



## Empowering Coastal Communities through Oyster Shell Waste Management and Circular Economy Practices in Gisik Cemandi

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### ABSTRACT

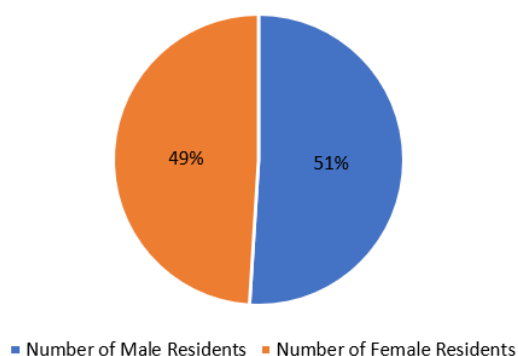
Managing oyster shell waste in coastal regions remains a significant issue, requiring solutions that add economic value while ensuring environmental sustainability. This community service program supported residents of Gisik Cemandi Village in converting oyster shell waste into livestock feed, aligning with circular economy principles. Activities included observations, interviews, educational sessions, discussions, training, and practical application. The initiative showed promising results: 90% of participants recognized the benefits of waste processing, and 70% showed enthusiasm for future training. It effectively increased community knowledge and skills in producing livestock feed from shell waste. From a scientific perspective, it highlights the application of circular economy and social innovation using local resources. Socially, it empowered the community—particularly women in the shellfish sector—and promoted local food security. Challenges such as limited processing tools will be addressed through proposed equipment support, the formation of small cooperatives, and ongoing community-based training. These efforts aim to ensure long-term sustainability and establish Gisik Cemandi as a model for community-driven waste management that aligns with sustainable development goals.

**Keywords:** Circular Economy; Community Empowerment; Community Service; Livestock Feed; Oyster Shell Waste

### INTRODUCTION

**G**isik Cemandi Village is located in Sedati District, Sidoarjo Regency. According to data from the Central Bureau of Statistics (BPS) of Sidoarjo (2022), Gisik Cemandi is one of sixteen villages in the district. It lies approximately 4 kilometers from the district center and 15 kilometers from the regency's administrative center, covering an area of 149 hectares, or about 1.88% of the total area of Sedati District. Geographically, Gisik Cemandi borders Banjar Kemuning Village to the north, Tambak Cemandi Village to the south, Lanudal Juanda to the west, and the Madura Strait to the east, situated at an elevation of 23 meters above sea level.

Based on interviews with village officials and official records as of July 2024, it was found that the demographic structure of Gisik Cemandi is dominated by the productive age group. The population composition by gender and age is presented in Figure 1. Additional data also highlight the residents' main occupations and the village governance structure under the leadership of Muhammad Alimin.



**Figure 1.** Population Composition of Gisik Cemandi Village as of July 2024 (Source: Interviews with Village Officials and Official Village Records, July 2024).

The productive age group plays a vital role in the development of a region. Radkar (2022) emphasized that in India, a demographic dividend—a situation resulting from a significant decline in fertility rates—creates a "golden opportunity" where a large proportion of the population falls within the working-age group, driving economic growth. Similarly, Kusrini et al. (2013) stated that productive-aged individuals possess optimal physical and psychological conditions for work performance. Furthermore, Ankesa, Amanah, and Asngari (2016) argued that individuals in this age group are more mature and thus more receptive to innovation across various activities.

One of the village's notable local resources is the abundant oyster shell waste generated from shellfish processing industries and household activities. Unfortunately, the community has historically sold this waste directly to collectors without any further processing. This situation is concerning, as unmanaged oyster shell waste can cause significant environmental problems, including soil and water contamination (Seesanong et al., 2023; Zhan & Wang, 2022), greenhouse gas emissions (Jović et al., 2019), aesthetic degradation and foul odors (Topić et al., 2023), and threats to marine ecosystems (Prasetyo et al., 2022; Morris et al., 2019).

Previous studies have explored the potential reuse of oyster shell waste, particularly in construction-related applications, such as substitutes for aggregates in building materials or cement clinker (Paris et al., 2015; Chiou, Chen, & Li, 2014). Additionally, oyster shells have been identified as promising recycled materials for removing phosphorus from water and air (Jung et al., 2016). A local enterprise even developed an artificial stone product by combining oyster shell waste with unsaturated polyester resin, achieving higher mechanical properties compared to natural and other artificial stones (Silva et al., 2019).

