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EVALUATION OF AQUATIC CARRYING CAPACITY FOR AQUACULTURE : A CASE STUDY ACROSS VARIOUS COUNTRIES

Evaluasi Daya Dukung Perairan Untuk Akuakultur : Studi Kasus Berbagai Negara

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ABSTRAK

Carrying capacity of aquatic ecosystems is a crucial concept in ensuring the sustainability of these ecosystems amidst increasing human activities, particularly intensive aquaculture. This study aims to review the literature on aquatic carrying capacity, focusing on the methods and parameters used in related research and the implications of these findings for environmental management. Using a literature study approach, several journals related to the aspects of aquatic carrying capacity were collected and analyzed. The review indicates that factors such as water quality, types of macrophytes used to control eutrophication, and aquaculture management techniques significantly influence the carrying capacity of aquatic systems. A comprehensive understanding of aquatic carrying capacity is essential for developing effective and sustainable management policies.

Keywords: aquaculture, carrying capacity, literature review

ABSTRACT

Daya dukung perairan merupakan konsep yang penting dalam memastikan keberlanjutan ekosistem perairan di tengah meningkatnya aktivitas manusia, diantaranya akuakultur yang intensif. Kajian ini bertujuan untuk mengkaji literatur mengenai daya dukung perairan, dengan menyoroti metode dan parameter yang digunakan dalam penelitian terkait serta implikasi hasilnya bagi pengelolaan lingkungan. Dengan menggunakan pendekatan studi literatur, beberapa jurnal terkait aspek daya dukung perairan dikumpulkan dan dianalisis. Hasil kajian menunjukkan bahwa faktor-faktor yaitu kualitas air, jenis tanaman makrofit yang digunakan untuk mengendalikan eutrofikasi, dan teknik manajemen akuakultur sangat mempengaruhi daya dukung suatu perairan. Pemahaman yang mendalam terhadap daya dukung perairan diperlukan untuk menyusun kebijakan pengelolaan yang efektif dan berkelanjutan.

Kata Kunci: akuakultur, daya dukung, studi literatur

INTRODUCTION

Aquatic ecosystems are resources that play an important role in supporting biodiversity and are the basis for various human activities, including aquaculture, irrigation, and clean water supply. However, human activities that continue to grow, especially in the aquaculture sector, can cause changes in environmental quality that lead to a decrease in the carrying capacity of waters. The carrying capacity of waters reflects the maximum limit of activity loads that can be accepted by an aquatic ecosystem without causing environmental degradation (Taskov *et al*. 2021).

Various studies have identified that various factors including the number of floating net cages (KJA), nutrient content in water, eutrophication levels, and the use of wetlands to treat waste play an important role in determining the carrying capacity of a body of water (Simangunsong & Hidayat 2017). Research on the Jatiluhur Reservoir observed that the high number of KJA exceeding the carrying capacity can affect water quality and trigger increased eutrophication, which in turn threatens the balance of the reservoir ecosystem (Weitzman & Filgueira, 2020). In addition, research in several reservoirs and lakes has shown that the application of management methods such as planting aquatic macrophytes can help control water quality, especially through the removal of excess phosphorus and other nutrients (Tavares 2019).

This study aims to review the literature related to water carrying capacity by highlighting studies that discuss various measurement methods and parameters used to assess carrying capacity, especially in reservoirs and lakes with intensive aquaculture pressure. In addition, this study also aims to provide recommendations for sustainable management that can be applied in managing water carrying capacity optimally.

RESEARCH METHODS

This study uses a literature study method by collecting various scientific journals related to water carrying capacity from reliable sources. The data reviewed include the research background, objectives, methods, observed parameters, and relevant main results. The literature collection method includes research analysis using a carrying capacity measurement approach, namely interviews, water quality analysis, load capacity calculations, and eutrophication models. The analysis is carried out by comparing various approaches and results found, so that a comprehensive understanding can be obtained regarding key factors in assessing water carrying capacity for aquaculture.

