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Economic and Employment Implications of Fish Farming in the Karaburun-Ildır Special Protection Area, Turkish Aegean Sea

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Abstract

This study examines the socio-economic and ecological implications of aquaculture in the Karaburun-Ildır Bay Special Environmental Protection Area (SEPA) in İzmir Province, Türkiye. The SEPA, encompassing diverse marine and terrestrial ecosystems, is crucial for biodiversity conservation and economic activities, particularly aquaculture. The study utilizes purposive sampling to focus on key stakeholders, including fish farms, processing facilities, and feed producers, all integral to the region's aquaculture industry. Survey data were collected through structured interviews, assessing employment generation, community development, and economic impacts. The region's aquaculture operations, primarily involving European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*), meagre (*Argyrosomus regius*), and Atlantic bluefin tuna (*Thunnus thynnus*), contribute significantly to Türkiye's total marine fish production, with the Karaburun-SEPA accounting for 14.44% of the national total and 33.23% of İzmir's marine fish output in 2021. The economic value generated by these operations was estimated at 174.17 million USD in 2021, constituting 37% of İzmir's and 10% of Türkiye's marine aquaculture economy. Employment data reveal that 486 individuals work in the region's fish farms, with an estimated 1,864 people benefiting from these operations when including family members. Additionally, significant infrastructure investments, such as floating cages and feed production facilities, underscore the capital intensity of the sector. The findings highlight the region's pivotal role in Türkiye's aquaculture industry, while also emphasizing the need for sustainable practices that balance economic growth with environmental preservation. The study provides valuable insights into the socio-economic benefits of aquaculture in a protected area and underscores the importance of integrating sustainability into aquaculture development to ensure long-term ecological and economic stability.

Introduction

The Karaburun-Ildır Bay Special Environmental Protection Area (SEPA) is a designated conservation zone situated within the Izmir Province of Türkiye, positioned along the western coast of the country. Recognized for its natural richness, diverse ecosystems, and substantial marine biodiversity, this region encompasses the Karaburun Peninsula, Ildır Bay, and adjacent marine waters (Oruç, 2024). Covering an expansive area of 946.56 km^2, it was officially established on March 15, 2019, as per the Official Gazette of the Republic of Türkiye (2019), affirming its vital role in safeguarding ecological integrity.

Managed by the Ministry of Environment and Urbanization, SEPA serves as a sanctuary for an array of terrestrial and marine life forms, showcasing remarkable biodiversity. The terrestrial landscape is characterized by forests comprising pine, juniper, and oak, alongside Mediterranean scrub and grassland (Keskin et al*.,* 2011). In the marine realm, an abundance of marine species thrives, including various fish, invertebrates, and algae. This area serves as a breeding ground for species such as loggerhead turtles, Mediterranean monk seals, and bottlenose dolphins (Keskin et al*.*, 2023; Türetken, 2023). According to Ozden et al. (2020) the region supports economically significant finfish species like sea bass and sea bream. SEPA attracts devoted birdwatchers with over 200 bird species documented within its borders (Tosun et al., 2024). The conservation objectives outlined in the management plan prioritize the protection of both natural and cultural heritage, alongside promoting sustainable development and facilitating recreational

and educational activities. Ağdamar and Acar (2022) emphasize the importance of SEPA in conserving biodiversity and fostering sustainable regional development.

Situated amidst the central Aegean Sea, the Karaburun-Ildır Bay SEPA spans across Izmir, Karaburun, Ildır Bay, and adjacent islands, encompassing a marine surface area of 503.23 km². Its declaration as a protected area in 2019 solidified its significance as a bastion of biodiversity preservation (Official Gazette of the Republic of Türkiye No.30715). The marine waters within the SEPA exhibit a dynamic equilibrium shaped by the interaction of currents from the outer Izmir Bay and the broader Aegean expanse. This dynamic sustains a rich tapestry of marine life, 121 fish species, crucial for the preservation of endangered species, including the Mediterranean monk seal (Akyol et.al., 2020; Dede et.al., 2015; Mavruk et al., 2024). Dede et al. (2015) underscores the intrinsic link between these pristine coastal waters and the breeding and habitat of the Mediterranean monk seal.

As vital habitats and breeding grounds, the coastal and marine realms within the SEPA serve as sanctuaries for a diverse array of flora and fauna, underscoring the imperative of safeguarding this ecological treasure from the intrusion of pollution and anthropogenic pressures (Taşeli, 2016). Kucuksezgin et al. (2021) highlight the importance of protecting SEPA to ensure the preservation of its natural beauty and ecological value for future generations.

Aquaculture, the controlled cultivation of aquatic organisms, has emerged as a vital solution to address the challenges posed by population growth and the depletion of wild fish stocks (Boyd et al., 2020). In Türkiye, as in many other parts of the world, the demand for seafood continues to rise, placing pressure on natural fish populations (FAO, 2024). This surge in demand highlights the urgent need for alternative solutions that can meet dietary requirements sustainably. Aquaculture supports the principles of blue growth and sustainability by encouraging the responsible use of ocean resources to drive economic development while safeguarding marine ecosystems (Elegbede, 2023). By leveraging technological innovations to improve efficiency and environmental responsibility, aquaculture operations in Türkiye optimize feed, water use, and waste management practices, thereby minimizing their ecological impact and alleviating pressure on vulnerable marine ecosystems (Ertör et al., 2019; Tosun and Ercan, 2024).

Türkiye produced 556.287 tons of aquaculture products in 2023 and continued its annual growth (TUIK, 2024). The promising future of aquaculture in Türkiye faces various challenges that necessitate careful consideration. With the anticipated expansion of aquaculture production, it is crucial to mitigate both environmental and socio-economic consequences (Tosun et al., 2024). This recognition underscores the importance of integrating sustainability principles into aquaculture practices. Sustainable aquaculture systems prioritize responsible resource management, reducing excessive water and energy consumption (Costa-Pierce, 2010; Boyd et al., 2020). Additionally, they create environments that replicate natural habitats for aquatic species, supporting their health and reducing the reliance on preventive antibiotics or chemicals (Bondad-Reantaso et al., 2023; Rajeev et al., 2021; Kılıç, N. & Gültekin, G., 2024).

In Türkiye, fish farming practices in regions such as Karaburun predominantly rely on off-shore mariculture technology, which entails the cultivation of marine species in open water environments (Tosun et al., 2024). This method, which targets species like sea bass and sea bream, provides significant benefits, including superior water quality and abundant space, supporting efficient and sustainable farming practices. The adoption of cutting-edge mariculture techniques highlights Türkiye's dedication to developing a prosperous and environmentally responsible aquaculture industry (Ertör and Ortega-Cerda, 2019), ultimately aligning with the principles of blue growth and sustainability.

To date, no studies have examined the impact of aquaculture operations on employment and the economy within the Karaburun-Ildır Bay SEPA where this research was conducted. Therefore, the findings of this study have been primarily evaluated by comparing them with nationwide studies conducted in Türkiye (Ertör and Ortega-Cerda, 2019; Arıkan and Aral, 2019; Ataman and Çağlak, 2023), as well as with research focusing on relevant aquaculture production regions (Tosun et al., 2024; Yiğit, 2024). The aim of this study is to analyze the socio-economic implications of aquaculture practices in the Karaburun-Ildır Bay SEPA. By examining the balance between aquaculture growth and ecological preservation, the study seeks to understand how these activities influence local livelihoods, economic opportunities, and the broader goals of sustainable regional development. This research explored the benefits and challenges associated with aquaculture expansion in the region, particularly in terms of its impact on local communities. The main hypothesis of this study is that aquaculture activities, fish feed factories, and processing-packaging industries within the Karaburun-Ildır Bay Special Environmental Protection Area have significant effects on the socio-economic structure of the local population.

