



A Review of Diving Equipment among Recreational Scuba Divers

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Abstract

Scuba diving is one of the most popular activities that involve risks with nature. It can lead to major injuries or even cause deaths. The rate of exposure to fatality among scuba divers has become a major concern. The number of fatalities among the divers in the United States (U.S.) and Canada is in between 80 to 100 per year. The statistic also shows over 16 fatalities rate among the divers in the U.S. and Canada for every 100,000 recreational divers per year. There are three countries with a high number of deaths among the divers in Asia, which are Malaysia, Indonesia, and Thailand. The statistic shows that these three countries have an increasing number of accidents in scuba diving activities. The upshot rate of fatalities should not be neglected and needed a critical emphasis. This paper aims to propose a framework that shows the effect of diving equipment on accidents among scuba divers. A review of previous studies was conducted to meet the objective. A previous study indicated that diving equipment had a relationship with human error in the scuba diving activity. Diving equipment condition can be measured based on equipment malfunction, faults, and misuse. Diving equipment can be one of the factors that lead to accidents among divers. For scuba diving, divers need to know the equipment before continuing with the activities to avoid any undesired situation. A direct relationship was proposed to find the effect of diving equipment and accidents. The study will contribute to the tourism sector for marine tourism's sustainability in reducing fatality accidents among recreational divers.

Keywords: Accident, Divers, Diving Equipment, Risk in Extreme Sport, Scuba Diving.

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INTRODUCTION

The diving is one of the activities in the tourism industry. It has also become one of the most popular and widespread water sports in the world. Jacques Yves Cousteau, who is a French navy known as a world-famous underwater explorer and conservationist, studied scuba diving in the middle of the 1940s during the Second World War. Besides that, scuba diving activity has expanded to more than one million worldwide since the Second World War. According to Ranapurwala (2014), a typical diving team may consist of a diving officer, a master diver, diving personnel, a diving supervisor, and a diving medical officer. The scope of each diving team is as follows:

1. Diving officer: Responsible for all diving operations' safe conduct within a command and is responsible to the commanding officer.
2. Master diver: The most qualified and experienced person to supervise dives, in charge of overall diving operations, and is responsible for the diving officer.
3. Diving supervisor: A first-class (senior enlisted) diver with advanced training responsible for the actual diving operations in a particular dive or dive series.

The tourism industry has boomed by the preference of scuba diving activities, which affected the significant investment in various products. The demand for the retail products used in scuba diving education has increased, such as scuba diving

equipment shops, scuba diving schools, and charter businesses (Dimmock et al., 2013). Besides, De Groot and Bush (2010) and Wongthong and Harvey (2014) reported that scuba diving has been growing to become a multi-billion-dollar industry, drawing millions of people to explore the underwater world. It also turns out to be one of the most widespread and popular water sports worldwide (Stemberga et al., 2013). The increasing number of divers exploring new diving destinations and developing marketable travel resources have become additional factors in developing the scuba diving recreational activity (Stemberga et al., 2013).

In the tourism industry, scuba diving activity focuses on two aspects, which are environmental and sustainable management (Dimmock & Musa, 2015; Haddock-Fraser & Hampton, 2012; Hillmer-Pegram, 2014). These two aspects are the cause of the increasing number of scuba diving activities. The attention towards the environment and the willingness to contribute to marine conservation among the divers are vital for the sustainability in the marine sector (Hillmer-Pegram, 2014). Therefore, nowadays, scuba diving is categorised as the most attractive underwater activity worldwide (Rushkult, 2019). Moreover, due to the growth of scuba diving activity, there is an increasing demand for scuba diving products, which encourages the development of scuba diving retail and education sector. Dimmock et al. (2013) also stated that the number of scuba diving schools, equipment

shops, and charter businesses are well developed in the recreational scuba diving activity.

Scuba diving is divided into recreational diving and occupational diving (Margiotta et al., 2016). Both types of scuba diving use a different kind of technique. Occupational diving is more technical. According to the Australian Diver Accreditation Scheme (ADAS) (2020), occupational diving is the course of emplacement, regardless of whether or not diving is the principal function of employment or merely an adjunct to it. Some examples are military diving, scientific diving, and police diving. On the other hand, recreational diving focuses on the enjoyment of exploring the underwater environment, such as snorkelling and scuba diving. Scuba diving has its regulations or rules that need to be followed, especially in occupational diving. Occupational diving has a tight law compared to recreational diving. Therefore, recreational and occupational diving need different type of divers and skills.

Scuba diving in tourism has grown to become a multimillion-dollar industry by drawing millions of people to explore the underwater world (De Groot & Bush, 2010; Wongthong & Harvey, 2014). On the other hand, Giddy (2018) noted that there had been a significant increase in the number of people participating in “hard” and “soft” adventure tourism in this area. Due to the growth of scuba diving activity, there is an increasing demand for scuba diving products (scuba diving schools, equipment shops, and charter businesses), which encourages the development of scuba diving retail and education sector (Dimmock et al., 2013).

