An Overview of the Indonesian Abalone Industry: Production, Market, Challenges, and Opportunities

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Abstract. The Indonesian abalone industry has been experiencing growth in recent years and holds significant potential for further expansion. This paper provides a comprehensive review of the current state of the abalone industry in Indonesia, including production processes, markets, and trade, as well as the challenges and opportunities faced by the industry. The study found that the growth of the Indonesian abalone industry is driven by both the domestic market and the increasing demand for Indonesian abalone in international markets. Despite these opportunities, the industry faces various challenges, such as illegal fishing practices, intense competition, and fluctuating prices. The Indonesian government has implemented regulations to promote sustainable harvest and trade practices to address these challenges. The industry is focused on producing high-quality abalone to maintain its competitive position in the global market. The Indonesian abalone industry needs to overcome these challenges to sustain its growth in the future, expand its market reach through international trade, and continuously produce high-quality products. This review provides valuable insights into the Indonesian abalone industry and highlights potential future directions for growth. The findings of this study could be useful for industry players, policymakers, and researchers interested in the development of the Indonesian abalone industry.

1 Introduction

Abalone is a type of shellfish that is highly valued for its meat and is widely cultivated and consumed in many parts of the world [1]. This mollusk species is known for its distinctive and attractive shell, often used for decorative purposes [2]. However, the meat of the abalone is of the most importance, as it is a delicacy that is highly sought after for its unique flavor and texture [3].

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Abalone cultivation was very prospective because international demands still high [4]. In 2017, the abalone market value was nearly USD 2.6 billion, and over 95% production come from cultivation [5]. In Indonesia, abalone cultivation has become an increasingly important industry, with many researchers and practitioners exploring various aspects of abalone technology [6]–[12]. The importance of abalone cultivation in Indonesia is partly due to the growing demand for domestic and international abalone and the increasing recognition of the importance of sustainable seafood production [13]. Consequently, understanding the current state of abalone research in Indonesia becomes paramount, ensuring the continuous prosperity of this valuable industry.

This article aims to present a comprehensive overview of abalone technology research in Indonesia, with a specific focus on *Haliotis asinina* and *Haliotis squamata*, as illustrated in (Fig 1). Our exploration will span a wide array of topics concerning abalone technology in Indonesia, delving into the biology and ecology of these species, the evolution and implementation of diverse cultivation methodologies, and the array of challenges and ramifications inherent to the abalone technology sector, impacting the local economy.

![Fig. 1. *Haliotis asinina* (a) and *Haliotis squamata* (b)](image)

### 2 Overview of abalone industry in Indonesia

Abalone has been traditionally harvested from wild populations along the Indonesian coast and has been an important source of food and income for coastal communities [14]. However, overfishing and the depletion of wild abalone stocks have led to a decline in the industry in recent decades [4], [14]–[16].

In response to this decline, the Indonesian government has implemented policies and programs to promote the development of a sustainable abalone industry and cooperate with research agencies, universities, and non-government organizations (NGOs). These initiatives have included investment in research and development, promoting abalone farming, and regulating wild abalone harvest [17]–[19]. These initiatives have helped to drive the growth and expansion of the abalone industry in Indonesia in recent years.

The growth of the abalone industry in Indonesia has been driven by rising demand for abalone in local and international markets, as well as investments in research and development. Indonesia exported 302 tonnes of abalone in 2019 [20] (Fig 2). Abalone’s exports went up by 4214.29 % between 2017 and 2019. As the result, the market value increased in 2019 to approximately USD 700,000 (Fig 3). This market value surges 993.75% from 2018’s total abalone export [20].
The abalone industry in Indonesia faces several challenges, including concerns about overfishing and depletion of wild abalone stocks, regulatory constraints, and environmental concerns. The rising demand for abalone has put pressure on wild populations, leading to concerns about overfishing and the depletion of abalone stocks [21], [22]. This situation has led to stricter regulations on wild harvest [23], including abalone, further increasing farmed abalone's importance in the Indonesian market. On the other hand, the industry also has significant opportunities for growth and development, such as developing new and innovative abalone culture systems, partnerships with research institutions, and expanding local and international markets. The advancements in abalone cultivation and production technology have created new possibilities for profitable and sustainable abalone production, including new culture systems, research into abalone health management, and feed and nutrition [24], [25].

The prospects for the abalone industry in Indonesia are promising. With continued investment in research and development, the Indonesian abalone industry is well-positioned to address ongoing challenges and ensure the industry's long-term sustainability. Additionally, the increasing demand for abalone in local and international markets provides a strong incentive for continued growth and expansion in the industry [5].

