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Adaptive Local Wisdom Management for Cetacean Conservation and Sustainable Marine Ecotourism in East Nusa Tenggara Indonesia

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Abstract: The study aims to explore the distribution, habitat, tracks, and migration tracks of cetaceans in the tropical seawater at Lamalera, Pantar, Alor, Ombai strait, Pura Island, Kabola Beach and Savu Sea East Nusa Tenggara for its management plan. The field explorative survey discovered several local wisdoms in this area such as managing *Dugong dugon* feeding on specific seagrass species *Halophila ovalis* and *Enhalus acoroides* at Kabola Beach Alor by an elderly key person, later set as the nucleus zone and limited ecotourism.

Traditional whale hunting at Lamalera Beach Lembata Island is controlled by a local elderly priest, and the spatial whale track at Pantar, Alor and Ombai strait is set as a limited zone and developed for whale-watching ecotourism. The cold seawater upwelling phenomena that attract school's dolphin and whale in Alor strait is set for limited zone and ecotourism. The anemone-city as a specific coral-reef ecosystem living above the volcanic underwater sea mount at Pura Island is set for the nucleus zone and limited diving ecotourism. Result of FGD and considering those specific ecological factors, the stakeholders agree to describe the adaptive local wisdom to develop the conservation and sustainable ecotourism of the Cetacean. The novelty is the development of a new paradigm of Marine-Geopark Cetacean management strategy for conservation and sustainable ecotourism. That is, the integration of coastal geo-morphological underwater sea mounts, ecological factors, local wisdom, social-economy, and sustainable generating income activities by the local community, as the first concept of scientific, community-based, and adaptive local wisdom policy will lead to an active participatory sustainable management plan. The study had implied progressively with four Governor Regulations of East Nusa Tenggara Province for the Cetacean sustainable resources management are Task-force Team for Integrated Coastal zonation and Management Plan, Diving spots-ecotourism, Co-management by stake-holders, and Development of Integrated and sustainable ecotourism

Keywords: Cetacean; whale; dugong; dolphin; management.

印度尼西亚东努沙登加拉省鲸类保护和可持续海洋生态旅游的适应性本地智慧管理

摘要：本研究旨在探究拉马勒拉、潘塔尔、阿洛、翁拜海峡、普拉岛、卡博拉海滩和东努沙登加拉萨武海热带海水中鲸类的分布、栖息地、轨迹和迁徙轨迹，并制定管理计划。实地探索调查发现了该地区的一些当地智慧，例如由一位年长的关键人物管理在阿洛尔卡博拉海滩以特定海草物种 Halophila ovalis 和 Enhalus acoroides 为食的儒艮，后来将其设为核心区并限制生态旅游。伦巴塔岛拉马勒拉海滩的传统捕鲸活动由一位当地年长的牧师控制，潘塔尔、阿洛和翁拜海峡的空间鲸鱼轨迹被设为限制区，并开发为赏鲸生态旅游。阿洛海峡吸引海豚和鲸鱼群的冷海水上升流现象被设为限制区并开发为生态旅游。海葵城是普拉岛火山海底山上方的一个特殊的珊瑚礁生态系统，被设定为核心区和有限的潜水生态旅游。焦点小组讨论的结果和考虑到这些特定的生态因素，利益相关者同意描述适应性的地方智慧，以发展鲸类的保护和可持续生态旅游。新颖之处在于开发了一种新的海洋地质公园鲸类保护和可持续生态旅游管理战略范式。也就是说，将沿海地貌海底山、生态因素、地方智慧、社会经济和当地社区的可持续创收活动结合起来，作为科学、以社区为基础和适应性的地方智慧政策的第一个概念，将导致积极参与的可持续管理计划。该研究逐步实施了东努沙登加拉省四项关于鲸类可持续资源管理的省长条例，包括综合沿海分区和管理计划工作组、生态旅游潜水点工作组、利益相关者共同管理工作组和综合可持续生态旅游发展工作组

关键词：鲸类；鲸鱼；儒艮；海豚；管理

1. Introduction

The waters of Indonesia are home to 31 species of cetaceans, including whales, dolphins, and the dugong (Dugong dugon), locally referred to as "duyung" [1]. These marine mammals are widely distributed throughout Indonesian waters, with dolphins and dugongs primarily inhabiting seagrass beds. In contrast, most whale species are long-distance migratory animals [2]. The eastern Indonesian waters serve as a significant migratory corridor for whales, connecting the Indian Ocean to the Pacific Ocean through Komodo Island (West Nusa Tenggara), Lembata (East Nusa Tenggara), the Banda Sea (Moluccas), and the regions of Southwest Sulawesi (Celebes), North Sulawesi, and Sorong-Fakfak

Papua [2, 3]. The world's marine scientists have increasingly focused on studying the migration patterns, distribution, and conservation of cetaceans [4, 5]. This heightened interest arises from the alarming decline in cetacean populations due to marine pollution and illegal fishing, necessitating urgent conservation actions [6-8]. According to data from the Indonesian Agency for Conservation of Natural Resources and Environment [9, 10], there are about 31 cetacean species, comprising 18 species of whales, 12 of dolphins, and 1 of dugong. These species primarily migrate and inhabit the Lembata-Lamalera, Alor, Ombai Strait and the Savu Sea on an annual basis, particularly during the east and west monsoon seasons. This condition has increased the importance of the Savu Sea as a critical area for cetacean conservation.

