DIVE GUIDES AND COMPETENCY SKILL

ARTICLES FOR FACULTY MEMBERS

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Source	*Frontiers in Psychology* Volume 13 (2022) Pages 1-15 https://doi.org/10.3389/fpsyg.2022.982480 (Database: Frontiers)

Title/Author	Does quality of scuba diving experience vary according to the context and management regime of marine protected areas? / Marconi, M., Giglio, V. J., Pereira Filho, G. H., & Motta, F. S.
Source	*Ocean and Coastal Management* Volume 194 (2020) 105246 Pages 1-11 https://doi.org/10.1016/j.ocecoaman.2020.105246 (Database: ScienceDirect)

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Assessment of water safety competencies: Benefits and caveats of testing in open water

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Drowning has been the cause of over 2.5 million preventable deaths in the past decade. Despite the fact that the majority of drownings occur in open water, assessment of water safety competency typically occurs in swimming pools. The assessment of water safety competency in open water environments brings with it a few difficulties, but also promises tremendous benefits. The aim of this position paper is to discuss the benefits and caveats of conducting assessments in open water environments as opposed to closed and controlled environments, and to provide recommendations for evidence-based practice. The first theoretical section discusses the effects of the environment and key variables (such as temperature and water movement) on various factors of assessment. These discussions are linked to the two perspectives of representative learning design (based on ecological dynamics) and information processing theory. The second section presents two pilot studies of relevance and provides practical implications for assessment of water safety competency. It seems that a combination of pool-based practice and open water education may be ideal in assessing aquatic skills competency. Assessment in open water presents clear benefits regarding validity, but often poses seemingly unsurmountable barriers, which providers may have reservations about in the absence of clear evidence. Hence this article provides a robust discussion about competency assessment and signals the practical importance of faithfully reproducing the environment in which skilled behavior is most relevant.

KEYWORDS

aquatic skills, environment, ecological dynamics, cognitive psychology, validity, outdoor, skill learning

Introduction

Drowning has been the cause of over 2.5 million preventable deaths in the past decade (UN General Assembly, 2021). It is responsible for more deaths than hepatitis or maternal mortality and close to that of malnutrition (World Health Organisation, 2022). The World Health Organisation (2021b) has made the provision of basic swimming and water safety

skills a strategic priority for the next decade. In emergencies, such as drowning situations, skilled behavior can save lives, hence it is crucial that skills are assessed robustly (Chan et al., 2020). Skill assessment forms an integral part of any instructional program, so practitioners need scientific evidence base to inform assessment policy (Langendorfer and Bruya, 1995).

In general, the assessment of motor skill competency takes place in controlled and predictable environments where knowledge and skills are initially broken down and demonstrated in turn. For example, in a typical car driving test learners are first required to pass basic theory and visual function tests, then they are asked to perform some rudimentary driving maneuvers (e.g., emergency stop, reverse park, etc.), and finally they need to demonstrate they can drive safely in more realistic traffic conditions. Only once a rudimentary level of skilled behavior can be reliably demonstrated in controlled settings do practitioners go on to assess skill in more realistic (and challenging) natural environments. Relatedly, assessments of children's fundamental movement skills (such as running, jumping, and throwing) are historically undertaken in the absence of play or game-related contexts (Ng and Button, 2018). For reliability and safety reasons one may appreciate why skill assessments are typically undertaken in such a way, but it is not well known whether such movement assessment batteries can discriminate amongst different levels of performance (Cools et al., 2009).

In this article, we focus attention on the assessment of water safety competency. There is clearly a need for evidence-based recommendations on instruction and assessment of these skills, and "[…] a more encompassing and dynamic view of water competence and drowning prevention education that addresses the dynamic and complex nature of drowning" (Stallman et al., 2017, p. 25). Consequently, we shall explain some important theoretical considerations from the motor learning perspective to help underpin the limited evidence currently available. Then, we go on to describe two case studies that illustrate some of the challenges of assessing skills in open water. The aim of this position paper is to discuss the benefits and caveats of conducting assessments in open water environments as opposed to closed and controlled environments (i.e., swimming pools or flumes).

Background: Assessment of aquatic skills

Aquatic skill competency is much more than being able to swim (Langendorfer and Bruya, 1995). Stallman et al. (2017) have proposed 15 different fundamental aquatic skills that form the basis of aquatic skill competency assessments, with swimming being only one of 15 competencies (see Figure 1). Robust assessments of water safety skills should include a range of competencies such as getting into and out of water safely, floating, breath control, underwater swimming, and recognizing hazards for oneself and others.

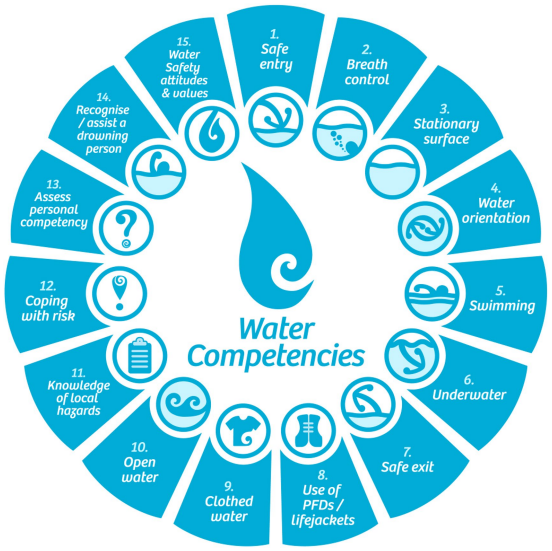

FIGURE 1
The 15 water competencies required to reduce the risk of drowning. Reproduced with permission of Drowning Prevention Auckland (https://www.dpanz.org.nz/courses/water-safety-for-children).

At least in developed nations, the assessment of swimming and water safety skills is typically undertaken in swimming pools, usually as part of education classes (Erbaugh, 1978; Moran et al., 2012; Stevens and NZCER, 2016; Di Paola, 2019; Chan et al., 2020). Swimming pools provide a seemingly "ideal" setting for competency assessments as the environmental conditions are relatively comfortable, stable, and reproducible (i.e., water temperature, currents, waves, depth, etc.). For example, Erbaugh (1978) showed that even when testing relatively unskilled individuals (i.e., 2–6 years old preschool children) it is possible to achieve high levels of inter-rater reliability when assessments are undertaken in a pool. However, introducing more variability in the water conditions of a swimming pool (such as waves) is likely to impact upon a learner's aquatic abilities. Indeed Kjendlie et al. (2013), showed that when open water-like conditions (i.e., waves) are simulated in a pool, the levels of skill competency are markedly lower. In their study, 66 11-year-old children performed identical tests in two different environments: a calm swimming pool and a simulated wavy environment (30–40 cm amplitude). The tests consisted of a 200 m swimming time trial, a 3 min floating test, a diving entry to the pool, and a rolling entry. The tests performed in the waves clearly showed a performance decrement (between 9 and 14% longer time to complete the swimming test and 21, 16, and 24% lower scores for rolling entry, diving, and floating tests, respectively). Kjendlie et al. (2013), highlighted the fact that children "should not be expected to reproduce swimming skills they have performed in calm water with the same proficiency in unsteady conditions during an emergency" (p. 303). To our knowledge no studies have compared learning of adults' performance of water safety-related competencies between

different environments, and similarly with children the evidence-base is poor (Quan et al., 2015; van Duijn et al., 2021b).

Whilst swimming pools are the chosen location for swim lessons in most developed countries around the world, the majority of drownings happen outdoors (Quan et al., 2012). For example, out of 74 drownings in 2020 in New Zealand, the large majority (87%, $n = 65$) occurred in open water environments (Water Safety New Zealand, 2021). In the United States, open water drownings outnumber swimming pool drownings, because open water is the major drowning site for school age children, adolescents, and adults (Quan et al., 2008). In lower and middle-income countries, the main locations of drowning are ponds, lakes, rivers and ditches (World Health Organisation, 2014). As the range of external factors causing open water drowning (e.g., travel, work, flood-related disasters, etc.) is much wider than that of factors causing swimming pool drownings, the burden of open water drowning is much more difficult to quantify (World Health Organisation, 2022a).

To address the issue of assessment in naturalistic environments Hulteen et al. (2015), conducted a systematic review of field-based assessments for movement skill competency in lifelong physical activities. Only two published studies satisfied the inclusion criteria in relation to swimming or aquatic activities (Erbaugh, 1978; Zetou et al., 2014). In both studies, children under the age of 12 years were tested, and a swimming pool was used for the assessments. Whilst Erbaugh (1978) assessed several aquatic skills (water entry, front and back locomotion, breathing, kicking, underwater object retrieval), Zetou et al. (2014) only assessed backstroke. For both studies the inter-rater reliability of the assessed skills was high (Erbaugh, 1978: $r = 0.89–0.99$; Zetou et al., 2014: $r = 0.79$). Unfortunately, neither study considered the validity of the methods used nor whether the skills were as well produced in a different environment other than a swimming pool. To our knowledge this is the only published research investigating the effects of environment on the production of fundamental aquatic skills, and more evidence is urgently needed (Button, 2016). Furthermore, very little has been done to investigate the transfer of skills from controlled environments to real-life open water situations, which is arguably one of the biggest questions to be addressed in drowning prevention globally (Button and Croft, 2017; Guignard et al., 2020). Neither have the reliability and validity of aquatic skills assessment tools been tested with regards to predicting open water competence, risk of drowning or injury.

Summarizing thus far, water safety skills are typically assessed in swimming pools, yet they are arguably most required in open water (e.g., Lepore et al., 2015; Quan et al., 2015). Assessment of skills in pools may be misleading, as these skills are not assessed under the added pressure and mental stress that the natural environment can provide. Factors such as waves, currents, depth, visibility, temperature, submerged obstacles, surveillance, and many more set different environments apart. It would appear that water safety practitioners have generally neglected the critical issue of skill transfer to different aquatic environments. Parents and teachers may falsely assume that if their child can swim in a pool they are "drown-proof," and likewise an increase in confidence by pool-trained swimmers may lead them to undertake more dangerous behaviors in the open water. On the contrary, according to the organization "Safe Kids Worldwide," the assumption that *a child that is able to swim in a pool will be safe in open water* may be one factor contributing to global drowning statistics (Mackay et al., 2018). Di Paola (2019) comments that: "Many swimming and lifesaving programs, although well-structured on paper, lack valid and reliable skills assessment and verification, which in turn might lead to inadequate skills acquisition and development, to a false sense of safety and to over confidence in the water that, as we all know, can be extremely dangerous." (p. 1).

Theoretical considerations for the design of water competency assessment

Motor skill performance is influenced by the task and environmental context (Newell, 1985), which may be problematic in the realm of water safety skills assessment: a multitude of factors differ between closed, controlled environments, and open water. Given the multitude of influential constraints that shape motor behavior, it can be very difficult to maintain fidelity in assessment environments (see section 4: practical considerations). Depending on the basic theoretical standpoint from which one views motor performance, one might make different conclusions on how skill should be assessed in open water surroundings. The two main theoretical frameworks that are common in motor behavior research are the ecological dynamics framework and information processing theory. In this next section, we will map out the conclusions that can be drawn when viewing the issue from each theoretical standpoint.

Information processing theories

Traditional information processing theories posit that programs stored within the central nervous system control muscle activation patterns for motor control. The organization of movement is seen as a top-down process driven by conscious processes and controlled in the cerebrum (Walsche, 1961). Skilled motor performance is viewed as an information processing activity guided by a general plan or program (Fitts, 1964). It may involve operations such as information translation, transmission, reduction, collation, and, most importantly, storage.

Information processing view on skill learning and assessment

The classical information processing model posits that information processing consists of three stages: stimulus identification, response selection, and response programming (Schmidt et al., 2018). During motor planning, a response (i.e.,

movement) and its control parameters (e.g., amount of force used) are selected and programmed, after which the motor command or program is executed *via* the motor cortex. During skill learning, relationships between control parameters such as speed and force and its outcomes, such as distance travelled, are learned (Schmidt, 1975, 2003; Sherwood and Lee, 2003). When we practice a motor skill that is relevant for water safety, we hope that this prepares us to cope with future situations – which are likely novel, unexpected and non-trained. Practice under more variable conditions is expected to accrue a more robust set of programs from which to inter-or extrapolate, and should therefore enhance learning (Boyce et al., 2006). Moreover, adaptation to novel situations (e.g., attempting to swim in waves) has also been shown to benefit from variable practice (Schmidt et al., 2018).

In variable environmental conditions, individuals have to identify and react to multiple, changing stimuli and select among a multitude of possible response options, while also adapting the control parameters of movement execution. Stimulus identification and response selection both become more complex. *Performing* in a more variable environment will therefore increase information processing demands and the chance of less-than-optimal response selection (Czyż, 2021), while *practicing* under such conditions may improve the future likelihood of succeeding in novel situations.

Based on recent efforts in computational and cognitive neuroscience (Clark, 2013; Koster-Hale and Saxe, 2013), a collection of models termed the *predictive processing framework* focus on the brain's ability to predict the future (see Spratling, 2017 for an overview of theories within this framework): The framework posits that an internal model of the world, created on the basis of movements and past sensory experience, is used to predict future sensory input (Hawkins and Blakeslee, 2004; Körding and Wolpert, 2004; Friston, 2005; Spratling, 2010). Being able to predict the future is a considerable advantage to the human brain. Not only can we anticipate the sensory consequences of our own movements, but also the dynamics of objects and other agents in the world (Keller and Mrsic-Flogel, 2018). For instance, an ocean-experienced person may look at a photograph or video of an ocean wave and instantly predict what will happen next.

Internal models are learned – indeed, experience shapes the circuits required for generating predictions and computing prediction errors. Therefore, it is the interaction with the world that refines these connections to generate precise internal models. In the context of water competence, it is experience in different aquatic environments (be it ocean, beach or harbor), and interaction with natural elements such as rips, currents, rocks or murky water, that enable us to predict potential consequences, make safe decisions, and coordinate our movements appropriately. Sensory experience sculpts the connectivity between neurons in an activity-dependent manner, e.g., neurons that code similar responses become functionally linked into a network (Ko et al., 2011, 2013; Cossell et al., 2015; Keller and Mrsic-Flogel, 2018).

During learning of skills, errors invariantly lead to a deviation of the sensory input from the model-based prediction. These prediction-error signals are processed by the primary sensory areas of the cortex, updating the predictive model. Variability in the learning environment is therefore crucial to the development of a valid and broad predictive model – or in other words, errors may be necessary to learn the full range of what the consequences are possible in which environment: this speaks for a broad range of aquatic experience in a variety of environments. When assessing learning, only a situation with sensory consequences that provides the full complexity of a predictive model may accurately measure the adequateness or "fit" of the model and its level of advancement (Schmidt et al., 1987).

Working memory and decision-making

When learning motor skills, the learner tests hypotheses about how best to perform the skill (Magill, 1998). For this they use sensory feedback to assess the success of their actions (Bruner et al., 2017). This hypothesis-testing strategy generates a set of performance rules (declarative knowledge) that the learner may retrieve during practice and performance, until the movement has become automated and can be released from declarative control (Maxwell et al., 2003). Information that is manipulated during a motor task is held in working memory, a mental "workspace" with limited capacity (Baddeley and Hitch, 1974; Baddeley, 2012). Human working memory has a limited capacity: usually, a person may be able to store, process or manipulate 7 bits of information at the same time (Baddeley, 1994). This leads to interesting conflicts when a person has to complete several tasks, as is often the case in water safety emergencies. A drowning situation requires appropriate execution of movements (swimming, floating, treading water) alongside complex decision-making (e.g., swim to shore or save energy by assuming HELP (heat escape lessening posture)). When deciding on the correct behavior after an immersion, it is therefore important that cognitive capacities are available to evaluate the options and choose correctly. The more complex the environment and the more sources of information need to be considered for a decision, the higher the load on information processing resources (Logie, 2011). Making decisions in complex environments is therefore an overarching skill that changes in the face of a changing environment. Concurrent decision-making and cognitive secondary tasks have been shown to have a detrimental effect on motor performance (Poolton et al., 2006). Based on this viewpoint, we would therefore predict that performance of a motor task when assessed in open water would be lower compared to a pool environment.

During accidental immersion and other drowning incidents, panic and psychological stress are likely to occur. Similar to cold shock, panic leads to a cascade of physiological, cognitive, perceptual, emotional, and behavioral responses (Cameron et al., 1987; Murray, 2004), which may hamper motor performance and decision making in an emergency (Page et al., 2016). To address issues related to information processing overload, teaching methods that avoid high cognitive load have been suggested by proponents of information processing theory. For example, the use of implicit learning methods has been suggested

in other fields (Masters, 1992; Hardy et al., 1996). Implicit motor learning refers to the acquisition of a skill in a non-verbal manner, with little conscious awareness of what is learned (Masters, 1992; Masters et al., 2004). This can be achieved by errorless learning, (i.e,, avoiding or minimizing errors during practice), or analogy learning, (i.e., an analogy is presented instead of declarative rules or instructions about the movement, e.g., "float like a starfish"). Studies using analogy in teaching swimming have shown that analogy instruction is effective for promoting efficient movement patterns (Komar et al., 2014, 2019). Focusing externally (on the effects of movements) may be a further strategy that benefits motor learning in a similar way (for a review, see Wulf and Prinz, 2001). Benefits of implicit and external focus-inducing instructions indicate that these may be powerful and cheap solutions to address the problem of information processing overload, however only two studies have used these approaches in water-related skills (Komar et al., 2014, 2019).

Ecological dynamics theory

In contrast to information processing theories, the role of environment is central when one considers human behavior from an ecological dynamics theoretical perspective. How the environment is perceived in terms of opportunities to move, i.e., *affordances*, is a key idea from the ecological psychologist James Gibson. Gibson (1979) proposed that humans perceive objects, surfaces, or events by what they offer, invite, or demand in terms of action opportunities. Aquatic environment features such as waves and currents afford different actions for different people, due to, among other constraints, their distinct physical properties, such as their buoyancy (see Fajen et al., 2008; for key features of affordances discussed in the context of sport). According to Gibson (1979) perceiving the environment in terms of affordances renders dispensable those cognitive processes described above (Section 3.1) that transform action-independent perceptions into action-oriented perceptions. That is, in the process of direct perception, there is no integration and combination of cues involved.

Brunswik (1956) proposed the term *representative design* to advocate the study of psychological processes at the level of organism–environment relations. It means that perceptual variables should be sampled from the organism's typical environment so as to be representative of the environmental stimuli from which they have been adapted, and to which behavior is intended to be generalized. The pedagogical principle of representative design ensures that the information-movement coupling of the structured practice environment is relevant and representative of the performance context (Pinder et al., 2011). What this means is that relevant information sources and affordances of the 'to-be-learnt' performance context should be present in a practice task (Button et al., 2020b). Ideally, such a practice task would not need to be a simulation of the real world, but rather a "sampling" of stimuli and affordances from the real context.

The importance of representative learning design may have particular significance when we consider the assessment of water safety skills. Guignard et al. (2020) suggest low skill transfer might be expected when people learn aquatic skills in a swimming pool versus in outdoor aquatic environments. To design representative performance (i.e., assessment) environments, practitioners should consider the following factors carefully. First, what are the interacting constraints on movement behaviors and how are they represented in the environment (i.e., action fidelity/realism). Second, it is crucial to adequately sample informational variables from the specific performance environments (i.e., relevant affordances) and thereby preserve the functional coupling between perception and action processes. Finally, practitioners should ensure that (i) the degree of success of a performer's actions is controlled for, and compared between contexts (supporting transfer of skill and learning), and (ii) performers are able to achieve specific goals by basing actions (movement responses, decision making) on comparable information to that existing in the performance environment (Pinder et al., 2011).

