboration include working in an advisory role with local government and technical service teams to improve disease and pre-slaughter mortality rates in Large yellow croaker in Fujian province (see case study 1 - appendix).[117] Finally, collaborating with higher education institutions or independent scholars could be an excellent way to access farm data, identify talent for hire, and, more generally, deepen one's understanding of the region.

Farm Visits

Farm visits will be essential to gaining further qualitative insights into the actual conditions on Chinese farms, the perspective of farmers, and the viability of implementing different welfare improvements. Core questions to explore should include what challenges farmers perceive, on-farm conditions, and whether farmers would be willing to work with an NGO or research institution to help improve production efficiency and fish health. When conducting farm visits, the organization

[113] Operationalizing welfare improvements may be particularly demanding for small-scale producers for various reasons. Many small-scale farmers operate with limited finances, feel that early production stages are already costly, and that they cannot spend money or time on quality and safety considerations, particularly during transport or slaughter. For these communities less likely to benefit from certification, it would be more effective to work on improving farm efficiency and knowledge sharing for small-scale producers through co-creating training events and/or online or print educational material.

[114] Examples include the China Blue's Tilapia CoGP and the RSPCA's Atlantic farmed salmon and trout standards.

[115] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.

[116] Yan, G; van Beijnen, J. (2019). Asian aquaculture: trends for 2019.

[117] Aquafeed. (2019). The large yellow croaker farming industry in China.

representative should be of Chinese nationality or possess sufficient language skill and cultural acumen.

Produce Chinese-language Material on Fish Welfare

As the familiarity with and acceptance levels of fish welfare are still relatively low, there is a window of opportunity to frame the relationship between fish health and human, economic, and planetary health to Chinese NGOs, academics, and government bodies. Therefore, it would be useful to produce a mobile-friendly article in Mandarin to summarize how fish-friendly business benefits multiple stakeholders.

Closing Remarks

We believe that Chinese producers and rural economies reliant on aquaculture are in particularly promising positions to profit from fish-friendly aquaculture. Due to the size and dynamism of the Chinese market, the exceptional scale of domestic production, and its scientific and technological capabilities, China is well-placed to steward this emerging trend in responsible aquaculture. High-level government has already made clear its commitment to higher quality, “green” fishery management, a vision which goes hand-in-hand with our understanding of higher-welfare aquaculture that advocates for the interests of fish as sentient beings. We hope that our work serves to strengthen the mutual benefits that our production systems, planet, and aquatic animals stand to gain.

Appendix

Case Study 1: Large yellow croaker

In 2003, croaker was the most-produced marine fish, by weight, of all marine fish cultured in China, making up about 25% of total production.[118] In 2019, production reached ~198,000 tonnes.[119] Farmed predominantly in sea cages,[120] the fish's production provides jobs for over 300,000 people.[121] Staggeringly, 83% of total production comes from Ningde,[122] a small prefecture-level city in Fujian province named one of the most concentrated aquafarming hubs in the world. Ningde boasts a long history of collaboration between research institutions and industry groups.[123] As such, Ningde authorities may be particularly receptive to collaborating with organizations to improve production efficiency, disease prevention, and long-term profitability.

Reported Large yellow croaker mortality rates in Ningde all exceed 30%, with 50% considered normal.[124] These mortality rates can be linked to a variety of factors including fatal diseases, high stress linked to their audio-sensitivity,[125] and inappropriate water temperatures.[126] Incidences of parasites, white spot disease,[127] large yellow croaker iridovirus (LYCIV), and white gill are all high in Large yellow croaker farming.[128] During transport, harvesting is frequently done mechanically, possibly causing crushing.[129] In all videos and articles reviewed, the croaker almost never lives through transport.[130] According to one video, croakers are often fed by-catch, or low-value fish of variable quality from catch fisheries.[131] When stored improperly, live feed has been linked to the spread of disease, as it is prone to carrying pathogens.[132] Video footage also suggests that Large yellow croakers may be farmed in very high densities.[133]

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[118] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.

[119] FAO. (2018). FishStatJ.

[120] In 2015, 93.3% of the large yellow croakers in Ningde were farmed in sea cages. GJYFish. (2010). http://www.gjyfish.com/nddhy/Feeding_Status.html.

[121] Xinhua News. (2020). 特稿：大黄鱼重回中国人餐桌的传奇.

[122] Zhejiang and Guangdong provinces account for the remainder of production output. Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.

[123] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.

[124] 水产热点. (2019). 去年大黄鱼成活率仅30%，如今养殖户不愿卖、鱼中不愿收，但不少人今年依然看好！; CAASS. (2015). 2015年渔业主导品种---大黄鱼.

[125] Anon. (2020). https://haokan.baidu.com/v?vid=9410139961559056379&pd=bjh&fr=bjhauthor&type=video; CCTV财经. (2019). https://www.youtube.com/watch?v=f4K5a6fq0BM&feature=youtu.be&t=560.