The main study area encompasses the Alor Strait, Flores, Pantar, Ombai Strait, Lamalera, Lembata and the Savu Sea in Indonesia. The whale population is considered trans-oceanic; hence, the focus of this resource management initiative will be on "whale-tracking" for sustainable ecotourism rather than whale hunting. Dolphins are a "regional migratory species" at Alor, Pantar, Flores and the Savu Sea, while the dugong is considered an endemic species inhabiting specific seagrass bed areas. The key outcome of this study is the development of cetacean management strategies based on spatial databases, oceanographic data, and bioecological variables. This research aims to conduct in-depth focus group discussions (FGDs) with multiple stakeholders to formulate the most suitable management strategies and policies for cetaceans in the Alor Strait, Pantar, Flores, Lembata and the Savu Sea, promoting sustainable marine ecotourism and contributing to sustainable development goals (SDGs). This will be achieved while fully considering the existing local wisdom and cultural practices of the community and village elders.

2. Materials and Methods

2.1. Data Collection

2.1.1. Field Observation of Species, Appearance, Behavior, and Habitat

Scientific methods for Cetacean observations were conducted by the field observation method, using a survey boat navigating along the coastal observation area at an average speed of 7-8 knots [5, 11-14]. The field time survey was conducted from 07:00 to 18:00 hours Central Indonesian Time (CIT). The research boat employed a zig-zag tracking method to estimate cetacean density while keeping glare from sunlight. The observer group, which consisted of four individuals, was positioned at the front deck and on the left, middle and right sides of the boat. Key field observation data included cetacean visual appearance time (VAT), GPS coordinates and date, all recorded in a logbook along the track. Supporting data comprised cetacean species, numbers, behaviors, and spatial bathymetry.

2.1.2 Tracking Cetaceans during the East and West Monsoon Seasons and Spatial Bathymetry

Spatial data processing was performed using ArcMap 10.3, SeaDas 7.3, and Er-Mapper software. Field coordinates for whale and dolphin appearances were recorded using a Garmin GPS. Seasonal tracks for whales and dolphins from 2018, 2019, and 2020 were overlaid on bathymetric data obtained from the General Bathymetric Chart of the Oceans [15] available at www.gebco.net. All satellite data acquisition and processing were carried out at the Laboratory of Marine Geomatic Center, Diponegoro University, Semarang, Indonesia. Whale and dolphin appearances were documented using a GoPro waterproof digital camera. Fish identification was performed using the FAO Species Identification Guide for Fishery Purposes [16].

2.1.3 FGD Forum Based on the Spatial Data

The development of management strategies for cetacean tracks in the Pantar Strait, Flores and the Savu Sea was conducted through FGD at the provincial level in East Nusa Tenggara in 2021, using a questionnaire and Zoom meetings. Participants included representatives from the BKKPN (National Marine Conservation Agency), the Branch Office of Marine and Fisheries of East Nusa Tenggara at Alor – KCD, Alor and East Flores; the Office of Tourism East Nusa Tenggara (ENT); the Legal Bureau Secretary Office of ENT; the Office of Research and Development of ENT; the Office of Environment; the Conservation Agency of ENT; the Secretary Office of Alor Regency; the Tourism Office of Alor Regency and WWF-Lesser Sunda, Local Community Development of Alor and Flores. The FGD focused on the management of cetacean tracks and all supporting databases compiled from earlier research. The management development plan was based on the existing conservation management plan, which was further developed for marine ecotourism using the specifically designed concept of 'Marine Geopark' for a sustainable cetacean management strategy. The principal FGD data included cetacean tracks, zonation, and the proposed management plan. Stakeholder responses were scored using a scale of 5 (fully agree), 3 (agree), and 1 (disagree), which were then calculated into three management plan options with three weight classes: ecosystem conservation (50%), socio-economic aspects (25%) and limited sustainable use of 25% [18]. The analysis employed the SWOT method [19-23] to develop the main management strategy, which was a comprehensive approach integrating all existing resources and earlier management systems. This research also considered the significant roles of local culture and inputs from village elders. The FGD results were communicated to all members of the local

community to encourage understanding, acceptance, and active participation, thereby fostering a fully community-based participatory sustainable management (CBPSM) approach, developed by, for, and with the community [17]. The SWOT analysis comprised Strength-Opportunity (S-O), Weakness-Opportunity (W-O), Strength-Threat (S-T), and Weakness-Threat (W-T). The main SWOT variables were

(1) Internal Factor Evaluation (IFE):

- a. Strengths, which comprised the existing conservation of the cetacean to be developed for the Cetacean Tracks sustainable management strategies in the new concept of 'Marine Geopark' [17];

- b. Weaknesses, which included all disadvantageous factors for the Cetacean Tracks sustainable management strategies in Alor, Flores, and the Savu Sea.

(2) External Factor Evaluation (EFE). According to [18], the SWOT analysis results yielded four strategic options: S-O, W-O, S-T, and W-T.