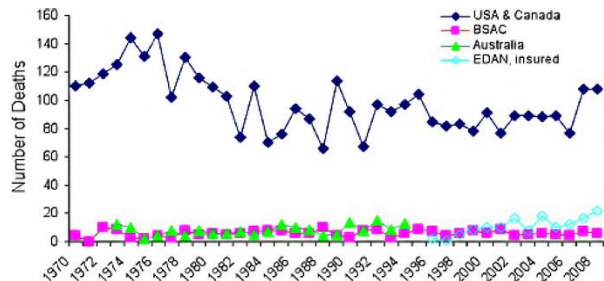
In a study conducted by Garrod and Gossling (2008), there are around 5 to 7 million divers worldwide. From the numbers, 34,600 of them are from Australia, 100,000 from the United Kingdom (UK), and the most prominent divers are from the U.S. with a total of 2.5 million divers. The emerging number of divers and tourism sectors has significantly affected the emergence of recreational scuba diving in developing countries such as Malaysia. Every year, more than 1,000 tourists visited Malaysia for scuba diving. Besides, Tourism Malaysia (2017) stated that scuba diving tourism has been listed as one of the tourism highlights that had targeted high-yield markets. Moreover, it has been underlined under the Economic Transformation Plan that tourism is known as one of the critical drivers for the economy or National Key Malaysia in achieving tourism targets (Tourism Malaysia Annual Report, 2020).

Therefore, this paper aims to propose a framework that shows the diving equipment risk on accidents among scuba divers.

ISSUES IN SCUBA DIVING

Tourism is an important industry that contributes to the economic growth of a country. According to the World Trade Organisation (WTO) (2020), the tourism industry can generate over US\$2.9 trillion and more than 983 million tourists from other countries visited the U.S. in 2019. This situation has made the tourism industry to become the largest industry in the world (Statista, 2019). One of the popular tourism activities for scuba diving is categorised under marine tourism (Higham and Lück, 2007). It has become one of the fastest-growing sports globally due to the increasing number of certified divers in scuba diving tourism (Zhang, 2016 & New Garrod, & Gössling (2008) & Orams, 1999). Besides, scuba diving is one

of the most popular marine activities in the U.S. that amounted to around 3 million participants (Ranapurwala et al., 2018). Safety issues between divers are not considered new issues. It has been a problem for the last 50 years. The statistics on death among recreational scuba divers were collected since 1970. Figure 1 shows the statistic of death among recreational scuba divers for a period of 38 years, from 1970 to 2008—these data were provided by four different organisations. The data for the U.S. and Canada recreational scuba divers were provided by Divers Alert Network (DAN), British Sub Aquatic Club (BSAC) provided the data for British divers, DAN Asia-Pacific provided the data for Australia divers, and Europe Divers Alert Network (EDAN) provided the data for European divers. Figure 1 shows that there were fatality cases among the recreational scuba divers every year.



Sources: Denoble, P. J., Marroni, A., & Vann, R. D. (2011). Annual fatality rates and associated risk factors for recreational scuba diving.

Figure 1: Annual Number of Scuba Deaths by Four Organisations

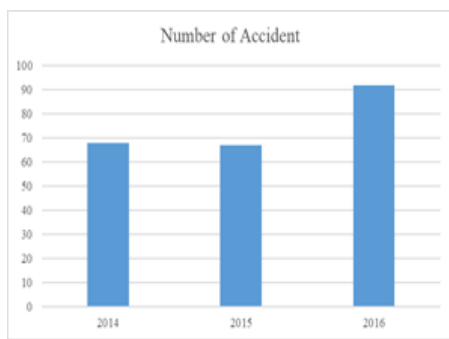
Historic Fatality Ratio in Training (fatalities per 100,000 dives)			
Program	1989-1998	1999-2008	Average
Entry Level	0.341	0.415	0.378
Advanced Open water	0.74	0.589	0.6645
Discover Scuba Diving	2.898	1.14	2.019
Rescue Diver	0.143	0.091	0.117
Specialties (deep, night)	0.287	0.82	0.5535
Divemaster	1.016	0.031	0.5235

*ratio was reduced from 6:1 to 4:1 in 2001

Sources: Undercurrent (2012). The “Discover Scuba Diving” Programs
https://www.undercurrent.org/UCnow/dive_magazine/2012/DiscoverScubaDiving201203.html

Table 1: Statistic Fatality Ratio in Training

Besides that, Table 1 shows the fatality ratio among recreational divers during training. From Table 1, even though the divers went for training for a higher diving certificate, which is a divemaster, fatality still occurred among the professionals. It shows that even professional divers experienced accidents. According to Bonnet et al. (2017), scuba diving can be categorised as a high-risk sport due to potential injury and death during the activity. Similar to other sports, scuba diving also involves risks, where the divers need to have a specialised skill and use complicated tools to survive and boost the length of their underwater duration in an unforgiving setting (National Center for Biotechnology Information [NCBI], 2020). The risks in scuba diving activity can lead to minor injuries, major injuries, or even deaths if the situation becomes uncontrollable. Figure 2 shows that the number of accidents in the US and Canada from 2014 until 2016. The number of accidents increases in these three years (DAN, 2019). The statistics show that over 16 fatalities occurred among the U.S. and Canadian divers out of the 100,000 recreational divers each year (Ranapurwala et al., 2017).