While various studies have discussed both the negative impacts and potential benefits of oyster shell waste, efforts to process this waste into high-value products like livestock feed remain rare, especially in small coastal communities such as Gisik Cemandi. This gap presents an opportunity for community service programs that not only address waste management but also enhance local economic empowerment.

In this context, the innovation introduced through the program can be categorized as a form of social innovation. Avelino et al. (2017) defined social innovation as transformations in social relations that involve new ways of doing, organizing, knowing, and framing societal issues.

This program aims to improve the community's economic value, mitigate environmental impacts, leverage available local resources, and serve as a model for sustainable, community-based waste management. Furthermore, it aligns with the concept of a green economy, which incorporates the principles of circular economy and bioeconomy. As explained by D'Amato et al. (2017), the circular economy, green economy, and bioeconomy share a common goal of integrating economic, environmental, and social objectives, and these concepts have increasingly been mainstreamed in academic and policy-making arenas as key approaches to achieving sustainability.

Based on the above background, this community service activity seeks to educate and assist the community in processing oyster shell waste into livestock feed products.

## METHODS

This section outlines the implementation strategy of the community service program in Gisik Cemandi Village, which focused on participatory methods to empower local residents—especially women shellfish workers—in processing oyster shell waste.

### 1. Approach and Methods Employed

The Community Service Program (CSP) activities in Gisik Cemandi Village adopted several standard approaches commonly used in community service projects, including field observation, interviews, lectures, discussions, training sessions, and hands-on assistance.

- a. Field observations and interviews were conducted to assess the existing conditions of oyster shell waste management. Interviews were held with village officials and groups of women shellfish workers, revealing that although the village hosts several organized fisher groups—such as Mutiara Laut, Laskar Laut, Mitra Bahari, Riski Bahari, and Dewi Reni—there was no optimal waste processing in place. Firdiati and Nurahaju (2021) noted that while some community members had initiated seafood-based product ventures (e.g., smoked fish, salted fish, fish crackers, and shellfish crackers), oyster shell waste was still being sold directly to collectors without further processing.
- b. Lectures were used to deliver material on the utilization of oyster shell waste for the production of poultry feed for chickens and ducks owned by local residents.
- c. Discussions aimed to deepen participants' understanding of processing techniques and the benefits of the resulting products.
- d. Training sessions and hands-on practice involved demonstrations of how to process oyster shell waste into livestock feed powder, accompanied by continuous

mentoring during the participants' initial trials.

### 2. Activity Stages and Implementation Timeline

The activities were organized into several stages:

- a. Preparation (1 week): Field observation and interviews to map the existing problems.
- b. Socialization (1 day): Delivery of lectures highlighting the potential for oyster shell waste processing.
- c. Training and hands-on practice (2 days): Demonstrations of oyster shell waste processing into livestock feed, followed by supervised practical exercises conducted by participants.
- d. Assistance and initial evaluation (1 week): Monitoring participants' outcomes and providing additional guidance based on early observations.

### 3. Location and Target Groups

The project was conducted in Gisik Cemandi Village, Sedati District, Sidoarjo Regency. The target groups were women shellfish workers and local fishers who regularly produce oyster shell waste from seafood processing activities.

### 4. Techniques and Tools Used

- a. A semi-structured interview technique was used for preliminary data collection.
- b. An interactive lecture method was used to deliver educational material.
- c. Demonstration and hands-on practice techniques were applied during training sessions.
- d. The tools utilized included a simple grinding machine, sieves, and drying equipment.

### 5. Partners and Their Roles

The partners involved in this activity were the village officials of Gisik Cemandi and local groups of fishers and women shellfish workers. Their roles included serving as sources of field information, participating in the activities, and acting as the primary agents responsible for continuing the waste processing practices after the program concluded.

## 6. Evaluation of Activities

The evaluation was carried out through direct observation of participants' practical outcomes, a group discussion session at the end of the activities, and monitoring the implementation of oyster shell waste processing for one week after the training sessions.

## RESULTS AND DISCUSSIONS

The following section presents the key findings and outcomes of the community service program in Gisik Cemandi Village, highlighting partner profiles, community responses, program achievements, encountered challenges, and their broader social and environmental impacts.