In summary, both the information processing and ecological dynamics theories argue that practice in variable settings may lead to the development of more adaptable movement patterns that are better equipped to negotiate unpredictable demands (Reid et al., 2007). With regards to skills assessment, the ability to adapt one's movement solutions to changing environmental demands is best assessed in situations that pose such demands.

Practical considerations

In the following, we aim to provide some "food for thought" on the practical realization of water safety skills assessment. Although the focus is on assessment, most of these considerations may equally apply to the design of learning opportunities. The limited number of studies that have compared aquatic skills assessment between different environments forces us to rely on studies from different fields, theoretical considerations and preliminary data. In this light, we decided to include findings from two pilot studies, in the interest of driving future research efforts. Our priority was to explore potential difficulties associated with skills assessment in open water. Presumably, the paucity of research in this field may be related to worries about safety, limitations in available safety personnel and equipment, and access to safe outdoor environments. Case study 1 is a first attempt to determine whether water skill assessments in open water (1) are feasible and can be safely conducted, and (2) can lead to outcomes that are comparable to assessments in swimming pools. A second priority was to assess whether the use of an indoor flume (i.e., a pool through which a water current can be channeled at adjustable speed) could be an intermediate option for assessment of cardiorespiratory and physiological demands, as well as skill, during aquatic activities (specifically in this case, rescue). Since

many physiological variables need to be assessed *via* advanced technological tools, it is – not least financially – near impossible to conduct such assessments in open water. If movement patterns (and, in future studies, physiological demands) could be replicated adequately in a controlled, indoor flume, this may open up avenues of skills assessment for the future (Pease, 1999). As such, case study 2 tells the story of a first attempt to simulate the full range of lifeguards' movement patterns in a flume.

Case study 1: Assessing children's aquatic skills in open water and closed environments

Background

Button et al. (2020a) have recently explored different methods and environments to undertake a range of water safety assessments for young children. In this case study, we draw upon some of that data (which was collected in an indoor pool), and compare it with more recent data (collected in open water, van Duijn et al., 2021a). This will enable us to compare the outcomes of the same water safety skill assessment battery between the two environments.

Method

The indoor swimming pool that was used for assessments by Button et al. (2020a) was an 8 × 25 m rectangle, with a shallow (1.2 m) and deep end (2.5 m) joined by a continuous sloping floor. The pool had an access ladder in each corner and a support rail along each wall. For all testing sessions, the water temperature was set at 25°C. The open water environments were two similar beach reserves located in a harbor (see Figure 2). For the open water assessments, weather conditions were closely monitored and testing only proceeded in relatively settled conditions (i.e., ambient temperature + 13°C, wind <30 km/h). The swimming pool was booked for the purpose of testing and therefore not accessible by the general public but the open water environments were publicly accessible.

Two different groups of school aged children (5–13 years old) undertook four fundamental water safety skills assessments either in the swimming pool or harbor environments described above. There were 98 pool-tested children (44 female and 54 male) and 58 harbor-tested children (20 female, 38 male). The samples did not include complete novices (i.e., non-swimmers). The four tasks assessed were: a) floating and treading water (1 min of floating on the back as in Figure 3, followed by up to 4 min of treading water), b) completing an obstacle course, c) an underwater swim (surface dive and retrieve a submerged object 2–5 meters away) and, d) a continuous swim (swim using any stroke continuously for either up to 5 min or 100 m). All assessments (both pool and open water) were closely supervised by lifeguards and undertaken by experienced observers. Each task was visually assessed and graded on a 4-point scale.

Results

There were no notable or consistent differences in competency between pool and harbor environments. Independent sample Mann–Whitney U tests confirmed that there were no significant differences ($p > 0.05$) between competency scores in any of the four tasks. Regardless of the environment in which assessment occurred, older children (9–12 years) were more competent than younger children (5–8 years). One might have predicted the younger children (i.e., lower skilled) would be more nervous than the older children about being tested outdoors and hence their competency assessments would be reduced. However, the data did not support this prediction as younger children did not appear to perform worse in the open water tests than in the pool. The four skills seemed equally challenging for the children although the younger children showed a tendency toward lower scores in the floating/treading water and continuous swim tasks (Figure 4).

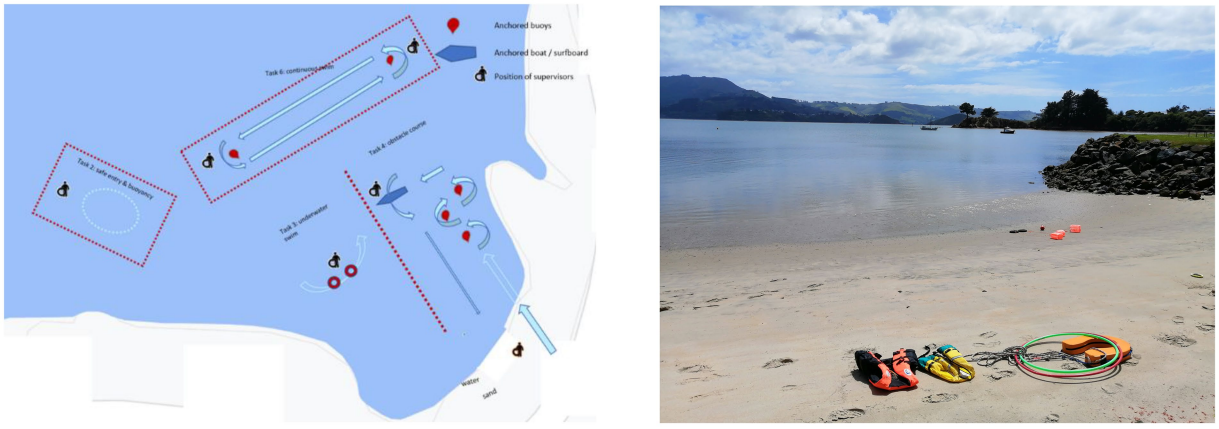

FIGURE 2
Experimental set-up for the outdoor testing sessions of the study. Left: Plan of the setup. Right: Overview of the beach testing location.

FIGURE 3
Impressions from the data collection: indoor testing in a pool (left) vs. outdoor testing in a harbor (right).

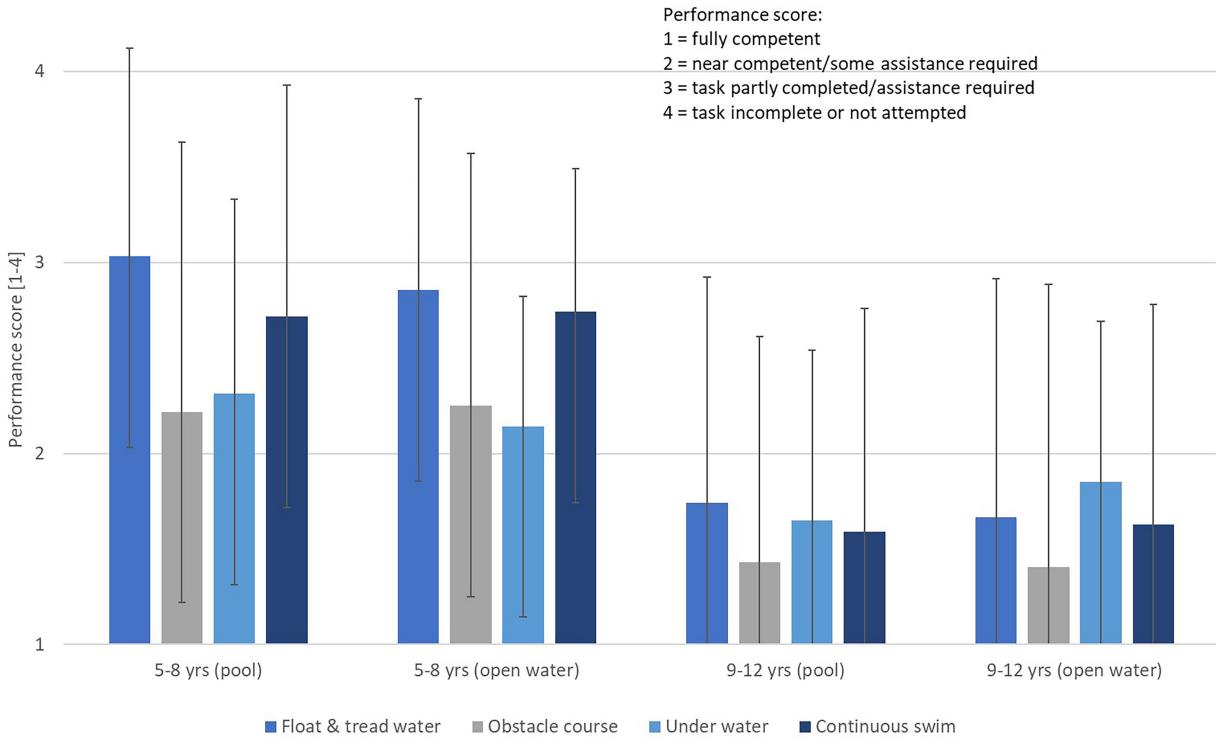

FIGURE 4
Comparison of water safety competency when children of different ages were assessed in a pool or in open water.

Discussion

An important component of water safety education is getting children to identify risks and how to manage them. This is very difficult to do in a swimming pool where the risks are different to outdoor aquatic environments. The fact that the open water assessments did not proffer different results from the study of Button et al. (2020a) imply that assessments of water competency may be successfully undertaken outside of a swimming pool. However, there were several challenges to overcome in terms of conducting skill assessments in a public harbor including ensuring adequate supervision, monitoring for boats and other water-users, and late cancelation of sessions due to poor weather. Assuming

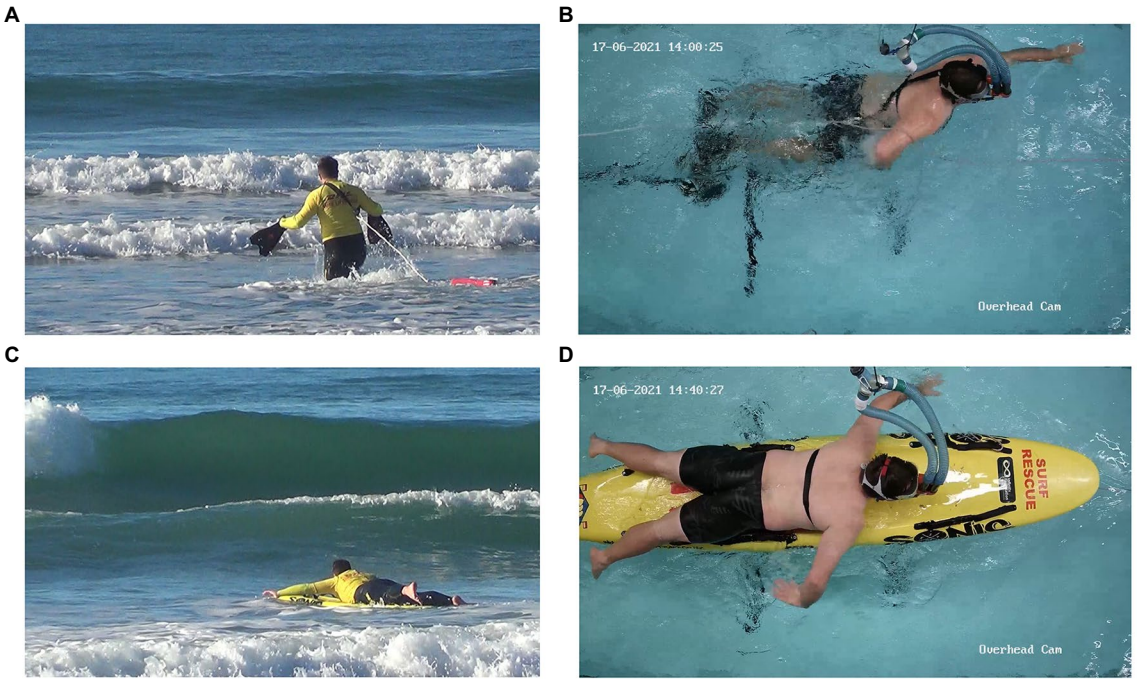

FIGURE 5
A lifeguard performing a tube rescue in open ocean **(A)**, a tube rescue in and controlled flume conditions **(B)**, a board rescue in open ocean **(C)**, and a board rescue in controlled flume conditions **(D)**.

that such risks are managed appropriately it is possible to test water safety competencies in open water. Although younger children tended to perform less competently than older children (as would be expected), there was no strong evidence to suggest this difference is exacerbated when assessments take place in open water.

Case study 2: Movement patterns used by surf life guards in open water and closed (laboratory simulation) rescues

Introduction

Typically, assessment of lifeguards' swimming abilities has been conducted in closed, pool environments (Daniel and Klauck, 1992; Prieto Saborit et al., 2010; Salvador et al., 2014). However, reducing environmental complexity has been shown to alter the interaction between lifeguard and patient (or manikin, Avramidis et al., 2009), as well as gaze behavior and likely information processing (Seth and Edelman, 2004). Therefore, the external validity of pool-based lifeguard assessment may be questioned (Davids et al., 2006; Tipton et al., 2008; Holleman et al., 2020). As a compromise, flume environments allow to simulate some factors of an outdoor environment (e.g., current, waves, multitasking, longer distances without pause), while controlling the elements that would hamper valid and reliable data collection. Although flume testing has also been shown to alter swim technique when compared to indoor pools (Pease, 1999; Wilson et al., 2011; Espinosa et al., 2015; Guignard et al., 2017), a direct comparison with open water swimming has not yet been performed to our knowledge.

Method

This pilot study was conducted with five male experienced lifeguards (age: 16–51 years, experience 2–22 years). Two simulated rescues were performed by the lifeguards in a beach environment (open ocean, waves up to 3 ft) – one rescue by rescue board, and one by using a rescue tube and fins. Participants were asked to retrieve a manikin that was positioned in the water 100 m from shore as fast as possible. The type, order and duration of aquatic locomotion movements during each field test were subsequently described by an expert, and replicated step-by step in an indoor flume (see Figure 5 for a direct juxtaposition of the two environments): i.e., participants performed running, bounding, diving, swimming and paddling movements while their own video recording from their beach trial was played back to them. The speed of water flow in the flume was matched to the average speeds at which participants were moving during the beach trial. Based on expert categorizations, the type and duration of each movement pattern during each of the four tests was analyzed exploratively.

Results

During beach trials, participants employed a wide range of movement patterns (see Figures 6, 7). The relative time that participants spent in each pattern showed likewise large variations

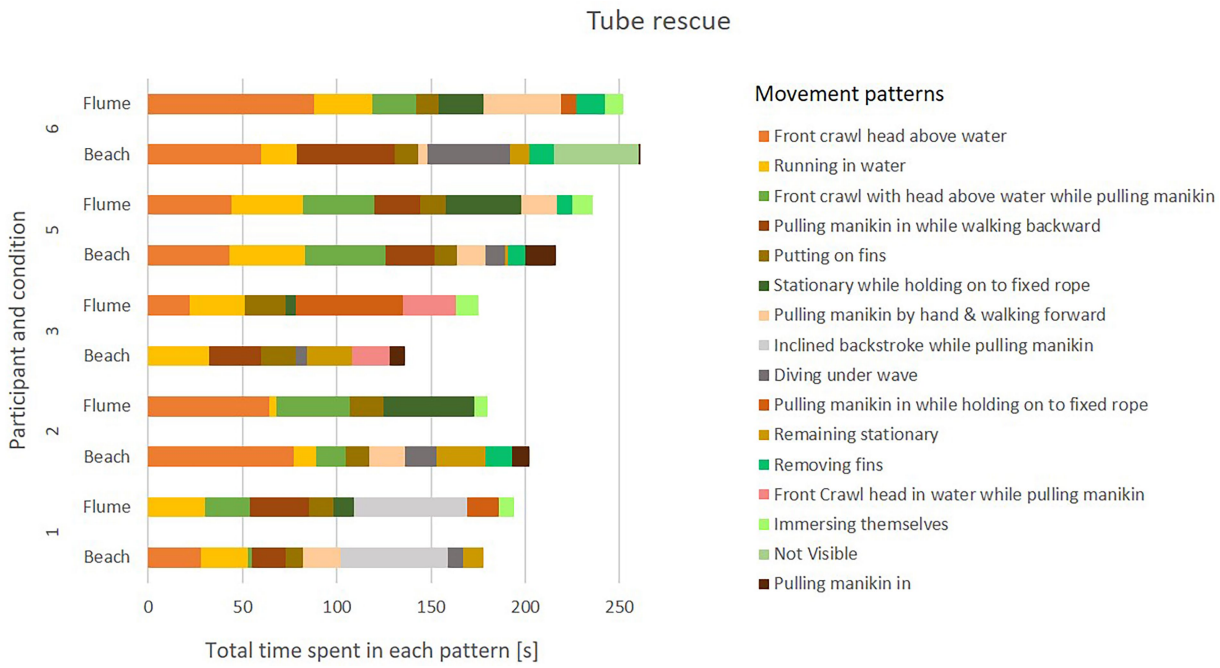

FIGURE 6
Movement patterns employed during tube rescue in ocean vs. flume conditions.

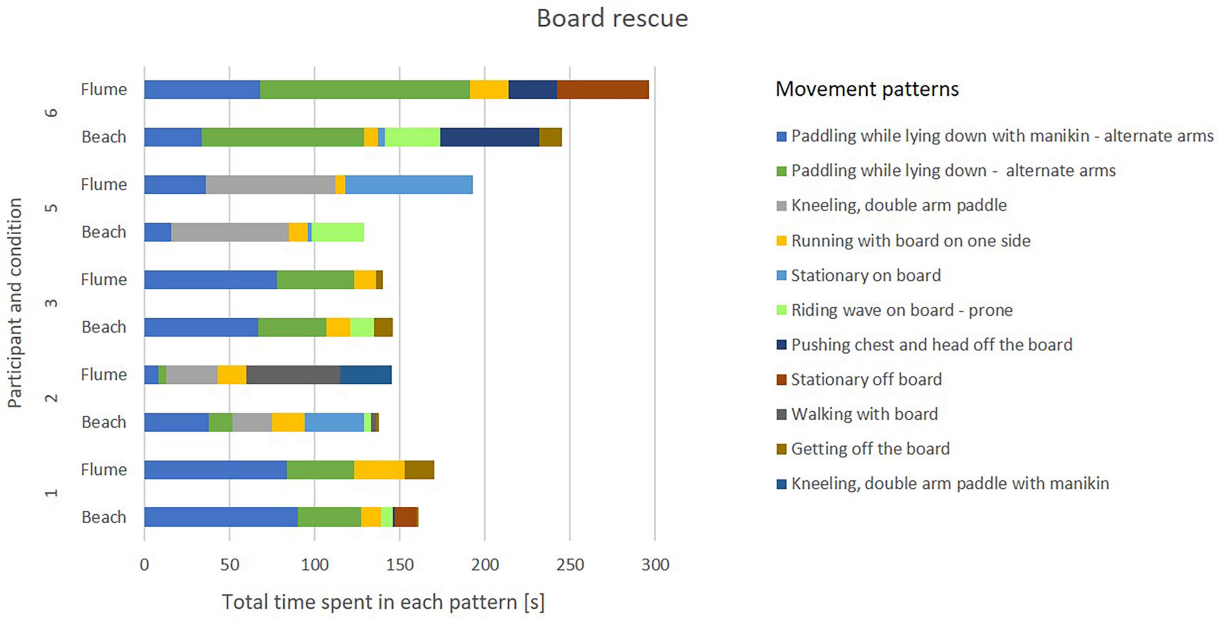

FIGURE 7
Movement patterns employed during board rescue in ocean vs. flume conditions. Note: The colors do not indicate the same patterns as in Figure 6.

between participants. Within-participant comparisons of beach vs. flume movements suggest that the replication of movement patterns in the flume may have been overall successful, however, modifications due to the environment (water flow and pool depth) are clearly visible in the exhibited movement patterns. As an example, the pattern "diving under wave" was replaced by "immersing themselves," a slightly adapted movement that mimics the former.

