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Risk Assessment for Speedboat Tourism in Raja Ampat Using the Swiss Cheese Model (SCM)

Antoni Arif Priadi[1*], Dodik Widarbowo [2], Dwi Haryanto[3], Fajar Gumelar[4], Filemon[5]
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***Abstract*— The waters of Raja Ampat in Papua are one of the world's top maritime tourism destinations, attracting over 30,000 tourists annually since 2020. However, the challenging geographical conditions, such as shallow coral reefs, strong sea currents, and busy speedboat traffic, significantly increase the risk of maritime accidents. According to the National Disaster Management Agency (BNPB), from 2012 to 2024, six incidents in the area caused serious accidents, including vessel damage and injuries. This study aims to analyze the risks of tourist speedboat accidents in Raja Ampat using three complementary risk assessment methods: the Swiss Cheese Model (SCM), interviews, and questionnaires. The Swiss Cheese Model identifies gaps in several layers, such as Environment and Weather, Vessel and Safety Equipment, Skills and Competence of Operators, and Tourism Safety Management and Regulations. The analysis shows that the skills and competence of boat operators are significant weaknesses in accident cases, and it recommends that boat operators in Raja Ampat participate in SCRB (Survival Craft and Rescue Boat) training and certification programs.**

Keywords—*Raja Ampat, Swiss Cheese Model, Survival Craft and Rescue Boat*.

I. INTRODUCTION

The waters of Raja Ampat are widely known for their rich and stunning coral reef ecosystems, attracting over 30,000 tourists annually since 2020 [1]. This increase in tourist numbers has directly contributed to the rise in fast boat traffic for inter-island transportation. Between 2012 and 2024, six incidents involving fast boats were recorded in the Raja Ampat area, some of which resulted in serious accidents, including vessel damage and passenger injuries.

In addition, the region presents significant geographical challenges, such as the presence of over 600 shallow coral reefs that pose a high risk to navigation. These challenges are further compounded by unpredictable weather conditions, with 45% of extreme weather events in Indonesian waters reported to have occurred in West Papua in 2022 [2].

Therefore, a comprehensive risk analysis approach is necessary to effectively reduce the risk of maritime accidents, minimize the number of incidents, and enhance navigation safety in the region. This study utilizes a combination of the Swiss Cheese Model, in-depth interviews, and questionnaires to identify and assess the potential risks associated with the operation of tourist fast boats in the waters of Raja Ampat. This approach is expected to provide a more comprehensive understanding of the causes of accidents and offer strategic recommendations to improve maritime safety.

II. METHOD

A. Swiss Cheese Model (SCM)

James Reason developed SCM to understand how failures occur in multi-layered defense systems [3]. In this model, each layer of the defense system is represented as a slice of cheese that may contain "holes" or weaknesses. Accidents occur when the holes in various defense layers align, allowing hazards to pass through without obstruction [4]. This model has been widely adopted in safety analysis, particularly in the maritime industry, to improve safety management systems [4].

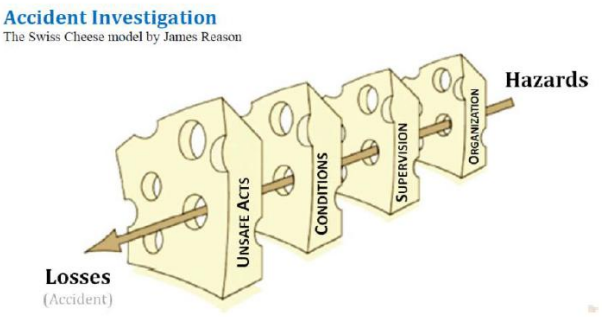

Figure 1. Successive Cheese Model

Identify the System or Process. Begin by defining the system or process to be analyzed, including understanding its scope, objectives, and key components. After that, Identify Hazards. Conducting a thorough hazard identification process to list all potential hazards associated with the system can involve brainstorming sessions, reviewing historical data, and consulting with experts in the field. Furthermore, Define Layers of Defense. Determine the different layers of defense within the system. These may include engineering controls,