Sources: DAN (2019). Annual Diving Report, 2017 Edition.
<https://www.diversalernetnetwork.org/medical/report/AnnualDivingReport-2017Edition.pdf>
 Figure 2: Number of Accidents among U.S. and Canadian Divers

According to DAN (2019), accidents among divers in three Southeast Asia countries, namely Malaysia, Indonesia, and Thailand, from 2009 to 2011 were increasing except for Thailand as shown in Figure 3. However, Thailand experienced the highest number of accidents in 2009 among these three countries before it decreased in 2010 and maintained the same amount of accidents in 2011. Figure 3 proves that accidents in scuba diving activities were increasing around the world. Scuba diving can be categorised as high-risk sports due to potential injury or death in the activity. Besides, it also requires the use of special equipment to minimise the risk level.



Sources: DAN (2019). Annual Diving Report, 2017 Edition.
<https://www.diversalernetnetwork.org/medical/report/AnnualDivingReport-2017Edition.pdf>
 Figure 3: Number of Accidents among Divers in Three Countries

According to Trevett (2001), the rate of exposure to fatality among divers in Australia is 0.57 per 100,000 divers; while in Scotland, the rate is 4 per 100,000 divers. Moreover, 13,860,956 divers were sent to the Emergency Room (E.R.), while 1,220 had an injury during diving (DAN, 2014). NCB's percentage of fatalities (2020) showed that 66% of deaths involved recreational dives, 21% from commercial diving activities, and 12% of them were involved in training exercises.

In Malaysia, the percentage of accidents among divers is increasing and it is parallel to the number of individuals involved in scuba diving activities (Malaysia Scuba Diving Association [MSDA], 2020). In 2017, there was a fatality accident reported on the death of a divemaster during the scuba diving. This accident happened due to decompression sickness (South China Morning Post [SCMP], 2017). The latest news was in 2018 involving a fatality accident of the royal family of Perak state during a scuba diving activity in

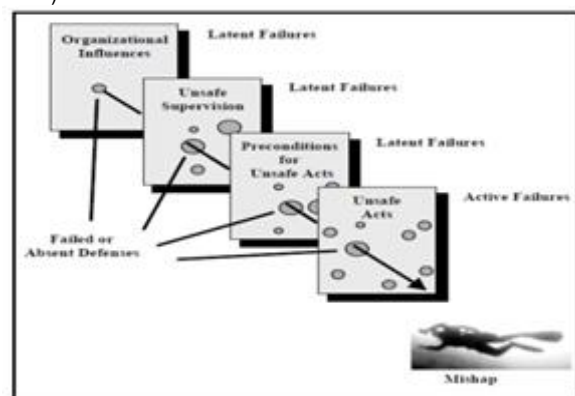
Perhentian Island, Terengganu. It was reported that the royalty drowned during scuba diving (Thestar, 2019). According to the MSDA (2020), there were seven fatality cases among divers in Malaysia from January 2019 until July 2019.

The literature shows that accidents happened mostly due to human errors, which is a part of human nature. Therefore, all human errors or any unsafe act of humans can cause an accident in any industry or sector. It is crucial to identify each root cause of accidents rather than identifying the final act of doing something wrong (Gareth Lock, 2020). In scuba diving, human error can be categorised into diving techniques and diving equipment. Diving equipment is a crucial part of diving either for the sport itself or the equipment's risk. According to Davis et al. (2002), the death rates of scuba divers in New Zealand are estimated to be at least 5.8 per 100,000 divers per year.

According to DAN (2020), many deaths were associated with inadequate training, poor water skills or fitness, and poor equipment. Therefore, it is vital to conduct a study to determine the relationship between diving equipment and accidents among recreational scuba divers. This study is crucial to foster safety awareness among recreational scuba divers and reduce the occurrence of accidents. The study is also vital for the benefit of the industry of sustainable marine tourism.

REVIEW OF LITERATURE

An accident usually occurs swiftly with some sudden and unanticipated turn of events that surprises the unfortunate and innocent victim. According to Suchman (1960), accidents constitute one of the leading causes of death and disability. Accidents can be defined as unexpected events, typically sudden in nature and associated with injury, loss, or harm. It can also happen anywhere, including home or during sports activities (Britannica, 2020). This study adapted the Swiss Cheese Model (SCM) proposed by Shappell and Wiegmann (2000). The SCM is generally related to accident causation and more focusing on accident investigation (Skybrary, 2019; INTeReSTS, 2014). The SCM explained controlling and analyzing equipment errors to prevent harm to humans (Permejer, 2005). Besides, Shappell and Wiegmann have underlined the four levels of human failure in this model, where each level will influence the next level (Cognitasresearch, 2019).