Discussion

Based on qualitative comparison of the movements, the replication of movement patterns in the flume seems feasible. However, it is likely that the flume replication may not have captured the intensity of the original movement, as participants reported finding it less taxing in the flume. Due to equipment limitations, it was not possible to fully replicate the "push back" resulting from waves, as well as some aspects of the original movements (e.g., walking in shallow water, overcoming breaking waves while fitting swim fins) and decision-making stimuli (e.g., timing, positioning, and patient status). Important aspects pertaining to the learner-environment interaction (perception-action coupling) may therefore have been missed in the simulation. If simulation fidelity is necessary for successful skill transfer to the real world, as suggested for example by Taber (2014), cognitive and psychological demands on the rescuer may also have to be simulated correctly.

Conclusion

This study was first attempt to replicate rescue movement patterns in a controlled flume setting. While flume-based simulations may allow correct replication of movement patterns, they are unlikely to represent the full range of demands (physical, cognitive, mechanical) presented when performing rescues in open water.

Reflections on the type of competencies required to be safe in the water

As case study 2 shows, navigating open water environments may require perceptual and motor skills that are difficult to simulate in a controlled aquatic environment. It is clear that the characteristics of the environment dictate which skills are necessary to safely move around in it. When assessing skill, the relative importance that is attributed to different motor competencies should, in our view, depend on the environment in which the skill is predominantly applied. As an example, it is clear that immersion in cold water poses a direct threat to survival - either *via* the initial cold shock response involving gasping, hyperventilation, hypocapnia, tachycardia and hypertension, or subsequent hypothermia (Datta and Tipton, 2006). Immersion in cold water also affects people's movements, rendering them stiff and inefficient. Thus, in a situation where a person falls into cold water, they need to have the knowledge that cold shock will cause them to gasp, have a high heart rate, and feel dizzy – but that it will subside after 2–3 min (Barwood et al., 2016). Such a situation would also require the person to be able to float first (i.e., for the time it takes for cold shock effects to dissipate) and then coordinate movement effectively to get out of the cold water quickly. In comparison, immersion in warm, but moving water might require a person to start swimming toward safety immediately, and would not require knowledge of cold shock. As a second example, many drownings or hospitalizations due to water-related injury have implicated clothing as an influential factor. Clothing likely impacts movement in the water *via* entrapment and by increasing the weight of the casualty (Keatinge, 1969), and thus also increases energetic, cardiorespiratory and cognitive demands on the swimmer (Choi et al., 2000; Stallman et al., 2011; Moran, 2014). Extending skills assessment to clothed swimming might be necessary to predict how well a person is able to cope in case of a realistic open water immersion incident. Whether a newly learned motor skill is transferred to performance in cold water and while wearing clothing has rarely been investigated (Schnitzler et al., 2017).

Another important component that defines the ability to move safely in aquatic environments is awareness of risks. Pitman et al. (2021) asked beachgoers to identify rip currents in photographs and *in situ* at a beach. They found that only 22% of respondents were able to identify the *in-situ* rip current, and of the respondents who correctly identified a rip current in photographs, 34% made correct *in situ* rip identifications. Furthermore, decision-making in aquatic environments heavily relies on accurate estimation of distance as well as one's own motor and fitness and energetic capacities (Baird and Burkhart, 2000; Ducharme and Lounsbury, 2007). This highlights that perceptual performance may differ depending on the environment: photographs may not be the best means of teaching, nor of assessing the skill of identifying risk factors of the environment (e.g., Proffitt, 2006). The use of immersive and realistic simulations may be an avenue to explore in this respect (Baird and Burkhart, 2000; Ducharme and Lounsbury, 2007). Different culturally and socially developed habits, traditions and practices in relation to interaction with water are an important factor that needs to be pointed out here. For example, in bicultural New Zealand, a traditional Māori practice is food gathering in the ocean, through which a deep spiritual connection with nature is reached for, while recreational swimming in swimming pools is not very common. The colonial *Pakeha* population (European New Zealanders), by contrast, spend more time relaxing on the beach, surfing, or swimming for fitness in indoor pools (Phillips, 2020; Wheaton et al., 2020). With regards to assessment, this means that cultural factors should be considered when the ideal skillset for a person, in a given environment, is defined and assessed.

In summary, assessment of water competencies should differ depending on the physical and cultural environment under consideration, since the nature of the skills that are required to be safe depend on this environment. Due to the wide variety of open water locations, and thus of environmental constraints, assessment of water competencies needs to be situation-specific and tailored to the goal competencies that are deemed relevant.

Reflections on optimal assessment tools in different environments

As we reflect on a wide range of complex issues, we must first acknowledge that perhaps the most important factor for assessing water safety competency that we have not discussed is the assessor

themselves. They must be familiar with the appropriate behaviors to be demonstrated in each aquatic environment. For this reason, it is vital that experienced and trained practitioners undertake water safety assessments whatever the location. However, as we have explained at length in this article, the environment also dictates what is feasible and effective in regards to assessment.

In case study 1, the open water environments impacted how assessments were undertaken. It was discovered that using fixed buoys as reference points was problematic, as the changing tides led to ever-changing water depth. Fluctuating water conditions introduces various difficulties for testing such as increasing anxiety for those being assessed and potential exposing objects (e.g., rocks) that may have been covered in sand. As another example, while video recording may be applicable on a steep beach where it is easy to achieve an overview in a single frame, a river may not afford this way of assessing. Vice versa, monitoring testees on a boat may be more suitable in a river compared to a beach-break situation.

Measurement of water safety skills often involves assessing the maximal distance or time that a person can swim. Measurement tools to achieve this in open water could include a floating rope, buoys (useful in still water), a range finder (especially useful in waves, see case study 2) or a video recording with fixed points on land (e.g., in a river). The environment sometimes dictates specific clothing, which may in turn affect movement characteristics. A pertinent example is the wearing of wetsuits in cold water, which, although arguably necessary, changes the buoyancy of the learner, and their performance at certain tasks. Open water assessments are also impacted by waves and wind, which are hard to control and likely reduce the reliability of a testing scenario. Choosing a sheltered spot, though it reduces this risk, may alter a key constraint associated with the task, simplifying it and rendering it less externally valid. On the other hand, simulating elements of unpredictability that are common for open water contexts may be possible in pool settings: Perhaps using technologies such as wave machines, lazy rivers, and cold-water cannons in a pool may allow for a closer representation of open water features.

Assessment tools also need to include retention of skill over time and transfer of skills to more complex environments. One difficulty with delayed retention tests are changes in air and water temperatures with the changing seasons: a retention test at the end of summer will likely involve cold water (effectively rendering it a transfer test, see effects of cold water on motor skills described above). A transfer test is an ideal opportunity to test whether a child can cope with a novel scenario – ideally, it would assess whether the individual skills are being recalled, linked and executed in a realistic, outdoor setting. An example could be a simulated self-rescue which might involve surfacing, floating, treading water, navigating around objects and returning to shore. By assessing skill over a longer time scale, it would further be possible to confirm whether general transfer and learning transfer is improved (i.e., learn to learn, see Oppici and Panchuk, 2022). Additional to physical skills such as swimming, it may also be relevant to assess decision-making capability, which is even more tightly related to information that is available in the environment, and benefits from outdoor assessment. For example, a task "swim as far out as you can and come back" includes distance estimation, decision-making and estimation of maximal action capabilities. Such tasks can easily be adapted to open water, including waves and currents to enable assessment of the robustness of such skills to variable environments.

Clearly, assessment tools (i.e., skills and knowledge tests, or observational grading scales) also need to be tailored to the expected variability in skill level: a fine-grained scale that allows to discern small individual differences may be necessary in one situation, whereas in another the main goal might be to determine who can be unsupervised, and a rougher grading scale or single criterion may be used. This points toward the use of complex, multifactorial tests of movement and decision-making in a realistic environment to capture the person's ability to cope in such situations. Transfer of each individual skill to a combined skill has rarely been tested in a water safety context (for an exception, see Button et al., 2022).

Summary: Benefits and caveats of assessment in naturalistic environments

As we have previously highlighted, the assessment and learning of skills are closely intertwined. The variability and unpredictability of naturalistic environments would require self-organization by the learner. Additionally, this type of environment may favor perception-action coupling in a sense of a representative testing design, as learners will engage with the real context of performance. Naturalistic environments can help us educate to intention, i.e., to engage in task-goal oriented activity, involving searching strategy and decision-making especially in estimating risky places to swim vs. safe places to enter in the water and swim. For instance, being aware of low/high tide times would change the intention of learners, as a beach could be safe because sandy and flat at low tide, whereas this same beach could be dangerous because rocky with steep slopes at high tide. Thus, naturalistic environments would require that a learner explores their various possibilities of action (and consequently make decisions), such as where to enter and exit; in comparison to a swimming pool where safe access is more obvious (i.e., ladder vs. edge of the pool). Furthermore, naturalistic environments help to educate to attention, i.e., to attune to relevant information for action. For example, instead of learning what a risky situation is from photographs and simulation in a swimming pool (which arguably represent the structural properties of an environment), learners are invited to perceive functional properties of the environment. This process supports the perception of affordances (opportunities for action) relative to the learner's own action capabilities.

More broadly, the naturalistic environment requires the learners to select, within a rich landscape of affordances, the action that best fits their action capabilities and intention. For instance,

entering clear water (i.e., ground is visible) does not afford the same actions as does blurry water, because potential seaweed and rocks may change what types of locomotion are best suited. When the ground is visible, a learner might jump into the water whereas when it is not, they might use water shoes or walk smoothly into the water. Hence, whether the aim for the practitioner is learning or assessment of water safety skills, there is potentially much to be gained from utilizing representative environments.

As summarized in Table 1, the numerous benefits of assessing in naturalistic environment are accompanied by caveats. For example, difficulties arise in maintaining high reliability, as practitioners must control the variability and unpredictability of naturalistic environments. Replicability of a testing scenario is also important to allow comparisons between different kinds of naturalistic environment. A sharper focus on skill transfer (rather than skill reproduction) also seems necessary which may require assessment in multiple open water environments. We recommend that practitioners should carefully weigh up such benefits and caveats in designing water safety assessments in naturalistic environments.

TABLE 1 Benefits and caveats of skills assessment in open water.

Aspect	Benefits of assessing in open water	Caveats of assessing in open water
Quality of assessment	High external validity	Need careful designing to enable high construct validity – often, skills are not clearly separable Replicability requires precise definition of all parameters
Assessment of competencies beyond motor skills	Accurate simulation of information processing load Adaptability of the skill can be assessed accurately Perception-action coupling is similar to what is required in open water Accurate representation of relevant information for decision-making assessment	Difficulty to separate motor skills from other aspects
Individual differences	Individual differences in open water skill may be adequately shown	High variability makes consistent testing difficult. Need for a fine-grained assessment scale and for splitting skills into sub-components
Skill transfer	Best way to assess transfer of skill into relevant environment	Difficult to separate skill learning from transfer
Cultural relevance	Possibility to include wide range of practices and forms of interaction with the environment	
Safety	Possible to conduct safely in appropriate environment	Requirements at schools often extreme: need for high ratio of supervisors: learners Requirement to choose predictable environment reduces value of open water testing
Time efficiency	–	Requires more time to plan and run

Conclusion and future research

In this article we have argued that water safety skill assessments must be carefully designed to reflect the range of competencies that may be required in naturalistic environments. Aquatic competency involves much more than just swimming. Assessment batteries that separate specific testable skills seem necessary to reflect the range of behaviors that may be required to remain safe in and around water. Contemporary motor learning theories support the inclusion of task and environmental variability to show how robust the performer is to variations that are common in natural aquatic environments. However, future research is needed to:

a. Determine the effects of environment on the production of fundamental aquatic skills.
b. To investigate the transfer of skills from the controlled environments to real-life open water situations.
c. To assess the reliability and validity of aquatic skills assessment tools with regards to predicting open water competence, risk of drowning or injury.
d. To find out whether, or to what extent, simulation of psychological and physiological demands is feasible in controlled lab-environments.

We have provided initial evidence that assessment in open water is possible, especially if the outdoor environment can be managed appropriately. There are important caveats that practitioners must carefully weigh up when designing assessment activities however, in our opinion the many benefits to be gained from testing in naturalistic environments outweigh such concerns.

Author contributions

TD contributed to study concept and design (case study 1 and case study 2), acquisition of subjects (case study 1), data collection (case study 1 and case study 2), and preparation of the manuscript. CB contributed to study concept and design (case study 1 and case

study 2), acquisition of subjects (case study 1), data collection (case study 1 and case study 2), analysis and interpretation of data (case study 1), and preparation of the manuscript. KC contributed to study concept and design (case study 2), acquisition of subjects (case study 2), data collection (case study 1 and case study 2), analysis and interpretation of data (case study 2). LS contributed to interpretation of data and preparation of the manuscript. All authors significantly contributed to the research process. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Does quality of scuba diving experience vary according to the context and management regime of marine protected areas?

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ABSTRACT

Sustainability of scuba diving tourism should be assessed not only in environmental terms, but also concerning the quality of the diving experiences. Through the application of semi-structured questionnaires, we assessed differences in the scuba diving experiences from three subtropical Brazilian marine protected areas (MPAs) with different contexts and management regimes. We found that MPAs of more restrictive categories attracted mostly divers motivated by their natural attributes. We also found that satisfaction levels were significantly lower in the no-take MPA, where public use planning is stricter. Although we could not replicate the MPAs' contexts, our findings highlight the importance of management strategy as well as the influence of MPA age and socio-ecological context on scuba diving experiences. In this regard, managers and dive operators are encouraged to assess user characteristics and the context in which the MPA finds itself to plan and develop sustainable tourism.

1. Introduction

Every year, millions of people seek entertainment in natural areas to enjoy scenic beauty and wildlife. Demand for nature-based tourism has shown significant growth in recent decades (Balmford et al., 2009; Huddart and Stott, 2019). Currently, tourism in protected areas is a major recreational and economic activity, generating about US$ 600 billion a year (Balmford et al., 2015). However, the quality of experiences directly affects the long-term sustainability of tourism, as tourists tend to stop visiting and/or recommending the destination after negative experiences (Wongthong and Harvey, 2014; Zimmerhackel et al., 2018). The quality of experience and the environmental integrity level have positive relationships, demonstrating that the human dimension of tourism can give clues about the conservation levels of natural attributes (Tonge and Moore, 2007; Uyarra et al., 2009; Zimmerhackel et al., 2018).

Among the types of nature-based tourism, diving is a multi-billion-dollar industry having a considerable socioeconomic importance in many coastal communities (Davenport and Davenport, 2006; Spalding et al., 2017). Diving affords one of the greatest recreationist-environment connections due to the immersion of the practitioner in an environment with distinct characteristics from the terrestrial one. Scuba diving also encourages conservation of destinations and has high sensitizing potential on aspects such as climate change and the current marine biodiversity loss crisis (Davis and Tisdell, 1996; Dearden et al., 2007). However, poorly managed diving tourism can negatively impact marine biota, reducing the diversity and complexity of benthic organisms (Giglio et al., 2020) and altering spatial trends of fish assemblages (Floros et al., 2013).

In addition to the responsible use of natural and social resources, the sustainability of diving tourism is assessed considering its economic viability, local community participation and the quality of diving experience (Wongthong and Harvey, 2014). Experiences are the psychological outcome from visiting the environment (Baker and Crompton, 2000; Prayag et al., 2013) and are affected by the visitor's profile, motivations, preferences, expectations and satisfaction with the destination (Gnoth, 1997; Baker and Crompton, 2000; Yoon and Uysal, 2005). Thus, to improve management responsiveness, it is necessary to understand the needs and expectations of divers (Manning and Lime, 2000; Ziegler et al., 2012).

Marine protected areas (MPAs) are created for the purpose of conserving biodiversity, restoring habitats and ensuring multiple ecosystem services, including nature-based tourism (Fabinyi, 2008; Halpern, 2014). Furthermore, for presenting a better conservation state, they are the preferred destinations for recreational divers (Davis and Tisdell, 1996; Davenport and Davenport, 2006). There are different

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Table 1
Summary of management context of studied MPAs. *International Union for Conservation Nature; **Levels of public use regulation: 0 = No regulations; 1 = Has few regulations; 2 = Has regulations, but with low supervision and 3 = Has regulations with high supervision. Information from MPAs were extracted from Brasil (2016), São Paulo (1993, 2008) and the management instruments (Fundação Florestal, 2014, 2018; ICMBio, 2017a, 2017b).

	Wildlife Refuge	State Park	EPA
Category (IUCN*)	III	II	V
Fishing/spearfishing restriction	No-take area	No-take area	Fishing and spearfishing allowed (multiple-use area)
Area (km²)	674,09	50	4530,83
Distance from the coast (km)	33	33	34,8
Age (years)	3	26	11
N° of dive sites	10	12	9
Divers use time (years)	<1	>30	<40
Autarchy	Federal	State	State
Management Instruments	Management Council (2016), Management Plan (2017) and Public Use Plan (2017)	Management Council (2009) and Emergency Plan for Public Use (2014) and Management Plan (2018)	Management Council (2008)
**Diving Regulatory Level ** **	3	2	0

categories of MPAs with distinct goals, but all involve management interventions in a defined geographic space (Christie and White, 2007; UNEP-WCMC and IUCN, 2016). In most of them, conservation is often achieved through the exclusion or managing of extractive activities, as well as encouraging the indirect use of resources through the contemplation of natural and landscape attributes, such as diving (Christie and White, 2007; Fabinyi, 2008).

The magnitude of the ecological and socioeconomic effects of MPAs are related to several factors, ranging from the characteristics of the species and habitats protected, to aspects related to the context of MPA, such as size, age, category, levels of enforcement and implementation of management instruments (Edgar et al., 2014; Gill et al., 2017; Ban et al., 2019). Thus, in general, no-take MPAs with strict regulations tend to have higher biodiversity and fish biomass and are therefore considered to be in a better conservation state (Edgar et al., 2014; Ban et al., 2019).

In MPAs where tourism is allowed, besides biodiversity conservation, an important goal is the promotion of human well-being, generating positive experiences for their visitors. However, the assessment of this MPA effect remains a global knowledge gap (Ban et al., 2019; Rasheed, 2020). Therefore, it is essential to understand the influence of the MPAs' management context on the quality of visitor experience to guide adaptive management and investment priorities aiming to ensure MPA effectiveness (Manning and Lime, 2000; Ziegler et al., 2012; Bentz et al., 2015).