RESULTS

The results of various literatures show that the carrying capacity of waters is influenced by environmental factors, namely water quality, type and number of floating net cages (KJA), and the management methods applied. Multipurpose reservoirs in densely populated areas, especially in Asia, KJA have become the main center for aquaculture development (Newton *et al*. 2021). However, the consistency of KJA aquaculture in providing benefits to humans is not accompanied by environmental conservation. The results of the literature show a diversity of approaches, challenges, and innovations in assessing the carrying capacity of waters for aquaculture in various parts of the world. Comparative analysis reveals the following key patterns :

1. Conceptual Diversity and Assessment Approaches
    - Four Pillars Model (Physical, Production, Ecological, Social):

Weitzman & Filgueira's (2020) study confirms that the concept of aquaculture carrying capacity has evolved beyond purely ecological limitations to a holistic approach that includes four main pillars :

a. **Physical**: Availability of physical space for farming operations (e.g. suitable area for KJA).
b. **Production**: Maximum stocking density to achieve optimal harvest without compromising fish health.
c. **Ecological**: Limits of farming activity before environmental impacts (eutrophication, decreased DO, waste accumulation) become unacceptable.
d. **Social**: Level of farming development before social impacts (space conflicts, decreased visual quality, community rejection) become unacceptable.

- Dominance vs Negligence :
  Global comparative studies show that most historical research and practical applications have focused more on Production and Ecological aspects. Social aspects are often the most neglected and challenging to measure quantitatively, despite being recognized as critical pillars for long-term sustainability and industry acceptance (Weitzman et al. 2020; Wetzman *et al*. 2021). Weitzman *et al*.'s (2022) study in Canada explicitly revealed that community distrust of industry and government is a major driver of social rejection of salmon aquaculture, more significant than demographic factors alone.

Table 1. Application of the Four Pillars of Carrying Capacity in Case Studies of Various Countries

Country/Region	**Main Focus of Support Capacity**	**Key Method/Parameter Example**	**Literature Sources**
Europe and North America	Ecological & Production (Dominant), Social (Emerging)	Ecosystem Model (DEB, FARM), Delphi Expert, Social Network Analysis, Water Quality Indicators (DO, BOD, Nutrient)	Weitzman & Filgueira (2020), Weitzman *et al*. (2022)
Asia (Indonesia)	Social & Production (Dominant)	Stakeholder Interviews, Nutrient Absorption Capacity (Beveridge Formula), Parameters	Weitzman *et al*. (2022)
Brazil	Ecological & Production	Hydrodynamic Model (MOHID), Artificial Wetlands, Macrophyte Experiments	Ferreira *et al*. (2013)
Global	Holistic (4 Pillars)	Socio-Ecological Approach, Multi-Stakeholder Participation, Environmental-Social Data Integration	Krause *et al*. (2024)

2. Regional Variations in Challenges and Priorities:
    - Europe & North America (Canada, Norway, Scotland):
      A key challenge lies in better integrating social aspects into assessment models and policies. Weitzman *et al*.'s (2022) study in Nova Scotia, Canada, highlighted significant differences in perceptions between urban and rural/coastal populations towards salmon aquaculture. Rural/coastal populations (who are more directly affected) tend to be more resistant, driven by higher environmental concerns and distrust of regulators, challenging the simplistic "NIMBY" (Not In My Backyard) assumption (Weitzman *et al*. 2022). These countries are also leaders in developing sophisticated numerical models (e.g. the Dynamic Energy Budget - DEB Model in Canada (Weitzman & Ferreira 2020), the Farm Aquaculture Resource Management
    - FARM Model in Europe (Ferreira *et al*. 2013) and applying the Delphi approach to formulate best practices for expert consensus-based holistic carrying capacity assessments (Weitzman *et al*. 2021).
    - Asia (Indonesia, China, Vietnam): The main pressure comes from the rapid intensification of aquaculture (especially marine cages) in reservoirs and lakes near population centers, often exceeding calculated ecological limits. As in the Jatiluhur Reservoir, Indonesia, the number of marine cages (23,000 units) far exceeds the estimated ecological carrying capacity (6,838 units) (Taskov et al. 2021). Policy focus is often stronger on socio-economic aspects (labor absorption, food security) and community-based management, albeit with limited monitoring resources. Methods often combine nutrient uptake capacity calculations (such as the Beveridge formula) with local stakeholder interviews.
    - Brazil: Research in reservoirs such as Itacuruba and the Parapanema River emphasizes a techno-ecological approach. They combine large-scale hydrodynamic modeling (MOHID platform) to simulate waste distribution and cumulative impacts in a 18-tiered reservoir, with nature-based solutions such as the use of artificial wetlands vegetated with macrophytes (Eichhornia crassipes, Egeria densa) for in-situ waste treatment. The effectiveness of macrophytes in reducing nutrients (33.36% Phosphorus, 28.72% Nitrogen) provides a relatively low-cost solution that is relevant for developing countries (Tavares 2019).
3. Effectiveness of Management Solutions:
    - Nature-Based Nutrient Control: Studies in Brazil and other locations have consistently confirmed the high effectiveness of aquatic macrophytes (Eichhornia crassipes, Egeria densa, etc.) in absorbing excess nutrients (N and P) from aquaculture-affected waters, with reduction rates reaching 28-50% 18. Well-designed constructed wetland systems offer a cost-effective and sustainable solution to increase ecological carrying capacity, especially in areas with limited centralized wastewater treatment infrastructure.
    - Advanced Simulation and Monitoring Models: The application of numerical models such as DEB, FARM, and MOHID allows for more accurate projections of the impacts of different aquaculture scenarios on the aquatic environment. These models facilitate more dynamic and adaptive assessments of carrying capacity. The use of bio-optical sensors (as in Japan (Chapman 2018) and other real-time monitoring technologies is increasingly important to rapidly understand ecosystem dynamics.
    - Participatory Social Approaches: Case studies in Canada and Indonesia show that involving local stakeholders (including potentially resistant communities) early in

