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# The Influence of Scuba Divers' Experience on Their Underwater Behaviour in Marine Ecosystem

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**Abstract:** Responsible tourism has become an established area of tourism research and practice. Although it shares much in common with 'sustainable tourism', 'eco-tourism', 'ethical tourism' and other related forms of socially conscious tourism practice, the label of 'responsible tourism' is by far the most favoured industry term. While dive tourism enjoys continued growth worldwide, concern exists that it is contributing to the degradation of coral communities, biologically and aesthetically. In this research, we investigated the rate of divers' contacts and physical damage by observing divers' underwater behavior in Tioman Island, Malaysia and tested the effectiveness of pre-dive briefing as a mitigation measure of divers. By observing thirty divers, only few divers contacted the live coral cover and caused skeletal breakage. The average contact frequency of the divers during diving trips was approximately 45 minutes. The study found that divers were highly responsible during underwater diving. The contact frequency of the divers decreased significantly after they listened to an environmental briefing among divers who could maintain neutral buoyancy, as opposed to those who could not do so. This study suggests that buoyancy control training for divers may also be important for coral reef conservation in addition to environmental education. Diver-induced damage decreases with increasing number of logged dives and attendance at pre-dive briefings. Marine Park managers can help reduce impact by identifying and directing use to sites that are resistant to damage, matching diver competence and site preferences and alerting operators to dive conditions. Minimizing impact requires dive master and dive operators to be proactive in promoting low impact diving behaviour. This includes selecting sites that match divers' expectation and experience and providing pre-dive briefings in the context of divers' activities and physical capacity and site susceptibility to impact and current strength. In response, the study suggests a new paradigm for the management of reef-based SCUBA dive tourism integrating the management and governance frameworks of the management strategy and multi-stakeholder approach.

**Key words:** Scuba diver · Underwater behaviour · Responsible tourism · Marine environment

## INTRODUCTION

Responsible tourism' has become an established area of tourism research and practice and is typically understood as a broad set of tourist interactions that engage with and benefit local communities and minimize negative social and environmental impacts [1]. The number of tourists' diver is growing rapidly, with around 1 million new divers being trained each year. The development of more reliable dive gear and inexpensive underwater cameras have accelerated this trend. Impacts of marine tourism on the environment have been studied by some researchers. These include impacts of boat anchoring, snorkeling [2] and trampling [3]. In earlier years, scuba diving was seen as having little ecological impact on coral reef ecosystems [4], probably because of the relatively small diver population at that time. However, with the rapid increase in the number of recreational scuba divers, the cumulative impacts they have on reefs have become more and more substantial [5].

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Some studies conducted more recently at very popular diving sites have found unsustainable levels of diving impact at those locations [6]. At many reef sites across the globe, coral reefs are showing increasingly visible signs of deterioration, caused by intensive recreational use [7].

**Literature Review:** Coral reefs are important habitats along tropical coastlines, providing humans with economic resources and services through cultural values, fishing, coastal protection and tourism [8]. This ecosystem is also a popular destination for scuba diving, one of the world's fastest growing recreational sports [9-10]. Scuba diving is considered to be a low-impact activity and provides an economic alternative to fishing through a non-extractive use of marine wildlife [11]. However, coral reefs are globally threatened by a wide range of anthropogenic activities, such as fishing, pollution and unplanned tourism [12]. These activities act in synergy with the high vulnerability of corals to climate change, rendering the sustainable use of coral reefs a complex task. The recent growth of diving tourism has raised concern among managers and scientists regarding its impacts. For instance, in Eilat reefs, Israel, visitation rates account for 250,000-300,000 divers and 400,000 instances of coral damage per year [13].

To mitigate diving impacts, studies have proposed the establishment of c arrying capacity approaches and the use of pre-dive educational briefings [14]. However, diver's behavior and compliance to the norms vary according to diver's profile, objectives and characteristics of the dive site. For example, the use of pre-dive briefings reduced 60 % of diver's contacts with corals in Egypt. On the other hand, in Santa Lucia (Lesser Antilles, Caribbean), group leader intervention was the only effective method to reduce coral damage [15]. The use of artificial reefs has been proposed as a strategy to reduce impacts on natural reefs. Shipwrecks are often used as a diving attraction, mainly due to their esthetic appeal. These structures generate revenue through diving tourism and consequently assist in local economic development. Historical shipwrecks represent an important cultural heritage and are fragile, non-renewable resources, generally protected by law. However, the impact caused by scuba divers on its benthic fauna incrusted remains little understood [16]. To implement and adequate artificial reef program, it is essential to understand diver impacts on historical structures and its fauna and assessing potential impacts of artificial structures on marine biota, such as phase shifts of benthic assemblages.

To address the above research gaps, this study aimed to: (i) provide insight into key issues confronting the sustainability of reef-based SCUBA dive tourism by incorporating the human dimension factors of the tourism industry into the management of physical ecological impacts and (ii) recommend approaches to sustainable management of dive tourism. As dive tourism has been developed in Peninsula Malaysia at a faster rate than other regions, Tioman Island in Malaysia, which is well-known as the busiest diving center in Peninsula Malaysia, was selected in this study.