Sources: Gareth Lock (2020). Dive training courses.
<https://www.tdisdi.com/sdi/get-certified/open-water-scuba-diver-course/>
 Figure 4: The Swiss Cheese Model of Human Error Causation

The slices of cheese in this model represent the organisation's defence, while the holes in the cheese represent the

weaknesses and opportunities to breach the defence. Both slices and holes cheese are essential in explaining what will happen if the holes on the slides and holes cheese align together. This model is also designed to prevent large and high severity problems in the organisation (ThinkReliability, 2017). However, the chances of accidents can be reduced by reducing the number of holes in the cheese.

Generally, SCM is divided into two stages, which are a latent failure and active failure. According to Aviationpros (2006), active failure is the error that has an immediate negative effect caused by the human. Active failure is typical in the last stage. Usually, people will see that active failure as the cause of an accident. For example, when the diver put off his mask because he was getting panic in the water. By way of example, the incident happens not only because of the diver's unsafe act who put off his mask but also because of another factor: getting panic in the water. However, this story explains that an accident happens not only because of the last stage but also because of the first stage, latent failure. Latent failure means an unclear cause in some situations (Medscape, 2019).

In this study, equipment error can be related to human error due to the skill that needs to have by the diver in handling the diving equipment during the scuba diving activity. It supported by Dekker (2005) that human error and equipment is a two thing that that can cause an accident in this sport. However, one insight of early human factors work was that mechanistic features and the human action are intertwined in ways that resist the neat, dualist, deconstructed disentanglement still favoured by investigations today (Dekker, 2005). Drews (2016) reported that 9% of human failure resulted from equipment failure and caused an accident. This factor will be the cause of an accident that happens not only in the industrial sector but also in other sectors.

Scuba diving has its specific equipment that needs to master by divers before doing the diving activities. It consists of mask, fins, snorkel, breathing apparatus, buoyancy control device (BCD), diving suit, weights, and accessories, including dive computers and gas. According to Ranapurwala (2014), every equipment has its purpose. For example, a mask was designed to compress the air between the eye and the skin to prevent the water from entering the mask. Besides, the designs also to make sure that the diver can see clearly in the water.

Moreover, fins enhance the force for the divers while diving. The snorkel is a curved tube open on both ends and has an exhaust valve near the mouth. It allows the diver to breathe on the water surface with a face immersed. Swimming on the water surface and all the diving gear could be cumbersome; using fins and snorkel eases this difficulty.

Diving equipment is a crucial part of scuba diving either for the sport itself or the equipment's risk. According to Zhang (2016), the increasing popularity of scuba diving activity has contributed to the low prices of reliable diving equipment and training costs. The scuba diving activity allows people to visit and experienced the underwater environment. It also changes people's perceptions of the sea from being alienated and inhospitable to fascinating, enjoyable, and accessible. Therefore, many deaths are associated with inadequate training, poor water skills or fitness, and poor equipment.

Due to the risk of scuba diving activities, accidents are unavoidable. There are several accidents recorded relating to scuba diving over the world. For instance, the death rate in New Zealand among scuba divers is estimated to be at least 5.8 per 100,000 divers per year (Davis et al., 2002). In conjunction with the estimation, Table 2 shows the total number of trigger fatalities among the U.S. and Canadian divers in 2016. Table 2 shows that the highest number of fatalities were caused by equipment malfunction or problem contributing to 6 cases out of 32 cases.

Table 2: Triggers for Fatalities among U.S. and Canadian Divers in 2016

Trigger	Count
Equipment malfunction/problem	6
Cardiac condition	5
Entrapment	2
Hit by a large wave	2
Alcohol	1
Current in a cave	1
Difficulty breathing	1
Exhaustion	1
Low in air	1
Panic	1
Rough seas	1
Other	2
Unknown	7
Total	32

Sources: DAN (2019). Annual Diving Report, 2018 Edition. <https://www.diversalernetnetwork.org/medical/report/AnnualDivingReport-2018Edition.pdf>

Moreover, an accident did not only happen to new beginners but also to experienced divers. According to DAN (2019), a case involved an experienced diver who failed to handle his new diving equipment, which caused an accident. The investigation found that it is vital to check the diving equipment before starting the activity either for experienced or non-experienced divers. Moreover, the equipment factors do not necessarily refer to equipment failure or equipment malfunction, but it also refers to divers who are not familiar with the diving equipment. Besides that, the procedure for handling the equipment is also a factor that can cause an accident. Additionally, NCBI (2020) highlighted that most cases happened because of the improper use or malfunction of buoyancy control, regulator issues, problems with rebreather devices, and failure of dive computers.

DAN (2018) reported there were multiple cases related to buoyancy control among divers. Most divers are unfamiliar with the control and failed to use the established nature buoyancy during the activity that led to an accident. A dive computer is essential to ensure that divers do not spend too much time at specific depths. The diver computer sounds the alarm if the divers are out of the area. Although the diving equipment plays a role in several diving-related accidents, the prevalence is much less than other common factors cited in diver accident.

