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Production Management of White Snapper *Lates calcarifer* Reared in Floating Net Cage

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Abstract

The cultivation of white snapper *Lates calcarifer*, also known as sea bass or barramundi, is gaining popularity in commercial aquaculture because of its fast growth and ease of maintenance. This study explores various aspects of white snapper farming in floating net cages (KJA) in Indonesia, a region where the species thrives in coastal waters and estuaries. Government support for marine aquaculture, particularly for white snapper, has contributed to increased production to meet the rising domestic and international demand. This research focuses on site preparation, seed stocking, feeding, water quality management, and disease prevention. The results indicated that maintaining optimal water conditions, careful feeding strategies with a mix of pellet and trash fish, and regular health monitoring are essential for successful cultivation. A key challenge is the prevention of benedeniasis, a parasitic infection managed through hydrogen peroxide treatments. The findings emphasize the importance of efficient farming practices to enhance productivity and profitability while ensuring environmental sustainability. The information provided serves as a reference for aquaculture business operators and contributes to the advancement of white snapper farming in Indonesia.

Keywords: floating net cages, growth, *Lates calcarifer*, marine aquaculture, sustainability

I. INTRODUCTION

The cultivation of white snapper *Lates calcarifer,* also known as giant sea perch, seabass, or barramundi, has attracted commercial fishing businesses due to its relatively fast growth, ease of maintenance, and ability to be raised in captivity (Windarto *et al.,* 2019). White snapper is commonly found in tropical and subtropical countries, such as Indonesia, where it inhabits coastal waters, brackish ponds, and river estuaries (Musbir *et al.,* 2020; Kusumanti *et al.,* 2022).

Since the enactment of the Minister of Maritime Affairs and Fisheries Regulation No. 32 of 2016, various forms of support have been provided for the development of marine aquaculture beyond grouper, particularly for white snapper, pomfret, and trevally (Utami, 2018). Several regions, including West Nusa Tenggara, Bali, the Riau Islands, Ambon, and other production centers, have also seen significant developments in meeting market demand (Iskandar *et al.,* 2022).

White snapper is an export commodity with high economic value, meeting both domestic and foreign consumption needs due to increasing demand and production each year. In 2012, import demand in European countries (Italy, Spain, and France) reached 14,285 tons, rising to 18,572 tons by 2014 (Luthfi, 2021). White snapper production in Indonesia has grown at an annual average rate of 3.40% over the last five years.

In 2018, Indonesia's aquaculture production included 16,114,991 tons of seaweed, with contributions from the top nine species being: tilapia (25.84%), pangasius (11.18%), catfish (17.29%), carp (9.93%), gourami (2.96%), snapper (0.14%), grouper (0.39%), milkfish (10.08%), and shrimp (14.19%) (DJPB, 2019).

Cultivating white snapper in floating net cages efficiently utilizes coastal waters, particularly where land-based aquaculture is limited. This method ensured good water quality, optimal oxygen levels, and a controlled environment for fish growth. It also allows for easier monitoring of health, feeding, and growth, improving survival and productivity while reducing escape and predation risks. As a high-value species with strong market demand, farming snapper in floating cages supports sustainable production and helps reduce the pressure on wild stocks. Drawing from the previously outlined information, this study was conducted to disseminate fish farming techniques to white snapper reared in KJA. The information gathered can serve as a reference for business operators, enabling them to economically and sustainably manage white sea bass cultivation.

II. MATERIALS AND METHODS

This study was conducted over a period of 45 days at a grow-out unit for white snapper, using floating net cages owned by PT. Bali Barramundi, located in Buleleng, Bali, from March to May 2024. In this study, the action research method was used to develop the most efficient working methods, thereby reducing production costs and increasing productivity (Darna & Herlina, 2018). Data collection was conducted using both primary and secondary data.

Primary data refer to information obtained directly from original sources through manual means, such as interviews, observation, active participation, or the use of specific measurement instruments according to the research purpose (Dwiyana, 2019). Secondary data were obtained from processed documents provided by other parties (government reports, academic articles, fishery statistics, etc.) to support the analysis.

The participatory and observational methods employed in this study involved the implementation of technical aquaculture procedures, including the preparation of floating net cages, seed stocking, feed administration, water quality monitoring, pest and disease control, and harvesting. Fish growth was evaluated weekly by measuring the length (cm) and weight (g). The water quality parameters analyzed included temperature (°C), pH, salinity (ppt), dissolved oxygen (mg/L), and nitrite (mg/L).