## Method

**Study Sites:** The study was conducted at several locations in the Marine Park of Tioman Islands from September to November 2018. The Islands are surrounded by well-developed fringing coral reefs. They are a popular tourism destination in Peninsula Malaysia and receive 200,000 thousand tourists per year, roughly 10% of whom are recreational divers. Diving is possible annually from March to November.

**Observation of Divers' Behavior Underwater:** With the cooperation of dive tour operators, the surveyors joined regular dive tours as ordinary recreational divers. Thirty dive trips were made in total. The intent of the survey was not to inform the guides or the guest divers, except the boat captains and dive shop managers, to avoid influencing the divers' normal behaviors. During each dive, each surveyor randomly selected one of the divers in the tour group and observed his/her behavior from the start of the dive for 45 min. At the start, the surveyors recorded whether the target diver had photographic equipment and whether the diver could maintain neutral buoyancy underwater. Divers who could maintain neutral buoyancy could be distinguished readily because they swam in a horizontal position and they could hover in the water column without moving their fins (Fig. 1, left). The divers who could not maintain neutral buoyancy were constantly kicking with their fins and swam in a tilted posture to maintain their position (Fig. 1, right).

The number of unintentional contacts with the substrate was counted and recorded together with the touching object (hands, fins, knees, gauge, octopus, sediment suspension and other). When the observed diver appeared to search carefully for dead substrate before contact, such contacts were not counted. If the diver's contact broke the coral, the genus of the broken coral and the lengths of fragments were also recorded. Dive sites were determined by the tour operator staff,

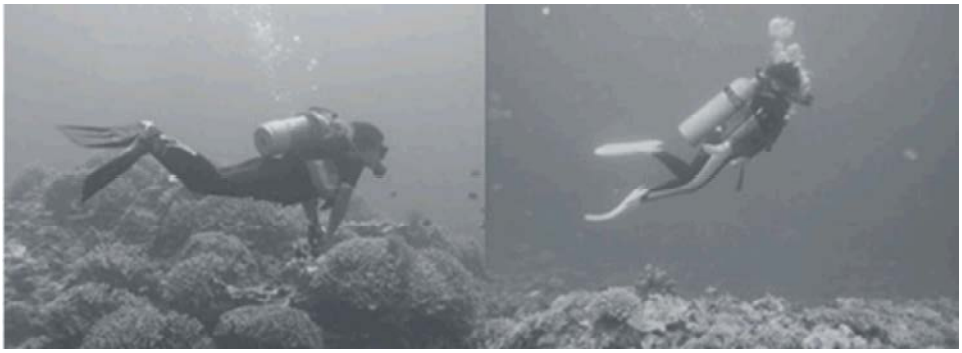

Fig. 1: A diver swimming with neutral buoyancy (left) and without neutral buoyancy (right).

based on requests from guests. Almost all dives were conducted on coral reefs or on sandy bottoms with coral patches. The percentage of coral cover was also recorded at each dive site by visual assessment.

## RESULT AND DISCUSSION

In total, 30 observations and semi-structured interviews were collected. Of these, 45% were males and 55% were females. Their ages ranged from 16 to 55, but most (88%) were in their 20s (33%), 30s (31%), or 40s (24%). In all, we observed 30 of these divers while they dove, before and after the educational briefing. The relationship between dive experience, certification level and buoyancy control ability are shown in Table 1. The participants' diving logged dives are shown in Table 2.

The present study showed that the buoyancy control ability of divers was the factor most strongly related to contact rate. Consistent with this, the contact rate decreased significantly in experienced divers (more than 50 dives), because they have learned buoyancy control skills. Thus, novice divers (fewer than 50 dives) are the group most likely to have negative impacts on the reef. Therefore, any management strategy should take into account how to better manage novice divers.

This is the first reported study to examine the relationship between divers' contact rate and buoyancy control. Among previous studies that have tested diver characteristics (such as dive experience, gender and use of photographic equipment), the results have been inconsistent [5, 10]. In these studies, different proportions of divers with and without buoyancy control skill among the different subject groups may have been a confounding factor causing the inconsistent results. Thus, in the future, similar studies should be designed carefully to control for the influence of variation in diver buoyancy control skills.