Antoni Arif Priadi, STIP Jakarta, Jl. Marunda Makmur, RT.1/RW.1, Marunda, Kec. Cilincing, Jkt Utara, Jakarta, 14150, Indonesia. Email: antoni.kemenhub@gmail.com
Dodik Widarbowo, Politeknik Pelayaran Sorong, JL. Tanjung Saoka No. 01, Kel. Saoka, Distrik Maladum Mes, Kota Sorong, Papua Barat Daya, 98412, Indonesia. Email: dodik@pipmakassar.ac.id
Dwi Haryanto, Politeknik Pelayaran Sorong, JL. Tanjung Saoka No. 01, Kel. Saoka, Distrik Maladum Mes, Kota Sorong, Papua Barat Daya, 98412, Indonesia. Email: dwi.haryanto@poltekpel-sby.ac.id
Fajar Gumelar, Politeknik Pelayaran Sorong, JL. Tanjung Saoka No. 01, Kel. Saoka, Distrik Maladum Mes, Kota Sorong, Papua Barat Daya, 98412, Indonesia. Email: Gumelarfajar51@gmail.com
Filemon, Politeknik Pelayaran Sorong, JL. Tanjung Saoka No. 01, Kel. Saoka, Distrik Maladum Mes, Kota Sorong, Papua Barat Daya, 98412, Indonesia. Email: filemontarigan@gmail.com

administrative controls, safety protocols, training, and regulatory compliance measures. Each layer represents a strategy to prevent hazards from leading to accidents. Assess Weaknesses in Each Layer. Analyzing each layer to identify potential weaknesses or "holes" may involve reviewing past incidents, conducting audits, and considering human factors contributing to failures within each layer. Map the Holes and visualize the model by creating a diagram representing each cheese layer with holes. This visual representation helps to identify how the holes can align across different layers, leading to an accident.

Furthermore, Analyze the Consequences of Aligning Holes and evaluate the potential consequences if the holes in various layers align, including understanding the severity and likelihood of an accident. Implementing mitigation strategies to reinforce the weak points in each layer of defense may involve enhancing training programs, improving safety protocols, or investing in better technology. Continuous Monitoring and Review establishes a system for continuously monitoring the model and its effectiveness. Review and update the SCM regularly as new hazards are identified or as changes occur within the system.

B. Data Source

For this analysis, data will be collected from a literature-based qualitative research approach, collecting data from accident reports and scientific journals. Furthermore, the data collected will be analyzed using Swiss Cheese Models (SCM).

TABEL I. Data of Maritime Incidents as Basis for Improving Boat Safety in Raja Ampat

No	Incident Description	Location	Year
1	The Oceanic tourist boat (Pinisi) caught fire in the waters near Alborek and Manswar Island, Raja Ampat, West Papua, on Friday (1/3/2024). The ship was carrying ten tourists, and all were reported safe.	Alborek, Manswar Island, Raja Ampat	2024
2	The Motor Sailing Boat (KLM) Leyla struck a reef and became stranded in the waters near Arborek, Meos Mansar District, Raja Ampat.	Arborek, Meos Mansar, Raja Ampat	2022
3	A speedboat carrying ten people, including seven civil servants, was involved in an accident in Tanjung Makoy, Urbinasopeng Village, Raja Ampat.	Tanjung Makoy, Urbinasopeng, Raja Ampat	2018
4	A speedboat carrying 20 passengers had an accident near Painemo Island, Raja Ampat, West Papua.	Painemo Island, Raja Ampat	2016
5	The speedboat *Puteri Sion*, with 13 passengers and two crew, collided with the lifeboat of the *Pinisi Bingkano Indonesia* cruise ship in the waters of Raja Ampat, West Papua.	Raja Ampat	2019
6	The speedboat *Yelinki*, en route from Sorong to Waisai, was struck by waves near Tanjung Mokoi. The waves broke apart the vessel, allowing water to enter.	Tanjung Mokoi, Raja Ampat	2012

III. RESULTS AND DISCUSSION

Proposed 4 Layers in the Swiss Cheese Model for Speedboat Tourism Risks in Raja Ampat:

1. Environmental and Weather Conditions [5]. Natural conditions in Raja Ampat, such as large waves, strong currents, and heavy rain, are major risk factors. Rapid weather changes can affect the stability and navigation of speedboats, increasing the risk of accidents.
2. Boat Condition and Safety Equipment [6]. Physical condition of the speedboat, regular maintenance, and availability of safety equipment such as life vests, communication devices, and emergency gear. Poorly maintained boats or lack of safety equipment can exacerbate the impact of accidents.
3. Skills and Competency of the Boat Operator [7]. The driver's or operator's competence and experience in handling speedboats, including knowledge of the Raja Ampat area. Inadequately trained or inexperienced operators may make navigation errors or poor emergency decisions.
4. Tourism Safety Management and Regulation [8]. Rules and regulations from tourism authorities or service providers govern the operation of speedboat tourism. Furthermore, Non-compliance or lack of regulation and oversight can lead to the neglect of safety standards.