the process of carrying capacity assessment and spatial planning not only improves the accuracy of social data but also builds trust and social legitimacy for the aquaculture industry (Weitzman 2021; Weitzman 2022; Krause *et al*. 2024). Methods such as Public Participation GIS (PPGIS) and well-designed perception surveys (taking into account geographic and demographic differences) are important tools (Weitzman 2022).

4. Key Challenges in Holistic Implementation:
   - Integrasi Disciplinary Integration: Linking data and models from the natural sciences (ecology, oceanography) with the social sciences (sociology, economics, politics) remains a significant methodological and operational challenge (Weitzman 2021).
   - Data Availability and Quality: Many regions, especially in developing countries, lack high-quality, long-term environmental and social data to support accurate modeling and assessments (Weitzman 2022).
   - Policy and Governance: The absence or inconsistency of regulatory frameworks that explicitly adopt a holistic carrying capacity-based approach (4 pillars) hampers implementation (Weitzman 2021; Krause *et al*. 2024). Fragmentation of authority between agencies is also often a problem.
   - Offshore Aquaculture: The development of aquaculture in more remote and exposed locations creates new social (public perception, labor, security, ownership) and technical (monitoring, enforcement) challenges that are not yet fully understood or regulated (Krause et al. 2024). Social science research specific to the “offshore” context is still very limited.
   - Climate Dynamics: Climate change is altering key parameters underlying carrying capacity (temperature, stratification, circulation, precipitation patterns, extreme events), requiring more adaptive and dynamic assessment approaches (Weitzman 2020).

Table 2. Comparison of Challenges and Dominant Solutions in Various Regions

Aspect	Europe and North America	Asia	Brazil and South America	Global Trends
Dominant Challenge	Integration of social aspects, coastal space conflicts, public trust	Over-intensification, population pressure, data limitations	Large scale operations (reservoirs), need for cost effective solutions	Climate change, offshore aquaculture, integration of disciplines
Solution	Advanced numerical models (DEB, FARM), Delphi, public participation	Absorptive capacity formula, community-based management	Hydrodynamic model (MOHID), macrophyte artificial wetland	Socio-Ecological Approach, advanced monitoring technology
Policy Focus	Strict environmental regulations, maritime spatial planning	Food security, labor absorption	Sustainable development, integrated reservoir management	Adaptive policy, holistic governance, blue economy
The Need for Social Research	Drivers of negative perception, social acceptance model	Socio-economic impacts of intensification, participatory model	Acceptance of techno-ecological solutions, participatory governance	Social impacts of offshore aquaculture, environmental justice