Equipment's failure is not necessarily due to the equipment itself because there are occurrences of human error. The diving equipment serves as an extension of the human error in the scuba diving activity. Several researchers have found the relationship between human error and diving equipment in the scuba diving activity. According to Reason (2016), some factors under the human error theory occurred during the promoting and developing diving activities. The factors include under-staffing and faulty equipment among the divers. According to Dekker (2005), the combination of human error and diving equipment can cause accidents in diving activity

and other sectors. It is reported that almost 9% of human failure was due to equipment failure that led to an accident. Therefore, this study used three indicators for diving equipment: equipment malfunction, equipment faults, and equipment misused. From these three indicators, this study identified the research instruments to measure the factor leading to the divers' accident.

Besides that, many fatalities were recorded by DAN (2019). Table 3 shows a summary of the cases of divers that lead to fatalities.

Table 3: The Summary of the Cases of Divers that Lead to Fatalities

Cases	Health Problem	Low of Air	Strenuous Exercise (Unfit)	Panic	Loss of Buoyancy	Equipment Malfunction	Drug
1-1	/	/	/				
1-2			/				
1-3		/		/	/	/	
1-4							
1-5	/						
1-6	/						
1-9	/			/			
1-11						/	
1-12	/						
1-13							/
1-14	/						
1-15	/						
1-18	/						
1-19				/			
1-20	/						
1-21	/						
1-22		/					
1-24		/					
Total	10	4	2	3	1	2	1

Sources: DAN (2019.). Diving Incident
<https://www.diversalertnetwork.org/diving-incidents/?a=caselist>

Table 3 shows the factors that lead to fatalities, which are categorised into three: medical (health problem, unfit, panic, and drug), diving equipment (low of air and equipment malfunction), and diving technique (loss of buoyancy). From the total number of cases, we can see that more than 60% of the fatality cases were caused by the medical factor (health problem, unfit, panic, and drug). The medical factor (health problem, unfit, panic, and drug) occurred because of the divers' medical conditions. However, the diving equipment factor is also one of the critical factors that lead to fatalities among the divers—the diving equipment factor caused almost 30% of the fatality cases.

Concerning the fatality accident among recreational scuba divers, Edmonds and Walker (1989) conducted a study to analyse the human factors contributing to the death in diving activities in Australia and New Zealand. The survey encompasses medical information, psychological problems, and various diving techniques that imply questionable judgment. The second extension deals with faults and misuse of equipment, and the third deals with environmental factors. Table 4 shows some previous studies on factors that lead to fatalities among the divers. There were six studies on diving equipment (Casadesús et al., 2019; Morgan, 1995; Edmonds & Walker, 1989).

Table 4: Summary for the Variables

Title	Author	Equipment	Medical	Diving Technique
SCUBA Diving Fatality by Overweighted Belt: An Autopsy Case	Kim (2019)	/		
Introducing Scuba Diving for Fishermen of Pantai Kondang Merak, Malang	Luthfi & Isdianto (2019)	/		
Recreational Diving Fatalities	Vann & Lang (2011)	/		
Dive Problems and Risk Factors for Diving	Buzzacott et al. (2009)	/		
Morbidity Developing Dive Site Risk Assessment Model (DSRAM) to Enhance Tourism Safety and Sustainability in Perhentian Island	Anuar et al. (2020)	/	/	
Anxiety and Panic in Recreational Scuba Divers	Morgan (1995)	/	/	
SCUBA Diving and Asthma: Clinical Recommendations and Safety	Coop et al. (2016)		/	
Dive-Related Fatalities among Tourists and Local Divers in the Northern Croatian Littoral (1980–2010)	Stemberga et al. (2011)		/	
Asthma and Recreational Scuba Diving	Koehle et al. (2003)		/	
A Survey of Scuba Diving-Related Injuries and Outcomes among French Recreational Divers	Monnot et al. (2019)		/	/
Autopsy and the Investigation of Scuba Diving Fatalities. Diving and Hyperbaric Medicine	Lawrence & Cooke (2006)		/	/
Annual Fatality Rates and Associated Risk Factors for Recreational Scuba Diving	Denoble et al. (2011)			/
Diving-related Fatalities: Multidisciplinary, Experience-based Investigation	Casadesús et al. (2019)	/		/
Human Factors in Diving	Blumenberg (1996)	/		/
Scuba Diving Fatalities in Australia and New Zealand: The Human Factor	Edmonds & Walker (1989)	/		/

Table 4 shows that diving equipment can influence the divers to be involved in an accident. Diving equipment focuses not only on the equipment itself but also the skill of the divers in handling the equipment. Divers need to have a skill or knowledge on how to use the diving equipment and handle the equipment in any situations, especially when the diving equipment is not functioning during the scuba diving activity.

DISCUSSION

Based on the literature, diving equipment is one of the prominent factors leading to accidents among recreational scuba divers. Moreover, equipment seems to be one of the critical factors in sports because most of the accidents happened due to this reason. It is important to highlight that diving equipment does not only refer to equipment failure, but it is also due to the unfamiliar equipment among divers. Good divers need to be familiar with their diving equipment and make regular maintenance to avoid any undesired situation. Based on the reviews, this study has proposed a framework to find the significant effect of recreational scuba divers' diving

equipment and accidents. Figure 5 presents the proposed framework. A few studies were conducted related to accidents and risks in recreational scuba diving. It is important to conduct a study to determine the significant effect of diving equipment on accidents among recreational scuba divers to promote safety awareness among scuba divers and provide a sustainable marine tourism activity.