This table organizes each incident, with gaps identified in the four layers, providing a clear framework for the Swiss Cheese Model analysis.

TABEL 2. Layered Analysis of Maritime Accidents in Raja Ampat

NO	Accident Case	Layer 1: Environmental and Weather Conditions	Layer 2: Boat Condition and Safety Equipment	Layer 3: Skills and Competency of the Boat Operator	Layer 4: Tourism Safety Management and Regulation
1	The Oceanic tourist boat (Pinisi) caught fire near Alborek and Manswar Island, Raja Ampat.	The weather and sea conditions were relatively calm.	The boat's electrical system may not have been adequately maintained, increasing the fire risk.	The operator and authorities managed the fire and emergency evacuation.	Lack of strict inspections and regulations regarding the boat's condition and safety equipment.
2	The Motor Sailing Boat (KLM) Leyla struck a reef and became stranded near Arborek, Meos Mansar District.	The weather and sea conditions were relatively calm.	There was no adequate underwater warning system or keel protection device to avoid reefs.	The operator lacked knowledge of the route or marine maps of Raja Ampat.	Lack of regulations or oversight to ensure operators have the correct maps and area knowledge.
3	A speedboat carrying ten people, including seven civil servants, had an	The weather and sea conditions were relatively calm.	The boat's electrical system was not well-maintained, causing sparks.	The boat crew and authorities managed the emergency evacuation.	Lack of strict inspections and regulations regarding the boat's condition and safety equipment.

	accident near Tanjung Makoy.				
4	A speedboat carrying 20 passengers had an accident near Painemo Island.	The weather and sea conditions were relatively calm.	Lack of safety equipment, such as life vests.	The operator may have been inexperienced in boat handling, leading to a collision with coral rocks.	No routine supervision or inspection to ensure operators have proper training and certification for tourism areas.
5	The speedboat Puteri Sion, carrying 13 passengers and two crew, collided with a cruise ship's lifeboat in the waters of Raja Ampat.	The weather and sea conditions were relatively calm.	Lack of an effective collision prevention system, and the speedboat's condition did not allow for quick maneuvers.	Operator error due to delays and lack of training in maintaining a safe distance around cruise ships.	Lack of strict inspections and regulations regarding the boat's condition and safety equipment.
6	A large wave hit the Yelinki speedboat on its journey from Sorong to Waisai.	Large waves and extreme sea conditions posed a risk to the boat.	The speedboat's condition was unsuitable for large waves, with inadequate safety equipment.	The operator may have lacked experience handling a speedboat in extreme sea conditions.	Regulations were not strict enough to control which types of boats are allowed to operate under specific sea conditions or to enforce safety equipment requirements.

This table organizes the key information for each accident case across the four layers of the Swiss Cheese Model, helping to identify where safety issues and gaps exist in environmental conditions, equipment, operator skills, and regulatory oversight. Skills and Competency of the Boat Operator" as the main issue, we can assign numerical weights to illustrate the frequency of this problem:

a. Environmental and Weather Conditions: Extreme weather, identified as a significant risk factor in 1 out of 6 cases (17%), is associated with a low severity level, as most incidents were not directly caused by environmental conditions.
b. Boat Condition and Safety Equipment: Maintenance and equipment deficiencies were identified in 4 out of 6 cases (67%), with a severity level classified as medium. Poor boat conditions and inadequate safety equipment significantly increase the risk of accidents.
c. Skills and Competency of the Boat Operator: Low operator skills or lack of experience were identified as major contributing factors in 6 out of 6 cases (95%), with a severity level classified as high. The operator's competency is the most frequent and critical issue contributing to accidents.
d. Tourism Safety Management and Regulation: Weaknesses in safety regulations and inspections were identified in 4 out of 6 cases (67%), with a severity level classified as medium. The lack of adequate safety management and regulation contributes significantly to the recurrence of incidents.