The quality of diving experience is a complex variable which we translated through the diver's overall satisfaction with the visit. This, in turn, has been defined as the emotion resulting from evaluations of the experiences lived during the activity (Babin and Griffin, 1998),

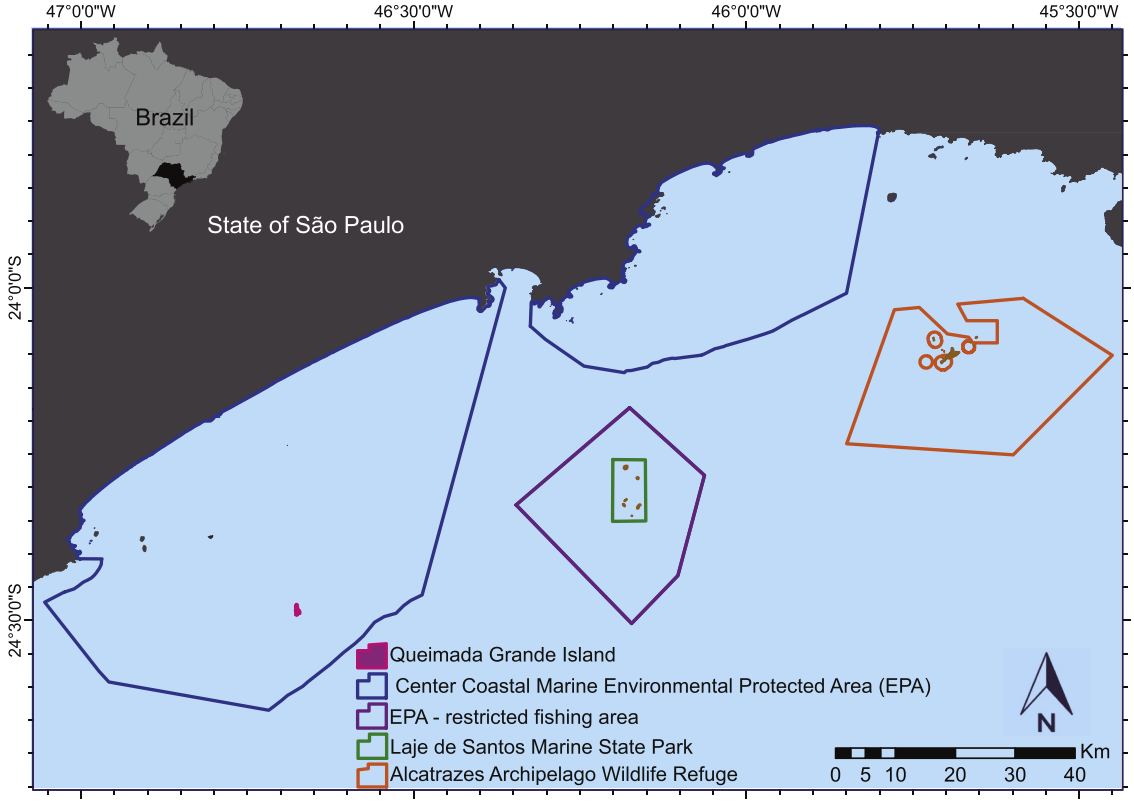

Fig. 1. Study Areas: Center Coastal Marine Environmental Protected Area (EPA), area of Queimada Grande Island; Laje de Santos Marine State Park; Alcatrazes Archipelago Wildlife Refuge.

reflecting the accumulated weight of various attributes (Albayraka and Caber, 2018). Here, we test the hypothesis that no-take MPAs with greater public use managing and fewer user conflicts, which theoretically are more well-conserved, produce better qualities of diving experiences. We characterized the divers' profile, considering demographic aspects, specialization, preferences and motivations. Subsequently, we compared overall satisfaction levels among MPAs in different management contexts and identified which attributes concerning management, service and environment were the most important for generating visitor satisfaction or dissatisfaction. With the results, managers will be able to understand the influence of the context of MPAs on visitation quality as well as better guide decision making as to which attributes should be prioritized to obtain excellence and sustainability of public use.

2. Study area

Recreational scuba divers were interviewed at three Brazilian subtropical MPAs (Table 1): the Alcatrazes Archipelago Wildlife Refuge (referred as Wildlife Refuge), the Laje de Santos Marine State Park (referred as State Park) and the Center Coastal Marine Environmental Protection Area (referred as EPA) that includes the Queimada Grande Island tourist area. Each one presents different management regimes and socio-political contexts. Although a greater number of divers visit the areas during the austral summer (from December to March), the diving operations occur throughout the year. The habitats of the three MPAs are characterized by rocky reefs covered by macroalgae, filamentous algae (i.e., turfs), encrusting coralline algae, sponges and corals (i.e., *Mussismilia hispida* and *Madracis decactis*) (Luiz et al., 2008; Rolim et al., 2019; Pereira-Filho et al., 2019).

2.1. Alcatrazes Archipelago Wildlife Refuge

According to the Brazilian National System of Nature Conservation Units (SNUC – Brasil, 2011), wildlife refuges have the primary objective of conserving biodiversity (corresponding to IUCN category III). The Wildlife Refuge (Fig. 1) was established in 2016 and is considered as the largest seabird-breeding site in southeastern Brazil (Campos et al., 2004), besides being reported to harbour one of the largest reef fish biomass on the Brazilian coast (Morais et al., 2017). Wildlife Refuge was established after three decades of clashes between researchers, environmentalists and the Brazilian navy. Overcoming this conflict, the area, once restricted and of military interest, was opened for visitation in December 2018. Since 2017, the administration has had three management instruments, the Management Council, the Management Plan and the Public Use Plan, all implemented since the beginning of visitation. Considering the regulations in its public use plan, Wildlife Refuge was the MPA with the most restrictive context to the visitors. It sets a maximum limit of 20 divers per site, with at least one guide for every four divers. Dive guides are trained and accredited by the MPA management and are responsible for ensuring low-impact diver behaviour. Divers are prohibited from using selfie sticks, stimulated to not approaching less than 1 m from the reef and not touch and/or disturbing marine biota. In addition, diving operators are responsible for submitting the divers to a briefing containing information on local natural attributes and the main rules of public use of the MPA.

2.2. Laje de Santos Marine State Park

According to SNUC, state and federal parks have the objective of protecting biological diversity, as well as providing environmental education and recreational use (corresponding to IUCN category II). The State Park is a no-take MPA established in 1993 (Fig. 1). In 2012, a fishing exclusion zone of 560 km^2 was established around the park and formalized in the Management Plan (in 2018) as a Buffer Zone. The State Park is considered one of the best diving spots of the Brazilian coast due to the good visibility of its waters and the seasonal occurrence of giant manta rays (Luiz et al., 2009). It was established as the result of the joint efforts of environmentalists and researchers and its purpose was to protect the area from intense fishing. Until then, this has been done through the management council, in operation since 2009, emergency public use plan, first edited in 2010 and management plan since 2018. Thus, considering the emergency public use plan, State Park, was considered as an intermediate context MPA concerning restrictions on users. The carrying capacity is established at 126 divers at the same time distributed across all dive sites. Also, the presence of dive guides in any commercial activity of public visitation is required, whom are trained and accredited by the management body. The guides are responsible for briefing the visitors with information about the natural aspects and rules of the MPA, as well as monitoring divers and reporting occurrences. However, there is no rule as to the maximum number of divers per guide, with only one guide per vessel being usual. Divers are also prohibited from using selfie sticks and touching and/or chasing marine organisms.

2.3. Center Coastal Marine Environmental Protection Area - area of Queimada Grande Island

According to SNUC, EPAs main goals are to conserve values of interaction between humans and nature (corresponding to IUCN category V). Thus EPAs allow the sustainable use of their natural resources. The marine environment of Queimada Grande Island is part of EPA established in 2008 (Fig. 1). Queimada Grande has 0.78 km^2 of emerged land portion and is located on the southern coast of São Paulo, at 34.8 km from the mainland. The marine area around Queimada Grande Island is widely used for commercial and recreational fishing (hook and line and spearfishing) and recreational diving. These uses are poorly monitored and do not have specific ordering. In 2019, in the EPA area was described the southernmost Atlantic coral reef (Pereira-Filho et al., 2019). EPA's administration takes place through a management council, which includes the main stakeholders. However, during the execution of this work, the area had no other management instrument. Even so, during this period, the production of the EPA Management Plan started. In it, approximately 19 km^2 of the marine portion of Queimada Grande Island was defined as an Area of Interest for Tourism, aiming to making economic activities compatible with the conservation of natural resources. Considering that EPA has no instruments to regulate public use in the Queimada Grande area, it was categorized as an unrestricted MPA to divers.

3. Methods

3.1. Questionnaire outline

A semi-structured questionnaire was applied to divers, consisting in 20 questions organized in five sections (i.e., diver profile, specialization,

Table 2
Individual attributes assessed in the questionnaire.

Category	Attribute
MPA management	1. Easy access to prior information on-site visitation
	2. Rules by managing to avoid environmental impact
	7. Low crowd of divers
	8. No Litter
	9. No fishing or lost fishing tackle
Service quality	3. Boarding/unloading location
	4. Quality of service Provided
	5. Briefing/additional conductor or instructor guidance
	6. Low impact diver behaviour techniques of other divers (buoyancy, touching organisms, etc.)
Natural environment	10. Water visibility
	11. Diversity and abundance of marine biota
	12. Encounters with animals
	13. Presence of orange cup coral *Tubastraea* sp. (invasive organism)

preferred organisms, motivations and satisfaction) and addressed aspects related to the experience during the visit in each MPA (Appendix A). To understand the diver's main preferences and motivations, respondents rated their responses on a 5-point unidirectional Likert scale (between 1 = not at all important and 5 = extremely important).

To obtain the overall satisfaction with the visit, divers were asked to rate their overall experience using a 10-point scale, where 1 = very dissatisfied and 10 = extremely satisfied. Divers also assessed the performance of 13 individual attributes regarding MPA's management, service quality and natural environment (Table 2) using a 5-point Likert-Type scale ranging from 1 = not at all satisfied to 5 = extremely satisfied.

Questionnaires were distributed to divers between September 2018 and September 2019. Divers were contacted upon return of the visit in person or via email, which was obtained by the management through reports from dive operators. To disseminate the online questionnaires, QR Code stickers were also affixed to the operators' vessels. To understand the context of the MPA, we participated in the meetings with the Management Councils and referred to the management instruments (São Paulo, 1993, 2008; Fundação Florestal, 2014, 2018; Brasil, 2016; ICMBio, 2017a, 2017b). The data collection was approved by the Research Ethics Committee of the Federal University of São Paulo (CEP: 0450/2018), Brazil Platform (Nº 890074718.9.0000.5505) and by the managing bodies of the MPAs (COTEC: Nº 260108–004.823/2018 and SISBIO: Nº 62932–1).

3.2. Data analysis

To estimate the reliability of the questionnaire, Cronbach's alpha coefficient was calculated using the *psych* package (Revelle, 2018). This coefficient is an internal consistency indicator that measures the degree of correlation of responses (Hora et al., 2010). Data related to socioeconomic profile, specialization, preferences and motivation were assessed using frequency descriptive methods through *likert* package (Bryer and Speerschneider, 2016). Differences between divers' overall satisfaction with the visit were tested using a nonparametric ANOVA (Kruskal-Wallis test) and Nemenyi's post-hoc test. To understand which attributes most impacted the diver's overall satisfaction and should be prioritized by management, the approach proposed by Mikulic and Prebezac (2008) was employed. This approach follows three main analytical steps, which are described below. All analyses were performed using R v. 3.6.1 (R Core Team, 2019).

Initially, a Penalty-Reward Contrast Analysis (PRCA) was performed, whose results were then used for the subsequent steps of this approach. The PRCA starts with the definition of two sets of dummy variables, generated from the attributes' performance values. The first set was created by recoding the lowest performance values as "1" (if the attribute's actual performance was 1), while all other values were recoded as "0" (if the attribute's performance was 2, 3, 4 or 5). The second set was created by recoding the highest performance values as "1" (if the attribute's actual performance was 5), while the other values were recoded as "0" (if the attribute's performance was 1, 2, 3 or 4) (Brandt, 1987; Matzler and Sauerwein, 2002; Mikulic and Prebezac, 2008).

A multiple regression analysis was performed using both sets of dummy variables as independent variables and global satisfaction values as dependent variables (Matzler and Sauerwein, 2002; Mikulic and Prebezac, 2008). Thus, each attribute obtained two standardized regression coefficients that were used to understand its ability to influence overall satisfaction. The first standardized coefficient refers to their ability to generate dissatisfaction when their performance was low (Penalty Index - p). The second refers to the ability of the attribute to generate satisfaction when its performance was high (Reward Index - r). The absolute values of each attribute's penalty and reward index were summed (Equation (1)) to provide their Range of Attribute-Impact on Overall Satisfaction (RIOS) (Mikulic and Prebezac, 2008).

The second step consists of an Impact Range-Performance Analysis (IRPA) (Mikulic and Prebezac, 2008), which is performed with the calculations of the grand means of each attribute's performance and RIOS values. This analysis allows us to build a didactic two-dimensional matrix for the dissemination of results to managers. In this matrix, the mean performance values are represented along the Y-axis of a two-dimensional grid, while the RIOS values are distributed along the X-axis. To guide managers on the priorities of management adjustments, the matrix was divided into a four-quadrant grid. A horizontal dotted line was drawn on the grand mean of attribute performances and a vertical one was drawn on the grand mean of RIOS values. The attribute was considered as of high priority for management when the RIOS value was high, but its performance was below the grand mean. When the RIOS value was high and the attribute performance was above the grand, the attribute was considered to be of medium priority (Mikulic and Prebezac, 2008).

The third step quantifies the asymmetry of the relationship between each attribute's performance and overall satisfaction through the "Impact-Asymmetry Analysis" (IAA). Thus, using the penalty and reward indices we measured the potential of a given attribute to generate dissatisfaction (DGP) and satisfaction (SGP) (Equations (2) and (3), respectively). Subsequently, these potentials were subtracted (Equation (4)) for the calculation of the Impact Asymmetry Index (IA). Attributes can be classified according to their IA values, being *delighters* (IA $\geq$ 0,4), *satisfiers* (0,4 $\geq$ IA $>$ 0,1), *hybrids* (0,1 $\geq$ IA $\geq$ −0,1), *dissatisfiers* (−0,1 $>$ IA $\geq$ -0,4) or *frustrators* (IA $<$ −0,4) (Mikulic and Prebezac, 2008). When the quality of experience is low, this analysis shows which attributes are responsible for generating satisfaction when their performance is above average (*delighters* and *satisfiers*) and which attributes generate dissatisfaction when their performance is below average (*frustrators* and *dissatisfiers*). Thus, the IRPA facilitates the prioritizing of attributes according to their performance, while the IAA allows for their categorizing according to their contribution to visitor satisfaction, facilitating decision making for managers and entrepreneurs regarding the investment of resources (Coghlan, 2012).

The following equations were used:

$$RIOS_i = |p_i| + |r_i| \quad (1)$$

Table 3
Recreational divers' socioeconomic profile and specialization sampled in the three MPAs. *Values expressed as mean and standard deviation. **Brazilian minimum wage was considered as R$ 998.00 = US$ 234.27.

	Wildlife Refuge	State Park	EPA
Gender - %			
Male	71	68	78
Female	29	32	22
Age (years) - %			
<25	6.4	9.3	7.8
25–35	26.2	38	38.3
36–45	40.4	33	40.4
46–55	17.7	19	21.3
56–65	7.7	1.5	0
>65	1.6	0.7	0
Schooling			
University Graduate	37	38	31
Postgraduate	51.8	51	55
Income (Brazilian minimum wages) -%			
Until 1	0.4	0	23.5
1–5	17.2	13	17.6
6–10	32	26	49
>10	38	48.6	9.8
Certification - %	28 Basic 42 Advanced	37 Basic 28 Advanced	22 Basic 32 Advanced
Average number of dives	282 ± 773	447 ± 1632	634 ± 2500
Average number of dives (last 2 years)	39 ± 64	56 ± 128	84 ± 236
Average travel expense (US$)	350 ± 143	201 ± 251	159 ± 94

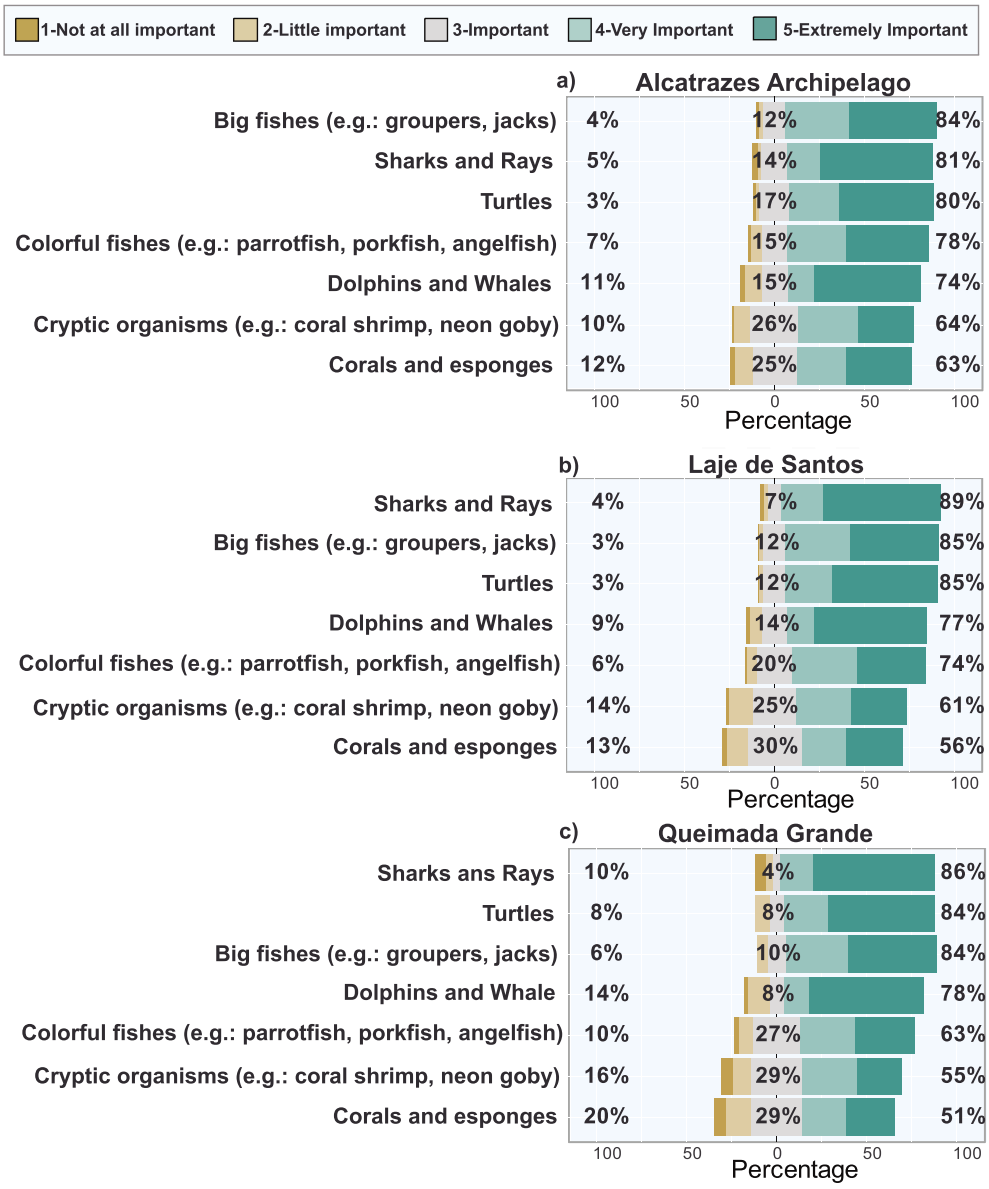

Fig. 2. Divers' preferred marine organisms. Organisms are organized (top down) in descending order from those with the highest percentage of positive responses (4 – Very Important and 5 - Extremely Important) to those with the highest percentage of more negative responses (1 – Not at all Important). From left to right, numbers represent: the summed percentages of responses.

$$DGP_i = |p_i| / RIOS_i \quad (2)$$

$$SGP_i = |r_i| / RIOS_i \quad (3)$$

$$IA_i = SGP_i - DGP_i \quad (4)$$

where, r_i = reward-index for attribute i; p_i = penalty-index for attribute i; $RIOS_i$ = range of impact on overall satisfaction for attribute i; DGP_i = potential of generate dissatisfaction of attribute i; SGP_i = potential of generate satisfaction of attribute i and IA_i = index impact-asymmetry of attribute i.

4. Results

4.1. Divers profile

A total of 456 questionnaires were obtained, 253 from Wildlife Refuge, 151 from State Park and 52 from EPA, representing 27%, 11% and 23% of the total number of divers who visited the areas during the study period, respectively. Cronbach's alpha coefficient was greater than 0.7 for all questions, suggesting that the internal consistency of the questionnaire is high.