### 1. Initial Profile of Partners and Problem Identification

As outlined in the Introduction, Gisik Cemandi Village holds considerable potential, given its predominantly productive-age population and the availability of local resources, particularly oyster shell waste. This provides a crucial foundation for implementing a community service program based on social innovation to address waste management and promote local economic empowerment.

As and Arief (2022) emphasized that young people play a vital role in development through their ability to foster innovation, contribute productive labor, and actively participate in social change. The innovations generated by youth can create new solutions, drive economic growth, and contribute significantly to both social and economic development.

Based on field observations and interviews conducted in Gisik Cemandi Village, Sedati District, Sidoarjo Regency, it was found that the community has several organized fisher groups, including Mutiara Laut, Laskar Laut, Mitra Bahari, Riski Bahari, and Dewi Reni. The existence of these groups reflects a collective community awareness of the importance of managing marine resources to improve economic welfare. D'Armengol et al. (2018) stated that co-managed fisheries not only

increase species abundance and habitat quality but also enhance fish catches, foster actors' participation, build adaptive capacity, and stimulate social learning processes.

Moreover, the community has developed seafood processing businesses, producing items such as smoked fish, salted fish, fish crackers, and shellfish crackers. These initiatives have contributed significantly to household incomes and diversified local seafood product offerings. According to Campos-Montes et al. (2016), Tsai et al. (2015), and Vandeputte et al. (2016), efforts to increase aquaculture efficiency through genetic improvement and advanced processing technologies aim to maximize the edible yield of seafood products.

However, a major issue identified is the lack of further processing of oyster shell waste, which is typically collected and sold directly to middlemen. Aduldejcharas (2024) similarly reported that in Bang Ja Kreng, Samut Songkhram Province, Thailand, large quantities of *Perna viridis* shell waste accumulate, leading to environmental pollution due to the absence of adequate waste processing.



**Figure 2.** Awareness-raising session on the potential of oyster shell waste in Gisik Cemandi Village.

This situation highlights the untapped opportunity to develop alternative strategies for transforming oyster shell waste into value-added products.

## 2. Community Assistance and Education Initiatives

In response to this situation, and based on the methods described previously (lectures, discussions, and training), the community service team from Nahdlatul Ulama University of Sidoarjo initiated a capacity-building program targeting women shellfish workers. This group was selected for their direct involvement in shellfish processing, making them a strategic target for waste management education efforts. Shahin et al. (2022) found that training programs significantly empower women, with approximately 93% of female participants reporting increased self-confidence, self-esteem, and decision-making capacity after attending previously inaccessible training sessions.

During the mentoring sessions, participants were introduced to techniques for processing oyster shell waste into livestock feed, based on successful practices documented in other communities (Setyaningrum, 2007; Katrina, 2014).



**Figure 3.** Field observations on oyster shell waste conditions

In addition to technical education, the team also presented case studies, such as the success story from Tambak Cemandi Village, where a similar waste management initiative was successfully implemented in 2019 (A'yuni et al., 2019). This approach aimed to build community confidence in the feasibility of the program while aligning with Circular Economy and Bioeconomy principles described earlier.

## 3. Community Response and Initial Achievement Indicators

The results of the socialization and discussion activities indicated that over 80% of participants (24 out of 30 individuals) expressed interest in the oyster shell waste processing initiative. They recognized that this alternative could generate economic benefits, particularly for those already raising small livestock, such as chickens and ducks.

Key early achievement indicators included:

- a. Knowledge improvement: 90% of participants demonstrated the ability to explain the benefits of oyster shell waste processing.
- b. Follow-up interest: Approximately 70% expressed willingness to participate in further training on feed production techniques.

These achievements suggest that practical, hands-on education methods effectively enhanced community understanding and motivation. This finding supports the argument made in the Introduction regarding the readiness of the productive-age group to adopt innovations (Ankesa et al., 2016). Moreover, measurable success indicators, as emphasized by Alfiana et al. (2017), are crucial for continuous program improvement and adaptation to evolving community needs.



**Figure 4.** Education and discussion session with women shellfish workers.

#### 4. Implementation Barriers and Proposed Solutions

Despite the high level of community interest, significant barriers hindered the independent implementation of oyster shell waste processing, particularly the lack of appropriate equipment, such as a disk mill machine necessary for grinding oyster shells into fine powder suitable for animal feed.

Without such equipment, the community remains dependent on traditional methods—selling raw waste to collectors at a much lower economic value. Therefore, appropriate technological innovation is urgently needed.