Materials and Methods

This study employed a mixed-method approach, using face-to-face surveys as the primary data collection tool to assess the socio-economic implications of aquaculture practices in the Karaburun-Ildır Bay Special Environmental Protection Area (SEPA). The surveys were conducted with key stakeholders involved in the regional aquaculture industry, including fish farms, fish processing facilities, and fish feed producers. The data collection process was structured as follows:

Study Area and Participant Selection

The study was conducted in the Karaburun-Ildır Bay SEPA, Turkish Aegean Sea, which encompasses key aquaculture activities, particularly in the cultivation of species like European seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*), meagre (*Argyrosomus regius*), and Atlantic bluefin tuna (*Thunnus thynnus*). In the context of our study, purposive sampling (Campbell, 2020; Ahmad and Wilkins, 2024) was used to select key stakeholders—fish farms, fish processing facilities, and fish feed producers—who are directly involved in aquaculture practices in the Karaburun-Ildır Bay SEPA. These participants were chosen because their experiences and operations are highly relevant to understanding the socio-economic and environmental dynamics of the region's aquaculture industry.

Fish Farms: Offshore mariculture operators were selected based on their size, production capacity, and technological practices. All fish farms operating in SEPA were sampled.

Fish Processing Facilities: Facilities responsible for the post-harvest handling and processing of aquaculture products. This study encompasses all processing facilities that procure products from fish farms within the SEPA region.

Fish Feed Producers: Data were collected and analyzed from approximately 70% of the feed factories supplying fish farms within the SEPA region. The collected data were deemed sufficient, as the feed factories surveyed encompassed all relevant information needed for the project, actively met the project's requirements, and preliminary information obtained from fish farms indicated that the remaining feed factories would not influence the study's outcomes.

Survey Design and Administration

A structured questionnaire was designed to gather both qualitative and quantitative data. The survey included questions on:

Socio-economic impacts: Employment generation, community development, and local market dynamics.

The surveys were conducted in person at each facility. This approach allowed for in-depth discussions, enabling participants to elaborate on their experiences and insights. By conducting face-to-face surveys with a targeted stakeholder group, an understanding of the socio-economic impacts of aquaculture in the Karaburun-Ildır Bay SEPA was achieved. The data collected from enterprises were analyzed using Microsoft Excel program.

Secondary Data Analysis

In addition to the primary data obtained from the surveys regarding the businesses, secondary data were analyzed from the following sources to provide a broader contextual understanding.

Government Reports: Official reports obtained from relevant ministries and institutions, including the Ministry of Environment and Urbanization, were used to assess the policy frameworks, regulatory standards, and socioeconomic statistics related to aquaculture in the region. (Çötelli, 2021, 2022, 2023, 2024, FAO 2022,2024, TUIK, 2022).

Academic Literature: Scientific articles published on the sustainability of aquaculture, its socio-economic impacts, and environmental conservation in the Karaburun-Ildır Gulf SEPA and similar regions were also analyzed. (Tosun et al*.,* 2024; Ümit, 2024). These sources provided valuable context for understanding trends in aquaculture development and the implementation of sustainable practices.

The findings obtained from the surveys have been analyzed in-depth and comparatively to understand the socioeconomic dynamics. The data were collected through face-to-face surveys conducted at 36 fish farms, 4 feed factories, and 7 fish processing facilities. To assess the impact of the obtained data on the socioeconomic structures of individuals, the Triangulation calculation method was employed for evaluation. (Patton, 1999; Carter et al*.,* 2014).

Results

Fish Farms in Karaburun SEPA Region

In the region, 13 companies were found to be actively engaged in aquaculture production under 36 different operating licenses (Table 1). The total licensed aquaculture production capacity of the enterprises listed in the table was determined to be 49,240 tons per year. Based on interviews with business owners or production managers and the examination of records, the actual production volume in 2022 was found to be 48,470 tons per year. This figure is slightly lower than the total projected capacity, which appears to be related to variations in production cycles. The Ministry of Agriculture and Forestry has approved production licenses for fish farms operating in this region, ranging from 250 to 3,000 tons per year (Figure 1).

Cultured Fish Species in the Karaburun SEPA Region

According to our research findings, the annual production in the region consists of 27,840 tons of European seabass, 14,610 tons of gilthead seabream, 1,820 tons of meagre, and 4,200 tons of Atlantic bluefin tuna. The proportions of seabass, seabream, meagre, and tuna in total production are 57.45%, 30.13%, 3.76%, and 8.67%, respectively (Figure 2).

According to 2021 data, the total marine fish production in Türkiye was recorded at 335,644 tons, while in the same year, İzmir province produced a total of 111,547 tons of marine fish (TEPGE, 2021). Based on

the data obtained for 2021, the total marine fish production in the Karaburun-SEPA region was calculated to be 48,470 tons (Figure 3). The production in the research area (2021) constitutes 14.44% of the total marine fish production in Türkiye and 33.23% of the total marine fish production in İzmir province.

Contribution of Production to the Economy

Based on the data obtained from the region where the study was conducted, the economic value generated by the fish farms within the Karaburun SEPA area has been calculated to be 174,169,153 USD. This calculation took into account the 2021 prices of gilthead seabream, European seabass, meagre, and Atlantic bluefin tuna. The economic value derived from the SEPA area represents 37% of İzmir province's total and 10% of Türkiye's total (Figure 4).

The annual changes in the total aquaculture production of Türkiye and Greece are shown in Figure 5. Upon examining the figure, it is evident that the production levels were similar until 2005. From 2005 onwards, Türkiye's aquaculture production steadily increased, reaching approximately 515,000 tons by 2022. In contrast, Greece's aquaculture production showed little growth after 2005, reaching 142,000 tons in 2022 (FAO, 2024).

Table 1. Fish Farms Operating in the Karaburun SEPA Region, Their Production Capacities, and License Allocations (Ministry of Agriculture and Forestry Records, 2024)

Fish Farms	License Capacity (ton)[1]	Number of Licences[2]
Abalıoğlu Grubu – Lezita Balık	7900	4
Çamlı Yem Besicilik Sanayii ve Ticaret A.Ş.	9450	5
Agromey Gıda ve Yem San.Tic.A.Ş.	17400	9
Gümüşdoğa Su Ürünleri A.Ş	5900	4
Akua Group AŞ.	1600	2
Kılıç Deniz Ürünleri Üretimi İhr. İth. ve Tic. A.Ş.	1840	1
Grup Sagun – Kemal Balıkçılık	2800	3
Yılmaz Su Ürünleri Balık Üretim Turizm Tic.Ltd.Şti.	300	1
Şenkopuz Balık Üretimi Gıda Sanayi ve Ticaret Limited Şirketi	300	1
Gerence Su Ürünleri San. Tic. Ltd. Şti.	300	1
Güven Balık Üretim ve Ticaret Limited Şirketi	600	1
Ertuğ Balık Üretim Tesisi A.Ş.	550	2
İskandil Balık Üretimi Gıda Turizm Ticaret ve Sanayi Limited Şirketi	300	1
Total	49240	35

[1]Indicates the official production capacities of the companies, [2]Represents the number of licenses owned by the company