In all MPAs, the predominance was of male divers between 25 and 45 years old (Table 3). More than half of the divers had a postgraduate degree and a family income of at least US$ 1405.62 per person per month. Regarding certification, entry-level divers predominated in State Park (37%), while in other MPAs most divers had advanced diving certificates (Wildlife Refuge: 42% and EPA: 32%; Table 3). Considering diving, transportation and lodging, the average spending varied widely among MPAs, ranging from US$159 ± 94 (±SD) in EPA to US$ 350 ± 143 in Wildlife Refuge.

Elasmobranchs (e.g., sharks and rays), sea turtles and large body-sized fishes (e.g., groupers, jacks etc.) were the preferred marine organisms by divers in all three MPAs (Fig. 2), while the least preferred were cryptic (e.g. coral shrimp, neon goby) and sessile organisms (e.g. corals and sponges). The most important motivation for the divers' visit

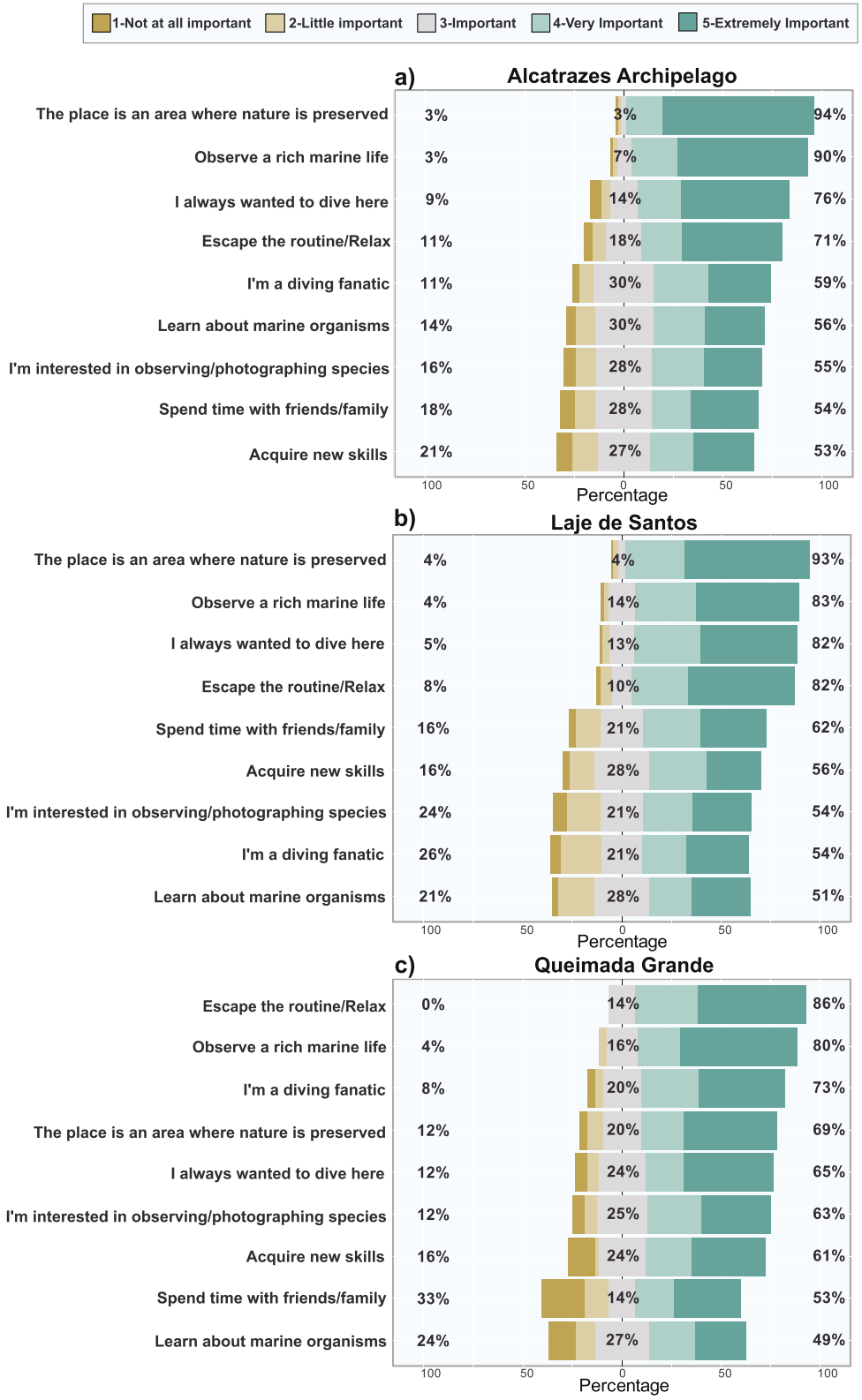

Fig. 3. Main motivations of recreational divers. Motivations are organized (top down) in descending order from those with the highest percentage of positive responses (4 – Very Important and 5 – Extremely Important) to those with the highest percentage of more negative responses (1 – Not at all Important). From left to right, numbers represent: the summed percentages of responses.

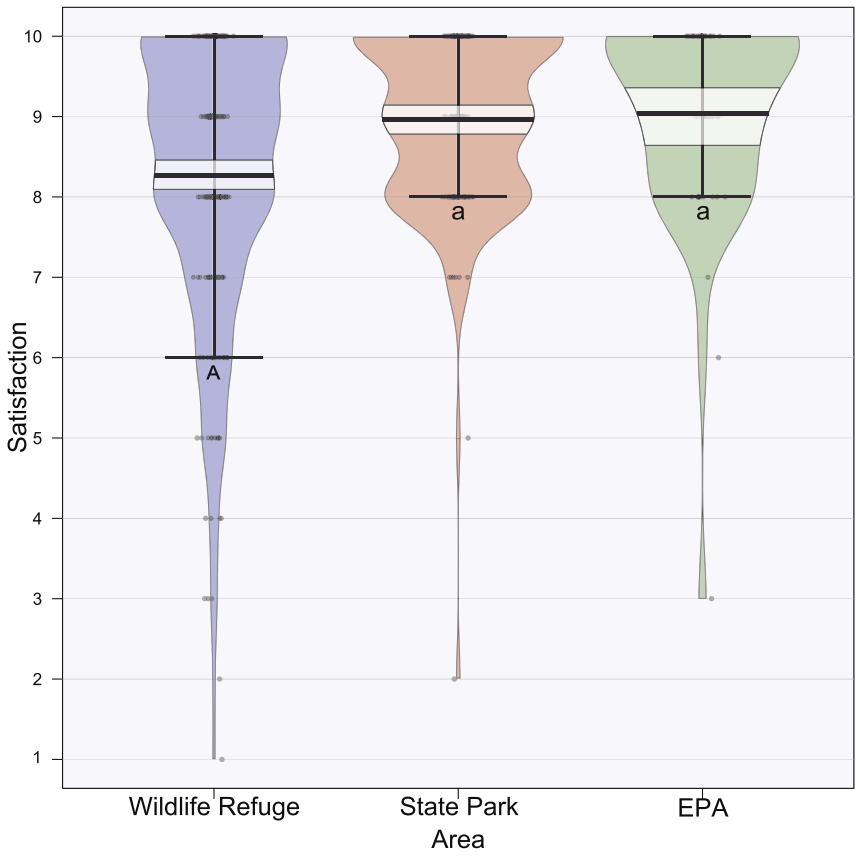

Fig. 4. Recreational Divers' Mean Overall Satisfaction. Points represent raw data, the dark line the mean, the bean the density, the band the 95% confidence interval and the deviations are the 10% and 90% percentiles. Capital letters represent significant difference in means ($p < 0.05$) according to Nemenyi's post-hoc test.

to EPA was "Escape the routine/Relax", while in Wildlife Refuge and State Park it was "The place is an area where nature is preserved" (Fig. 3). However, the least important motivation for Wildlife Refuge divers was "Acquire new skills", while for State Park and EPA divers was "Learning about marine organisms".

4.2. Quality of experience

Although all studied MPAs achieved high satisfaction levels, visitors of the Wildlife Refuge had comparatively lower values (8.27 ± 1.73, mean ± SD) than those from the State Park and EPA (8.96 ± 1.13 and 9.03 ± 1.29, respectively) (Wildlife Refuge *vs.* State Park $p < 0,05$, $H = 5.04$; Wildlife Refuge *vs.* EPA $p < 0.05$, $H = 4.27$; State Park *vs.* EPA $p > 0.05$, $H = 0.79$, Nemenyi's post-hoc test). (Fig. 4).

The IRPA analysis (Fig. 5.A1; Appendix B.1) indicated that the environmental attributes were classified as high-priority in influencing the global satisfaction of Wildlife Refuge's visitors, while "medium-priority" attributes were related to management. Moreover, Wildlife Refuge presented the highest number of attributes with the potential to generate dissatisfaction (*frustrators* and *dissatisfiers*). Only for Wildlife Refuge the attributes "1. Easy access to prior information on-site visitation", "6. Low impact techniques of other divers" and "10. Water visibility" were classified as *frustrators* or *dissatisfiers* (Fig. 5.B1).

At State Park, the high-priority attributes were "1. Easy access to prior information on-site visitation" and "6. Low impact techniques of other divers" (Fig. 5.A2; Appendix B.2). Only for divers from State Park, attribute "5. Briefing/additional conductor or instructor guidance" appeared as a priority for management. The IAA analysis also showed that State Park was the MPA that obtained the highest number of attributes classified as delighters or satisfiers (Fig. 5.B2). Thus, for these divers most of the attributes have a strong potential to generate satisfaction when their performance is high but display little influence on satisfaction when their performance is low. Only the attributes "3. Boarding/unloading location" and "13. Presence of orange cup coral (invasive organism)" were able to negatively impact satisfaction when their performances is low.

For EPA divers, the IRPA analysis also revealed that the attributes "9. No fishing or lost fishing tackle" and "13. Presence of orange cup coral (invasive organism)" were a high priority for management (Fig. 5.A3; Appendix B.3). Medium-priority attributes were related to management and quality of service ("1. Easy access to prior on-site visit information", "3. Boarding/unloading location" and "7. Low crowding of divers at the same point"). According to the IAA analysis (Fig. 5.B3), EPA was the second area that obtained the most attributes capable of generating diver dissatisfaction when their performances are low (*frustators* or *dissatisfiers*). Interestingly, the attribute "11. Diversity and abundance of marine fauna and flora" appeared to be a frustrator only for this area.

Regarding all three MPAs, there were differences in the attributes that most impacted overall satisfaction (RIOS). In Wildlife Refuge the attributes that most impacted satisfaction were "7. Low crowding of divers at the same point", "8. No litter" and "9. No fishing or lost fishing tackle". In State Park, the attributes "1. Easy access to information on visitation" and "12. Encounters with animals" and in EPA attributes "3. Boarding/unloading location" and "9. No fishing or lost fishing tackle" most impacted satisfaction. Curiously, attribute "11. Diversity and abundance of marine fauna and flora" obtained higher RIOS values only in Wildlife Refuge, where it also appeared as a strong satisfaction generator (*delighter*).

5. Discussion

We found that higher levels of restrictions and ordering of uses in

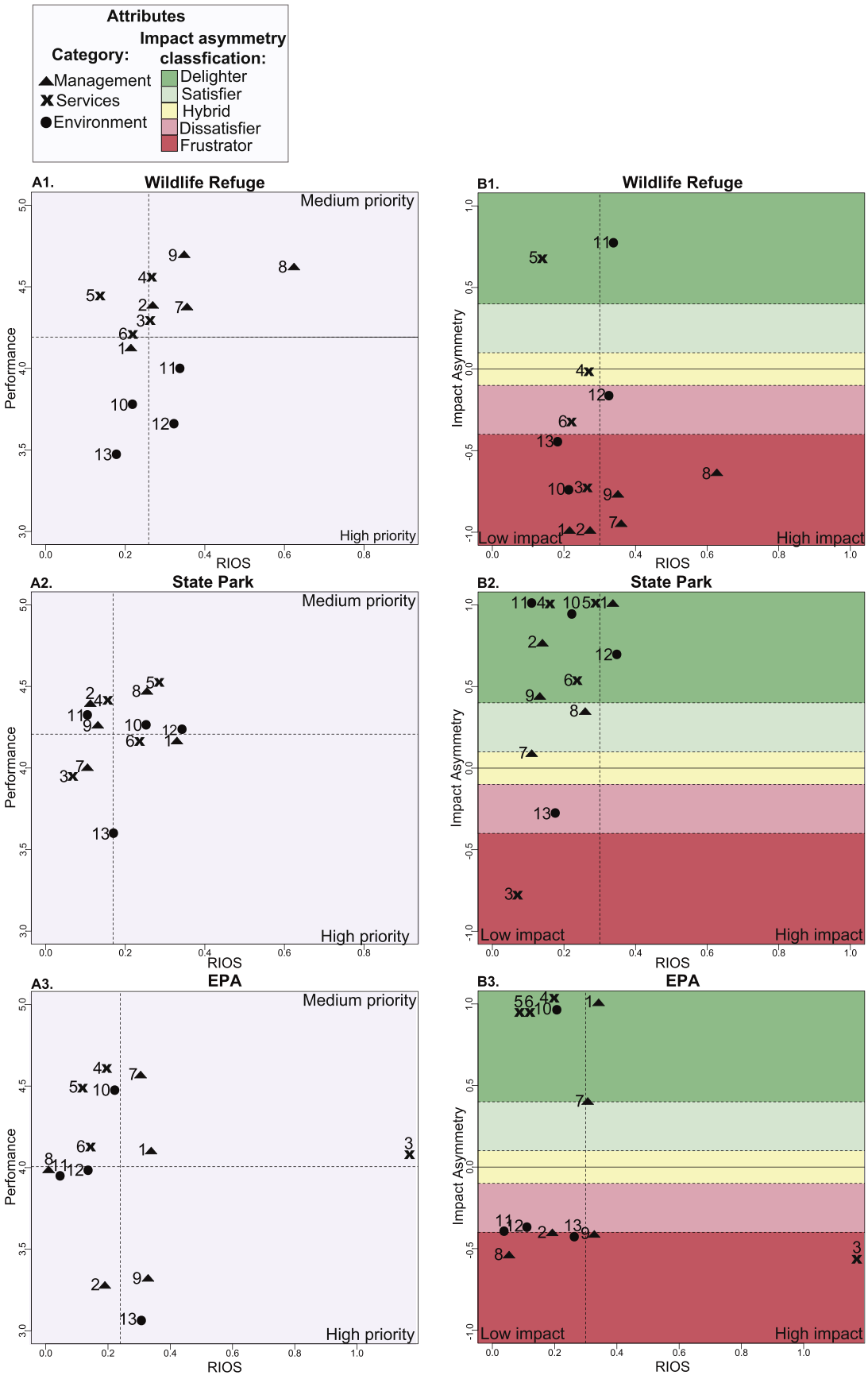

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Fig. 5. A. **Impact range-performance Analysis (IRPA).** The range of attribute-impact on overall satisfaction (RIOS) is represented along the X-axis and the average performance of the attributes is represented along the Y-axis. The horizontal dotted line was drawn on the grand mean of attribute performances, while the vertical one was drawn on the grand mean of RIOS values of each attribute. **B. Impact-Asymmetry Analysis (IAA).** The range of attribute-impact on overall satisfaction (RIOS) is represented along the X-axis while the Impact Asymmetry Index (AI) is represented along the Y-axis. The attributes are: 1.Easy access to prior information on-site visitation; 2. Management rules to avoid environmental impact; 3.Boarding/unloading location; 4.Quality of service provided; 5.Briefing/additional conductor or instructor guidance; 6.Low impact techniques of other divers; 7.Low crowding of divers at the same point; 8.No litter; 9.No fishing or lost fishing tackle; 10.Water visibility; 11.Diversity and abundance of marine fauna and flora; 12. Encounters with animals; 13.Presence of orange cup coral (invasive organism).

MPAs are not synonymous with higher levels of visitor quality of experience. Contrary to our expectations, Wildlife Refuge (more restrictive MPA) achieved a lower mean overall satisfaction than the other studied areas. Wildlife Refuge also obtained the highest number of attributes classified as *dissatisfiers* or *frustrators* (i.e., capable of generating dissatisfaction when their performances are low). In addition, we showed that both Wildlife Refuge and State Park (no-take MPAs) attracted more divers motivated by the conservation status of the area when compared to EPA (sustainable-use MPA). In the latter, most divers were practicing diving to escape routine and relax. We suggest that more restrictive MPAs tend to attract visitors who are more demanding about having their expectations regarding biodiversity met. Therefore, managers and entrepreneurs who aim for long-term sustainable tourism should consider evaluating visitor profile alongside the socio-ecological context in which the MPA is inserted for public use planning.

5.1. Divers profile

In all three MPAs, diver profiles were typical of the scuba diving population (Verkoeyen and Nepal, 2019). Divers' preferred organisms were all from the megafauna, which are attractive due to their popularity and iconic status (Miller, 2005; Giglio et al., 2015). Encounter with megafauna may affect the experience primarily of less experienced divers (Miller, 2005), but previous studies observed this preference regardless of diver's specialization levels (Lucrezi et al., 2013). In the MPAs with more restrictive rules for divers, Wildlife Refuge and State Park, the attribute related with encounters with animals was classified as a priority, albeit being an attribute that is not under management control. We suggest that in no-take MPAs the expectations of encountering preferred organisms during diving are higher. Effect related to the global trend of no-take MPAs generally having higher fish biodiversity and biomass.

In tourism two types of motivations are described, those that push visitors to a destiny (*push*) and those that attract visitors to a destiny (*pull*) (Dann, 1977; Crompton, 1979). The former is related to internal and emotional aspects, such as relaxing and getting away from routine, while the latter involve external and cognitive factors, such as environmental characteristics (Gnoth, 1997; Yoon and Uysal, 2005). Our results revealed that the level of restrictions applied by MPAs is directly related to attraction motivations. This difference is probably due to expectations of finding better conservation status in no-take MPAs better regulated. So, the fact that Wildlife Refuge divers are less satisfied may be related to their motivations and expectations, because it is well known that motivations can influence the satisfaction of tourists (Devesa et al., 2010; Albayraka and Caber, 2018). Therefore, managers should understand the main visiting motivations for effective planning of public use and advertising of the MPA.

5.2. Quality of experience

Although the three areas are MPAs, their categories and management arrangements are different. Wildlife Refuge has been an area restricted to public use for over 30 years and, after more than a decade of demand, has been open for visitation for less than a year. This factor contributed to a high publicity and higher costs with the activity. By contrast, visitors are strictly supervised, the management-user relationship is grounded in environmental monitoring, and managers understand the presence of visitors as potential source of impacts to the environment. This, according to the new MPA visitation paradigm proposed by Weaver and Lawton (2017), makes it a Second Generation MPA. In this sense, expectations that are not consistent with reality are known to affect the quality of the tourist experience (Pizam and Milman, 1993). Consequently, divers' poor knowledge of the conservation status of Wildlife Refuge, rigorous ordering and the high costs of the activity may explain unrealistic expectations with the local context and, subsequently, lower levels of satisfaction than other areas (Pizam and Milman, 1993; Ziegler et al., 2012). As the Widllife Refuge is still in the beginning of diving operations, we need to consider the low experience of diving operators with this destination (e.g., choosing the best dive sites according to environmental conditions, since some can become difficult to divers when currents are too strong) can have on the quality of the dive and the satisfaction of the visitors.

Furthermore, all the highest priority attributes for Wildlife Refuge management were related to the environment. This contrasts with a previous study which have considered the Wildlife Refuge as one of the largest fish biomasses in Brazil (Morais et al., 2017). The fact that Wildlife Refuge was also the MPA where most attributes were classified as *frustrators* may again indicate that, despite being more restrictive, there are factors related to its context that are influencing visitors' experience and should be taken into account for the MPA to contribute to the well-being of visitors. In light of these observations, we recommend that managers and other stakeholders involved in diving in MPAs disclose accurate information about the conservation status of natural attributes and the management context of the area. This initiative could help to generate realistic expectations and, therefore, improve the experience for the divers. Parallel to this, managers also need to seek closer relationships with users to achieve greater support for conservation regulations and actions.