Proposed and discussed solutions include:

- a. Equipment assistance proposal: Preparing a collaborative proposal to obtain equipment support from local government agencies or corporate social responsibility (CSR) programs.
- b. Joint financing schemes: Encouraging the establishment of small cooperatives to collectively manage the gradual acquisition of necessary equipment through member contributions.
- c. Ongoing training: Organizing continuous training on small business management and waste-based product processing techniques.

These steps are intended to ensure the sustainability of the program and foster innovative social change, consistent with the concept of social innovation outlined by Avelino et al. (2017).

#### 5. Social and Environmental Implications

Socially, the program has the potential to strengthen women's empowerment in the village, particularly among shellfish workers, by opening new business opportunities based on local resources. Environmentally, reducing the amount of waste disposed of in nature could help preserve the coastal ecosystems that form the backbone of the village's economic activities. Consistent with Pelly, Fauziah, and Susanti (2018), coastal zones represent regions where ecological, social, and economic forces

interact intensively, providing crucial ecosystem services of significant economic value to communities.

This program aligns with the broader vision of sustainable resource management by integrating the principles of Circular Economy, Green Economy, and Bioeconomy, as discussed by D'Amato et al. (2017).

Looking forward, if equipment-related barriers can be overcome, Gisik Cemandi Village has the potential to become a model for community-based waste management that enhances local economic value while supporting sustainable development goals. Capah et al. (2023) noted that effective waste management programs are closely linked to achieving Sustainable Development Goal (SDG) 12, which emphasizes responsible consumption and production, aiming to minimize waste generation and achieve a zero-waste society. Proper waste processing not only reduces environmental pollution but also mitigates the negative health impacts associated with unmanaged waste.

#### CONCLUSION

This community mentoring program on oyster shell waste utilization in Gisik Cemandi Village successfully enhanced residents' knowledge and motivation to process waste into livestock feed products, with 90% of participants demonstrating an understanding of the benefits and 70% expressing interest in further training. Scientifically, the initiative contributes to the practical application of circular economy principles and social innovation based on local resources, while socially it strengthens women's economic empowerment and supports local food security. However, limitations such as the short observation period, the lack of advanced processing equipment, and the absence of a comprehensive economic feasibility analysis constrained the program's broader impact. Future studies should focus on long-term socio-economic and environmental impact assessments, cost-benefit analyses, and the

development of affordable technological innovations to support wider adoption. It is anticipated that this program can serve as a replicable model for sustainable, community-based waste management in other coastal regions, contributing to the achievement of sustainable development goals.

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#### REFERENCES

- Aduldejcharas, R. (2024). Bio responsive block: The performance of bio waste material with reduced environmental impact. *Results in Materials*, 23, 100589. <https://doi.org/10.1016/j.rinma.2024.100589>
- Alfiana, A., Mulatsih, L. S., Kakaly, S., Rais, R., Husnita, L., & Asfahani, A. (2023). Community empowerment in realizing a digital education village in the technology era [in Bahasa]. *Community Development Journal: Jurnal Pengabdian Masyarakat*, 4(4), 7113–7120. <https://journal.universitaspahlawan.ac.id/index.php/cdj/article/view/18698>
- Ankesa, H., Amanah, S., & Asngari, P. S. (2016). Participation of women's environmental care groups in waste management in the Sub-Cikapundung Watershed, West Java [in Bahasa]. *Jurnal Penyuluhan*, 12(2), 105–113. <https://doi.org/10.25015/penyuluhan.v12i2.10929>
- As, F., & Arief, M. (2022). Empowerment of village youth organizations and youth organizations in organizational governance during the COVID-19 pandemic [in Bahasa]. *Jurnal Abdimas Berdaya: Jurnal Pembelajaran Pemberdayaan dan Pengabdian Masyarakat*, 5(1), 80. <https://doi.org/10.30736/jab.v5i01.216>
- Avelino, F., Wittmayer, J. M., Pel, B., Weaver, P., Dumitru, A., Haxeltine, A., ... & O'Riordan, T. (2017). Transformative social innovation and (dis)empowerment. *Technological Forecasting and Social Change*, 145, 195–206. <https://doi.org/10.1016/j.techfore.2017.05.002>
- A'yuni, Q., Widiyanti, A., Ulfindrayani, I. F., Prayogi, Y. R., Arif, S., & Ningsih, A. F. L. (2019). Utilization of oyster shell waste as quality livestock feed in Tambak Cemandi Village, Sidoarjo [in Bahasa]. *Journal of Science and Social Development*, 2(2). <https://doi.org/10.55732/josssd.v2i2.180>
- A'yuni, Q., Widiyanti, A., Ulfindrayani, I. F., Prayogi, Y. R., Arif, S., & Ningsih, A. F. L. (2019). Empowerment of coastal communities in Tambak Cemandi Village, Sidoarjo through processing oyster shell waste into livestock feed [in Bahasa]. *e-Prosiding Seminar Nasional Teknologi dan Sains (SNasTekS)*, 463–472. <https://journal.unusida.ac.id/index.php/snts/article/view/117>
- BPS Kabupaten Sidoarjo. (2022). Sedati District in figures 2022 [in Bahasa]. *BPS Kabupaten Sidoarjo*. <https://sidoarjokab.bps.go.id/id>
- Campos-Montes, G. R., Montaldo, H. H., Armenta-Córdova, M., Martínez-Ortega, A., Caballero-Zamora, A., & Castillo-Juárez, H. (2016). Incorporation of tail weight and tail percentage at harvest size in selection programs for the Pacific white shrimp *Penaeus (Litopenaeus) vannamei*. *Aquaculture*, 468, 293–296. <https://doi.org/10.1016/j.aquaculture.2016.10.034>