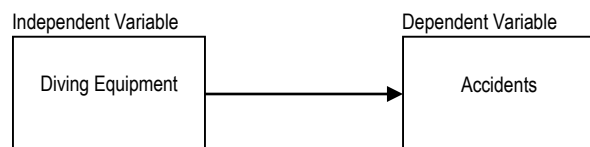


Figure 5: The Proposed Framework

CONCLUSION

In conclusion, a few points are highlighted in this paper. First, although there is a significant increase in the number of recreational scuba diving activities, the risk relating to it should be prevented. Several accidents are recorded among recreational scuba divers which caused concerns regarding safety precautions.

Therefore, this study conducted a review by on one of the most prominent factors that contributed to accidents among recreational scuba divers, namely diving equipment. Three indicators were measured for diving equipment: equipment malfunction, equipment faults, and equipment misused. A proposed framework is suggested to test the diving equipment's effect on accidents among recreational scuba divers from the chosen indicators.

The proposed framework is supported by theories, where equipment error can be related to human error due to the skill needed by divers in handling the diving equipment during the scuba diving activity. The study's findings will contribute to the tourism industry, specifically sustainable marine tourism by reducing the accident rate among recreational scuba divers.

REFERENCES

- Austrian Diver Accreditation Scheme (ADAS) (2020, February 4) ADAS is the world's foremost International occupational diver certification scheme. <https://adas.org.au/adas-overview/>
- Anuar, M. A. H., Salleh, N. H. M., & Jeevan, J. (2020). Developing dive site risk assessment model (DSRAM) to enhance tourism safety and sustainability in Perhentian Island. *Journal of Sustainability Science and Management*, 15(1), 125-135.
- Aviation Pros (2006, September 26). Who is Responsible? Understanding situations that trigger errors. Retrieved from <https://www.aviationpros.com/home/article/10383416/who-is-responsible>
- Beckett, A., & Kordick, M. F. (2007). Risk factors for dive injury: a survey study. *Research in Sports Medicine*, 15(3), 201-211.
- Blumenberg, M. A. (1996). *Human factors in diving*. California Univ Berkeley. Britannica (n.d). Sport in the Workplace. Retrieved from <https://www.britannica.com/topic/accident>
- Buzzacott, P., Edelson, C., Bennett, C. M., & Denoble, P. J. (2018). Risk factors for cardiovascular disease among active adult U.S. scuba divers. *European journal of preventive cardiology*, 25(13), 1406-1408.
- Casadesús, J. M., Aguirre, F., Carrera, A., Boadas-Vaello, P., Serrando, M. T., & Reina, F. (2019). Diving-related fatalities: multidisciplinary, experience-based investigation. *Forensic Science, Medicine, and Pathology*, 15(2), 224-232.
- Cognitasresearch (2019, October 25). Cognitas Incident Research and Management. Retrieved from <https://cognitasresearch.wordpress.com>
- Coop, C. A., Adams, K. E., & Webb, C. N. (2016). Scuba diving and asthma: clinical recommendations and safety. *Clinical reviews in allergy & immunology*, 50(1), 18-22.