3. Results

3.1. Whale Species and their Visual Appearance

The whale species, locations, and visual appearance (VAT) during the east monsoon from May to October 2020 as in Figure 1 and during the west monsoon November 2020-April 2021 in Figure 2.

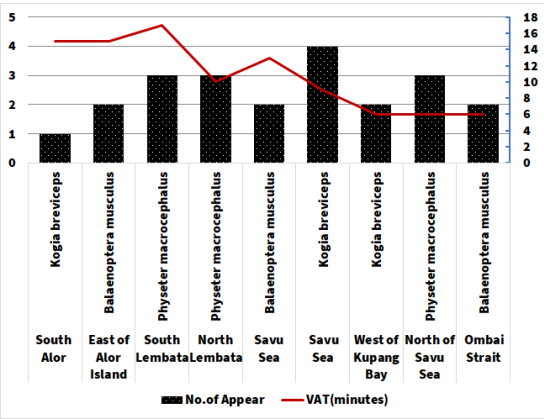

Figure 1. Whale locations, species, behavior and appearance during the east monsoon (May-October 2020). *Source: by the authors*

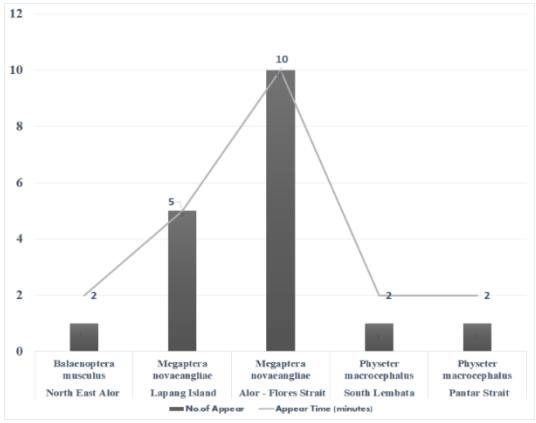

Figure 2. Whale species, locations, behaviors, and appearance during the western monsoon (November 2020–April 2021) *Source: by the authors*

Appearance spot is Pantar strait (between Alor and Pantar Islands), Flores, Lamalera Beach-Lembata Island, and the Savu Sea recorded three species of whales: three pygmy sperm whales (*Kogia breviceps*), six blue whales (*Balaenoptera musculus)* and 3 sperm whales (*Physeter macrocephalus*). The appearance ranged from six to nine times, with VAT ranging from 30 to 45 minutes (Figures 1, 2 and Table 1).

The sperm whale (*P. macrocephalus*) exhibited the highest appearance frequency, with nine sightings in the Savu Sea and the straits of Alor and Flores, whereas the blue whale *B. musculus,* with six sightings. The highest VAT was recorded for the blue whale (*B. musculus*), while the pygmy sperm whale *(K. breviceps)* had the lowest. The study identified four specific behaviors exhibited by *K. breviceps*, *B. musculus*, and *P. macrocephalus:* bobtailing, feeding, avoidance, and breaching (Figures 1, 2 and Table 1).

The field study conducted during the west monsoon from November 2020 to April 2021 in the same area recorded three *P. macrocephalus* and 15 humpback whales (*Megaptera novaeangliae*), with 5 appearances at the Alor-Flores Strait and the Savu Sea, and a VAT of 30 min. *P. macrocephalus* appeared thrice with a VAT of 9 min (Figures 2 and 3). The observed behaviors of these two species included logging, spy hopping, aerial displays, bobtailing, and feeding (Table 1).

Table 1. Whale location, species, behavior, and Number of Appearance (compiled by the authors)

Location	Species	Behavior	No	VAT (*minutes*)
South Alor	*Kogia breviceps*	Lobtailing, Feeding	1	15
East of Alor Island	*Balaenoptera musculus*	Lobtailing, Feeding	2	15
South Lembata	*Physeter macrocephalus*	Lobtailing, Avoidance	3	17
North Lembata	*Physeter macrocephalus*	Lobtailing, Feeding	3	10
Savu Sea	*Balaenoptera musculus*	Bobtailing	2	13
Savu Sea	*Kogia breviceps*	Lobtailing, Feeding	4	9
West of Kupang Bay	*Kogia breviceps*	Feeding	2	6
North of the Savu Sea	*Physeter macrocephalus*	Breaching	3	6
Ombai Strait	*Balaenoptera musculus*	Bobtailing	2	6

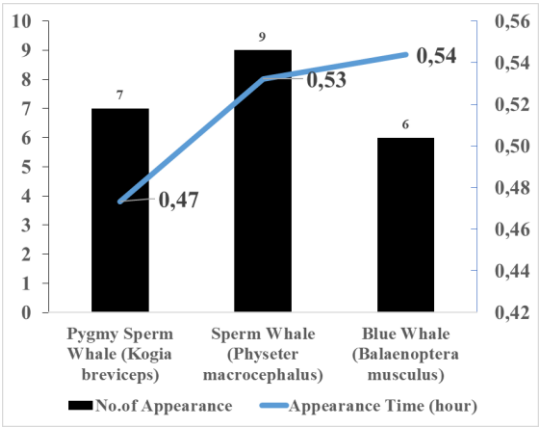

Figure 3. Whale species and VAT in the west monsoon (November 2020–April 2021) *Source: by the authors)*

3.2. Dolphin Species and Appearance

The field study during the east monsoon in the same area identified four species of dolphins: the spinner dolphin (*Stenella longirostris*), Risso's dolphin (*Grampus griseus*), bottlenose dolphin (*Tursiops truncatus*), and false killer whale (*Pseudorca crassidens*) (Figure 4).