[126] Anon. (2020). https://haokan.baidu.com/v?vid=15471026016116960521&pd=bjh&fr=bjhauthor&type=video.

[127] Anon. (2019). https://www.sohu.com/a/326635723_720210.

[128] Reports of disease in Large yellow croaker, both fry and adults, include over twenty different diseases, among which the most serious is parasitic infestation. Wang et al. (2012). Diagnosis and prevention treatment of cryptocaryon irritants of pseudosciaena crocea in marine cages.

[129] In this video, Large yellow croakers are observed being moved into boxes from some heights, most likely causing crushing and extreme stress responses. Anon. (2018). https://haokan.baidu.com/v?vid=16936541916432735983&pd=bjh&fr=bjhauthor&type=video.

[130] Huo, Z et al. (2018). 传统"弓鱼"技术对延长大黄鱼存活时间的探讨. Anon. (2020). https://haokan.baidu.com/v?vid=9410139961559056379&pd=bjh&fr=bjhauthor&type=video.

[131] About one million tonnes of low-valued fish are estimated to be utilized in Ningde city, Fujian Province for Large yellow croaker culture in a year. CCTV财经. (2019). https://www.youtube.com/watch?v=f4K5a6fq0BM&feature=youtu.be&t=560.

[132] Usage rate of formulated feeds is reported to be less than 30%. Aquafeed. (2019). The large yellow croaker farming industry in China.

[133] CCTV财经. (2019). https://www.youtube.com/watch?v=f4K5a6fq0BM&feature=youtu.be&t=275; Anon. (2019). https://www.bilibili.com/s/video/BV1pt411x7s6. Additionally, Ningde industry received a huge blow from white dot disease in 2009 and 2010 - a disease claimed to be correlated with overdensity in stocking. Sina News. (2009). http://news.sina.com.cn/s/p/2009-07-01/021718127604.shtml; Sina News. (2010). http://fj.sina.com.cn/news/s/2010-10-28/102875136.html.

Case Study 2: Nile tilapia

Globally, Nile tilapia are widely cultured due to their disease resistance, high growth rate, short culture period and reproductive cycle, wide-ranging food habits, and suitability for high stocking densities.[134] In 2018, they were the sixth most farmed freshwater fish in China by tonnage.[135] In the reviewed video footage, Nile tilapia were most often farmed in semi-intensive polyculture pond systems.[136] Tilapia are often raised for export by producers who, with access to foreign markets, may be more interested in and more likely to benefit from certification schemes that mark their products as either sustainable or welfare-minded. A high-profile species and household name, Chinese tilapia production could become an early model for best practices in aquaculture globally. Founded in 2015, the Hainan Tilapia Sustainability Alliance was the first Chinese NGO to promote sustainable fisheries in an industry-led initiative that provides training on best practices and institutional development for producers and industry leaders. Working specifically on tilapia production in Hainan, over 40 pilot farms have applied their Code of Good Practices (CoGP).

There is a more mature research base around the specific requirements of Nile tilapia than other species. There is, for example, strong evidence to support the acute stress response of Nile tilapia to handling and to environmental and social stressors.[137] There is also evidence of improvements in health with the addition of in-farm oxygen aerators.[138, 139] Despite the high disease resistance of Nile tilapia, mortality rates associated with disease are high.[140] According to one source, Nile tilapia are typically fed soy or wheat compound feeds,[141] feeds which present some anti-nutritional properties and are correlated with slowed growth rates.[142] Approximately half of China's Tilapia are sold live,[143] either in wet markets or restaurants, where they may die of asphyxia or manual percussive stunning.

[134] Wang, W. (2008). Fish Stocking Enhancement and Farming.
[135] FAO. (2018). FishStatJ.
[136] 军迷天下. (2015). https://youtu.be/-NbzBCMxIRY?t=1009; 军迷天下. (2014). https://www.youtube.com/watch?v=PFXaC0OUmR4.
[137] Barreto, R; Volpato, G. (2006). Stress responses of the fish Nile tilapia subjected to electroshock and social stressors; Li, M et al. (2018). Metabolic response of Nile tilapia (Oreochromis niloticus) to acute and chronic hypoxia stress; Khaldi, A. (2010). Effect of different stress factors on some physiological parameters of Nile tilapia.
[138] Ganti; Selker. (2016). Semi-Intensive Aeration System Design for Rural Tilapia Ponds.
[139] Haque, M et al. (2017). Effect of aeration on growth and production of fish in intensive aquaculture system in earthen ponds.
[140] One source reported a mortality rate of Tilapia between 80% and 90% at sites within Leizhou Bay due to Sreptococcal-based infections. Towers, L. (2016). Counting the Cost of Aquatic Disease in Asia.
[141] Gui, J; Tang, Q; Li, Z; Liu, J. (2018). Aquaculture in China: Success stories and modern trends.
[142] Ibid.
[143] Total annual consumption of fresh Tilapia is above 600000 tonnes accounting for nearly 50% of China's annual production. Chen, L. (2011). Policy recommendations on sustainable development of tilapia industry in China.