One area of particular promise for the abalone industry in Indonesia is the development of new and innovative abalone culture systems. These culture systems include recirculating aquaculture systems (RAS) and land-based systems, which offer significant advantages over traditional abalone culture methods. For example, RAS and land-based systems provide greater control over water quality and temperature, which can improve abalone
health and growth rates. They also offer opportunities for increased efficiency and reduced costs, making them more economically viable for farmers [26]–[28].

In conclusion, the abalone industry in Indonesia has a long history and is a growing and dynamic industry with significant prospects for the future. With continued investment in research and development, the Indonesian abalone industry is well-positioned to meet the local and international markets' demands and ensure its long-term sustainability.

3 Abalone culture and production

Wild harvest is the oldest and most traditional method of abalone production, where the animals are collected from their natural habitat in the wild. This production method is less controlled than hatchery-based culture and on-growing systems and can result in over-fishing and depletion of wild populations [19]. However, wild-harvested abalone can still be found in Indonesia, especially in areas where natural populations are abundant [29].

Hatchery-based culture is a more controlled method of abalone production, where the animals are reared from eggs in a controlled environment. This method allows for greater control over growing conditions and the ability to produce a consistent supply of abalone year-round [7], [9]. However, hatchery-based culture also requires higher technical expertise and investment than wild harvest [30].

On-growing systems involve rearing abalone from juvenile stages to maturity in tanks or net pens. This method allows the animals' growth to be controlled and monitored, leading to greater consistency in the size and quality of the final product [31]. On-growing systems can also provide opportunities for research and development of new production techniques [10].

In Indonesia, research on abalone culture and production is limited but ongoing. Several studies have been conducted to assess the potential for abalone farming in Indonesia, including the suitability of local water conditions, the availability of appropriate feeds, and the feasibility of different production methods [3], [11], [15], [31]–[33]. These studies highlight the potential for Indonesia to become a major player in the global abalone industry, providing the necessary infrastructure and investment [34].

4 Abalone feed and nutrition

Abalone growth and health depend on feeding and nutrition. This feeding and nutrition ensure growth and survival and affect product size, color, and meat texture. Thus, understanding abalone nutritional needs and how feed types and diets affect growth and health in aquaculture is crucial.

Abalone species like H. asinina and H. squamata need specific nutrients to grow and survive. These abalone eat seaweed and other macroalgae, according to several studies [35], [36]. Abalone grow best on a diet of various seaweed species, according to the study. H. asinina grew and survived best on Ulva lactuca and Gracilaria sp. [37], [38]. Microalgae like Isochrysis sp. and Tetraselmis sp. improve abalone growth and disease resistance [33, 39].

Several Indonesian studies have examined how feed and nutrition affect abalone growth and health. Abalone-fed mixed macroalgae and artificial diets had the highest growth and survival [37]. Other study examined how dietary protein levels affected H. squamata growth and survival [38]. High-protein diets promoted faster growth and higher survival rates than low-protein diets [39], [40].
Abalone feed quality and type can have a big impact on the environment. Eutrophication from excessive artificial diets can harm aquatic species [41]. Abalone farmers should choose to feed carefully and use environmentally friendly methods. Therefore, abalone aquaculture requires proper feeding and nutrition. Better feeding and nutrition improve growth, survival, and product quality. A diet rich in seaweed species and microalgae improves abalone growth and disease resistance. However, it is important to consider the environmental impact of feed used for abalone culture and to use sustainable practices [42].

5 Abalone health and disease management

Abalone health and disease management is crucial to Indonesia's abalone industry's success. Many diseases affect abalone, especially H. asinina and Haliotis squamata, which can affect its growth, survival, and health. To manage these diseases, one must understand their etiology, pathogenesis, and effective treatment and prevention.

Many Indonesian studies have examined abalone health and disease management. Probiotics treated Vibrio infection and increased abalone growth [43], [44]. Probiotics in abalone diets reduce disease severity and improve nutrition, according to these studies. Probiotics prevent disease in Indonesian abalone culture, according to research.

Another study examined abalone growth with different Vitamin C doses [45]. A higher Vitamin C dose improved antioxidant and immune responses, the study found. These studies show that Indonesian abalone health and disease management requires prevention and treatment. Indonesia's abalone industry needs ongoing research to survive and grow. Water quality, temperature, and nutrition also affect abalone health [3], [11], [21], [28], [46]. Therefore, abalone industry disease management strategies must consider these factors and mitigate their negative effects.

6 Abalone market and trade

The abalone industry in Indonesia is profoundly influenced by competition and international trade dynamics. The interplay between supply and demand significantly impacts pricing and profitability within the industry. A study revealed that the global demand for abalone has been steadily rising [13]. This surge in demand can be attributed to the high nutritional value of abalone and its increasing popularity as a luxury food item. Consequently, this increased demand has driven up the price of abalone in the market, creating profitable opportunities for industry players.