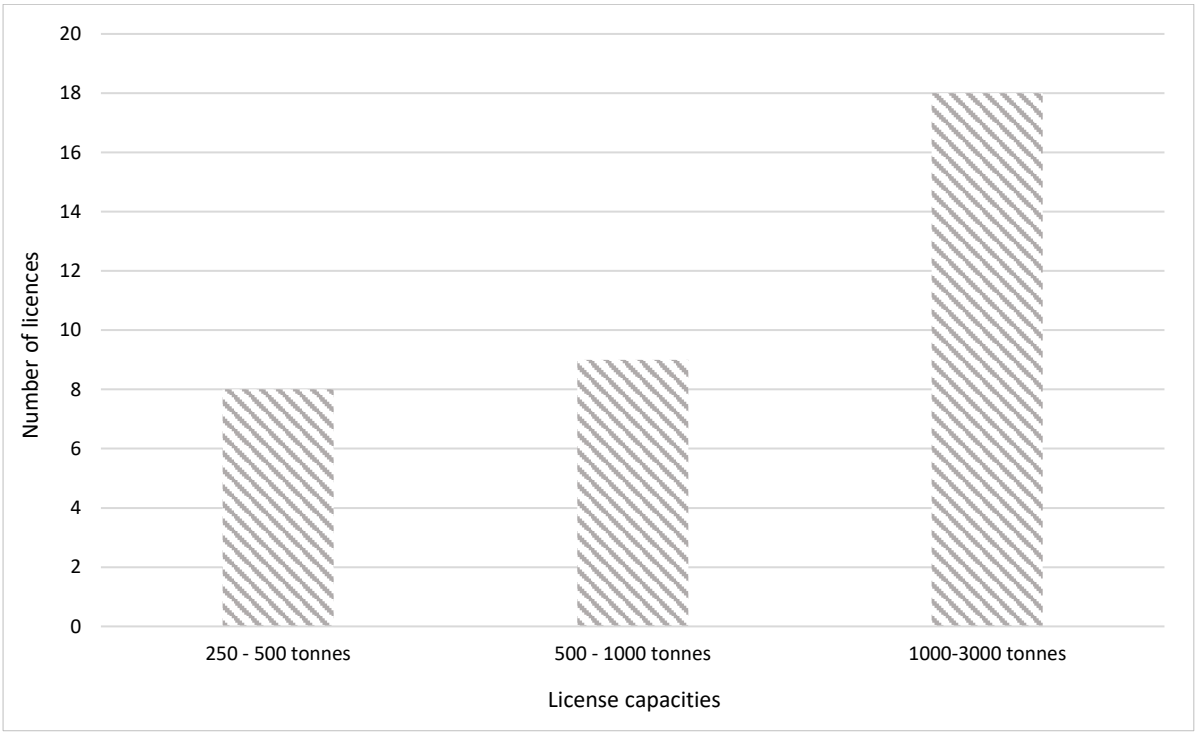

Figure 1. Distribution of Fish Farms Operating in the Karaburun SEPA Region by Licensed Capacity.

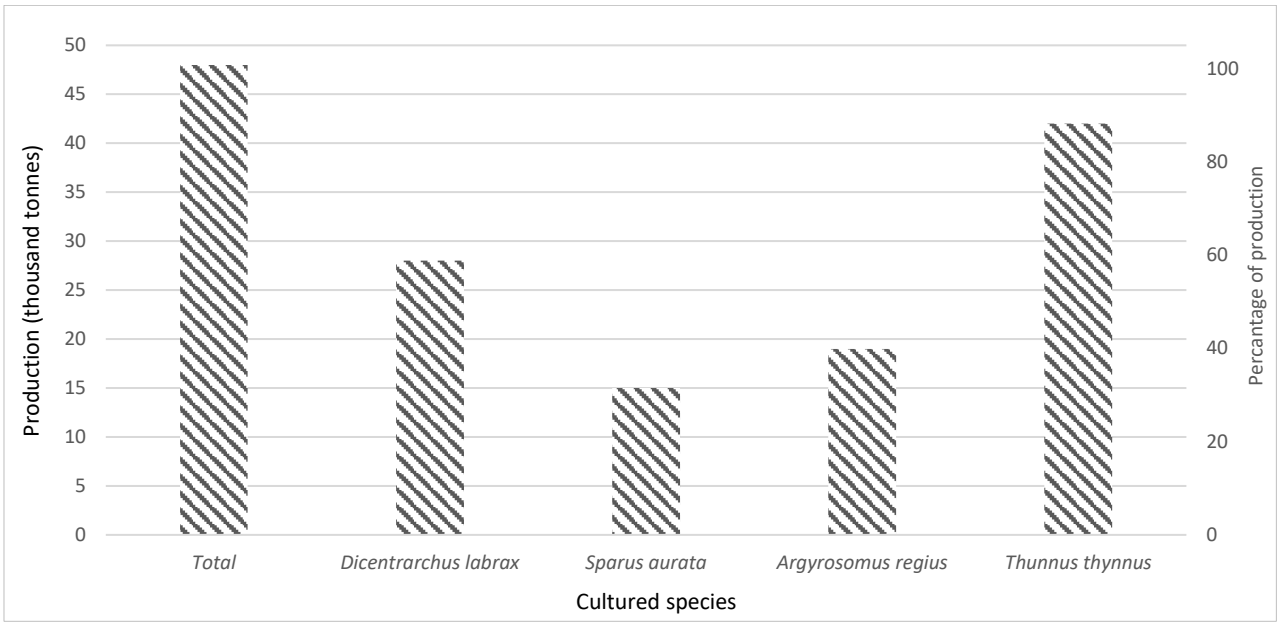

Figure 2. Production quantities of fish species produced in the Karaburun-Ildır Gulf SEPA and their ratio to the total production in the region (%) (Survey results, 2022).

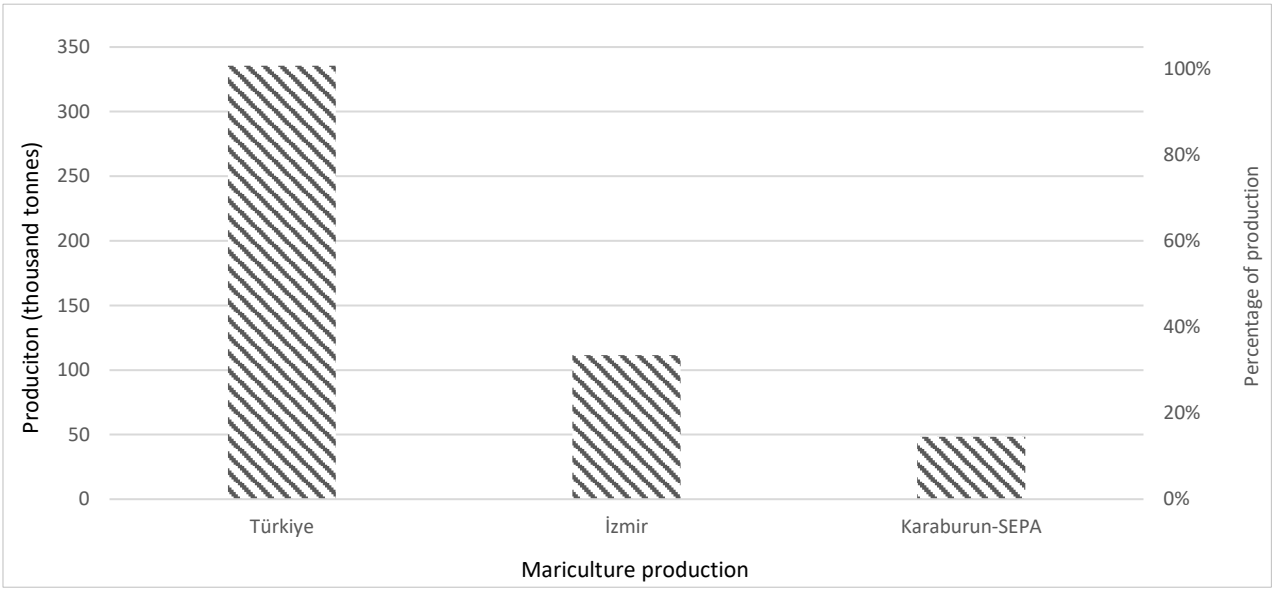

Figure 3. Marine Fish Production Volumes and Their Proportions (%) in the Karaburun-Ildır Gulf SEPA Region and İzmir Province, Compared to Total Production in Türkiye (Survey results, 2022).