- Capah, B. M., Rachim, H. A., & Raharjo, S. T. (2023). Implementation of SDG's-12 through community development in CSR programs [in Bahasa]. *Share Social Work Journal*, 13(1), 150. <https://doi.org/10.24198/share.v13i1.46502>
- Chiou, I. J., Chen, C. H., & Li, Y. H. (2014). Using oyster-shell foamed bricks to neutralize the acidity of recycled rainwater. *Construction and Building Materials*, 64, 480–487. <https://doi.org/10.1016/j.conbuildmat.2014.04.101>
- D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., ... & Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*, 168, 716–734. <https://doi.org/10.1016/j.jclepro.2017.09.053>
- D'Armengol, L., Castillo, M. P., Ruiz-Mallén, I., & Corbera, E. (2018). A systematic review of co-managed small-scale fisheries: Social diversity and adaptive management improve outcomes. *Global Environmental Change*, 52, 212–225. <https://doi.org/10.1016/j.gloenvcha.2018.07.009>
- Firdiati, R. A., & Nurahaju, R. (2021). Subjective well-being of fishermen's wives in Gisik Cemandi Village, Sidoarjo [in Bahasa]. *Jurnal Psikologi Perseptual*, 6(1), 46–52. <https://doi.org/10.24176/perseptual.v61.5086>
- Jović, M., Mandić, M., Šljivić-Ivanović, M., & Smičiklas, I. (2019). Recent trends in application of shell waste from mariculture. *Studia Marina*, 32(1), 47–62. <http://dx.doi.org/10.5281/zenodo.3274471>
- Jung, S., Heo, N. S., Kim, E. J., Oh, S. Y., Lee, H. U., Kim, I. T., ... & Huh, Y. S. (2016). Feasibility test of waste oyster shell powder for water treatment. *Process Safety and Environmental Protection*, 102, 129–139. <https://doi.org/10.1016/j.psep.2016.03.004>
- Katrina, G. (2014). Utilization of oyster shell waste as sand substitute and bagasse ash as cement substitute in K-225 concrete mix [in Bahasa]. *Journal of Civil and Environmental Engineering*, 2(3). <https://core.ac.uk/reader/267823170>
- Kusrini, N., Amanah, S., & Fatchiya, A. (2013). Community attitudes towards the development program of resilient coastal villages in Teluknaga, Tangerang, Banten [in Bahasa]. *Sosio Konsepsia*, 3(1), 287–300. <http://ejournal.kemsos.go.id/index.php/SosioKonsepsia/article/view/782/380>
- Paris, J. M., Roessler, J. G., Ferraro, C. C., DeFord, H. D., & Townsend, T. G. (2016). A review of waste products utilized as supplements to Portland cement in concrete. *Journal of Cleaner Production*, 121, 1–18. <https://doi.org/10.1016/j.jclepro.2016.02.013>
- Pelly, D. A., Fauziah, N., & Susanti, R. C. (2018). Coastal area function directives for improving community economy towards sustainable spatial planning [in Bahasa]. *Seminar Nasional IV Pengelolaan Pesisir dan Daerah Aliran Sungai*, Yogyakarta. [https://www.researchgate.net/publication/334282702\\_Arahan\\_Fungsi\\_Kawasan\\_Pesisir\\_Untuk\\_Peningkatan\\_Ekonomi\\_Masyarakat\\_Menuju\\_Perencanaan\\_Tata\\_Ruang\\_Wilayah\\_Pesisir\\_Yang\\_Berkelanjutan\\_Studi\\_Kasus\\_di\\_Kecamatan\\_Gragab\\_Kabupaten\\_Purworejo](https://www.researchgate.net/publication/334282702_Arahan_Fungsi_Kawasan_Pesisir_Untuk_Peningkatan_Ekonomi_Masyarakat_Menuju_Perencanaan_Tata_Ruang_Wilayah_Pesisir_Yang_Berkelanjutan_Studi_Kasus_di_Kecamatan_Gragab_Kabupaten_Purworejo)
- Prasetyo, B., Subali, E., Hendrajati, E., Trisyanti, U., & Moerad, S. K. (2022). Branding and promotion of Pesona Desa Gisik Cemandi coastal tourism area [in Bahasa]. *Bakti Budaya: Jurnal Pengabdian kepada*