However, it's important to note that Indonesia currently does not rank among the top ten abalone exporting countries, as indicated in Table 1 [47]. While abalone prices in Indonesia typically range from USD 22 to USD 26 per kilogram [7], the production supply falls short of meeting the demand by a substantial 40% [14]. The domestic market in Indonesia predominantly consumes locally produced abalone [16], [48]. Nevertheless, there is a growing appetite for Indonesian abalone in international markets, particularly in countries like the USA, Japan, and Germany [49]. Several factors, including supply and demand dynamics, product quality, and food safety, exert influence on abalone prices in Indonesia.

The surge in demand for abalone has also attracted illegal fishing practices, posing a threat to the sustainability of abalone populations and the long-term health of the industry. To combat this, the Indonesian government has implemented stringent regulations and laws to monitor and control the harvesting and trade of fisheries, including abalone [23]. These regulations have played a pivotal role in ensuring that only sustainably sourced abalone

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reaches the market, enhancing the reputation of the Indonesian abalone industry and bolstering its competitiveness on the global stage.

### Table 1. Top ten exporting countries of Fresh Abalone in 2021 (source: [47])

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Share in Export Value</th>
<th>Export Value</th>
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<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>31.18%</td>
<td>$62.69M</td>
</tr>
<tr>
<td>2</td>
<td>Australia</td>
<td>23.95%</td>
<td>$48.14M</td>
</tr>
<tr>
<td>3</td>
<td>South Korea</td>
<td>23.37%</td>
<td>$46.98M</td>
</tr>
<tr>
<td>4</td>
<td>South Africa</td>
<td>13.11%</td>
<td>$26.36M</td>
</tr>
<tr>
<td>5</td>
<td>New Zealand</td>
<td>6.20%</td>
<td>$12.46M</td>
</tr>
<tr>
<td>6</td>
<td>Chile</td>
<td>0.66%</td>
<td>$1.32M</td>
</tr>
<tr>
<td>7</td>
<td>Japan</td>
<td>0.48%</td>
<td>$968.07K</td>
</tr>
<tr>
<td>8</td>
<td>Hong Kong</td>
<td>0.36%</td>
<td>$721.74K</td>
</tr>
<tr>
<td>9</td>
<td>Mexico</td>
<td>0.25%</td>
<td>$499.63K</td>
</tr>
<tr>
<td>10</td>
<td>Taiwan</td>
<td>0.09%</td>
<td>$171.70K</td>
</tr>
</tbody>
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Moreover, the Indonesian abalone industry faces competition from other abalone-producing nations, such as Australia and South Africa. Indonesia must focus on consistently producing high-quality abalone to maintain its position in the global market. Achieving this goal involves streamlining production processes and establishing effective marketing and distribution channels.

In the realm of international trade, Indonesia exports abalone to various countries, including the USA, Japan, and Germany. The USA stands as the largest importer of Indonesian abalone, accounting for a substantial 88.5% of Indonesia's total abalone exports [49]. This statistic underscores the tremendous potential for growth and expansion in the international market for Indonesian abalone.

In conclusion, the abalone market and trade in Indonesia hold significant promise for future growth. To realize this potential, the Indonesian abalone industry must grapple with challenges such as competition and price fluctuations. Key strategies include implementing sustainable harvest and trade practices, consistently producing high-quality abalone products, and expanding market reach through international trade. By addressing these challenges, the Indonesian abalone industry can continue to flourish and thrive in the years ahead.

### 7 Conclusion and future directions

The abalone industry in Indonesia has the potential for significant growth and expansion in the future. The demand for abalone has been increasing globally due to its high nutritional value and popularity as a luxury food item. Indonesia has a growing domestic market for abalone and a growing demand for Indonesian abalone in international markets. The Indonesian government has implemented regulations and laws to ensure that only sustainably sourced abalone is sold in the market, improving the reputation of the Indonesian abalone industry and increasing its competitiveness in the global market.

However, the Indonesian abalone industry faces challenges such as competition from other countries, fluctuating prices, and illegal fishing practices. Therefore, the industry must focus on producing high-quality abalone, implementing sustainable harvest and trade practices, and expanding its market reach through international trade to address these challenges.

In conclusion, the future of the Indonesian abalone industry is promising, but continued efforts will be needed to ensure sustainable growth. However, by addressing the challenges faced by the industry, such as competition and fluctuating prices, focusing on producing
high-quality abalone, implementing sustainable harvest and trade practices, and expanding its market reach through international trade, the Indonesian abalone industry can continue to grow and thrive.

Future directions for the Indonesian abalone industry include exploring new markets, improving production processes, and further investing in research and development to improve the industry's quality and sustainability. Additionally, it may be beneficial to continue monitoring and addressing illegal fishing practices to ensure the sustainability of the abalone population. The future of the Indonesian abalone industry holds great potential, and continued efforts will help ensure its continued success.

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