Infrastructure Investment

In the fish farms operating in the Karaburun-SEPA region, there are a total of 704 floating cages, along with their associated mooring systems. Based on the data obtained from the enterprises and the calculations performed (number of cages x unit cost per cage), the investment costs for cages with diameters of 16-30 meters were found to be €55,000, while cages with diameters of 30-60 meters incur an investment of €100,000. Analyzing the number and sizes of cages within the existing facilities, the total investment in cage systems for the entire research area was calculated to be $45,100,000. Furthermore, through interviews with fish producers and the data they shared, it was determined that the required investment cost for producing 1 kg of fish is approximately $1.70. Considering all factors — including the cages used for fish production and the non-production expenses of the operations (such as personnel, electricity, transportation, machinery and equipment, fry supply, feed, and accommodation) — the total investment cost

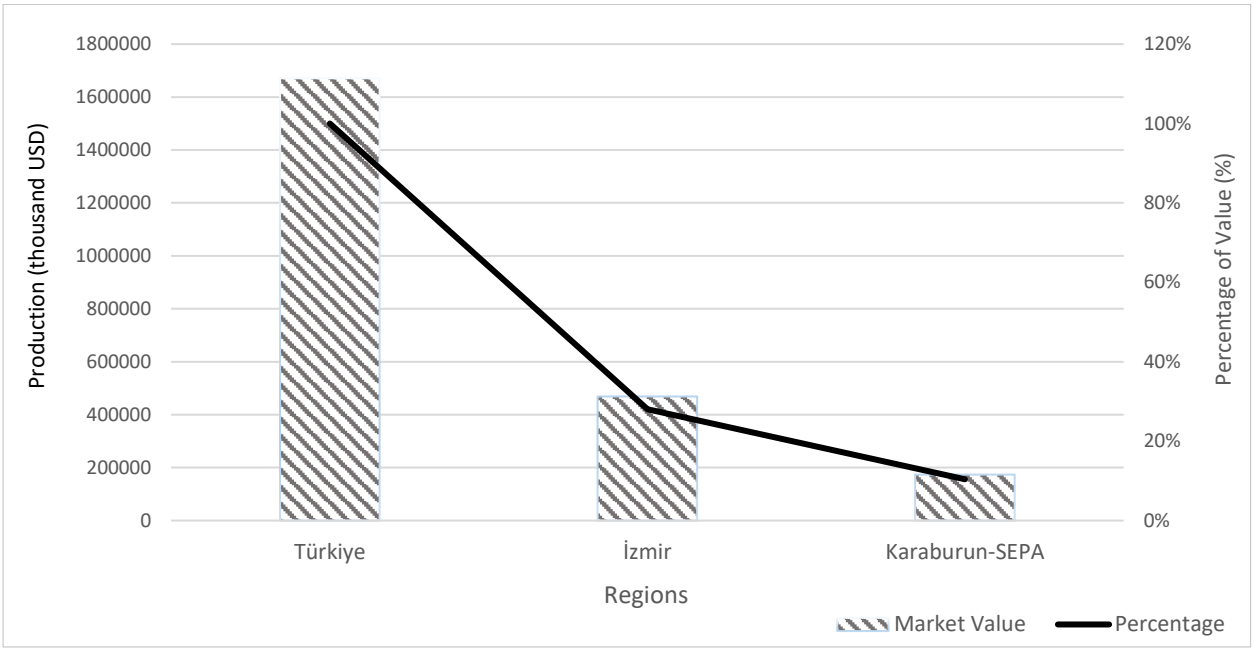

Figure 4. Economic Value of Marine Fish Production in the Karaburun-Ildır Gulf SEPA Region and İzmir Province, and Their Proportions (%) Compared to Türkiye (Survey results, 2022).

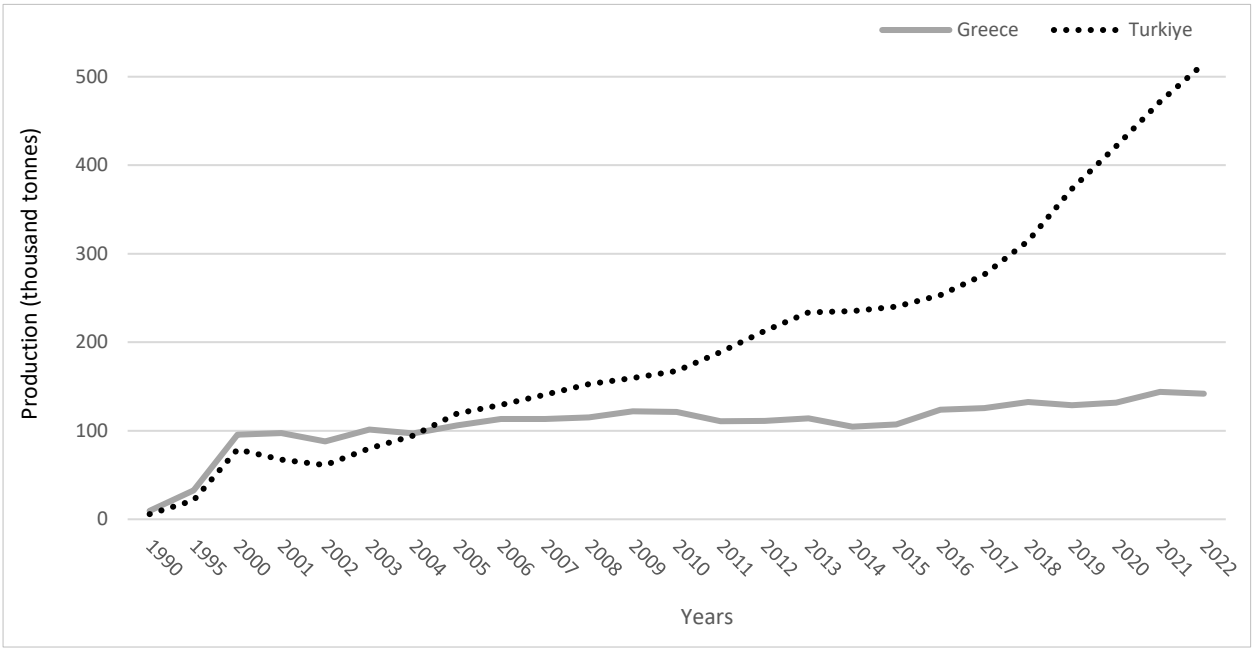

Figure 5. Annual Changes in Aquaculture Production Volumes of Türkiye and Greece (FAO, 2024).

for production in the SEPA region was calculated as $84,218,000 (total production in the SEPA region × 1.70 USD).These figures underscore the significant capital required for aquaculture production in the region, highlighting the financial scale of the industry and its dependence on infrastructure investments.

Feed Factories

According to the data of the Ministry of Agriculture and Forestry of the Republic of Turkey, there are 30 feed factories producing fish feed in the country, 11 of which are operating in the Aegean region. These results correspond to 37% of the fish feed factories in the Aegean region of the relevant factories in Türkiye (Figure 6). Based on findings from interviews with the managers of feed factories in the Aegean region, it was determined that approximately 70% of these factories, including those in the Karaburun-SEPA region, primarily produce feed for their own fish farms, as well as for the fish farms in their respective regions.