DISCUSSION

The KJA system in the Asian region has failed to manage eutrophication, which is actually caused by a number of human activities such as agriculture, land conversion, urban and industrial waste that occurs around the cultivation and fishing areas (Sunardi *et al*, 2020). Therefore, a rational management approach that includes aquaculture is needed, one of which is in the Citarum River Basin (DAS) which is one of the largest rivers in West Java and supports 20% of Indonesia's gross domestic product (Lubis *et al*. 2018). However, the increasing volume of domestic, agricultural and industrial waste has caused the Citarum River to become one of the most polluted rivers in the world (Kerstens *et al*. 2014). Research on the Jatiluhur Reservoir shows that the excessive increase in the number of KJA has had a negative impact on water quality and ecosystem balance. Based on interviews with reservoir managers and fish farmers, the ideal number of KJA to support the carrying capacity of the Jatiluhur Reservoir is around 6,838 units, but the reality in the field shows the existence of 23,000 units, so efforts are needed to regulate the density of KJA to prevent degradation of water quality and reservoir ecosystems (Simangunsong & Hidayat 2017). This imbalance highlights the importance of planning water carrying capacity to ensure sustainability.

To improve water quality and support the carrying capacity of waters, several studies recommend the use of aquatic macrophytes such as *Eichhornia crassipes* (water hyacinth) and *Egeria densa* (Brazillian waterweed) which have been proven effective in absorbing 33.36% of phosphorus and 28.72% of nitrogen, thereby reducing the risk of eutrophication. A study in Itacuruba, Brazil, showed that these two plants can play a role in improving water quality around aquaculture areas through artificial wetlands, which are operated as nutrient cleaning systems (Tavares 2019). The roots of Eichhornia crassipes function as barriers, slowing the flow of water entering the reservoir body, causing sediment and pollutants below to settle. In its metabolic process, the roots, which are up to 1 m long, can absorb several pollutants from the water and convert them into fresh material through photosynthesis (Rodella *et al*. 2006). In facing the increasing drought crisis, it is necessary to strategize water use. So far, there is no monitoring of the quality of KJA waste in most parts of the world, so the cheapest and easiest way is to return the KJA waste flow to the reservoir. The use of wetlands in the upstream and downstream parts of the reservoir with *Eichhornia crassipes* (water hyacinth) and *Egeria densa* (Brazillian waterweed) is an alternative that, if managed properly, will provide economic, social and environmental benefits to ensure the sustainability of aquaculture (Tavares 2019).

Berbagai Various methods have been applied in the study of water carrying capacity, and the differences in these methods also affect the measurement results and interpretations obtained. According to (Ferreira *et al*. 2014), carrying capacity is determined in 4 pillars, namely social, governance, ecological, and production. In America, Europe, and Canada, the carrying capacity criteria are more based on the production pillar, while in the Asian region, carrying capacity is more emphasized on the social pillar for economic and food security reasons. For example, interview methods and field data collection were applied in a study in Indonesia that combined local perceptions with water quality data to calculate carrying capacity, so that the results were more contextual according to local needs (Simangunsong & Hidayat 2017). Conversely, in Brazil, a study used an experimental approach through artificial wetlands to test the effectiveness of macrophyte plants in reducing nutrients in water, which provided quantitative results regarding the influence of plants in the aquaculture environment (Tavares 2019). Another study in Brazil applied hydrological and hydrodynamic models generated and calibrated from the MOHID (Marine Environment & Technology Centre, Portugal) computational platform in estimating the carrying capacity and storage capacity of eight large reservoirs in the Parapanema River, Brazil (Montanhini *et al*. 2017).

Other methods include PCA analysis models used in China to identify key factors affecting carrying capacity in Hebei Province waters (Wang et al. 2021) and classify key factors for carrying capacity evaluation in Xianjiang (Hong, 2020). Meanwhile, Japan uses natural fluorescence bio-optical sensors to monitor phytoplankton primary production and understand oxygen dynamics to determine coastal carrying capacity (Furuya 2001). In terms of equations, the calculation of water carrying capacity often uses a formula that considers nutrient concentration factors (phosphorus and nitrogen). One common formula used is the Beveridge equation (1984) as used in Chandra et al. (2018) in determining carrying capacity in Kedungombo Waters, Indonesia. The equation includes:

1. **Morphology and Hydrology of Reservoirs**

$$Z = V / A \quad (1)$$

$$\rho = Q / V \quad (2)$$

Description = Z : Average depth of reservoir (m) V : Reservoir volume (million m3) A : Reservoir area (Ha) ρ : Reservoir water turnover rate (per year) Q : Number of reservoir water discharge (million m3/year).