The data obtained were then analyzed based on the approach described by Hariyati (2010), incorporating elements of the systematic review method. This involved the use of relevant literature to reinforce and clarify the findings, the assessment of studies by synthesizing results and categorizing them to derive meaning, and the formulation of outcomes to be discussed to draw conclusions that serve as recommendations from the study.

III. RESULT

3.1. Preparation of Grow Out Site

PT Bali Barramundi is a subsidiary of PT I AM BE U Mina Utama Denpasar, Indonesia's leading commercial fishing company. It operates a sustainable white snapper (barramundi) aquaculture business; encompassing hatchery, grow-out, and marketing activities, and supplies products to both domestic and international markets, including Australia, Singapore, Canada, Japan, the United States, and various countries in Asia and the Middle East.

White snapper grow-out activities at PT Bali Barramundi were conducted in floating net cages (KJA) of various types and sizes. The initial preparation involved drying the nets in the sun for two days to facilitate cleaning. The nets were then sprayed using a water gun machine with seawater as the source. The nets were repeatedly turned over until the dirt, moss, and shells adhering to them were dislodged. The next step is to inspect the nets for damage, tears, or the remaining shells. Torn nets were sewn back together using a coban rope, while nets with attached shells were cleaned by striking them with stones or wood. Care must be taken during this cleaning process to avoid damage or tearing the nets.

3.2 Seed Distribution

The distribution of white snapper seeds into KJA is crucial during the initial stage of rearing. High-quality white snapper seeds for rearing should be 12-15 cm in size, exhibit agile movements, be free from injuries, respond well to movement, have strong scales, bright eyes, and have no defects in body shape. Seed distribution was conducted in the morning with a stocking density of 45-50 fish/m³ (Table 1), as temperature fluctuations tended to be lower, reducing the stress levels on the fish. The stocking density of white snapper is reduced according to their weight to ensure uniform fish size, prevent size variations that can lead to cannibalism, and avoid situations where smaller fish are outcompeted for food by larger ones, which can hinder overall fish growth.

Before stocking the seeds in KJA, they were acclimatized to the new environment. The plastic bags containing the seeds were floated on the water for several min until the inside of the bag becomes foggy, indicating that the seeds had begun to adjust to new environmental conditions. The plastic bag was then slowly opened, and seawater was gradually introduced into the bag, allowing the seeds to emerge on their own in the new rearing container.

3.3 Feeding

White snapper fish were fed using artificial feed in the form of sinking pellets, specifically the Megami brand. The use of artificial feed aims to increase production with a shorter maintenance period, maintain cost-effectiveness, and ensure profitability, even with high stocking densities. Megami feed contains 48% protein, 10% fat, 10% ash, 2% crude fiber, and 10% moisture content. The protein content in the feed is crucial for promoting fish growth. In addition to pellet feed, fish were also provided with other types of feed, such as trash fish, on the 3rd or 4th day. The types of trash fish used as supplementary feed include karesai and scad. The trash fish was cut into pieces according to the mouth size of the white snapper. The ratio between pellet feed and trash fish ranged from 70% to 30%.

Feeding was performed carefully considering the fish condition. Newly stocked seeds are fed as frequently as possible to support growth and development. The nutritional contents of pellet feed and trash fish are presented in Table 2. Once the fish reached a weight of > 500 g, the feeding frequency was adjusted accordingly. White snapper are typically fed twice a day, once in the morning at 09:00 a.m. and again in the afternoon at 14:00 *p.m.* Proper feeding methods are essential to ensure efficient operations. Feed is distributed at specific points within the cultivation area so that all fish can access the food, and prevent waste through the net mesh. Unconsumed feed that does not escape through the mesh can settle, potentially degrading the water quality and quickly dirtying the net. These issues can negatively affect the survival rate of the fish.

Table 1. White snapper fish stocking density in KJA size 3 m × 3 m × 3 m

Fish Size (g)	Density (Fish)
<200	500
200 – 300	400
>300	300

Feeding was conducted ad libitum (to satiation), with a feed conversion ratio (FCR) of 1.3. Feed was distributed by throwing it from a small basket into the middle of the cage. It is important to monitor response of fis to feed to ensure efficient feeding. If the fish's response is slow, the feeding process can be adjusted by slowing down or stopping feeding. Uneaten food may indicate that the fish are full or that their appetite has decreased, leading to cessation of feeding activities. Conversely, if fish respond eagerly to the feed, additional feed can be provided without waiting for the previous feed to be consumed.

3.4 Monitoring and Managing Water Quality

Monitoring and managing water quality during the white snapper rearing stage in KJA involves regular measurements to assess the conditions of cultivation waters. Water quality significantly affects the health and growth of living organisms; therefore, it is crucial to pay close attention to these parameters.