Employment in the Aquaculture Industry

A total of 486 individuals were employed in production at the fish farms operating in the region. Of these employees, 74 are engineers (15%), 279 are skilled workers (59%; including technicians, divers, etc.), and 113 are unskilled workers (24%). Among the total workforce, 39 women were employed, representing 8.3% of the overall number of workers (Figures 7 and 8). When the 466 individuals employed at the fish farms and their families — calculated as 4 people per employee — are taken into account, it is estimated that a total of 1,864 people in the region derived economic income from these activities.

The impact of aquaculture activities in the Karaburun-Ildır SEPA Region on employment is presented in Figure 9, and the total number of individuals benefiting from income is shown in Figure 10. Upon examining the figures, it is evident that the highest number of employees is in the processing and packaging enterprises, while the lowest number is in the feed factories. Additionally, the proportion of female workers among the total workforce is highest in the processing and packaging sector. In contrast, the proportion of female workers in fish production farms and feed factories is relatively low.

The total number of individuals benefiting from income in the research area's industries is presented

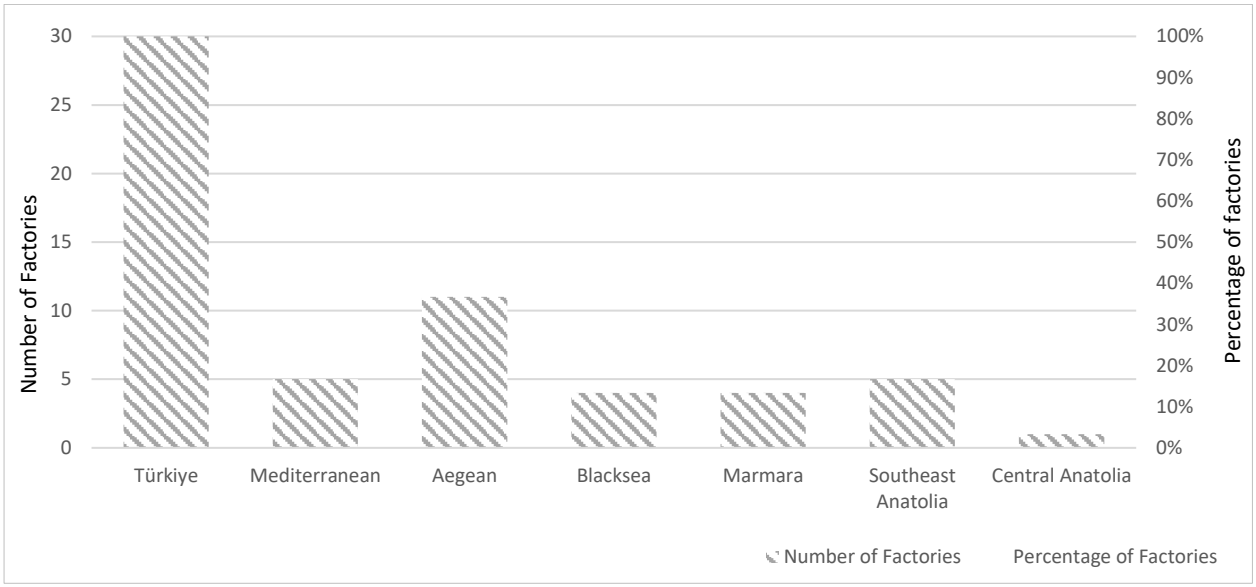

Figure 6. Total Number of Feed Factories Producing Fish Feed in Türkiye and Their Distribution by Region (Ministry of Agriculture and Forestry of the Republic of Türkiye, 2023).

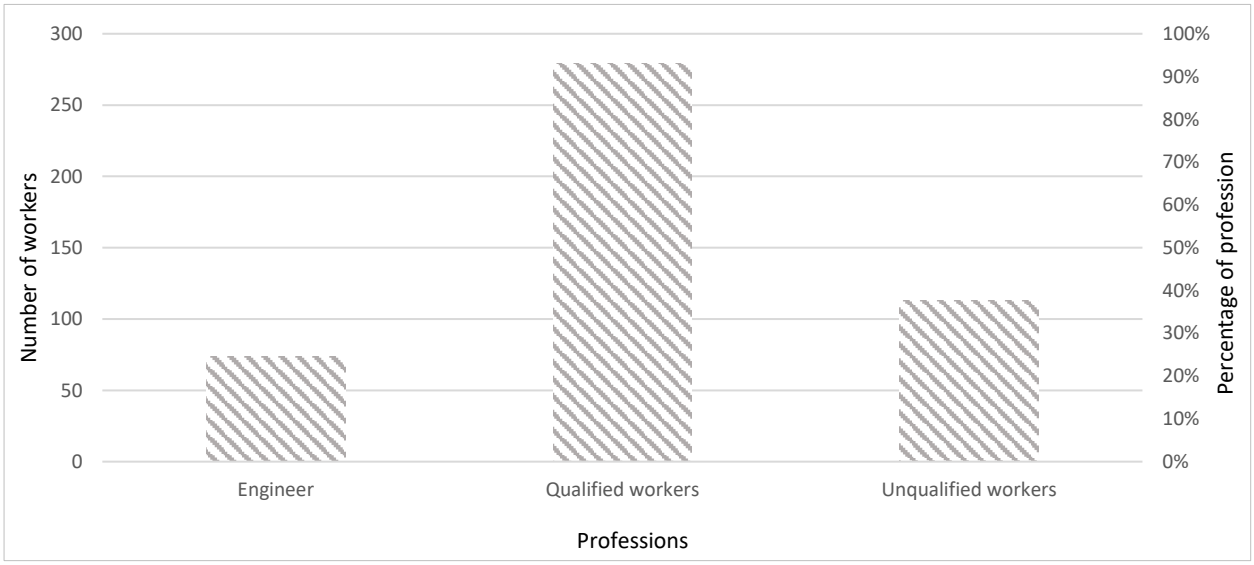

Figure 7. Distribution of Employees at Fish Farms in the Karaburun-Ildır Gulf SEPA Region (Survey results, 2022).

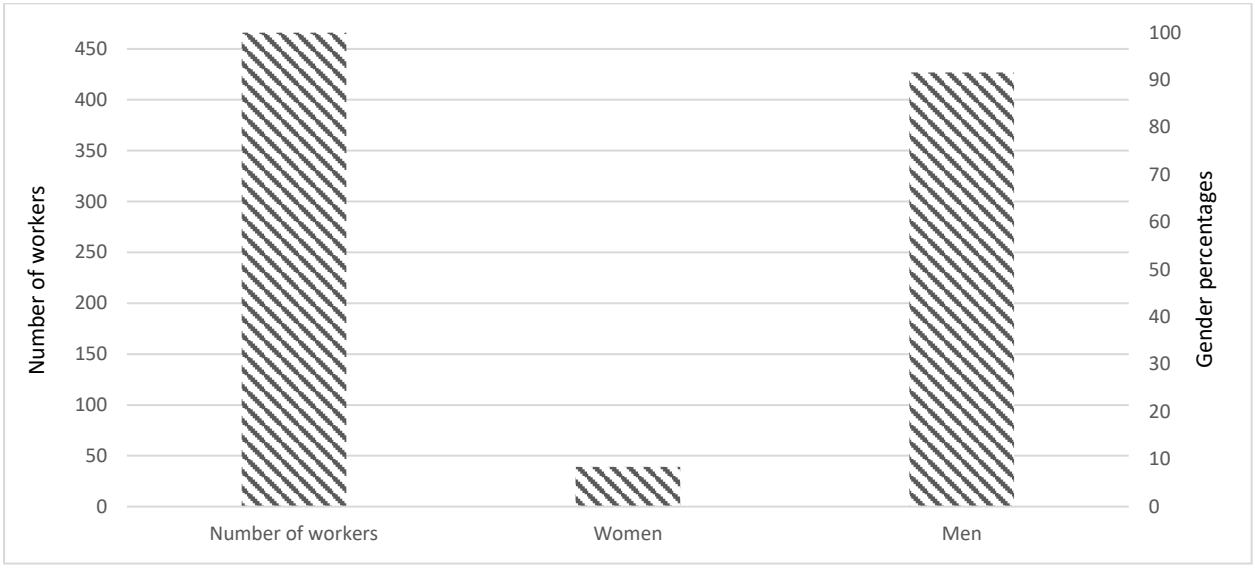

Figure 8. Gender Distribution of Employees at Fish Farms in the Karaburun-Ildır Gulf SEPA Region (Survey results, 2022).