2. Allocation of Phosphorus (P) Pollution Load

$$\Delta[P] = [P]f - [P]i \quad (3)$$

Description = Δ[P] : Total-P allocation for fish farming (mg/m3) [P]f : Maximum Total-P level condition according to water quality standards or water class (mg/m3) [P]i : Total-P parameter from reservoir monitoring (mg/m3).

3. Total P Pollution Load

$$L_{fish} = \Delta[P]\, Z\, \rho / (1 - R_{fish}) \quad (4)$$

$$R_{fish} = (1 - x)*R + x \quad (5)$$

$$R = 1 \div (1 + 0{,}515\ \rho 0{,}551) \quad (6)$$

$$La = L_{fish} * A \quad (7)$$

Description = Lfish : Total-P fish waste capacity per unit area of reservoir (g/m2/year) La : Total Total-P fish waste capacity in lake waters (g/year) R : Total-P remaining with sediment Rfish : Proportion of Total-P dissolved into sediment after cages are in place X : Proportion of Total-P permanently entering the base, 45 - 50%.

4. Feed and P Waste from KJA

$$P_{LP} = FCR \times P_{feed} - P_{fish} \quad (8)$$

Description = PLP : Total P entering the reservoir from fish waste (kg/ton fish) FCR : Feed Conversion Ratio (ton/ton fish feed) Pfeed : Total-P Levels in feed (kg/ton feed) Pfish : Total Levels – P in fish (kg/ton fish). (kg/ton ikan).

5. Number of Aquaculture

$$LI = La / P_{LP} \quad (9)$$

$$LP = LI \times FCR \quad (10)$$

Description = LI : Total net cage cultivation production (tons of fish/year) LP : Total net cage cultivation feed (tons of feed/year).

6. Determining the Capacity of KJA

Ideal number of KJA = LI / Total fish production per year in net cages (11)
Number of cages to be reduced = Total number of existing net cages – Ideal number of KJA (12)

By using this equation, researchers can determine the carrying capacity limit for the optimal number of KJA without damaging the water quality in the waters (Buyukapar 2006).

Based on the review of related literature, the best and most applicable method in various countries for evaluating water carrying capacity is a combination of ecological parameter-based approaches, modeling, and local community participation. This method is considered effective because it considers the specific needs of the ecosystem while utilizing data and technology available in each country.

1. Ecological Parameter-Based Approach
   This method involves measuring water quality including nutrient concentrations (phosphorus and nitrogen), DO, BOD, and eutrophication levels. These parameters can

be measured with simple tools to sophisticated technology, so they are flexible to apply in both developed and developing countries.

2. Modeling and Simulation
   The use of simulation models such as the Carrying Capacity Model (CCM) or the hydrological-hydrodynamic approach allows for projections of the impact of aquaculture activities on the environment in the long term. This model helps with more accurate planning, for example, which is applied in Brazil using the MOHID platform.MOHID.
3. Participatory Approach
   This method involves local communities in data collection and carrying capacity planning, namely interviews and field surveys. This approach increases the relevance of the results to local needs, for example, which was carried out in Indonesia to determine the carrying capacity of KJA in the Jatiluhur Reservoir.
4. Use of Macrophyte Plants
   The use of plants such as water hyacinth and Egeria densa has been shown to be effective in reducing excess nutrients, reducing the risk of eutrophication, and improving water quality. This method is cost-efficient and easy to implement, especially in developing countries.

This approach is relevant for all countries because it is flexible and can be adapted to local resources, technologies and regulations. By integrating the three methods, water carrying capacity can be managed sustainably to support aquaculture activities and protect aquatic ecosystems.

CONCLUSION

Overall, the results of these studies indicate that water carrying capacity is highly contextual and depends on the characteristics of the local ecosystem, the type of macrophyte used to control eutrophication, and the management methods applied. With proper planning and monitoring, water quality can be maintained to support the sustainability of aquaculture activities. This study underscores the importance of a holistic approach in determining the appropriate water carrying capacity for each ecosystem to ensure long-term sustainability.

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REFERENCES

Beveridge, M. C. M. (1984). *Cage and pen fish farming: Carrying capacity models and environmental impact* (FAO Fisheries Technical Paper). Food and Agriculture Organization of the United Nations.

Chandra Binsar Hamonangan Simanjuntak, I., & Muhammad, F. (2018). Carrying capacity of Kedungombo Reservoir for net cage culture. *E3S Web of Conferences, 73*, 03018. https://doi.org/10.1051/e3sconf/20187303018

Chapman, E. J., & Byron, C. J. (2018). The flexible application of carrying capacity in ecology. *Global Ecology and Conservation, 13*, e00365.