- Corlew, B. (2013). Effects of cardiovascular conditions on mortality among scuba divers (Doctoral dissertation, Middle Tennessee State University).
- DAN (2019, September 5). Annual Diving Report, 2017 Edition. Retrieved from <https://www.diversalertnetwork.org/medical/report/AnnualDivingReport-2017Edition.pdf>
- DAN (2019, September 5). Annual Diving Report, 2018 Edition. Retrieved from <https://www.diversalertnetwork.org/medical/report/AnnualDivingReport-2018Edition.pdf>
- DAN (2019 September 6). A fully serviced first stage gave an air-out after 12 dives. Retrieved from <https://www.diversalertnetwork.org/diving-incidents/a-fully-serviced-first-stage-gave-an-air-out-after-12-dives>
- DAN (2019, September 6) Diving Incident Retrieved from <https://www.diversalertnetwork.org/diving-incidents/?a=caselist>
- Davis, F. M., Warner, M., & Ward, B. (2002). Snorkeling and scuba diving deaths in New Zealand, 1980-2000.
- De Groot, J., & Bush, S. R. (2010). The potential for dive tourism led entrepreneurial marine protected areas in Curacao. *Marine Policy*, 34(5), 1051-1059.
- Denoble, P., Marroni, A., & Vann, R. (2011). Annual fatality rates and associated risk factors for recreational scuba diving. *Recreational Diving Fatalities*. Proceedings of the Divers Alert Network 2010 April, 8-10.
- Dimmock, K., & Musa, G. (2015). Scuba diving tourism system: a framework for collaborative management and sustainability. *Marine Policy*, 54, 52-58.
- Dimmock, K., Cummins, T., & Musa, G. (2013). 10 The business of scuba diving. *Scuba diving tourism*, 161.
- Edmonds, C., & Walker, D. (1989). Scuba diving fatalities in Australia and New Zealand: The human factor.
- Farrell, P. J., & Glanville, P. (1990). Diving practices of scuba divers with asthma. *BMJ: British Medical Journal*, 300(6718), 166.
- Fields, B. R. (1996). Two case studies of the effects of a clinically oriented psychological skills training program on perceived anxiety, perceived efficacy, scuba performance, and progress in the therapy of scuba diving clients (Doctoral dissertation, Temple University).
- Frontiers, (2019, Jun 12). Ocean observing and the blue economy. Retrieved from <https://www.frontiersin.org/articles/10.3389/fmars.2019.00330/full>
- Gabbe, B. J., Finch, C. F., Cameron, P. A., & Williamson, O. D. (2005). Incidence of serious injury and death during sport and recreation activities in Victoria, Australia. *British Journal of Sports Medicine*, 39(8), 573-577.
- Gareth Lock (2020, February 27). Dive training courses. Retrieved from <https://www.tdisdi.com/sdi/get-certified/open-water-scuba-diver-course/>
- Garrod, B., & Gössling, S. (2008). New frontiers in marine tourism: diving experiences, sustainability. *Management Geographies*, 16(4), 598-614.
- Haddock-Fraser, J., & Hampton, M. P. (2012). Multistakeholder values on the sustainability of dive tourism: case studies of Sipadan and Perhentian Islands, Malaysia. *Tourism Analysis*, 17(1), 27-41.
- Higham, J. E., & Lück, M. (Eds.). (2007). *Marine wildlife and tourism management: Insights from the natural and social sciences*. CABI.
- Hillmer-Pegram, K. C. (2014). Understanding the resilience of dive tourism to complex change. *Tourism Geographies*, 16(4), 598-614.
- INTeReSTS, D. O. (2014). Hot cheese: a processed Swiss Cheese Model. *JR Coll Physicians Edinb*, 44, 116-21.
- Kim, Y. S. (2019). SCUBA diving fatality by overweighted belt: an autopsy case. *Korean journal of legal medicine*, 43(4), 164-166.
- Koehle, M., Lloyd-Smith, R., McKenzie, D., & Taunton, J. (2003). Asthma and recreational scuba diving. *Sports Medicine*, 33(2), 109-116.
- Lawrence, C., & Cooke, C. (2006). Autopsy and the investigation of scuba diving fatalities. *Diving and Hyperbaric Medicine-South Pacific Underwater Medicine Society*, 36(1), 2.
- Luthfi, O. M., & Isdianto, A. (2019). Introducing Scuba Diving for Fishermen of Pantai Kondang Merak, Malang. E-Dimas: *Jurnal Pengabdian kepada Masyarakat*, 10(1), 34-40.
- Margiotta, G., Benvenuti, M., Bellini, E., Iacovissi, E., Bencini, S., & Gabbrielli, M. (2016). Fatal scuba diving accident. A case reports. *Rom J Leg Med*, 24, 177-179.
- Medscape, (n.d). Multiple Latent Failure Align to Allow a Serious Drug Interaction to Harm a Patient. Retrieved from https://www.medscape.com/viewarticle/752972_5