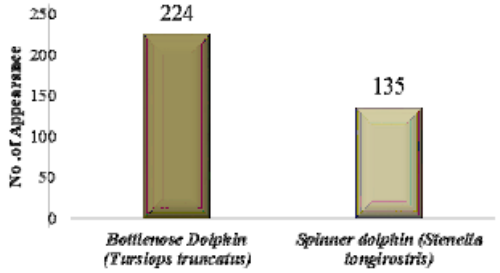

Figure 4. Dolphin species and number of appearances during the east monsoon (May-October 2020) *Source: by the authors*

The number of appearances ranged from 6 to 225 individuals. The bottlenose dolphin *(T. truncatus)* had the highest appearance frequency, with 225 individuals observed 19 times. In contrast, the false killer whale (*P. crassidens)* had the lowest appearance frequency, with 6 individuals observed twice and a VAT of 0.52 h (Figure 5).

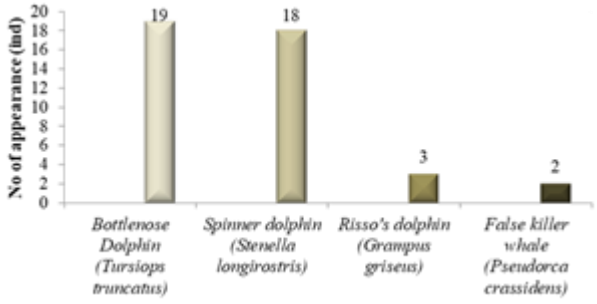

Figure 5. Dolphin species and number of appearances during the west monsoon (November 2020–April 2021) *Source: by the authors*

The longest VAT was recorded for the spinner dolphin (*S. longirostris*) at 2.27 h VAT and the lowest was for *Pseudorca crassidens* at 0.5 h VAT. Five types of behaviors were observed among the four species: bow riding, aerial displays, feeding, avoidance, and logging. During the west monsoon, two dolphin species were recorded: *S. longirostris* and *T. truncatus.* The highest individual appearance was again *T. truncatus* with 224 individuals observed 19 times and a VAT of 3 hours. The lowest was *S. longirostris* with 135 individuals, six appearances and a VAT of 1.1 h. The behaviors of these two species included bow riding, avoidance, aerial displays, and feeding (Figures 4 and 5). Only one dugong (*Dugong dugon*) habitat was found in Kabola Beach, Alor Island. The two main seagrass species constituting its primary diet are *Halophila ovalis* and *Enhalus acoroides*. The dugong and its habitat were voluntarily maintained by Mr. Onesimus Laa.

3.3. Spatial Track and Zonation

The spatial database of whale and dolphin tracks during the east and west monsoons is indicated in Figures 6 and 7, with a dominant south-north migration pattern.

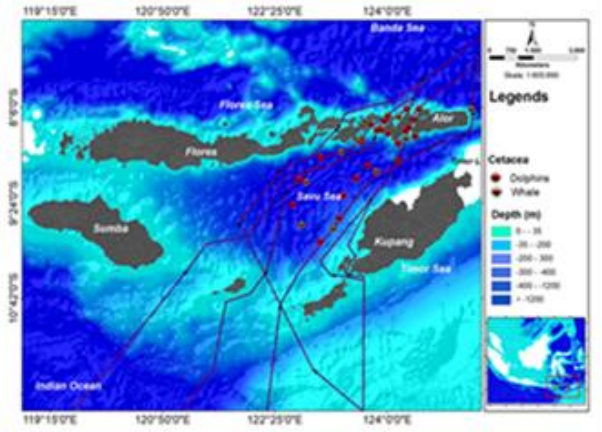

Figure 6. Whale and dolphin tracks during the east monsoon May-October 2020 *Source: by the authors*

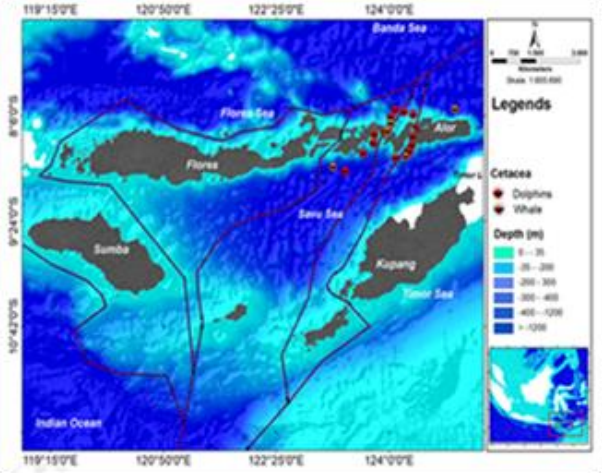

Figure 7. Whale and dolphin tracks during the west monsoon November 2020–April 2021 *Source: by the authors*