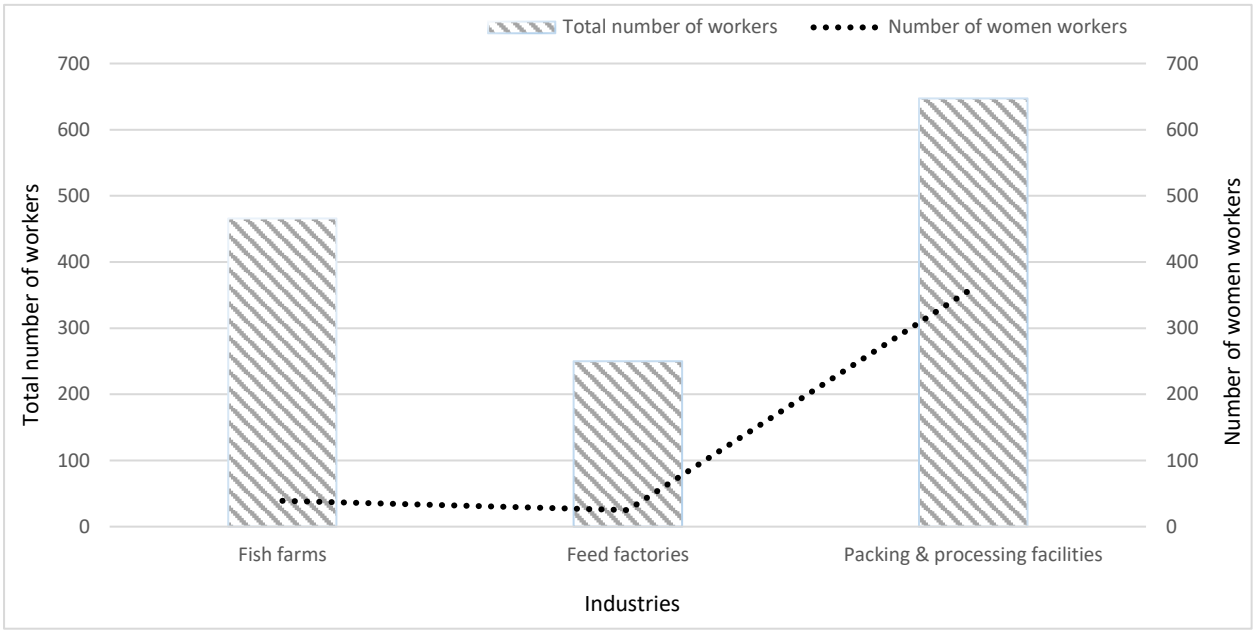

Figure 9. Distribution of Employees in the Aquaculture Industry in the Research Area.
[1]All fish farms involved in production in the Karaburun SEPA region have been evaluated.
[2]Approximately 80% of the feed factories in the Aegean Region have been evaluated.
[3]Approximately 90% of the processing and packaging facilities in the Aegean Region have been evaluated.

based on calculations made using 4-person families (Figure 10). This calculation method accounts for the broader socio-economic impact of the industries in the region, reflecting not only direct employment but also the potential income generated for households. According to the results, it is observed that the highest employment levels are in the processing and packaging units, which are integral to the value chain of aquaculture products. In contrast, the feed factories, which play a crucial role in supporting fish production, show the lowest employment numbers. This disparity highlights the labor intensity of different sectors within the aquaculture industry, where processing and packaging require a larger workforce compared to the more automated feed production process.

The number of individuals earning income from the aquaculture industry in Türkiye, İzmir province, and the Karaburun-SEPA region, as reflected in the 2022 GDP calculations, is presented in Figure 11. The data reveals that, nationwide, approximately 148,000 individuals benefit from the industry, with 49,000 in İzmir and 15,000 in the research area.

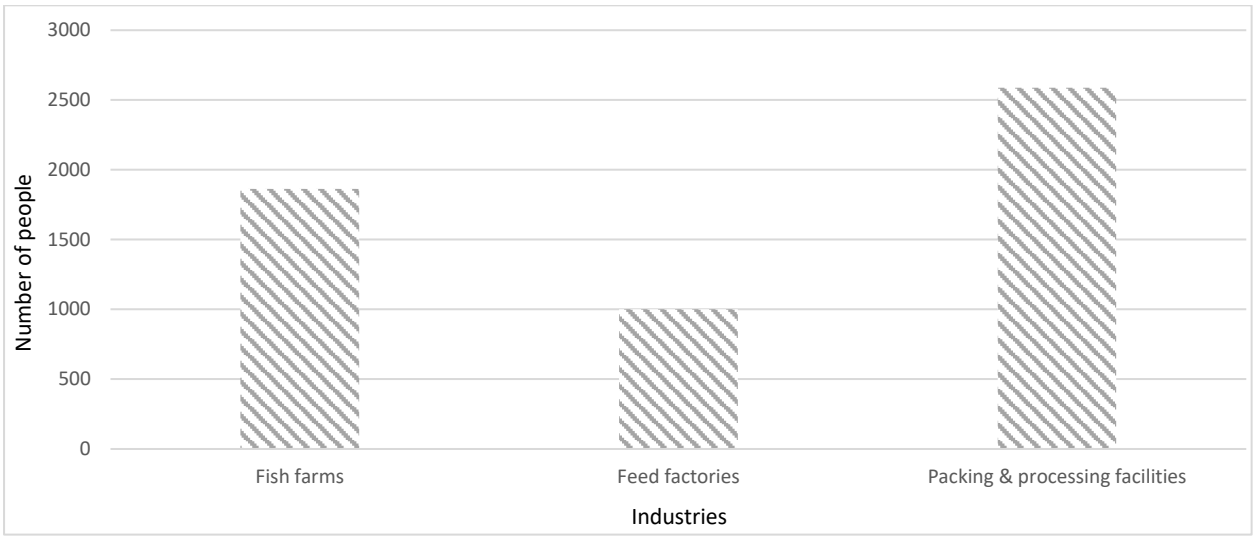

Figure 10. Total Number of Individuals Earning a Living from the Aquaculture Industry in the Research Area*. *The total number of individuals benefiting from income is calculated based on a 4-person family.[1]All fish farms involved in production in the Karaburun SEPA region have been evaluated.[2]Approximately 80% of the feed factories in the Aegean Region have been evaluated. [3]Approximately 90% of the processing and packaging facilities in the Aegean Region have been evaluated.