- Mirasoglu, B., & Aktas, S. (2017). Turkish recreational divers: a comparative study of their demographics, diving habits, health, and attitudes towards safety. *Diving and hyperbaric medicine*, 47(3), 173.
- Morgan, W. P. (1995). Anxiety and panic in recreational scuba divers. *Sports Medicine*, 20(6), 398-421.
- MSDA, (2020, September 1). Malaysia Scuba Diving Association. Retrieved from <https://www.msda.my>
- Monnot, D., Michot, T., Dugrenot, E., Guerrero, F., & Lafère, P. (2019). A survey of scuba diving-related injuries and outcomes among French recreational divers. *Diving and Hyperbaric Medicine*, 49(2), 96-106.
- Musa, G., Seng, W. T., Thirumoorthi, T., & Abessi, M. (2011). The influence of scuba divers' personality, experience, and demographic profile on their underwater behavior. *Tourism in Marine Environments*, 7(1), 1-14.
- National Oceanic and Atmospheric Administration (2020, Januari 20). NOAA's National Ocean Service is positioning America's coastal communities for the future. Retrieved from <https://www.noaa.gov/oceans-coasts>
- NCBI, (2020, May 10) DAN annual diving report 2018 edition. Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK459389/>
- Orams, M. (1999). The economic benefits of whale watching in Vava'u, the Kingdom of Tonga. Massey University, Centre for Tourism Research.
- Pemeger, T. V. (2005). The Swiss cheese model of safety incidents: are there holes in the metaphor? BMC health services research, 5(1), 71.
- Ranapurwala, S. I. (2014). *Prevention of scuba diving mishaps using a pre-dive checklist: A cluster-randomized trial* (Doctoral dissertation, The University of North Carolina at Chapel Hill).
- Ranapurwala, S. I., Kucera, K. L., & Denoble, P. J. (2018). The healthy diver: A cross-sectional survey to evaluate the health status of recreational scuba diver members of Divers Alert Network (DAN). *PloS one*, 13(3), e0194380.
- Ranapurwala, S. I., Wing, S., Poole, C., Kucera, K. L., Marshall, S. W., & Denoble, P. J. (2017). Mishaps and unsafe conditions in recreational scuba diving and pre-dive checklist use: a prospective cohort study. *Injury Epidemiology*, 4(1), 16.
- Reason, J. (2016). *Managing the risks of organizational accidents*. Routledge.
- Rushkult (2019, Demcember 15). What is Scuba Diving? – All You Need to Know and More. Retrieved from <https://rushkult.com/eng/scubamagazine/what-is-scuba-diving/>
- Safety and industry news (2020, January 2). Australian Diver Accreditation Scheme. Retrieved from <https://adas.org.au/careers/onshore-supervisor/>
- Scubadiving.com (2020, January 13). Learn to scuba dive. Retrieved from <https://www.scubadiving.com/learn-to-dive>
- SCMP (2017, March 6). Hongkonger dies after early morning dive in Malaysia. Retrieved from <https://www.scmp.com/news/hong-kong/health-environment/article/2076405/hongkonger-dies-after-early-morning-dive-malaysia>
- Shappell, S. A., & Wiegmann, D. A. (2000). The human factors analysis and classification system--HFACS.
- Skybrary (2019, Jun 24). Safety and procedures. Retrieved from https://www.skybrary.aero/index.php/Portal:Safety_and_Procedures
- Statista, (2019, December 1). Statista Research Department, 2018. Retrieved from <https://www.statista.com>
- Statista, (2020, October 26). Global tourism industry - statistics & facts. Retrieved from <https://www.statista.com/topics/962/global-tourism/>
- Stein, J. E., & Heiss, K. (2015, December). The Swiss cheese model of adverse event occurrence—closing the holes. In *Seminars in pediatric surgery*, 24(6), 278-282. WB Saunders.
- Stemberga, V., Petaros, A., Rasic, V., Azman, J., Sosa, I., Coklo, M., ... & Bosnar, A. (2013). Dive-Related Fatalities Among Tourist and Local Divers in the Northern Croatian Littoral (1980–2010). *Journal of travel medicine*, 20(2), 101-106.
- Stopsportsinjuries (2019, September 25). Sports injury Prevention. Retrieved from https://www.stopsportsinjuries.org/STOP/Prevent/STOP/Prevent_Injuries/preventinjuries.aspx?hkey=605a1398-5a54-49ab-924e-7f55965d8409
- Suchman, E. A. (1960). A conceptual analysis of the accident phenomenon. *Social Problems*, 8(3), 241-253.
- Thestar (2019, March 24). Member of Perak royal family drowns while diving off Pulau Perhentian. Retrieved from <https://www.thestar.com.my/news/nation/2019/03/24/member-of-perak-royal-family-drowns-while-diving-off-pulau-perhentian>
- ThinkReliability (2017, June 2). Great conceptual model for communicating our ability to mitigate risk <https://blog.thinkreliability.com/holes-in-the-swiss-cheese-model>
- Tourism Malaysia (2017, August 13). Pulau dan pantai. Retrieved from <http://tourism.terengganu.gov.my/index.php/2013-03-25-09-25-49/pulau-pantai>
- Tourism Malaysia (2020, June 10). Tourism Malaysia 2018 Annual Report. Retrieved from <https://www.tourism.gov.my/activities/view/tourism-malaysia-2017-annual-report-1>
- Trevett, J. (2001). *Coinage and democracy at Athens. Money and its uses in the ancient Greek world*, (pp. 23-34) Oxford University Press
- Undercurrent (2012, March 1). The "Discover Scuba Diving" Programs Retrieved from https://www.undercurrent.org/UCnow/dive_magazine/2012/DiscoverScubaDiving201203.html
- Vann, R., & Lang, M. (2011). Recreational diving fatalities. *Undersea and hyperbaric medicine*, 38(4), 257-260.
- Wongthong, P., & Harvey, N. (2014). Integrated coastal management and sustainable tourism: A case study of the reef-based SCUBA dive industry from Thailand. *Ocean & coastal management*, 95, 138-146.
- WTO, (2019, October 13). Internasional Trade Statistic, 2012. Retrieved from https://www.wto.org/english/res_e/statistics/its2012_e/its12_toc_e.htm
- Yusof, Y., (2017). Customer Satisfaction with Green Initiative in Malaysia Hotel (Doctoral dissertation, Terengganu: Universiti Sultan Zainal Abidin)
- Zhang, L., Zhang, L., & Du, B. (2016). Deep learning for remote sensing data: A technical tutorial on the state of the art. *IEEE Geoscience and Remote Sensing Magazine*, 4(2), 22-40.
- Zin, B. M., & Sulaiman, A. (2008). Decompression illness secondary to occupational diving: recommended management based current legislation and practice in Malaysia. *Med J Malaysia*, 63(2).