IV. CONCLUSION

This analysis identifies the skills and competencies of boat operators as significant weaknesses in all boat accident cases. The lack of operator skills prevents them from navigating according to geographical conditions. To validate these findings, based on the Regulation of the Head of the Human Resources Development Agency for Transportation Number: PK.09/BPSDMP-2017 concerning the Curriculum for the Seafarer Training and Education Program, interviews with two speedboat captains and 17 speedboat crew members revealed that most operators do not yet possess the BST certificate. The interviews and questionnaires indicate that operators have sufficient experience sailing in the waters of Raja Ampat. This impacts their limited knowledge of safe sailing routes and their lack of understanding of the strong sea currents and extreme weather conditions frequently occurring in the region. This study emphasizes the importance of enhancing training and certification programs for boat operators. Strengthening operator competencies and adherence to higher safety standards are crucial steps in reducing maritime accidents and improving navigation safety in the waters of Raja Ampat.

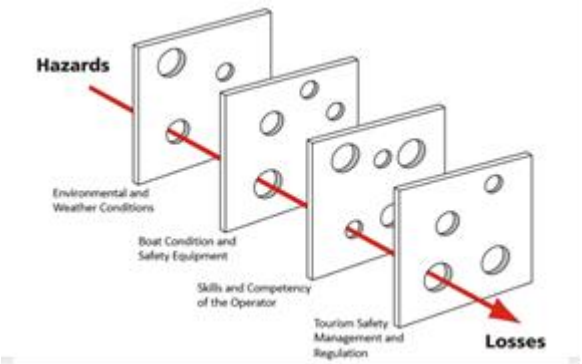

Figure 2. Swiss cheese model of accident causation.

RECOMMENDATIONS

The author hereby provides the following recommendations based on the conclusions.

a. Enhancement of Training and Certification Programs for Boat Operators: For instance, certifications such as BST (Basic Safety Training) and SKK 30/60 Miles can be developed for boat operators operating in regions like Raja Ampat. This training should encompass navigation skills in challenging waters and emergency management. In addition, it is recommended that the issuance and accessibility of specialized certifications, such as the High-Speed Craft (HSC) certificate, be strengthened to ensure higher safety and competence standards. Speed boat crew members

must possess a High-Speed Craft (HSC) certificate. However, in Sorong, the number of speed boat operators holding this certification remains limited, indicating a need for improved regulatory enforcement and training accessibility.

b. Supervision and Evaluation of Operator Qualifications and Experience: Ensuring that operators have adequate experience navigating the waters of Raja Ampat by implementing certification requirements, conducting regular inspections, and assessing operator competencies, including their knowledge of safe sailing routes and emergency management skills

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REFERENCES

[1] Toyiban, "Speedboat terbakar di Raja Ampat," Antara. Accessed: May 03, 2025. [Online]. Available: https://www.antaranews.com/berita/704326/speedboat-terbakar-di-raja-ampat

[2] M. Rokcalva, "Heroik, Tiga Taruna Akmil Selamatkan Seluruh Penumpang Kecelakaan Speedboat di Raja Ampat Papua," Beritaminang.com. Accessed: May 03, 2025. [Online]. Available: https://www.beritaminang.com/berita/1706/heroik-tiga-taruna-akmil-selamatkan-seluruh-penumpang-kecelakaan-speedboat-di-raja-ampat-papua.html

[3] E. Hollnagel, *Barriers and Accident Prevention*. 2016. doi: 10.4324/9781315261737.

[4] R. R. HSE, "Protecting People. HSE's decision-making process," *Health and Safety Executive, UK, London*, 2001.

[5] A. Carreño and J. Lloret, "Environmental impacts of increasing leisure boating activity in Mediterranean coastal waters," *Ocean Coast Manag*, vol. 209, 2021, doi: 10.1016/j.ocecoaman.2021.105693.

[6] X. Yang *et al.*, "Review of risk assessment for navigational safety and supported decisions in arctic waters," 2024. doi: 10.1016/j.ocecoaman.2023.106931.

[7] C. G. Soares and A. P. Teixeira, "Risk assessment in maritime transportation," *Reliab Eng Syst Saf*, vol. 74, no. 3, 2001, doi: 10.1016/S0951-8320(01)00104-1.

[8] D. Hamm and C. H. (Joan) Su, "Managing tourism safety and risk: Using the Delphi expert consensus method in developing the event tourism security self-beliefs scale," *Journal of Hospitality and Tourism Management*, vol. 49, 2021, doi: 10.1016/j.jhtm.2021.10.001.