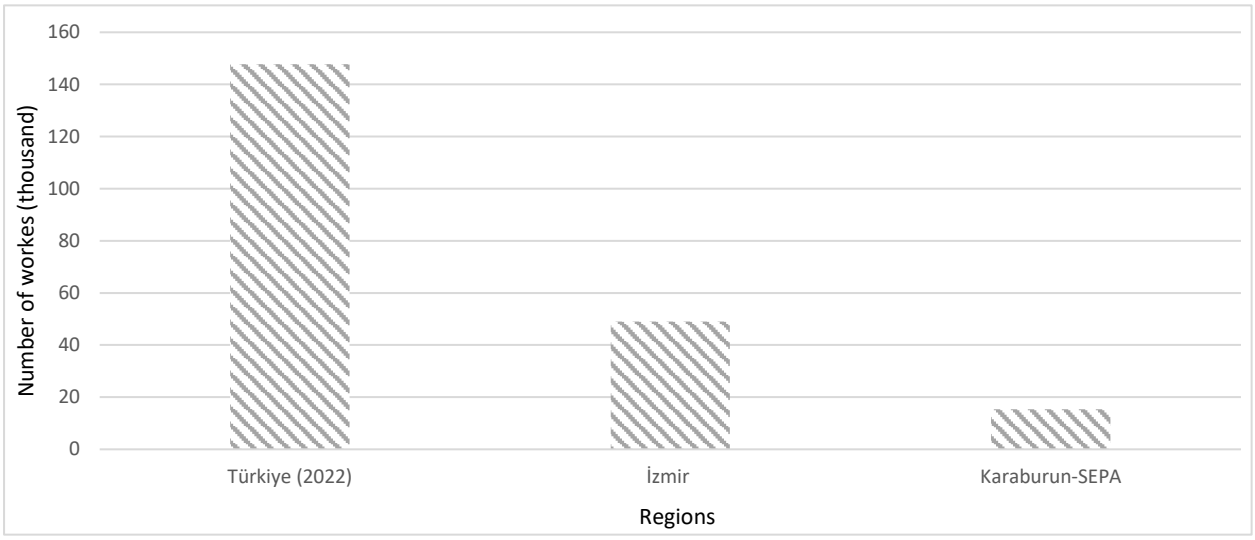

Figure 11. Number of Individuals Employed in the Aquaculture Industry in Türkiye, İzmir, and the Karaburun-SEPA Region Based on GDP (TUIK, 2022).

Discussion

According to TÜİK's 2021 data, a total of 471,686 tons of aquaculture production was reported in Türkiye. Of this, 335,640 tons were from marine fish, while 136,042 tons were from freshwater fish. The total marine fish aquaculture production within İzmir province significantly contributes to Türkiye's overall fish production. According to the report by Çötelli (2021), a total of 105,843 tons of aquatic products are produced annually in the seas surrounding İzmir using aquaculture methods. This amount accounts for 34% of Türkiye's total marine fish production. In the enterprises operating in the Karaburun SEPA area, 48,470 tons of production were achieved according to 2021 data. This production accounts for 31.4% of the total aquatic product production in İzmir province, representing a significant share and serving as an important food source and economic resource both regionally and nationally. Additionally, it is recognized as a food product that is exported globally, particularly to European Union countries, without issues. According to the Ministry of Agriculture and Forestry, in 2022, Türkiye's aquaculture export generated an economic return of 1,568,952,622 USD. Of this, 520,892,270 USD came from the İzmir region, while the income generated

from the Karaburun-Ildır SEPA region amounted to 163,560,172 USD. Given the production potential mentioned above, it has become increasingly important to assess the impact of enterprises on employment and the economy in the research area. Therefore, data from fish farming operations and key stakeholders in the sector operating in the research area have been evaluated.

In Türkiye, it is known that 366 enterprises produce 399,529 tons of marine fish (Çötelli, 2024). In the study conducted in the SEPA region, it was determined that 36 enterprises produce 48,470 tons per year of gilthead sea bream, sea bass, tuna, and grouper. As indicated by the production data presented, the production in the research area holds a significant place within Türkiye's marine fish sector. The horizontal expansion of intensive marine aquaculture from European Mediterranean countries to Türkiye marked the emergence of a highly profitable industry during its initial stages in the late 1990s and early 2000s. However, as Ertör and Ortega-Cerdà (2019) emphasize, the subsequent consolidation of the sector favored larger firms with substantial capital, capable of implementing commodity deepening strategies and achieving vertical integration. These firms continued to benefit from the ecological surplus, while smaller enterprises were forced out of the market. This shift also carried an export-oriented focus, ensuring that production could be effectively marketed on a global scale. Our findings align with this broader narrative, indicating that marine aquaculture in the study area operates predominantly on a significant scale. Approximately 22.9% of the farms hold licenses for production capacities between 250–500 tons, 25.7% are licensed for 500–1000 tons, and the majority, 51.4%, are licensed for 1000–3000 tons (BSGM, 2024). This demonstrates the dominance of mid-to-large-scale operations, reflecting the consolidation described by Ertör and Ortega-Cerdà (2019). Furthermore, nearly all farms in the study area focus heavily on exporting their production, underscoring the critical role of external markets in sustaining profitability. These findings highlight the structural dynamics of the sector, where large-scale, export-oriented firms drive production, consistent with the trends observed during the horizontal expansion of aquaculture in Türkiye (Arıkan and Aral, 2019).

The main fish species actively produced in Türkiye are European sea bass, gilthead sea bream, meagre, and tuna (Çötelli, 2024, FAO, 2024) According to FAO's FishStat data (FAO, 2024), the production volumes of European sea bass, gilthead sea bream, meagre, and tuna accounted for 46%, 40%, 1.7, and 1,47 of the total marine fish production in Türkiye, respectively. In our 2021 study conducted in the SEPA region, the production volumes of European sea bass, gilthead sea bream, meagre, and tuna were calculated to constitute 57.45%, 30.13%, 3.76%, and 8.67% of the total, respectively. The production in the research area was calculated to account for 14.44% of Türkiye's total marine fish production and 33.23% of İzmir's total marine fish production (Çötelli, 2022). As can be seen, the SEPA region holds significant importance both in terms of the diversity of species produced and the production volumes.

The diversification of farmed species is a significant strategy within intensive aquaculture, aimed at enhancing sustainability and profitability by expanding beyond traditional commodities. As Ertör and Ortega-Cerda (2019) highlights, this process involves producing various species concurrently and exploring the farming potential of new ones based on their physical adaptability and market viability. In Türkiye, the government supports such diversification efforts through direct subsidies fostering innovation within the sector (Official Gazette, 2024). However, our findings reveal that aquaculture in the study area remains concentrated on four dominant species: sea bass, sea bream, meagre, and bluefin tuna. This focus reflects the industry's dependence on species with well-established demand and proven farming practices. Nonetheless, the pursuit of new species, as emphasized by Ertör and Ortega-Cerda (2019), could enable Turkish aquaculture to access niche markets, generate higher revenues, and reduce the risks associated with reliance on a limited number of species. These efforts could be particularly valuable in export markets, where the demand for luxury products is growing. Balancing current production with strategic diversification is therefore crucial for the long-term sustainability and resilience of the sector and the region.

When examining fish production quantities in our country over the years, it is observed that until 2005, marine fish farming production in Türkiye and Greece followed similar trends (FAO, 2024). However, from 2005 onward, aquaculture production in Türkiye increased steadily, reaching approximately 515,000 tons in 2022 (Çötelli, 2022). In contrast, Greece's aquaculture production saw limited growth since 2005, reaching 142,000 tons in 2022 (FAO, 2024). The rapid growth in Türkiye's marine fish production can be attributed to the development of related sectors, such as feed factories, processing and packaging facilities, and supply companies, which have grown alongside the aquaculture industry.