Water quality measurements were conducted once a week, in the morning at 08:00 *a.m.* and in the afternoon at 16:00 *p.m.* The measured parameters included pH, dissolved oxygen (DO), temperature, and salinity. The results of water quality measurements are presented in Table 3. Based on the data from the water quality measurement results in KJA, it was classified as good, because it is in accordance with the SNI reference. The temperature in KJA ranges from

Table 2. Nutritional content of pellets and trash fish

Nutritional content	Pellets	Trash Fish
Protein (%)	42-45	28.26
Fat (%)	10	1.49
Crude fiber (%)	2-3	4.10
Ash (%)	13-14	4.82
Moisture (%)	10	59.57

Table 3. Water quality measurements result average in KJA

Parameter	Result	SNI 6145.3:2014
Temperature (°C)	29 – 30	28 - 32
pH	8.3 - 8.47	7.5 – 8.5
Salinity (g/L)	33 – 34	30 – 34
Disolved oxygen (mg/L)	4.84 - 5.76	3 – 7
Nitrite (mg/L)	<0.001	<1

29 °C to 30 °C according to SNI 6145.3: 2014, and temperature greatly affects the life and development of marine biota.

3.5 Pest and Disease Prevention

Fish disease is an abnormal condition in which organs of the body cannot function properly. When fish experience stress, their body defences decrease, making them more susceptible to infections. The emergence of diseases in aquaculture systems is the result of complex interactions among the fish, the environment, and pathogens. Fish diseases can be categorised into infectious diseases and non-infectious diseases based on their causes. Infectious diseases are caused by viruses, parasites, bacteria, or fungi. Non-infectious diseases, on the other hand, are caused by genetic factors, nutrition, and water quality.

During the rearing stage of white snapper, the prevention of pests and diseases is crucial for monitoring fish health and conditions. Benedeniasis, caused by the parasite *Benedenia* sp., is a common disease affecting white snapper in KJA. To prevent this disease, fish were treated by deeping in fresh water or hydrogen peroxide (H_2O_2) at a concentration of 32% for 15 min Preparation involves installing tarpaulin around the KJA, following the shape of the cage net to prevent H_2O_2 from leaking out during treatment. H_2O_2 was then poured into the covered cages to soak sick fish for 15 min.

To prevent secondary infections from bacterial contamination due to parasitic bites, the fish were quarantined. After the soaking process, the tarpaulin was removed. Soaking is performed routinely every four days to aid in the recovery of sick fish. Daily checks were conducted to collect and remove dead fish from each cage because dead fish can pose a risk of spreading infectious diseases to healthy fish.

3.6 Fish Harvesting

Harvesting can be carried out using two methods: selective harvesting and total harvesting. Selective harvesting involves harvesting fish of a specific size based on market demand, particularly when the selling price is high. Total harvesting involves harvesting all the fish, usually when market demand is very large, or when all the fish have reached the desired selling size. The purpose of the grow-out phase is to increase the size of the juvenile white snapper to a marketable consumption size. The final activity is harvesting, where a white snapper is generally harvested once it reaches a size that meets market demand. Market-sized white snapper typically weigh between 500 and 3,000 g per fish

The fish to be harvested were fasted for one day. Fasting helps to empty the stomachs of fish, reducing the release of metabolic waste during transportation. The harvesting process began with scooping the fish using a fish trap. The fish were then collected in a drum container and graded. Grading ensures that the harvested fish meet consumer demand and are healthy and defect- free. The selected fish were then placed on a motorboat and transported to the shore.

Harvesting was performed when the white snapper reached a weight of 300 - 500 g per fish, after a rearing period of 5-6 months. The selling price for white snapper is IDR 40,000 per kilogram for consumption size and IDR 75,000 per kilogram for white snapper weighing 500 g.

IV. DISCUSION

The rearing phase involved raising fish from the nursery stage until they reached a consumption size of 400-500 g. During this phase, the risk of fish mortality is relatively lower than that during the nursery stage, as the fish are larger and better adapted to their environment (Parson *et al.,* 2014). Mulyani *et al.* (2023), describe the stages of the rearing process, which include preparing containers, stocking seeds, feeding, preventing pests and diseases, managing water quality, sampling, harvesting, packaging, and transportation. At the study location, repairs to floating net cages were conducted to ensure the well-being of the fish and produce high-quality output (Wei *et al.,* 2020). It is further noted that fish reared under optimal conditions can achieve harvest size while focusing

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on both quality and quantity by maintaining an ideal living environment, providing appropriate feed, and effectively controlling pests and diseases.