Ferreira, J. G., Grant, J., & Verner-Jeffreys, D. W. (2013). Carrying capacity for aquaculture: Modeling frameworks for determination. In *Encyclopedia of Sustainability Science and Technology* (pp. 1–23). Springer. https://doi.org/10.1007/978-1-4614-5797-8_107

Furuya, K. (2001). *Evaluation of biological productivity of lower trophic levels and carrying capacity of aquaculture areas*.

Buyukapar, H. M., & Avsar, A. A. (2006). The carrying capacity and suitability of the Menzelet Reservoir (Kahramanmaras-Turkey) for trout culture in terms of water quality. *Journal of Applied Sciences, 6*(13), 2774–2778.

Hong, X. (2020). Analysis of water resources carrying capacity in Xinjiang based on principal component analysis. *Water Resources Planning*.

Kerstens, S. M., Hutton, G., van Nes, A., & Ilham, F. (2014). *Downstream impacts of water pollution in the Upper Citarum River, West Java, Indonesia: Economic assessment of interventions to improve water quality* (Technical Paper). Asian Development Bank and The World Bank.

Krause, G., Weitzman, J., Rector, M. E., Filgueira, R., van den Burg, S., Dankel, D. J., ... & Osmundsen, T. C. (2024). The social science of offshore aquaculture: Uncertainties, challenges and solution-oriented governance needs. *Frontiers in Aquaculture, 3*, 1384037.

Lubis, R. F., Delinom, R., Murdohardono, S., & Haryadi, B. (2018). Water-food nexus in Citarum watershed, Indonesia. *IOP Conference Series: Earth and Environmental Science, 118*, 012017.

Montanhini Neto, R., Nocko, H. R., & Ostrensky, A. (2017). Carrying capacity and potential environmental impact of fish farming in the cascade reservoirs of the Paranapanema River, Brazil. *Aquaculture Research, 48*(7), 3433–3449. https://doi.org/10.1111/are.13169

Newton, R. W., Zhang, W., Xie, Z., & Beveridge, M. C. M. (2021). Intensification, regulation and diversification: The changing face of inland aquaculture in China. *Ambio*. https://doi.org/10.1007/s13280-021-01503-3

Rodella, R. A., Costa, N. V., & Costa, L. D. N. C. (2006). Diferenciação entre planta Egeria densa e Egeria najas pelos caracteres anatômicos foliares. *Planta Daninha, 24*(2), 211–220.

Simangunsong, N. F., & Hidayat, A. (2017). Carrying capacity and institutional analysis of floating net cages in Jatiluhur Reservoir. *Sustinere: Journal of Environment and Sustainability, 1*(1), 37–47. https://doi.org/10.22515/sustinere.jes.v1i1.6

Sunardi, S., Ariyani, M., Agustian, M., Withaningsih, S. P., Juahir, H., & Othman, A. A. S. (2020). Water corrosivity of polluted reservoir and hydropower sustainability. *Scientific Reports*.

Taskov, D. A., Telfer, T. C., Bengtson, D. A., Rice, M. A., Little, D. C., & Murray, F. J. (2021). Managing aquaculture in multi-use freshwater bodies: The case of Jatiluhur Reservoir. *Environmental Research Letters, 16*(4), 045004. https://doi.org/10.1088/1748-9326/abe009

Tavares Marques, É. A. (2019). Improving wastewater quality of a fish farm in Itacuruba, Northeastern Brazil. *Advances in Oceanography & Marine Biology, 1*(3). https://doi.org/10.33552/aomb.2019.01.000515

Wang, S., & Chen, B. (2021). Unraveling energy–water nexus paths in urban agglomeration: A case study of Beijing–Tianjin–Hebei. *Applied Energy, 304*, 117924.

Weitzman, J., & Filgueira, R. (2020). The evolution and application of carrying capacity in aquaculture: Towards a research agenda. *Reviews in Aquaculture, 12*(3), 1297–1322. https://doi.org/10.1111/raq.12383

Weitzman, J., Filgueira, R., & Grant, J. (2022). Identifying key factors driving public opinion of salmon aquaculture. *Marine Policy, 143*, 105175.