On the other hand, State Park represents the MPA with longer protection time and is close to one of the largest metropolises in the world (i.e., São Paulo), where divers regularly visit in a one-day trip. The high levels of satisfaction obtained may be linked to the sense of loyalty that divers and operators have with the area (Yoon and Uysal, 2005). These circumstances may justify the low number of attributes classified as *frustrators* and a large number of *delighters* and *satisfiers*. State Park is predominantly visited by divers with basic certification, which may explain the attribute "6. Low impact techniques of other divers" having underperformed and appearing as a high priority for management only for this MPA. To mitigate potential impacts on benthic organisms, we propose that the first few minutes of diving should be directed for divers to adjust their buoyancy. In addition, attribute "5. Briefing/additional conductor or instructor guidance" also appeared as a priority only for State Park. This suggests the need for better guide training and the inclusion of warnings regarding the potential impacts of diving in the briefing, as well as close supervision of divers to ensure minimum impact behaviour. The diving guide ability to intervene and correct the behaviour of divers reduces as the size of the group they are conducting increases (Roche et al., 2016). Therefore, we recommend the establishment of a maximum number of guided divers, so diving guides may be more effective to intervene whenever they perceive damage or contact with benthic organisms.

EPA, in turn, is inserted in a multiple-use MPA, that is, it allows for direct extraction of natural resources, such as fishing and spearfishing. However, this MPA obtained values of satisfaction as high as the State Park. This result contradicts common expectations, since it is an area that supposedly presents greater anthropic impacts due to its various

uses. High levels of satisfaction may be explained by more modest expectations, probably generated by the low cost of the visit and the little advertising the region receives (Pizam and Milman, 1993). Another factor that may have influenced such findings is that divers in this area were mostly interested in escaping routine and relaxing, motivations that do not depend directly on the conservation status of natural attributes. However, only for EPA the attribute related to lack of fishing or lost fishing tackle presented below-average performance and was considered a strong generator of dissatisfaction. This result indicates a conflicting context between uses in EPA marine area. Thus, the spatial planning of public use should be one of the priorities for the management of this area.

Wildlife Refuge and State Park are no-take MPAs, however there are contextual differences that may have contributed to differing mean satisfaction scores and the results of the IAA analysis to be different. Among them is the protection time, with State Park being the oldest MPA studied, whereas Wildlife Refuge is the younger. Hence, age can be an important factor because the level of enforcement increased after the establishment of the Refuge, although the area where it is located was restricted to public use for three decades. This factor may influence not only the conservation status of biodiversity, but also the social benefits generated by MPAs (Hargreaves-Allen et al., 2011). In addition, Wildlife Refuge divers had much higher RIOS values for the attribute related to marine biota than other MPAs, indicating that the quality of the experience of divers in this area exhibits a greater dependence on the conservation status of natural attributes. It is also worth considering that the RIOS values of this attribute in the multiple-use MPA were close to zero, suggesting that those divers were the least dependent on natural attributes for a good overall experience. Further research is needed to understand which variables influence the impact that diversity and abundance of marine organisms have on the quality of visitor experience.

Those interested in developing sustainable diving tourism in MPAs should make efforts to achieve or maintain high levels of diver experience, aiming at the conservation of natural resources and the competitiveness of the destination (Ziegler et al., 2012). We demonstrated that more restrictive MPAs attracted mainly divers motivated by the natural attributes. In addition, divers' experiences were influenced by the socio-environmental context of the MPA, being significantly lower in the more restrictive MPA. This indicates that fishing restriction is not the only decisive factor for visitor satisfaction and that the quality of visitors' experience should be considered when assessing MPA effectiveness. Therefore, diving stakeholders must be aware of the expectations and motivations that divers create in relation to their destination. Moreover, in the present work, a deeper understanding of the influence of contexts and management strategies on the quality of diver's experience was proposed. This is intended to help managers and other actors in the development of a more sustainable use of resources in MPAs, also considering the perceptions of visitors. Nevertheless, we could not replicate the MPAs' contexts, which limits the scope of our generalizations and reiterates the need for further studies to confirm our findings for other regions.

6. Final remarks and management recommendations

We investigated the influence of AMP context and management strategies on the quality of the scuba diving experience. Our main findings were: (1) scuba divers in no-take MPAs were more motivated by the area's natural attributes than those in sustainable-use MPA; (2) mean satisfaction values were significantly lower in the more restrictive MPA for public use; (3) management context can contribute to unrealistic expectations and therefore undermine the quality of visitor experience; and (4) the diversity and abundance of marine organisms was more important for the no-take MPA and stricter regulations for public use.

Sustainable use development is one of the purposes of diving tourism management in MPAs. For this we suggest the adoption of the following management strategies: (1) consider the profile and motivation of visitors during planning; (2) improve the communication of information about the area, paying attention to the expectations and motivations that the divers create regarding the destination; (3) seek a closer relationship between managers and users, aiming to increase the support of divers to MPA rules and regulations; (4) establish maximum numbers of divers per guide in State Park; (5) promote actions that encourage visitor participation and interest in public use management decisions; and (6) prioritize the spatial planning of public use in contexts where there is conflict among the different types of use. The success of these strategies depends on a collaborative process that involves managers and diving stakeholders in developing adaptive public use planning. Monitoring and actions that promote positive visitor experiences are essential for MPAs open to tourism to produce human well-being and biodiversity conservation.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2020.105246.

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ARTICLES FOR FACULTY MEMBERS

DIVE GUIDES AND COMPETENCY SKILL

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Getting In: Safe Water Entry Competencies

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Abstract

In high income countries, jumping and diving into water are a small but persistent cause of death and serious injury especially among male youth and young adults. Although water entries maintain a high media profile, little is known about what entry competencies and underlying water safety knowledge youth bring to this practice. Undergraduates enrolled in aquatics (*N*= 76) completed a survey before attempting 7 entry jumping and diving tasks. While safety attitudes and self-reported behaviours were generally good, considerable variation in practical entry competence was evident. Most completed a deep-water compact jump (87%) and PFD jump (88%) with ease. Many completed a crouch dive (57%) and standing dive (53%) into deep water with ease, but only 33% completed a standing dive from a block/bulkhead (<1m height) with ease. Ways of addressing weaknesses in knowledge, attitudes, and behaviours are discussed and recommendations made to enhance the teaching of safe water entry.

Keywords: water competency, drowning prevention, water safety education, jumping, diving

Introduction

In high income countries, jumping and head-first dive entries into water (referred to as diving within this manuscript) are a small but persistent cause of death and serious injury associated with recreational activity. In the 10 years from 2009-2018, 15 fatal incidents from jumping/diving into water were reported in New Zealand (Water Safety New Zealand, 2019). Of these, all victims were male, and most were aged between 15-24 years (60%). Many drowning incidents occurred in river locations (67%), and were the consequence of jumping in (87%). In Australia, 'jumping in' accounted for 4% of the 291 drowning deaths in 2017 (Royal Life Saving Society-Australia, 2017). In the UK from 2006-2010, jumping off high cliffs and other structures into water (commonly referred to as tombstoning in the UK) resulted in 139 incidents requiring an emergency response, with 14 resulting fatalities and many more causing spinal cord and limb injuries (Wills & Dawes, 2011). A study on diving-related admissions to US emergency departments (EDs) from 2002-2014 reported 83,000 cases (mainly young adult males) accruing charges approaching US$620 million (Tadros et al., 2018).

Although water entry incidents have a high-profile media reporting, little is known of the water safety knowledge, perceptions, and practices of young adults when entering water. Much of the literature on water entry has focussed on the mortality and morbidity related to unsafe behaviours and practices in order to identify high risk groups and make recommendations to prevent future harm. One of the most frequently reviewed catastrophic outcomes of headfirst (dive) entries is spinal cord injury (SCI). Diving has been identified as the most frequent sporting activity related to SCI (Hartung et al.,

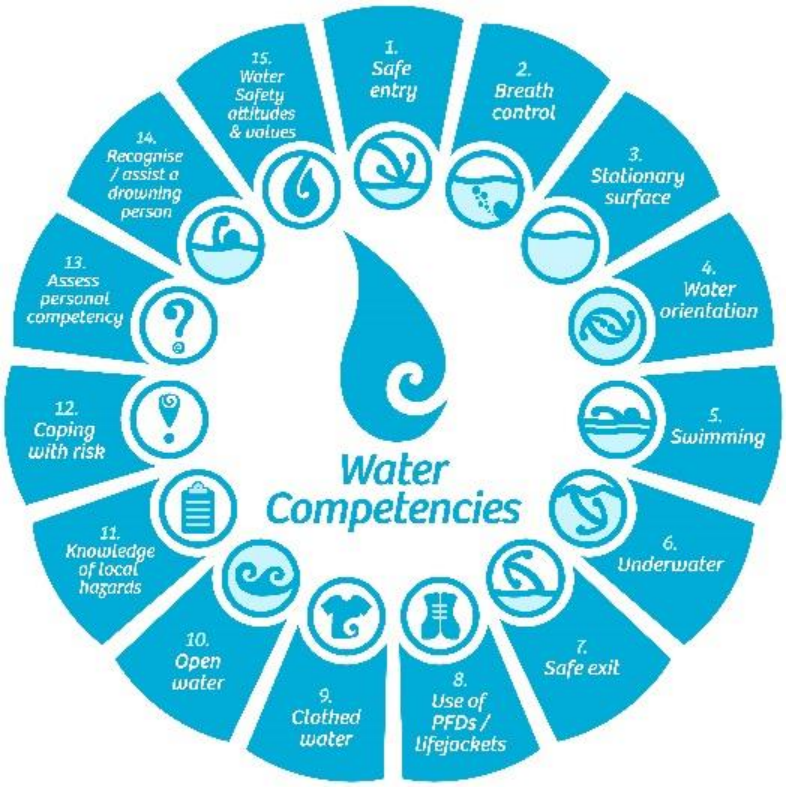
1990; Katoh et al., 1996; Schmitt & Gerner, 2001). Several studies have focussed on diving injuries in swimming pools (DeVivo & Sekar, 1997; Tadros et al., 2018). In open water environments, entering the water from a pier or dock, diving headfirst, not having checked water depth, and being unfamiliar with location have been identified as risk factors (Branche et al., 1991). Alcohol consumption has also been identified as a risk factor associated with entering the water during aquatic recreation (Aito et al., 2005; Blitvich et al., 1999; Herman & Sonntag, 1991). Biomechanical analysis of unsafe techniques has resulted in clear recommendations with regard to head-first entry (Blanksby et al., 1997; Blitvich et al., 1999) and evidence-based specific techniques for teaching enhanced dive entry safety have been developed and published (Blitvich et al., 2000).

Other studies have shown that youth and young adult males are most likely to engage in high-risk entries from height (Moran, 2014a) and to adopt unsafe entry behaviours (Moran, 2008; 2011). As a way of promoting safe entry learning and teaching, Langendorfer (2010) suggested the use of a dynamical constraints model to help focus attention on the constraints associated with the person-task-environment triad that influence entry risk and safety.

Following a review of available research evidence, Stallman and colleagues (2017) included safe entry competence as one of 15 essential elements of water competency required to prevent drowning. They noted that further research was required on the teaching of safe entry competence especially among high-risk groups such as male youth and adolescents. They concluded that future inquiry focus on what is taught, the nature and extent of safe entry competencies, and the associated knowledge, attitudes, and behaviours that inform current practice.

In keeping with the promotion of the concept of water competency (see Figure 1), the authors established a foundational project entitled the *Can You Swim? Study* that focussed on real and perceived swimming and floating competence (Moran et al. 2012; Petrass et al., 2012). Further research focussed on other essential competencies including: swimming and floating competence in open water simulation (Kjendlie et al., 2013; Kjendlie et al., 2018); swimming and floating competence in clothing (Moran, 2014b; 2015; Rejman et al., 2020); safe exit competence (Moran, 2014c); stationary surface competence (Moran, 2019a), and lifejacket competence (Moran, 2019b). Rescue competence has also been studied in an effort to promote safe practice of bystanders in an emergency situation (Pearn & Franklin, 2009, 2012; Moran & Stanley, 2013; Moran et al., 2016; Petrass & Blitvich, 2018), and a 12-week water safety intervention was conducted and evaluated to provide evidence of the effectiveness of such an approach for improving water safety competencies (Petrass & Blitvich, 2014).

Figure 1
Components of water competence (after Stallman, et al., 2017)



Note. Reproduced with permission of Drowning Prevention Auckland [DPA], Auckland, New Zealand

Consequently, the purpose of the study was to explore safe water entry competence to ascertain:

1. Safety perceptions and practices of young adults getting into the water;
2. Actual water entry competencies of young adults, with a specific focus on feet first and headfirst entry; and
3. Water entry knowledge, attitudes, and behaviours of young adults.

Method

A cross sectional study was undertaken in the summer term of 2016 at the University of Auckland, New Zealand and Federation University Australia, Victoria. Ethics clearance for the study was obtained from both the Federation University Australia Human Research Ethics Committee (*Project No: A16-007)* and the University of Auckland Human Participants Ethics Committee (UAHPEC) as an extension of the *Can You Swim? Study* (Case number 010667).

Participants

Undergraduate students enrolled in Bachelor of Health and Physical Education or Bachelor of Exercise and Sports Science degrees that included an aquatics

education course as part of their studies were invited to participate. Most enrollees in such programs were active in sport and recreation and were likely to have previous exposure to aquatic activities. Students reporting any medical or physical disability likely to impact on performance or safety were excluded from the study. Participants who did not complete any part of the practical activity but had completed the written questionnaire were withdrawn from the final analysis.

Procedures

All participants who agreed to take part in the study completed an initial questionnaire prior to the commencement of the pool-based activities. Practical testing took place during normal timetabled classes and was completed over 3 weeks during the summer term (March–April 2016).

Research Instruments

Self-Report Questionnaire

Prior to engaging in the pool-based activities, students were asked to complete a questionnaire that consisted of 15 close-ended questions designed to be completed in 15 minutes. To reduce the possibility of response bias, participants were not told that some of the survey questions related directly to the practical tasks they would complete during their aquatics program. Data were collected based on the original *Can You Swim? Study* (Moran et al., 2012). The questionnaire sought information on sociodemographic characteristics including age and gender. Self-estimates of swimming competence included the use of a four-point scale of *high, good, low,* or *no competence,* and an estimate of how far participants thought they could swim nonstop in a pool. A three-part question sought information on their perceived capacity to jump feet first and dive headfirst from the poolside and dive from 3m height into the pool.

In addition to seeking information on their self-reported perceptions of water competence, participants were asked to report on whether they had been taught how to enter the water safely, whether they had ever injured themselves when entering the water, and whether they had ever pushed someone into the water without prior warning. Three multiple part questions that determined the knowledge, attitudes, and behaviours that informed their understanding of safety when entering the water were also included. A true/false question consisting of 6 statements was included to test their knowledge of safe entry techniques (for example, *lift head before entering water*). To ascertain their attitudes towards safe entry, a seven-part question asked whether they agreed or disagreed with statements related to safe entry (for example, *diving into shallow water is okay if you know how to dive*). A 10-part question with 4 frequency categories (*never*, *once or twice*, *often* and *very often*) was used to obtain self-reported entry behaviours (for example, *have you ever dived into water after drinking alcohol?*).

Practical Tests of Safe Water Entry

The practical component of the study consisted of a series of seven entry activities with increasing levels of difficulty that included: a feet first jump into shallow water (1m); a compact jump into deep water (2m) wearing a PFD; a compact jump into deep water; a stride entry into deep water; a crouch dive into deep water; a standing dive into deep water, and a standing dive from height (<1m) into deep water (see Table 1 for further details). Participants who could not complete any task or considered themselves at risk of injury informed the assessor of their wish to withdraw from that task.

Table 1

Practical entry tests and brief descriptors

Level	Title	Brief Descriptors
1	Jump into shallow water	Chest depth water with full submersion
2	Compact jump into deep water (PFD)	Full submersion
3	Compact jump into deep water	Overhead depth, full submersion
4	Stride entry into deep water	Head kept above water on entry
5	Crouch dive into deep water	Hips higher than head on entry
6	Standing dive into deep water	Flush poolside < 200mm height
7	Standing dive from height into deep water	Entry point >400mm height

All entries were executed into the deep end of the pool except the shallow water jump. The authors were the sole assessors and participants were allowed two attempts at each task with the highest score recorded. All entries took place from the poolside apart from the last dive entry that was executed from a bulkhead or starting block. All entries were scored on a 6-point scale ranging from 1-2 = achieved with difficulty, 3-5 = achieved with ease, with 6 = did not complete. Scores were dichotomised for ease of interpretation to *achieved with ease* or *achieved with difficulty/not completed.*

Data Gathering and Analysis

All data were double-entered and cleaned in Microsoft Excel and then transferred to SPSS (Version 24, Armonk, NY, USA) for statistical analysis. Descriptive statistics were reported via numbers and percentages. Measures of central tendency included mean (*M*), median (*Mdn*), and standard deviation (*SD*). Chi-square tests of independence were used to determine relationships between independent (such as age and gender) and dependent variables (such as practical entry score).

Results

Self-Report Questionnaire Responses

The participants (n = 76) were young adults with most aged between 17–20 years (67%) and slightly more than half were male (55%, n = 42). Most (78%) self-reported their water competency as good (50%) or high (28%), with significantly more females (44%) than males (14%) self-reporting high swimming competence ($\chi 2$ = 9.757 (3), p = 0.021). When asked to estimate how far they could swim without stopping, almost one third (30%) estimated they could swim less than 50m, one quarter (25%) thought they could swim 200 m, and almost one third (32%) estimated they could swim 400 m (20%) or more (12%).

The majority of participants (80%) reported that they had been taught to enter the water safely, with primary school the most frequently cited source of instruction (56%), followed by private lessons (25%), high schools (12%), family (5%), and self-taught or others (3%). No significant differences were evident when analysed by age or gender, although quantitatively more males (24%) than females (15%) reported having never been taught safe entry.

Most participants reported that they had never hurt themselves getting into the water (82%). Of those who had, the injury had occurred mainly to the abdomen (50%), followed by back injury (29%), head injury (14%), and lower body (7%). No significant differences were evident between age and gender regarding whether they had ever experienced injury because of an unsafe entry.

In response to the question asking had they ever pushed someone into the water without the person knowing they were going to, more than half (60%) reported they had done so. Significantly more males (71%) than females (47%) reported that they had pushed someone into the water ($\chi 2$ = 4.272 (1), p = 0.039).

Participants were asked to describe how competent they felt about performing three entry tasks, jumping feet first into a swimming pool; diving headfirst into a pool, and diving in from a height of 3m (Table 2). Most participants (88%) considered that they could easily jump feet first from the poolside while 8% thought that they could not jump in. Fewer thought they could easily dive in headfirst (68%), almost one third (29%) thought they could do so with difficulty and, of these, some reported not being able to enter the water headfirst (16%). Less than half considered they could easily enter the water headfirst from a height of 3m (43%), 41% thought they could do it with difficulty and, of these, almost one third (29%) thought they could not dive in headfirst from that height.

Table 2
Self-estimates of entry competency by gender

Self-estimated competency	Total		Male		Female	
	n	*%*	*n*	*%*	*n*	*%*
How would you describe your ability to jump feet first into deep-end of pool?						
Complete with ease	67	88%	38	90%	29	85%
Complete with difficulty/ Can't jump in	7	9%	2	5%	5	15%
Don't know	2	3%	2	5%	-	-
How would you describe your ability to dive headfirst into deep end from poolside?						
Complete with ease	52	68%	29	69%	23	68%
Complete with difficulty/Can't dive	22	29%	11	26%	11	32%
Don't know	2	3%	2	5%	-	-
How would you describe your ability to dive headfirst into deep end from 3m height?						
Complete with ease	33	43%	21	50%	12	35%
Complete with difficulty/Can't dive	31	41%	14	33%	17	50%
Don't know	12	16%	7	17%	5	15%

No significant differences were evident when self-estimations were analysed by age or gender, although females were less likely descriptively than males to report being able to easily perform the entry competencies (i.e., jump entry females 85%, males 91%; dive entry from poolside females 67%, males 69%, and dive entry from 3m females 35%, males 50%).