The density of white snapper stocking is reduced based on weight to equalize fish size, prevent size variations that can lead to cannibalism, and avoid situations where smaller fish are outcompeted by larger ones for food, which can disrupt overall fish growth (WWF Fisheries Team, 2015). White snapper fish seeds experience continuous stress during transportation, which makes them more susceptible to disease. To prevent fish death due to transportation stress, acclimatization was performed by adjusting the temperature and distribution time to match the aquatic environment (Makaras *et al.,* 2021). A high-density distribution is also not recommended, as it increases susceptibility of fish disease (Ellison *et al.,* 2020).

White snappers are nocturnal and typically feed at night until morning. Their nocturnal feeding habits are similar to those of their natural diet, which includes shrimp. While shrimp is the primary food source in their natural environment, white snapper can also consume other types of feed. According to Ridho and Patriono (2016), white snapper prefer live and active food, such as crustaceans and fish. Feed can be both natural and artificial. Feeding in white snapper fish farming was conducted using artificial sinking pellets branded Megami. The use of artificial feed aims to increase production with a short maintenance period, while being economically efficient and beneficial, even under high stocking densities (Kizhakudan *et al.,* 2024). Thomas (2013) mentions that feeding is adjusted based on the fish's condition; newly stocked seeds are fed frequently to support their growth and development, while feeding is reduced for fish that weigh over 500 g.

Water is a crucial component in fish farming, as it provides an environment in which fish and other aquatic animals live, grow, and develop. Water used as a cultivation medium must meet specific quantity and quality standards to support fish life (Ahmad *et al.,* 2021). A good environment promotes optimal fish growth and development. Managing water quality can be challenging in an open-system setup. According to Bozorg-Haddad (2021), water quality can be assessed through various tests, including chemical, physical, biological, and sensory (smell and colour) tests. Water quality management involves maintaining water to meet the desired standards and ensuring that it remains in its natural condition. Quality control was achieved by collecting water samples and analyzing them in a laboratory.

During this investigation, the temperature readings in the white snapper KJA ranged from 29 to 30 °C. According to SNI standards, this range is ideal for growth. The dissolved oxygen (DO) levels were between 4.84 and 5.76 mg/L, aligning with SNI guidelines, which indicate that temperatures between 28 °C and 32 °C and DO levels above 3 mg/L are optimal for white snapper growth. Salinity measurements ranged from 33 to 34 g/L, which is consistent with the literature. White snapper have good salt tolerance and can be raised in ponds, floating net cages, and other environments (Tarwiyah, 2001).

Fish farming is closely linked to pest management and disease. Pests and diseases can significantly affect marine fish farming efforts in KJA by affecting both juvenile and adult fish (Elgendy *et al.,* 2023). In a broad sense, pests are disturbances to humans, livestock, and plants, and in fish farming, they can cause substantial losses. Effective pest and disease control includes monitoring water quality, as fish are constantly in contact with the aquatic environment and can easily become infected with pathogens. Unlike land animals, which can be infected through air, fish frequently contract bacterial and parasitic infections through water (Dar *et al.,* 2022). Foyle (2022) noted that in aquaculture, water serves not only as a habitat for fish but also as a conduit for pathogens. Therefore, prevention and treatment measures are essential, both before and after a disease outbreak (Ziarati *et al.,* 2022).

The *Benedenia* sp. found in this study is a type of Monogenea worm with characteristics similar to those of *Neobenedenia girellae* (Septa, 2023). However, Hirazawa *et al.* (2023) reported that in vivo research on kuwe fish Seriola sp., revealed that *Benedenia* sp. is more sensitive to the anti-parasitic drug praziquantel (PZQ) than *Neobenedenia girellae*. Soaking with hydrogen peroxide (H_2O_2) prevents ectoparasites. According to Lindgren and Dobrogosz (1990), hydrogen peroxide has a bactericidal effect that causes strong oxidation in bacterial cells and damages the basic molecular structure of cell proteins, including those of *Benedenia* sp.

V. CONCLUSION

The growth-out of white snapper *Lates calcarifer* in floating net cages (KJA) is vital for optimizing yield and health. At PT Bali Barramundi, integrated management including net maintenance, acclimated stocking, high-protein feeding (FCR 1.3), water quality control, and disease prevention ensured efficient production. *Benedenia* sp. was effectively managed with H_2O_2 treatment and quarantine. Water parameters met the SNI standards, and fish reached market size in 5–6 months. These integrated grow-out practices at PT Bali Barramundi demonstrate a science-based, sustainable, and scalable model for marine aquaculture in Indonesia, serving as a reference for the country's expanding industry.

CONFLICT OF INTEREST

We certify that there are no conflicts of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript.

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