3.4. Results of the Focus Group Discussion

Participants in the FGD included representatives from local fishermen in Alor Kecil, the local elder caretaker of dugong conservation, village elders from Lamalera, the Planning Office (BAPPEDA) of ENT, the National Marine Conservation Bureau-BKKPN Kupang, the Legal Office of the Government of ENT, the Conservation Section of the Marine and Fisheries Office, the Branch Office of Marine and Fisheries of ENT at Alor - KCD-Alor, the KCD Flores, the Office of Tourism Alor Regency, the Office of Environment Alor Regency, the Kupang Marine Police, the Search and Rescue Office-BASARNAS of ENT, the Office of Transport ENT, the Navy Post at ENT, the Dean of the Faculty of Fisheries UNTRIB Kalabahi-Alor, the Marine and Fisheries Office Alor Regency, local community NGOs, diving operator clubs, the Indonesian Tourism and Creative Economy Office, the World Wildlife Fund for Nature Research (WWF) at Solor-Alor, and MALLA Tours. The results of the FGD for the Lembata-Lamalera, Savu Sea, Pantar and Alor Marine Protected Area (MPA). The four agreements from the FGD results are as follows: (a). Protection of cetacean species and habitats in the ENT, (b) protection of the natural ecosystem and feeding habits of cetaceans in the ENT, (c) protection of the migration routes and tracks of cetaceans in the ENT and (d) development of eco-friendly marine tourism for cetaceans in the ENT, a sustainable management strategy based on the new concept of 'Marine Geopark'. Further discussions were held regarding these four agreements to ensure that strategy data processing could be carried out with a SWOT analysis to derive a suitable management strategy. Each SWOT indicator was compiled into a matrix reflecting the decisions and agreements reached during the interviews and FGDs, as shown in Tables 2, 3, and 4. Results of the SWOT Diagram Analysis of Cetacean Management Strategies in the Savu Sea and Flores Alor Strait are presented in Figure 8.

Table 2. Matrix of strength and weakness in the FGD points of interest and agreements (compiled by the authors)

Strengths-S
1. Cetacean Tracks for Whale-Watching Ecotourism in the Savu Sea, Lamalera Beach-Lembata Island, Ombai Strait
2. Dolphins' appearance during the cold-seawater upwelling phenomena at the Alor Strait
3. *Dugong dugon* feeding area, in the seagrass bed of Kabola beach, already self-local wisdom awareness and voluntarily managed by local elders
4. Optimalization of the diving and snorkeling spots at Pura Island Alor Strait
5. Optimalization of the potential of inshore fish resources: tuna, skipjack
6. The potential and innovation of fish products such as 'Sei-Tuna' or smoked dried fish; the use of mangrove pigment for natural dye printing garments
Weaknesses-W
1. Need transformation of traditional whale-hunting to be a whale-watching ecotourism, Need trained local guides
2. Very limited spatial database to be used in the current management plan and actions
3. Need to develop seagrass rehabilitation and replantation with the involvement of tourists. Need trained local guides
4. The role of the community in carrying out conservation has not yet proceeded
5. The fishing method that has not been environmentally friendly using bombs and potassium; Need adjustment and Law enforcement on Minister of Marine Affairs and Fisheries Regulation No. 1 of 2014 Management of Coastal Areas and No. 31 of 2020;
6. Inadequate facilities in the surrounding coastal and marine areas to support tourism;

Table 3. Matrix of opportunities and threats in the FGD points of interest and agreements

Opportunities-O
1. The Cetacean track can be developed into a Cetacean observation tour; in the east and west monsoons.
2. Cetaceans as an issue for managing and zoning for sustainable management;
3. Government policy on the management of Cetacean tracks adapted to the Minister of Forestry Regulation No. 32 of 2020 concerning Spatial Planning;
4. Zoning determination and revision for tourism development;
5. Use of the Area as a Center of Excellence (COE) such as dugong habitat to develop seagrass replantation package by incoming tourists to ensure sufficient feeding for dugong
6. Can be developed as a center for studies and in situ Cetacean captivity by academics and the wider community;
7. Improving the community economy through the Cetacean track tourism sector.

Table 4. Matrix of IFAS and EFAS (compiled by the authors)

Indicator	X	Y	Value	Rating
Strengths vs Opportunities	0.28	0.32	0.60	1
Weaknesses vs Opportunities	0.00	0.32	0.32	2
Weaknesses vs Threats	0.00	0.16	0.16	4
Strengths vs Threats	0.28	0.16	0.44	3

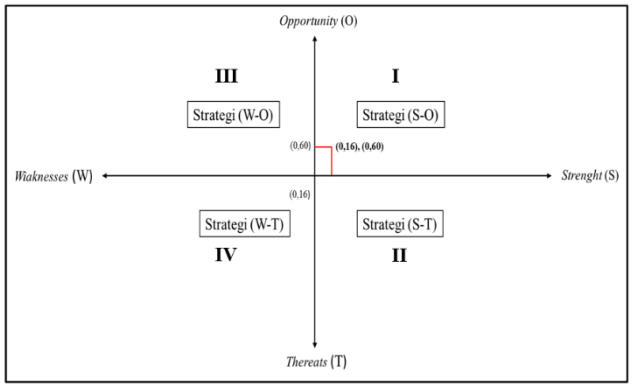

Figure 8. Results of the SWOT diagram analysis of cetacean track management strategies in the Savu Sea and Flores Alor Strait *Source: by the authors*