Practical Tests of Safe Entry

Most participants completed the shallow water jump (96%), PFD compact entry (88%), and the deep-water compact entry (87%) with ease; less than half (45%) completed the stride entry with ease (Table 3). More than half of the group completed the crouch dive (57%) and standing dive into deep water (53%) with ease, but only one third (33%) could complete the standing dive from the block/bulkhead (<1m height) with ease.

No significant differences were found when practical entry tests were analysed by age, gender or having previously been taught safe water entry. When entries were analysed by estimates of self-reported competency, in each instance those with higher self-reported competency were significantly more likely to complete the tasks with ease: stride entry ($\chi 2$ = 42.489 (1), p = 0.016), the crouch dive ($\chi 2$ = 41.505 (1), p = 0.020), the standing dive ($\chi 2$ = 36.867 (1), p = 0.049), and the standing dive from height ($\chi 2$ = 40.929 (1), p = 0.023).

Table 3
Practical entry tests by gender

	Completed with ease			**Completed with difficulty/ Did not complete**		
	Total *n (%)*	**Male** *n (%)*	**Female** *n (%)*	**Total** *n (%)*	**Female** *n (%)*	**Male** *n (%)*
Shallow water jump	73 (96%)	40 (95%)	33 (97%)	3 (4%)	2 (5%)	1 (3%)
Compact jump into deep water with PFD	67 (88%)	36 (86%)	31 (91%)	9 (12%)	6 (14%)	3 (9%)
Compact jump into deep water	66 (87%)	35 (83%)	31 (91%)	10 (13%)	7 (17%)	3 (9%)
Stride entry	34 (45%)	19 (45%)	15 (44%)	42 (55%)	23 (55%)	19 (56%)
Crouch dive	43 (57%)	24 (57%)	19 (56%)	33 (43%)	18 (43%)	15 (44%)
Standing dive	40 (53%)	22 (52%)	18 (53%)	36 (47%)	20 (48%)	16 (47%)
Block/bulkhead dive	25 (33%)	14 (33%)	11 (32%)	51 (67%)	28 (67%)	23 (68%)

Knowledge of Safe Entry Technique

Most participants were able to identify correct and incorrect techniques related to safe entry (Table 4). Some significant differences in knowledge of safe entry technique were evident when analysed by gender but not by age. Significantly more females (97%) than males (74%) correctly identified the correct responses relating to placement of the chin onto chest ($\chi 2$ = 7.638 (1), p = 0.006), and more females (94%) than males (78%) identified the incorrect technique of lifting the head before entering the water ($\chi 2$ = 3.835 (1), p = 0.050).

While the remaining responses were not significantly different, descriptively more males (17%) than females (6%) incorrectly responded on palm down placement of the hands, pulling arms back to start swimming on entry (males 28%, females 21%), steer downwards to make dive deeper (males 22%, females 18%), and leaning backwards and twisting to one side (males 13%, females 9%).

Table 4
Knowledge of entry technique by gender (Q10)

Technique	Total		Male		Female	
	n	%	*n*	%	*n*	%
Tuck chin onto chest (correct technique)						
Correct response	64	84%	31	74%	33	97%
Incorrect response	12	16%	11	26%	1	3%
Place both hands together palm down (correct technique)*						
Correct response	66	88%	34	83%	32	94%
Incorrect response	9	12%	7	17%	2	6%
Lift head up before entering water (incorrect technique)*						
Correct response	64	85%	32	78%	32	94%
Incorrect response	11	15%	9	22%	2	6%
Pull arms back to start swimming straight away (incorrect technique)*						
Correct response	59	80%	29	73%	26	79%
Incorrect response	15	20%	11	27%	7	21%
Steer downwards to make dive deeper (incorrect technique)*						
Correct response	55	75%	32	78%	27	82%
Incorrect response	18	25%	9	22%	6	18%
Lean backwards and twist body to one side (incorrect technique)*						
Correct response	65	89%	35	88%	30	91%
Incorrect response	8	11%	5	12%	3	9%

Note. *Missing cases not included in calculations

Attitudes towards Safe Entry Practices

Table 5 shows whether participants agreed or disagreed with six statements relating to safe entry practices. Almost all students (>90%) agreed with the statements: 'diving in without checking the depth can be dangerous'; never dive/jump in if you don't know the depth of the water', and 'teaching water entries in schools is very necessary'.

Most (67%) also agreed that jumping in feet first was safer than diving in headfirst and disagreed that diving into shallow water was okay if you knew how to dive (82%). Most students (86%) disagreed that diving should be banned in public pools, but opinions were mixed on whether people should be allowed to jump from heights. No significant differences were evident when attitudes were analysed by age or gender with the exception of the statement relating to jumping from heights where significantly more males (66%) than females (38%) agreed that it was okay for people to jump in from height into water if they wanted to ($\chi 2$ = 5.807 (1), p = 0.016).

Table 5
Attitudes towards safe entry practices

	Agree		Disagree	
	n	**%**	***n***	**%**
Diving in without checking the water depth can be dangerous*	73	99%	1	1%
Never dive /jump in if you don't know the depth of the water*	69	93%	5	7%
Teaching water entries in schools is very necessary*	73	99%	1	1%
Diving into shallow water is okay if you know how to dive*	13	18%	61	82%
Diving should be banned in all public swimming pools*	10	14%	64	86%
If people want to jump from heights into water that's okay*	39	53%	34	47%
Jumping in is safer than diving*	49	67%	24	33%

Note. * missing cases not included in calculations

Self-reported Behaviours Related to Safe Entry

About two thirds of respondents reported that they *never* dived headfirst into water of unknown depth (68%), and *never* dived in after drinking alcohol (62%) (Table 6). Slightly more than half indicated that they *never* dived headfirst into shallow water (57%); *never* dived in from a height greater than 5m (56%) or jumped in from a height greater than 10m (55%). Jumping in became more prevalent as the jump height decreased (64% had *jumped once or twice,* or *often/very often* from a height of 6-10m, while 91% reported jumping in from a height of 1-5m *once or twice,* or *often/very often*). Half (50%) reported *often/very often* diving into water from a height of 1-5m, and 29% said they did this *once or twice*. More than half of participants (57%) reported that they *often/very often* ran into the water and dived headfirst when at the beach, while 28% did this *once* or *twice.* One third (32%) reported that they *never* dived into water in the dark or at night.

When analysed by gender, males were more likely than females to have engaged in any of the risky water entry behaviours. Significantly fewer males (57%) than females (82%) had *never* dived into water of unknown depth ($\chi 2$ = 5.623 (2), p = 0.050) and had *never* dived into water after consuming alcohol (males 50%, females 77%) ($\chi 2$ = 6.239 (2), p = 0.044). Although not statistically significant (p > 0.05), descriptively more males had *often/very often* dived into water at night or in the dark (males 19%, females 9%), jumped in from a height greater than 10m (males 14%, females 9%), run and dived headfirst into the

water at the beach (males 62%, females 50%) and jumped from a height greater than 6m (males 77%, females 53%).

Table 6
Self-reported behaviours related to safe entry

	Never	Once or twice	Often/Very often
	n (%)	*n (%)*	*n (%)*
Dived headfirst into water of unknown depth	52 (68%)	21 (28%)	3 (4%)
Dived headfirst into water you knew was shallow	43 (57%)	30 (39%)	3 (4%)
Run and dived into the water at the beach	12 (16%)	21 (28%)	43 (57%)
Dived into any water after drinking alcohol	47 (62%)	22 (29%)	7 (9%)
Dived into water in the dark or at night	24 (32%)	41 (54%)	11 (14%)
Dived into water from a height 1-5m	16 (21%)	22 (29%)	38 (50%)
Dived into water from a height > 5m*	42 (56%)	20 (27%)	13 (17%)
Jumped into water from a height of 1-5m	7 (9%)	23 (30%)	46 (61%)
Jumped into water from 6-10m*	27 (36%)	18 (24%)	30 (40%)
Jumped into water from a height > 10m	42 (55%)	25 (33%)	9 (12%)

Note.* missing cases not included in calculations

Discussion

The primary goal of this study was to explore the perceptions and practices of young adults in getting into the water safely using a range of entry techniques in shallow and deep water. Recording self-estimates of entry proficiency prior to the practical testing allowed for a comparison of real and perceived competency and thus an indication of their capacity to assess personal competency (See Figure 1, competency 13).

Safe entry is considered one of the fundamental elements of water competence (See Figure 1, competency 1). When asked to predict the ease or difficulty they might have in entering the water, most were confident in their capacity to jump feet first into the pool (88%) but fewer thought they would do this with ease when diving headfirst (68%), and fewer still (43%) thought they could dive from a height of 3 metres. When tested, however, significantly fewer participants (53%) were able to safely execute a standing dive from the poolside

into deep water with ease and even fewer (33%) were able to safely complete a dive with ease from height (<1m).

This overestimation of competency is consistent with the findings of previous studies (for example, Moran et al., 2012; Petrass et al., 2012) although, perhaps surprisingly, no gender differences were evident. While other studies have found that, in comparison to females, males were more likely to overestimate a range of water competencies (for example, Gulliver & Begg, 2005; McCool et al., 2008; Moran, 2008, 2011, 2014c, 2015; Moran et al., 2012; Moran & Stanley, 2013; Rejman et al., 2020), for the water entry competencies in the current study, this was not the case. The inaccuracy in predicting personal competency is concerning given most participants considered they were proficient swimmers (78%) and most reported having been taught to enter the water safely (80%). We recommend that, in addition to being taught safe techniques of entering the water, water safety programs should simultaneously challenge students to: identify hazards associated with water entry (see Figure 1, competency 11); learn how to cope with the risks associated with those various hazards (see Figure 1, competency 12), and be taught how to assess their personal competency accurately (see Figure 1, competency 13).

A secondary goal of the study was to ascertain the knowledge, attitudes and behaviours that inform students' water entry practices (See Figure 1, competencies 11 and 15) and thus provide an indication of their capacity to identify hazards and cope with risks (See Figure 1, competencies 11 and 12). Results of the pre-test questionnaire suggested many students had a sound knowledge of safe entry techniques, with most (75–89%) being able to identify correct and incorrect entry techniques (Table 4). Most respondents also held mainly positive attitudes toward safe entry practice, especially with regards to acknowledging that diving without checking water depth can be dangerous and that you should never dive/jump into water of unknown depth. Previous studies involving school age youth reported males especially more likely to hold at-risk views on these practices (Moran 2008, 2011). Interestingly, most respondents disagreed (87%) that dive entries should be banned in public pools. Not surprisingly, significantly more males agreed that jumping into water from a height was acceptable (males 66%, females 38%), reinforcing findings of a previous study of *YouTube* videos (Moran, 2013).

The self-reported behaviours of participants when getting into the water suggest some risky practices are undertaken and many of these are gender specific (Table 6). The most frequent cause of aquatic spinal cord injury is headfirst entry into shallow water (Blanksby et al., 1997; Blitvich et al., 1999) and it is concerning that some young adults in our study had, at some time, dived headfirst into water of unknown depth (32%), dived into water known to be shallow (43%), or run and dived into the water at the beach (84%). Males were more likely than females to have engaged in risky behaviours, especially diving

into shallow water as reported by Branche and colleagues (1991), and after alcohol use (Aito et al., 2005, Blitvich et al., 1999). Respondents in the present study reported that they had most frequently been taught safe entry techniques at primary school (56%); however, since the risky behaviours appeared prevalent in youth recreational activities, it would be prudent to engage adolescents at high schools in appropriate water entry education related to their socio-cultural background and in its social context. Furthermore, given the gender differences in attitudes and behaviours reported here, it is recommended that attempts to change male practices and mind-sets are a priority if water entry competence is to be improved.

Limitations

While the results of this study advance our understanding of the safe entry problem identified by previous research, several limitations merit consideration when planning further studies on safe entry competence and suggest caution when attempting to generalize the findings of this study to other situations and populations. First, the participants were not representative of the general population because, as students of physical education and sports sciences, their water competency and confidence were likely to be higher than the norm. Second, the sample size was relatively small, and the power of the findings requires further validation with larger and more diverse samples. Third, the tests of entry competence were developed specifically for this study and content validated by the authors in conjunction with peer expert advice and observations of students in a pilot test before the commencement of the study. Fourth, the entry activities took place in the confines of a pool and thus did not wholly reflect the demands of entering open water in a variety of more demanding environments such as cold water, slippery ledges, underwater obstacles, swift currents, waves, and darkness. Further studies involving different subpopulations (such as children and adolescents) and different environments (such as beaches, rocky foreshores, and rivers) will help address these limitations. Fifth, because the study was undertaken in two separate countries under time and funding constraints, it was not possible to tests inter-rater accuracy. Future studies involving the research instruments developed here should bear in mind inter-rater reliability in order to address this limitation. These limitations notwithstanding, the results of this study suggest that inaccurate perceptions and practice of safe entry into water continue to pose a serious risk of drowning and serious injury especially among male youth and young adults.

Conclusion

Given the shortcomings identified in this study on the perceptions and practices of safe entry into water by young adults, it would appear prudent to place greater emphasis on this aspect of water safety education. In addition, given the disparity between the preconceived ideas of personal competency of getting into the water and the actual entry tasks when tested, it would also seem prudent to

promote teaching strategies that incorporate experience of simulated entry scenarios so that youth are forewarned about potential dangers and are able to more effectively manage the life-threatening challenges associated with getting into the water. Targeted interventions that focus on males, the risks of jumping or diving into water from a height, the dangers of peer pressure to engage in risky behavior, and linking actual personal competency with perceptions are recommended. Further research on the safe entry perceptions and practice of others who are less water competent is advised.

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ARTICLES FOR FACULTY MEMBERS

DIVE GUIDES AND COMPETENCY SKILL

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How University Students Assess Their Water Skills

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The aim of this study was to determine the gender differences between students' actual and perceived water abilities, how respondents assess risk in the described situations, and whether there are gender differences for those situations. The cross-sectional study was conducted on 150 students aged 19–20 years (males, $n = 88$; females, $n = 62$) from the faculty of sport and physical education, University of Novi Sad. Using calculated frequencies and estimates, students' self-assessment and actual measures of their swimming and survival skills and their perceived risk of drowning are described. Based on the results, Mann-Whitney U tests were applied. The differences between independent variables (gender) were analyzed according to dependent measures (water competency). To determine the significance of the relationship between actual and perceived skills, Spearman-rank correlation coefficients were calculated. The results of this study confirmed gender differences between students' actual and perceived water abilities, and that the male and female students had inaccurate perceptions of their own perceived and real water abilities. Both male and female students, with high precision, assessed their ability to swim long distances (rs = 0.601; rs = 0.694) just as female students assessed their ability to float (rs = 0.698). Male students greatly overestimated their backstroke swimming, while female students underestimated their ability to dive into the water. Both groups overestimated underwater swimming and underestimated their surface dive skill. Also, there was gender differences between students in assessing the risk for described situations.

Keywords: water safety, gender comparison, risk assessment, drowning, swimming

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INTRODUCTION

Activities for work or pleasure that are near or on the water have drowning risks. An awareness of this risk, along with achieving water safety knowledge and skills improve enjoyment and safety. When staying near or in the water, it is very important to take care of your own safety and the safety of others. Safety is "a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community" (Maurice et al., 2001). When you are confident, it is much easier to enjoy. Perceived motor skills are not real motor skills, but are someone's perception of own possibilities (Logan et al., 2015). If someone wrongly perceives their own competencies, especially if they overestimated them, he can be in great danger. An important factor of water competencies is the ability to accurately assess the actual level of one's own skills in water (Stallman et al., 2017).

It was previously determined that males (Petrass et al., 2012) and children (Queiroga et al., 2013) could approximately predict their own water skills. Some research has shown that males cannot predict their swimming abilities correctly in moving water (Kjendlie et al., 2013), in swimming in clothes (Moran, 2015), and in safely getting out of the water (Moran, 2014). It should be emphasized that younger children more often overestimate their real abilities in the water (Costa et al., 2020). It can be especially dangerous for young children if their parents also overestimate their abilities (D'Hondt et al., 2021). Drowning can occur anywhere there is water: oceans, seas, lakes, pools, bathtubs, rivers, or even water collections on the side of the road. Drowning is the 3rd leading cause of unintentional injury and death worldwide, accounting for 7% of all injury-related deaths (World Health Organization., 2021). Among many factors influencing adult fatal and non-fatal drowning, mortality is lacking a level of risk awareness, knowledge on water safety (Wu et al., 2017), an overestimation of their own self-assessed swimming skills (Moran et al., 2012), and a lack of water competencies (Stanley and Moran, 2016).

Awareness of the risk of drowning is a signpost on how to spend time next to or in the water without negative consequences. Insufficiency of knowledge and practice on prevention of drowning influence insufficient awareness of the risk of drowning among children (Farizan et al., 2021). Many countries are developing plans to reduce drowning. Drowning and failed rescue attempts have resulted in physiological, sociological, legal, and financial consequences for the injured, the rescuer, and society (Avramidis, 2009). Reducing the number of drownings can be achieved by implementing prevention measures in parallel and raising awareness of drowning, which has been implemented by high-income countries (HIC). This measure has been successfully applied in both low- and middle-income countries (LMICs) (World Health Organization., 2014). Adults and parents should be especially aware of the risks for young people and children. In public swimming pools where there is a high risk of drowning, the absence of risk awareness is best seen (Brenner et al., 2003). It was found that younger men are less likely to improve their safety even though they are aware of the risks of drowning (Titchener et al., 2011). Supervision is mandatory for children under the age of 6 without swimming abilities. Related authorities can organize public cardiopulmonary resuscitation (CPR) classes, establish strict regulations on safety at the pool, and raise community awareness about the risk factors of drowning (Jeswani et al., 2021). Risk-awareness is a way to change safety culture (Hopkins, 2005). Applying this definition to staying in the water, the assessment of the risk of drowning implies considering the situation and making a decision on further activities based on one's abilities.

When and where there is a risk of drowning or injury, water safety invokes the precaution, procedures, and policies that correlate with the safety of the bodies in and on the water or around it (US Coast Guard Auxiliary, 2022). Some of the strategies of HIC for the prevention of drowning are as follows: raising awareness, educating the public, and increasing supervision (Ramos et al., 2015). In these countries, as in others, adults should have good water skills as they are responsible for supervising children around the water where there is a possibility that they are closest to the scene of the incident and have to react (Peden et al., 2019). Water safety education is constantly advancing and improving, so this process is defined as a dynamic process "in which effectiveness is the result of multi-level interaction between the individual, the environment, and the task at hand" (Langendorfer, 2015). Water safety education trains people to acquire knowledge of recognizing and reducing the potential risk in aquatic environments and water activities. The program also includes personal survival and water rescue skills which can help them save themselves in the event of an incident in the water (Red Cross., 2014). There are also somewhat broader definitions of water skills, which say that water safety education is like any other education. The goal of this education "is about equipping people of all ages with the right skills, knowledge, and experience to make informed decisions about their own safety and protect themselves and possibly others from situations that may harm them" (RoSPA., 2008). Although research suggests a positive link between water safety education and the reduction of drowning (Red Cross., 2014), it should be noted that increasing knowledge or awareness alone does not necessarily change safety behavior (Wright, 2016).