Table 1: Relationship between participants' experience and buoyancy control skill.

| Dive experience | Percentage of participants who could maintain neutral buoyancy |
|---|---|
| 20 to 50 dives | 14.8% |
| 51 to 100 dives | 52.8% |
| More than 100 dives | 72.2% |
| Certification level | Percentage of participants who could maintain neutral buoyancy |
| Open water | 10.0% |
| Advanced | 66.7% |
| Rescue or higher | 70.0% |

Table 2: Number of divers' logged dives

| *Groups* | *Frequency* | *Percent* |
|---|---|---|
| Novices (20-50 dives) | 5 | 17 |
| Enthusiasts (51-100 dives) | 7 | 23 |
| Experts (more than 100 dives) | 18 | 60 |
| Total | 30 | 100 |

Our study also provides direct evidence that pre-dive briefings help reduce physical contacts with reefs, at least for divers with adequate buoyancy control skills. In previous studies, differences in contact rate were compared between two distinct groups of divers: those who listened to an environmental briefing and those who did not. In this study, because the contact rates of the same individuals were compared before and after the briefing on the same day, the comparison is more direct, ruling out influences of other factors, such as the personal level of dive experience of individual divers.

The types of environmental briefing offered to the divers were also different among previous studies. The simplest type of briefing was that used by [14, 17], which was the inclusion of only one or two brief sentence (s) on environmental impacts in a regular pre-dive briefing by dive guides. [18] found that the briefing was not effective while other researchers concluded that such a briefing was effective. In fact, the briefing they offered was similar to the one we used,

Table 3: SCUBA diving stakeholder actions to minimize SCUBA Diving impact

| *Marine Park Section* | *Dive operator and dive master* |
|---|---|
| Define dive sites with marked mooring buoys indicating recommended experience levels | Promote minimal impact diving techniques in all promotional material. |
| Develop partnerships with dive masters and dive operators to communicate best practice diving technique that includes minimum impact diving. | Include information on potential for substrate-contact in all pre-dive briefings. |
| Provide information on diver impacts generally and especially to dive masters and dive-boat operators. | Give greater emphasis to divers are beginners and novices, Underwater photography the dive site is rich in fragile corals. |
| Marine environment education | Provide minimal impact diving instruction to dive masters and dive operators. |
| Identify dive sites with coral and marine life abundance | Inform divers (dive operators) of dive conditions daily and recommend dive sites for divers of different levels of experience. |

which covered various aspects of coral biology and impacts caused by divers, supported by photographs and diagrams and they also found a significant decrease in the contact rate. Pre-dive briefings should be prepared by coral biologists and cover basic aspects of coral biology with visual materials, rather than just a few sentences mentioning “please do not touch live corals.”

However, the briefing was only effective for divers with buoyancy control suggests that an environmental briefing alone is not enough to reduce the negative impacts of diving activities on coral reef ecosystems [19]. In fact, 4 of 8 divers showed increased contact rates after listening to the briefing. The divers with poor buoyancy control skills may have tried to avoid contact after listening to the briefing, but could not do so because of their lack of ability. Thus, environmental briefings should be combined with buoyancy control training targeted at inexperienced divers. In the present study, majority of the divers told that they could maintain neutral buoyancy underwater in the interview, but only a few of divers could actually do so according to our observations. Thus, there was a huge gap between divers' skills and self-assessments. In addition, not all experienced divers could maintain neutral buoyancy, because approximately 30% of divers with higher levels of certification and experience of more than 100 dives could not do so. Diving instructors should note this gap; more time and effort should be spent training divers regarding buoyancy control skills.

## CONCLUSION

At one extreme, divers’ impact could be minimized by focusing all SCUBA diving in resistant sites that are current free. Throughout the world and especially tourism-dependent Tioman Island, such action would be unacceptable to users, operators and management and would confiict with park management objectives. The largest proposed constraint is water characteristics (e.g. current strength): a constraint that will be acceptable to divers because safety and comfort are desired by recreational SCUBA divers. Equally desired by divers, especially by experienced divers, are sites with a high proportion of the more fragile coral types (e.g. branching and plate coral types). For park management then, the task is to identify and facilitate SCUBA diving at sites that match divers’ expectations for safety and quality experiences, but within the experience of the divers to dive with minimum impact.

Practically, such an approach can only be achieved with the cooperation of divers, dive operators and dive masters. Therefore, marine park managing agencies must take the lead in building partnerships with key stakeholders to implement such a policy. For the partnership to succeed, all multi-stakeholders must make a commitment to a shared vision. Actions that will demonstrate commitment are presented in Table 3.

While implementing minimal impact awareness programmes for divers is recommended in many reef areas, these have largely been conducted only by marine park managing agencies. As dive-based tourism is an important revenue earner for many resource users and if the sites are to maintain their aesthetic appeal and biological characteristics, then it is in the interests of dive operators to ensure their clients dive safely and with minimal impact. While protected area managers could take draconian zoning action to minimize impacts by focusing use away from sensitive areas, this would have the effect of reducing the attractiveness of Tioman Island and clients would probably move elsewhere.

It is suggested that collaborative action is a more sensible and indeed a more effective and responsible approach. Marine Park managers need to identify suitable diving sites with stakeholders and provide data such as presented here to inform selection of diving sites. Then, a coordinated diver education programme that informs divers of their responsibilities is needed to continually deliver a minimal impact diving message.

Diving federations and associations, such as PADI, NAUI or SDI and tour operators, as well as individual dive schools and instructors can probably take a lead in this.

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