3.5. Management Strategy and SWOT

The management strategy, developed in collaboration with all relevant stakeholders, including the ENT Government, academics, community members, NGOs, environmentalists, environmental observers, community leaders, and village elders, considers local culture and customs in managing cetaceans in the Savu Sea-Flores Alor Strait within a 12 nautical mile area based on SWOT analysis, as illustrated in Figure 8. The study identified several important ecological phenomena, such as the specific seagrass feeding habitat of Dugong dugon at Kabola Beach Alor, managed through local wisdom by key elders. This area is designated as a nucleus and a limited-use zone for ecotourism. Traditional whale hunting at Lembata-Lamalera Beach should be regulated by local priests, and the whale track spatial data in Pantar, Alor and Ombai Strait designated as buffered limited-use zones should be developed into a 'whale-watching' ecotourism package. The cold seawater upwelling phenomenon attracts dolphins and whales in the Alor Strait, which is set for limited ecotourism use.

The discovery of the 'anemone city,' a unique coral reef ecosystem located above the volcanic underwater seamount at Pura Island, is designated for nucleus and limited diving ecotourism use. The results of the FGD with stakeholders, considering the existing ecological factors and local wisdom, have led to the formulation and optimal development of conservation sustainable ecotourism strategies for cetaceans. The strategy option is indicated in quadrant-I with the strength-opportunity (S-O) option, as shown in Table 4 and Figure 8.

4. Discussion

4.1. Management Strategy for Cetacean Tracks for Conservation and Sustainable Marine Ecotourism with the New Concept of Marine Geopark

The field survey results revealed that sightings of both whales and dolphins vary by species, location, and season [24] and estimated the mean of dolphin sightings at Shaab El-Erg at an average of 5.1±4.9 individuals per day. Therefore, the main discussion for formulating the cetacean management plan in the Savu Sea, based on the FGD results and SWOT analysis, focuses on the following cetacean eco-biology data: species, season, tracks, feeding habits and sightings. The collective agreement resulted in six indicators of Strength (Strength-S), six of Weaknesses (Weaknesses-W), seven of Opportunities (Opportunities-O), and five indicators of Threats (Threats-T). Scoring was done on each of these indicators to analyze the IFAS and EFAS strategies through weighting. The results of the IFAS and EFAS strategy analyses are presented in Table 3. The matrix of internal and external (IE) factors combines sectors from the IFAS and EFAS to determine the position or cell quadrant of the existing problems [18-21]. This was achieved by calculating the IFAS and EFAS matrices. Based on the IFAS and EFAS matrices in Table 4, the highest value is found in the Strengths-Opportunities quadrant, with a value of 0.60 and a rating of 1. The lowest value is in the Weaknesses-Threats quadrant, with a value of 0.16 and a rating of 4. This indicates that the strengths and opportunities in managing cetacean tracks outweigh the weaknesses and threats.

According to the SWOT analysis and IFAS factor matrix, the main strength of this issue is the indicator of the area of cetacean tracks and feeding habitats. Conversely, the weakness is the lack of capable and well-trained local human resources. Based on the EFAS analysis, the primary opportunity indicator is the zoning determination and strengthening for tourism development, using cetacean tracks and feeding habitats as a Center of Excellence Zone (COEZ). The main threat indicator is changes in oceanographic factors and uncontrolled whale hunting in Lamalera Beach, Lembata and Alor Island. [20] assessed the indicator values in the IFAS and EFAS matrix analyzed through SWOT, indicating that when one indicator value surpasses all others, it is highly influential and should be prioritized for sustainable management. Considering all indicator values of strengths, weaknesses, opportunities, and threats, those with the highest value are accorded priority for sustainable management and conservation, focusing on developing strength-opportunity options, which hold the highest value of 0.6 and a rating of 1. In this context, local governments should pay greater attention to strategies aimed at addressing weaknesses and threats in management. Commitment to collaborative and sustainable management in the Savu Sea and Alor Strait, Flores, ENT, is essential to overcome any weaknesses and threats. The SWOT diagram analysis related to the position for cetacean tracks management strategy in the Savu Sea and Flores-Alor straits is displayed in Figure 8. The quadrant mapping results in Figure 8 indicate that the Cetacean track management strategy in the Savu Sea and Flores-Alor Strait has strong and weak points against existing