In 2021, Türkiye's aquaculture exports generated an economic return of 1,568,952,622 USD, with the SEPA region contributing 163,560,172 USD (Çötelli, 2022). According to the data obtained from our research in the region, production resulted in an economic return of 174,169,153 USD. In this study, the calculations performed indicate that the economic value obtained represents a significant portion of the total national aquaculture revenue.

In our study, an evaluation of the recorded data revealed that a total of 649 active floating cages and their mooring systems were used by fish farms in the Karaburun-SEPA region. Additionally, cost assessments in the research estimated that cages with diameters

ranging from 16 m to 30 m would cost approximately 55,000 USD, while cages with diameters between 30 m and 66 m were projected to cost around 100,000 USD. In a cost analysis conducted by Yiğit (2024) for marine fish farming facilities to be established in the Black Sea region, it was stated that a single cage with a diameter exceeding 40 m would cost approximately 112,000 USD. The costs of cages over 40m in our study area align with Yiğit's (2024) findings. When evaluating the number and size of cages in the existing facilities, the total investment in cage systems in the research area has been calculated at 45,100,000 USD. In the same study, Yiğit (2024) calculated the investment required for producing 1 kg of fish to be 2.4 USD. However, in this study, based on discussions with producers in the research area, it has been determined that the cost for one kg fish production is 1.7 USD. This difference is believed to stem from the distinction between Turkish Salmon farming in the Black Sea region and the focus on sea bream and sea bass production in our study area. Additionally, the proximity of cage system manufacturers and their logistical advantages in the region may also contribute to the cost differences. Including cage investments of the recent study, the total investment cost for producing 1kg of fish in the SEPA region has been calculated to be 84,218,000 USD.

One of the most important components of aquaculture is feed (Yıldız et al., 2008; Damir et al., 2024). Feed directly influences the growth performance, health and profitability of the fish that is produced (Yıldız et.al., 2018; Ünal-Şengör et al., 2025) Feed costs, which account for a significant portion of production expenses, are critically important for activities in this sector (Roberts et al., 2024). Globally, the cost of feed in fish production typically ranges from 45% to 70%, while in Türkiye, this range is between 65% and 75% (Ertör & Ortega-Cerdà, 2019; Korkut et al., 2017). Therefore, the feed industry plays a fundamental role in aquaculture. For those involved in aquaculture, improving both the quantity and quality of feed is of great importance.

Korkut et.al. (2017) reported in their study that the geographical distribution of fish feed factories by region was 15 in the Aegean, 2 in the Black Sea, 2 in Southeastern Anatolia, 2 in the Marmara region, 2 in the Mediterranean, 1 in Central Anatolia, and 1 in Eastern Anatolia. In our study, however, it was found that this distribution has changed, with 11 factories in the Aegean, 5 in the Mediterranean, 5 in Southeastern Anatolia, 4 in the Black Sea and Marmara regions, and 1 in Central Anatolia (Figure 8). Looking at the results of both studies, it is evident that fish feed production factories are concentrated in the Aegean region, and they mostly produce feed for sea bass and sea bream. The high volume of fish production in the Aegean is supported by the integration of feed factories into the production process. Fish producers, by adding feed factories to their operations, are able to reduce feed costs and ensure the supply of feed with the desired quality. In their study, Ertör and Ortega-Cerdà (2019) stated that fish producers who aim to reduce feed costs are not only establishing fish feed factories but also making efforts to facilitate access to raw materials through fishing fleets. In addition, it is evident that producers also explore opportunities abroad to fish in different geographical areas.

In our country, there are 252 registered food businesses involved in the processing and packaging of fishery products (Doğan and Çanak, 2024, GGBS, 2023). Of these businesses, 48 operate within the İzmir province (GGBS, 2023). As part of our study, data has been collected regarding the contribution of companies engaged in the processing and packaging of sea bream, sea bass, meager and bluefin tuna which are farmed in the Karaburun-Ildır SEPA area, to employment.

It has been determined that a total of 647 people are employed in the processing and packaging businesses operating in the region. Among these employees, 361 are found to be women. In a study conducted by Altun and Çağlak (2023) in the Black Sea region, it was reported that a total of 532 people were employed in processing and packaging facilities, of which 192 were women. When comparing the Aegean and Black Sea regions in this respect, it can be stated that there is a higher rate of female employment in the Aegean region. In the same study mentioned above, it was also stated that businesses primarily convert products obtained from fishing into fresh and frozen products. In a study conducted by Erdem et al. (2022), it was stated that the number of male employees in the Black Sea region was three times higher than that of female employees. In another study by Çağlak and colleagues (2012) conducted in Balıkesir, it was reported that the proportion of female employees was 79%. In the enterprises operating in our study area, it has been observed that the primary source of products processed is from fish farming enterprises, and unlike the Black Sea region, in addition to fresh and frozen products, there is a high preference for fillet products. This preference aligns with the higher employment of women. In fillet production lines, women are preferred due to their dexterity and precision (Altun & Çağlak, 2023). Similarly, in a study conducted by Ataman and Çağlak (2023) in Istanbul, it was reported that out of 175 employees working in 11 processing plants with fillet products and shellfish processing lines, 84 were female employees.

Conclusion

This study highlights the significant role of the Karaburun-Ildır SEPA region in Türkiye's marine aquaculture sector, emphasizing both its contribution to national production and its economic impact. The region's marine fish production plays a crucial part in meeting the growing demand for seafood, with products primarily focused on sea bass, sea bream, meagre, and tuna. The data presented illustrates that the SEPA region accounts for a considerable portion of Türkiye's total marine fish production, underscoring its importance

within the Aegean region and the broader Turkish aquaculture industry.

Fish farms in the research area have been observed to have significant positive effects on employment and the socio-economic well-being of people not only at the local level but also in İzmir and other nearby provinces.

Most of the enterprises in the research area are large-scale operations, and to ensure profitability and sustainability in production, they have established feed factories capable of meeting their own needs. Moreover, these facilities also supply feed to smaller farms operating in the region. According to our assessments, this structure has significantly contributed to the profitability of the enterprises in a positive way.

Additionally, the research reveals a notable trend in female employment within the region's aquaculture sector, particularly in the processing and packaging of farmed fish. Women are disproportionately employed in fillet production lines due to their dexterity and attention to detail, which also correlates with higher levels of female employment compared to other regions in Türkiye, such as the Black Sea. This highlights the social dimension of the aquaculture industry in the region, which not only supports economic development but also contributes to gender inclusiveness in the workforce.

Finally, the economic returns from the SEPA region's aquaculture activities are substantial, with exports playing a pivotal role in sustaining production levels. The high cost of infrastructure, including cage systems, demonstrates the significant investment required for the continued success of the sector. These findings emphasize the need for strategic investments, policy support, and further research into sustainable practices to ensure the long-term growth of Türkiye's marine aquaculture industry.

In conclusion, the Karaburun-Ildır SEPA region represents a key area in the future development of Türkiye's marine aquaculture sector, with its economic, employment, and export contributions positioning it as a vital player in the national and international seafood markets. Moving forward, balancing large-scale production with efforts to diversify species and promote sustainability will be essential to maintaining the sector's growth and resilience.

Ethical Statement

There is no necessity for ethical approval for this research.

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Author Contribution

D.D.T., M.Y., K.D. and M.D.D planned and executed the field study and data collection. D.D.T and M.Y. wrote the initial manuscript draft with input from all authors. All authors contributed to the article and approved the submitted version.

Conflict of Interest

No potential conflict of interest was reported by the authors.

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