- Masyarakat, 5(2), 146–157.  
<https://doi.org/10.22146/bakti.3548>
- Radkar, A. (2022). Realities of Indian population. In *Changing Dynamics of The Indian Economy: The Decade of Twenty-Tens and Ahead* (pp. 211–220). S A Printers LLP.  
<https://www.researchgate.net/publication/384701396>
- Seesanong, S., Seangarun, C., Boonchom, B., Laohavisuti, N., Thompho, S., Boonmee, W., Mongkol, S., & Rungrojchaipon, P. (2023). Bio-green synthesis of calcium acetate from oyster shell waste at low cost and reducing the emission of greenhouse gases. *Sustainable Environment Research*, 33(1).  
<https://doi.org/10.1186/s42834-023-00187-6>
- Setyaningrum, H. I., Mangisah, I., & Wahyono, F. (2007). Increasing the productivity of Kedu chicken farming through ration quality improvement and biosecurity against avian influenza in Kedu District, Temanggung Regency [in Bahasa]. *Faculty of Animal Husbandry, Diponegoro University, Technology Application Program Report*.
- Shahin, M., Khanam, M., Aktar, S., Siddiqua, A., & Sharif, N. (2022). Resiliency of livelihood and empowerment of women: Results of a cash-based intervention in Bangladesh's Lalmonirhat District. *International Journal of Disaster Risk Reduction*, 79, 103137.  
<https://doi.org/10.1016/j.ijdr.2022.103137>
- Silva, T. H., Mesquita-Guimarães, J., Henriques, B., Silva, F. S., & Fredel, M. C. (2019). The potential use of oyster shell waste in new value-added by-product. *Resources*, 8(1), 13.  
<https://doi.org/10.3390/resources8010013>
- Topić Popović, N., Lorencin, V., Strunjak-Perović, I., & Čož-Rakovac, R. (2023). Shell waste management and utilization: Mitigating organic pollution and enhancing sustainability. *Applied Sciences*, 13(1), 623.  
<https://doi.org/10.3390/app13010623>
- Tsai, H. Y., Hamilton, A., Guy, D. R., Tinch, A. E., Bishop, S. C., & Houston, R. D. (2015). The genetic architecture of growth and fillet traits in farmed Atlantic salmon (*Salmo salar*). *BMC Genomic Data*, 16(1).  
<https://doi.org/10.1186/s12863-0150215-y>
- Vandeputte, M., Puleda, A., Tyran, A. S., Bestin, A., Coulombet, C., Bajek, A., ... & Haffray, P. (2016). Investigation of morphological predictors of fillet and carcass yield in European sea bass (*Dicentrarchus labrax*) for application in selective breeding. *Aquaculture*, 470, 40–49.  
<https://doi.org/10.1016/j.aquaculture.2016.12.014>
- Zhan, J., Lu, J., & Wang, D. (2022). Review of shell waste reutilization to promote sustainable shellfish aquaculture. *Reviews in Aquaculture*, 14(1), 477–488.  
<https://doi.org/10.1111/raq.12610>

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