threats and weaknesses, concerning bioecological and oceanographic aspects. The internal and external positions in quadrant-I necessitate a progressive growth-oriented strategy (GOS). Earlier studies [19, 21, 24, 25] asserted that a progressive strategy is the most beneficial option. The local government possesses internal opportunities and strengths, enabling it to leverage these opportunities while minimizing the weaknesses and threats in the management strategy. More specifically, the progressive strategy in quadrant I (Figure 8) requires government involvement through relevant agencies (BKKPN Kupang and DKP East Nusa Tenggara Province) and the community. They should actively support the sustainable integration of cetacean track management in the waters of the Savu Sea and the Flores-Alor Strait. The recommended strategy of progressive approach means that the Savu Sea and Flores Alor Strait, with their geographical position and potential for cetacean passages, have the opportunity options for sustainable integration of cetacean track management. Further, by leveraging all strengths and opportunities while minimizing weaknesses and threats in the management of cetacean tracks, its sustainability can hopefully be used as tourism potential so that residents can use this potential as a source of income. The Provincial Government of East Nusa Tenggara, the Office of Marine and Fisheries, Kupang National Water Conservation Area-BKKPN and all relevant stakeholders are currently running every program, especially the management of cetacean passages in the Savu Sea and Alor-Flores Strait. This program should be implemented effectively with respect to habitat conservation and protection of cetacean tracks. However, optimal implementation in terms of conservation and rehabilitation will require the empowerment of local communities residing in cetacean track areas. The alternative formulation for coastal managers or the Marine and Fisheries Office regarding cetacean track utilization strategies in the Savu Sea and Flores-Alor Strait necessitates several approaches to ensure the actual program runs optimally, considering the strengths, weaknesses, opportunities and threats to the aquatic environment as cetacean tracks, as well as socio-economic conditions and community development program. The results of the SWOT analysis, as stated by [26-28], indicate that a progressive strategy formulation for managing an environment with dynamic characteristics is unpredictable, as environmental factors involve complex interaction problems caused by the differing interests of various parties. Moreover, humans tend to exploit the environment as a resource provider, leading to management challenges due to ongoing demands and changes. The strategic options derived from the SWOT matrix analysis were compiled into four groups: S-O, W-O, S-T, and W-T strategies, as follows.

4.2 The S-O (Strengths-Opportunities) strategies

The cetacean track in the waters of the Savu Sea and the Flores-Alor Strait represents a significant potential for development as a national and international tourism destination. This cetacean track is poised to become a leading tourist attraction for the region, enhancing the economy of coastal communities, particularly the locals. If this tourism program is developed and promoted on an international scale, it could emerge as a premier new destination in Indonesian waters, especially in East Nusa Tenggara, thereby supporting the local economy of coastal communities residing in the Cetacean tracks area. It is essential for the management and zoning determination, particularly in the waters of East Flores and Alor, to ensure the conservation of cetacean tracks for sustainable purposes. Currently, the East Flores and Alor District Water Conservation Areas (KKPD) have not included cetacean protection in their zoning plans for coastal areas and small island management (RZWP3K). Currently, the local government is revising both areas to incorporate cetacean tracks into the protection and sustainable tourism zone, as per Minister of Marine Affairs and Fisheries Regulation Number 31 of 2020 dated 22 September 2020 regarding the Management Plan and Zoning of Marine Protected Areas. Protecting the track zone of cetacean species and other marine mammals, including their habitats and oceanographic parameters such as upwelling 0.000079 m. s^{-1}, downwelling 0.000025 m. s^{-1}, current, and chlorophyll-a 0.67 $mg.m^{-3}$ [6,9] is crucial. This is essential, particularly in the waters of the Flores-Alor Strait, where hunting activities for marine mammals, especially whales, were historically prevalent in several locations like Lamalera and Pantar Island. Therefore, careful planning is required to protect marine mammals. One strategy to improve the mindset of coastal communities, particularly fishermen, requires equal socialization and training for the development of alternative employment opportunities to reduce hunting activities for marine mammals, especially whales and dolphins.

4.3. Socialization and Establishment of Collaborative Institutions for Cetacean Track Management Maintaining the status of the conservation area as a habitat for cetaceans and other marine mammals, which often have extensive migratory patterns, is challenging and necessitates the establishment of robust strategic zones, alongside comprehensive aquatic environmental data. This is particularly relevant due to the seasonal migration and the need for suitable aquatic environments for cetaceans. Thus, a key strategy involves collaboration with stakeholders from the government, universities, NGOs, environmentalists, and the community to facilitate joint efforts in sustainable management. Protecting the feeding habitats of marine mammals (cetaceans) and

their ecosystems within the cetacean track is vital. The protection strategy for the food chain requires in-depth identification of the characteristics of the protection and its ecological functions. Specifically, based on each species and type of food, conservation areas at the ecosystem level necessitate a large protection mechanism for cetacean species to access food sources. Therefore, identifying the natural diet of whales and dolphins, such as small shrimp, small fish, and squid, is essential for their protection. Dugong dugon Species Conservation. The study identified one dugong species currently residing in the Kabola waters of Alor, known for its friendly disposition toward humans, making it a popular tourist attraction. This significantly impacts the sustainability of the species, necessitating its inclusion in a comprehensive protection or conservation zone to ensure its long-term viability.

4.4. S-T (Strengths and Threats) Strategies.

Global climate change poses a significant threat to cetacean tracks, necessitating careful consideration in management decisions. Specifically, collaboration among domestic, foreign and NGO researchers is essential to predict cetacean tracks from the Savu Sea to the Flores-Alor Strait for sustainability. The dissemination of laws and regulations regarding the conservation of marine mammals, particularly cetaceans, is crucial. Strategies to mitigate threats to whale and dolphin fishing in the waters of East Flores and Alor are necessary due to a lack of awareness regarding laws and regulations governing marine mammal species, especially protected cetaceans. The strategy for this socialization should incorporate local cultural elements, which can aid significantly in reducing whale and dolphin hunting in East Flores, particularly in Lamalera, Lamakera and Pantar Island, Alor. Human resource development in cetacean track management is essential. Community empowerment programs and socialization regarding the management and protection of marine mammal species should be directed toward local communities residing around cetacean tracks in the Savu Sea and Flores-Alor Strait.

4.5. W-O (Weaknesses-Opportunities) Strategies

Improvements in management and utilization strategies for cetacean tracks are necessary, such as developing tourist destinations for whale and dolphin observation and using areas as COEZ. Additionally, establishing research centers can contribute economically and provide data for the sustainable management of cetacean tracks in the Savu and Flores-Alor straits. Determination and revision of zoning for cetacean tourism development within cetacean tracks are crucial. Revising the existing zonation, particularly within the 12-mile limit included in the provincial area according to Law No. 23 of 2014 regarding local governments, will facilitate the management and development of a whale observatory area. This strategy will have a significant economic impact on the coastal communities residing in the area. Uncontrolled fishing of whales and dolphins in the waters of Lamalera and Alor, particularly within cetacean tracks, is a pressing concern. Conducting an annual whale and dolphin catching festival using buoys designed to resemble whales and dolphins, as per local customs, in the waters of Lamalera, Lamakera and Alor can educate local communities and incoming tourists about whale and dolphin hunting activities that may pose the threat of species extinction in these waters. This festival can be promoted as a new destination, attracting local, national, and international visitors annually to witness this symbolic whaling attraction, thereby improving the economy of coastal residents through accommodation and culinary businesses.

4.6. W-T (Weaknesses-Threats) Strategies

The cetacean tracks are used as a location for the uncontrolled fishing of whales and dolphins in the waters of Lamalera and Alor. Previous uncontrolled whale and dolphin hunting in the Lamalera, Lamakera, and Alor seawaters has occurred due to suboptimal management, particularly concerning law enforcement under species conservation legislation. Therefore, collaboration with local cultural approaches is essential for managing and raising awareness about the importance of species conservation, particularly for dolphins and whales, within the sustainability program. Community involvement in managing cetacean tracks has been initiated but not yet optimized [29]. Community activities that are not environmentally friendly, such as using explosives and potassium for fishing, pose significant threats and weaknesses that can lead to habitat destruction. A strategic approach grounded in local culture, informed by conservation laws, is needed to socialize and educate the locals about environmentally friendly fishing practices and activities for sustainable cetacean resource management.

5. Conclusion

This initial approach of community-based participatory sustainable management (CBPSM) and adaptive local wisdom-based policy for management planning. It advocates for a transition from traditional whale hunting to whale-tracking ecotourism. The conservation of dugongs and their seagrass habitats is integral to sustainable marine ecotourism. Specific oceanographic phenomena, such as cold seawater upwelling and dolphin schools, should be promoted as dolphin-watching ecotourism packages. Additionally, the unique coral reef zone, referred to as the “anemone city,” situated above an underwater volcanic rock slope, is designated for nucleus conservation and limited

ecotourism. All specific habitats, oceanographic phenomena and non-extractive marine resource approaches have been integrated into the development of a new concept of 'Marine Geopark' management planning. All-inclusive points mutually agreed upon by stakeholders in the FGD forum are positively supported by the adaptive local wisdom of respected local elders, which progressively supported with the new Governor Regulations are recommended for further study, approach and applied in the related case.

Declarations

Author Contributions

Conceptualization, A.H., and J.F.M.; methodology, J.F.M.; software, spatial data, J.F.M., and M.H.; validation, A.H., M.R.M., and M.H.; formal analysis, economic review, M.Y.A.; investigation, ecotourism E.J.J.A.; resources, regulation, law, R.A.A.; data curation, R.A.A., and S.S.; writing-original draft preparation, J.F.M., and M.R.M.; writing-review and editing, M.R.M., and S.S.; visualization, J.F.M., and M.H.; supervision, A.H.; project administration, S.S.; funding acquisition, A.H. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data presented in this study are available on request due to restrictions, privacy or ethical issues from the corresponding author. The data are not publicly available due to a Team collaboration group of the related stakeholders.

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Informed Consent Statement

Ethical review and approval were waived for this study due to Reason (The study does not involve humans or animals directly).

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and falsification, double publication and submission, and redundancies have been completely observed by the authors.

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Appendix A

The field Cetacean observation is using a survey boat with focus on the Cetacean appearances, time and behavior.

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Disclaimer/Publisher’s Note:
The whole case presented in this study is based on the conditions of the tropical area and may differ in other areas and oceanographic conditions.
This study is based on the field survey and observations of the Cetacean’s track to be developed for the sustainable eco-tourism and not being extracting directly on the Cetacean resources.