There is a self-assessment model which starts from the assumption to render future outcomes more predictable and controllable. People seek to assess abilities that determine important future outcomes (Trope, 1980). This interpretation indicates the need for a good assessment of one's own abilities for being safer next to and in the water. Self-assessment of ability is very important because research indicates that adult men, children, and their caregivers often underestimate water incidents (Morrongiello et al., 2013). Other studies reported that men are more likely to overestimate more water abilities than women (Moran and Stanley, 2013; Rejman et al., 2020). Studies analyzing the personal water competency conclude that most think they swim well, while twice as many men and women think they can swim longer than 200 m and feel safer in open water (Stanley and Moran, 2016). In addition, more men are confident in their rescue abilities (Stanley and Moran, 2018). Also, there is an opinion of younger adults who do not believe that injuries in or on the water can be prevented, and that they can do everything to improve their own safety (Costa et al., 2020). Every swimming training program should ultimately have an assessment of what has been learned based on which each participant or his or her parent would know what his or her abilities are.

Foremost, it is recommended to endorse swimming ability as a necessary module of water skills, but it is also significant to consider the fact that the ability to swim, every so often, is not enough to prevent drowning (Brenner et al., 2006). In the following years, there was an explanation that it is a set of abilities of an individual in the water, which reduce the risk of drowning and increase the ability to perform various tasks in the water (Langendorfer, 2011). Water competence was defined in a drowning prevention context as "the sum of all personal aquatic movements that help prevent drowning as well as the associated water safety knowledge, attitudes, values, judgment and behaviors that facilitate safety in, on

and around the water" (Moran, 2013). There is international research that identifies 15 water competencies that include physical, cognitive, and affective characteristics that should prevent drowning (Stallman et al., 2017). These competencies are safe entry (entry, surface, and level off), breath control, stationary surface (front and back float, tread water), water orientation (turn and roll), swimming competencies (on the front, back, and side), underwater competencies (surface dive, swim underwater), use of lifejackets (and other flotation devices), safe exit, clothed water competencies, open water competencies, knowledge (of local hazards and water safety rules), critical decision making–assessing and managing the risk, assess personal competency–to cope with the risk, recognition/assisting a drowning person, and attitudes and behaviors. The importance of floating and swimming, among other water competencies, as a preventive measure against drowning, is emphasized (Stallman et al., 2017; Langendorfer et al., 2018). Nowadays, water competency implies a method to forestall, avoid, and survive drowning situations, along with the ability to foresee, identify, and help persons in possibly dangerous situations. It incorporates water skills, water intelligence, and helping others (Pool Safely collaborator Water Safety USA., 2020).

The objectives of this study are to determine the gender differences between students' actual and perceived water abilities, and also how respondents assess risk in the described situations and whether there are gender differences in risk assessment in the described situations.

MATERIALS AND METHODS

Water competencies are one of the drowning prevention measures. Knowing your own abilities in water can be an important factor in water safety for each individual. This is the reason why this study was conducted. The cross-sectional study was conducted on 150 students aged 19–20 years (males, $n = 88$; females, $n = 62$) from the faculty of sport and physical education, University of Novi Sad. The research was conducted according to the protocol of the project "Can you swim?" (Moran et al., 2012). All respondents voluntarily joined the research and signed consent forms when they were acquainted with the purpose of the research and the manner of its implementation. The research consisted of **two** parts. In the **first** part of the research, the respondents filled in a questionnaire which referred to some forms of water abilities and survival skills. The **second** part of the research was testing **six** water skills. This part of the research lasted for **ten** consecutive days wherein 30 students took **three** tests per day. The testing was conducted in a pool that was 25 m long and 2.2 meters deep, with a water temperature of 23°C and a constant presence of lifeguards. Testing was completed

TABLE 1 | Students self-estimated water competencies by gender.

	Total		Male		Female		Mann-Whitney U	*p*
	N	%	*N*	%	*N*	%		
How many nonstop laps of a 25 m pool can you swim?								
<50 m	8	5.3	3	3.4	5	8.1	2577.000	0.554
51–100 m	39	26.0	28	31.8	11	17.7		
101–200 m	34	22.7	21	23.9	13	21.0		
201–300 m	36	24.0	14	15.9	22	35.5		
>300 m	33	22.0	22	25.0	11	17.7		
How long can you stay afloat?								
<2 min	96	64.0	67	76.1	29	46.8	1899.500	<0.001
2–6 min	39	26.0	17	19.3	22	35.5		
7–15 min	11	7.3	0	0	11	17.7		
>15 min	4	2.7	4	4.5	0	0		
Can you swim 100 m on your back?								
Yes, can swim 100 m nonstop back	115	76.7	69	78.4	46	74.2	2613.000	0.549
No, c'an't swim 100 m nonstop back	35	23.3	19	21.6	16	25.8		
Can you dive into the deep end of the pool?								
Yes, can dive headfirst into the pool	135	90.0	88	100.0	47	75.8	2068.000	<0.001
No, can't dive headfirst into pool	15	10.0	0	0	15	24.2		
Can you swim underwater?								
Yes, can swim underwater	136	90.7	80	90.9	56	90.3	2712.000	0.904
No, can't swim underwater	14	9.3	8	9.1	6	9.7		
Can you surface dive to a depth of 2 m?								
Yes, can surface dive to 2 m	128	85.3	80	90.9	48	77.4	2360.000	0.022
No, can't surface dive to 2 m	22	14.7	8	9.1	14	22.6		
Total	150	100	88	58.7	62	41.3		

before the beginning of the practical part of the lessons in the pool in order to avoid the possible effects of learning from the practical part of the activity. The water skills assessment was conducted **5** days after the end of the survey to avoid completing the survey based on the results achieved in-water skills. The evaluation of real skills in the water, according to the stated standards, was performed by **two** swimming coaches. These skills were as follows: distance swimming, backstroke swimming, floating, dive entry (head first), surface dive (head first), and underwater swim. Swimming skills were assessed by continuous swimming for 15 min using any technique and speed. The swimming distance of each respondent was assessed on a five-point scale: <50 m, 51–100 m, 101–200 m, 201–300 m, and >300 m. Backstroke swimming was assessed by 100 m swim on the back using any technique and speed. This skill was assessed on a four-point scale as follows: did not complete, completed with poor form, completed with satisfactory form, and completed with good/excellent form. To assess respondents' floating skills, they were asked lay on the water surface with minimal movement. This skill was assessed on a four-point scale: <2 min, 2–6 min, 7–15 min, and >15 min. Dive entry skill was tested with dive (head first) into the pool. This skill was assessed on a four-point scale: did not complete, completed with poor form, completed with satisfactory form, and completed with good/excellent form. Then underwater swim was tested. The respondents started with a dive (head first) and swam underwater as far as they could. This skill was assessed on a five-point scale: did not complete, completed 10 m, completed 15 m, completed 20 m, and completed 25 m. Surface dive (head first) was tested with surface dive (head first) to the bottom of the pool. This skill was assessed on a four-point scale: did not complete, completed with poor form, completed with satisfactory form, and completed with good/excellent form.

TABLE 2 | Student water competencies by gender.

	Total		Male		Female		Mann-Whitney U	*p*
	N	%	*N*	%	*N*	%		
Swimming ability								
<50 m	6	4.0	1	1.1	5	8.1	1743.000	<0.001
51–100 m	40	26.7	32	36.4	8	12.9		
101–200 m	45	30.0	36	40.9	9	14.5		
201–300 m	15	10.0	4	4.5	11	17.7		
>300 m	44	29.3	15	17.0	29	46.8		
Floating ability								
<2 min	131	87.3	86	97.7	45	72.6	2042.000	0.003
2–6 min	19	12.7	2	2.3	17	27.4		
7–15 min	0	0	0	0	0	0		
>15 min	0	0	0	0	0	0		
100 m swim on back								
Did not complete	27	18.0	20	22.7	7	11.3	2513.500	0.388
Completed with poor form	27	18.0	11	12.5	16	25.8		
Completed with satisfactory form	64	42.7	41	46.6	23	37.1		
Completed with good/excellent form	32	21.3	16	18.2	16	25.8		
Dive into pool (2 m depth)								
Did not complete	9	6.0	1	1.1	8	12.9	1922.000	<0.001
Completed with poor form	14	9.3	4	4.5	10	16.1		
Completed with satisfactory form	39	26.0	23	26.1	16	25.8		
Completed with good/excellent form	88	58.7	60	68.2	28	45.2		
Underwater Swim								
Did not complete	50	33.3	25	28.4	25	40.3	2331.500	0.118
Completed 10 m	36	24.0	22	25.0	14	22.6		
Completed 15 m	26	17.3	16	18.2	10	16.1		
Completed 20 m	15	10.0	9	10.2	6	9.7		
Completed 25 m	23	15.3	16	18.2	7	11.3		
Surface dive 2 m								
Did not complete	15	10.0	3	3.4	12	19.4	2153.000	0.022
Completed with poor form	41	27.3	25	28.4	16	25.8		
Completed with satisfactory form	42	28.0	25	28.4	17	27.4		
Completed with good/excellent form	52	34.7	35	39.8	17	27.4		
Total	150	100	88	58.7	62	41.3		

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board (or Ethics Committee) of the University of Novi Sad, Faculty of sport and physical education, Novi Sad, Serbia (Ref. No. 47-12-11/2021-1).

The collected data were processed by the statistical program IBM SPSS (20.0). Using calculated frequencies and estimates, students' self-assessment and actual measures of their swimming and survival skills and their perceived risk of drowning are described. Shapiro-Wilk test was used to test the normality of the distribution ($p < 0.001$). Based on the results, Mann-Whitney U tests were applied, the differences between independent variables (gender) were analyzed according to dependent measures (water competency). To determine the significance of the relationship between actual and perceived skills, Spearman-rank correlation coefficients were calculated. Spearman's correlation coefficients (r) were used to investigate associations among actual and perceived water skills. The degrees of statistically relevant Spearman's correlation is defined in the relationship as trivial, very small, insubstantial, tiny, practically zero (±0–0.1); small, low, minor (±0.1–0.3); moderate, medium (±0.3–0.5); large, high, major (±0.5–0.7); very large, very high, huge (±0.7–0.9); nearly, practically, or almost; and perfect, distinct, infinite (±0.9–1) (Cohen, 1988). The level of significance was set at $p \leq 0.05$.

RESULTS

At the beginning of the research, there were a total of 164 students. During testing, some of them did not do a questionnaire or did not complete tests in the water. Incomplete data were excluded, and the research continued with a sample of 150 students. Analyzing the results in **Table 1** which shows the students' self-assessed water competencies, it is evident that only 5% of respondents estimated that they could not swim more than 50 m continuously for 15 min using any technique and speed. The assessments of the other respondents were very uniform (22–26%). A large number of the respondents (64%) estimated that they could stay afloat < 2 min, and a small number of them (2.7%) could stay afloat longer than 15 min. Analyzing the surface floating ability by gender, it is noticeable that there is a statistically significant difference. Much more male students (76.1%) estimated that they could stay afloat < 2 min, and only male respondents (4.5%) could stay afloat longer than 15 min. More female respondents (53.2%) could stay afloat in the range

TABLE 3 | Male students-comparison of estimated and real water competencies.

	Swim estimate	Float estimate	Backstroke estimate	Dive entry estimate	Underwater swim estimate	Surface dive estimate
Swim	0.601**					
Float		0.085				
Backstroke			−0.421**			
Dive entry				-		
Underwater swim					−0.335**	
Surface dive						−0.331**

***Correlation is significant at the 0.01 level (2-tailed).*

TABLE 4 | Female students-comparison of estimated and real water competencies.

	Swim estimate	Float estimate	Backstroke estimate	Dive entry estimate	Underwater swim estimate	Surface dive estimate
Swim	0.694**					
Float		0.698**				
Backstroke			0.222			
Dive entry				−0.107		
Underwater swim					−0.353**	
Surface dive						−0.352**

***Correlation is significant at the 0.01 level (2-tailed).*

of 2–15 min. Most students estimated that they could swim 100 m on their back (76.7%), dive into the deep end of the pool (90%), can swim underwater (90.7%), and surface dive to a depth of 2 m (85.3%). Statistically, differences were found by gender in self-estimates of water competencies for diving into the pool where all male students estimated that they can dive into the pool and for surface dive to a depth. Meanwhile, a small number (22.6%) of female students estimated that they could not dive to a depth of 2 m.

According to **Table 2**, just 29% of students were able to swim nonstop more than 300 m and 4% swam < 50 m. Analyzing the swimming ability by gender, there is noticeable statistically significant difference. Most female students (64.5%) were able to swim nonstop more than 200 m compared to male students (21.5%), and fewer female students (8.1%) could not swim for more than 50 m. Most male students (77.3%) swam 50–200 m compared to female students (27.4%). The small number of respondents (13%) showed ability to float. Particularly, female students (27%) floated for 2–6 min compared to men (2%), which is a statistically significant difference. On the backstroke swim test, participants are of similar ability. The students were statistically significantly better at diving into the pool. Students (68%) performed the dive as excellent, while female students (13%) did not dive into the pool. In the underwater swim, participants are of similar ability. Male students (97%) were statistically significantly better in surface dive, while female students (19%) did not complete the task.

If the perceived and real water abilities of male students are analyzed, there is a noticeable (**Table 3**) high statistically significant relationship between real and expected distance swimming skills. This skill is very important for the safety of the individual in the water. There are also moderate, negative, and statistically significant relations between perceived and actual 100 m backstroke swimming, underwater swimming skills, and surface diving skills. A negative sign of the relations indicates a wrong assessment of skills in the water, which can be very dangerous for any individual. In this sample, the negative sign indicates an overestimation of the backstroke swimming 100 m, underwater swimming skills, and underestimation of the surface diving skills.

By analyzing the perceived and real abilities in the water of the female students, there is a noticeable (**Table 4**) high statistically

TABLE 5 | Perceptions of risk of drowning by gender.

	Total		Male		Female		Mann-Whitney U	*p*
Risk scenario	***N***	**%**	***N***	**%**	***N***	**%**		
Capsized canoe 100 meters offshore								
Extreme risk	20	13.3	10	11.4	10	16.1	2231.000	0.046*
High risk	24	16.0	13	14.8	11	17.7		
Slight risk	46	30.7	23	26.1	23	37.1		
No risk	60	40.0	42	47.7	18	29.0		
Caught in rip current at surf beach								
Extreme risk	22	14.7	13	14.8	9	14.5	2532.000	0.435
High risk	44	29.3	22	25.0	22	35.5		
Slight risk	54	36.0	35	39.8	19	30.6		
No risk	30	20.0	18	20.5	12	19.4		
Chased toy into deep end of swimming pool								
Extreme risk	6	4.0	3	3.4	3	4.8	2559.000	0.328
High risk	10	6.7	5	5.7	5	8.1		
Slight risk	10	6.7	5	5.7	5	8.1		
No risk	124	82.7	75	85.2	49	79.0		
Fell into deep river when fully clothed								
Extreme risk	8	5.3	5	5.7	3	4.8	2579.000	0.530
High risk	15	10.0	9	10.2	6	9.7		
Slight risk	48	32.0	25	28.4	23	37.1		
No risk	79	52.7	49	55.7	30	48.4		
Swept off isolated rocks while fishing								
Extreme risk	14	9.3	6	6.8	8	12.9	2038.000	0.005*
High risk	24	16.0	10	11.4	14	22.6		
Slight risk	45	30.0	25	28.4	20	32.3		
No risk	67	44.7	47	53.4	20	32.3		
Total	150	100	88	58.7	62	41.3		

significant relationship between perceived and real ability of distance swimming skills and floating skills. As mentioned, these two skills are very important for the safety of the individual in the water. There is a moderate, negative, and statistically significant relationship between actual and expected 100 m backstroke swimming, underwater swimming skills, and surface diving skills. A negative sign of the relations indicates a wrong assessment of skills in the water, which can be very dangerous for any individual. In this sample, a negative sign indicates an overestimation of the underwater swimming skills and an underestimation of surface diving skills.

In addition to assessing their water skills, respondents also assessed the degree of risk in the five situations described to them. Analyzing respondents' responses (**Table 5**), it is noticeable that there is no statistically significant difference between the answers of male and female respondents. When asked about the risk assessment when they were caught in the current on a surfing beach, they ran a toy into the deep end of the swimming pool and fell fully clothed into a deep river. In all three described situations, female students were more careful than male students in risk assessment. The existence of a statistically significant difference in the answers can be noticed in the questions for the situation of overturning a canoe 100 m from the shore ($p = 0.046$) and being swept off isolated rocks while fishing ($p = 0.005$). The answers of the female students to these questions indicate their even greater caution compared to male students for the previously described situations.

DISCUSSION

When analyzing the assessments of abilities of the respondents in distance swimming, there were no big differences between the two groups of respondents, unlike the analysis of skills where female students were significantly better due to how more of them swam over 200 m. This difference between gender in distance swimming could be a consequence of better swimming abilities, physical constitution, and better motivation. Both groups of respondents were highly realistic in assessing their distance swimming ability. The ability to swim for a long time in some incidents can save lives. Swimming ability is one of many ways to prevent drowning (Brenner et al., 2003). Participation in formal swimming lessons is associated with a reduction in the risk of drowning (Brenner et al., 2009).

Floating is the main skill of survival in water and a method of preventing drowning (Andrews, 2019). Both in the assessment and in the real situation, female students were statistically significantly better than male students in the skill of floating on water. All respondents rated their ability to float in water well. The female's rating was highly accurate, and the male rated it well as not being able to swim for long. A smaller number of female students were able to float for < 2 min, and more of them floated for 2–6 min. Such difference between gender in floating ability could be a consequence of the physical constitution and the ability to relax while lying on a surface. This ability can be useful after a long swim or a stressful situation in the water; to lay on your back, relax, breathe, concentrate, and decide what to do next. Basic water competency skills, floating, diving, underwater swimming, and swimming technique, are the essence of the concept of water competence and survival skills (Langendorfer and Bruya, 1995; Stallman et al., 2011). There are claims that some different skills from the above are the main skills in the water that may be crucial in a drowning situation. These skills are: buoyancy control (floating), treading water, re-orienting oneself, breath control, and propulsion above and below the water surface (Stallman et al., 2008; Hulteen et al., 2018).

Assessment of swimming ability on the back and real possibilities are similar between two groups of respondents. The male students moderately overestimated their capabilities. This overestimation of the skill of swimming on the back in males is a consequence of their opinion that lying on the back makes breathing "easier." Hence, they would be able to swim 100 m, which proved to be incorrect. A poor assessment of this ability could jeopardize the safety of an individual who may once have set out to swim a section in this way. It is especially dangerous when abilities are overestimated. Swimming on the backside allows easier breathing, solid propulsion, and poor forward visibility. Drowning survivors who did not know how to float or swim on their backs had to be rescued (Stallman et al., 2008).

In HIC, jumping and diving into water is a small but persistent cause of death and serious injury, especially among male youth and young adults (Moran Dr et al., 2021). Diving headfirst is a popular water activity, but the risk of head, neck, and spinal cord injury means that diving could be extremely dangerous. Diving injuries as a consequence of aquatic recreational activities are the cause of devastating trauma, primarily affecting the cervical spine (Korres et al., 2006). All the male students wrote that they knew to dive headfirst into the pool, with a third of the female respondents saying that they did not know to dive headfirst. In the skill of diving on the head in the pool, the male students were better, and during the testing, more of them were rated as satisfactory and excellent. There are fewer female students than they estimated. Those who did not dive headfirst into the water underestimated their skills. The observed difference between gender in diving into the water in favor of males is caused by their desire to prove themselves and their courage. The headfirst entry in the pool is most often used by divers and swimmers in competitions. Bathers also like to use this type of diving for enjoyment. After such entry into the water, the airways are "closed" and the eyes are in contact with water for some time, which could be a problem for individuals. This skill is important because it indicates that there is no fear of diving into the water, which can sometimes be the only way to enter the water, especially in incidental situations.

According to the underwater swimming skills, respondents are similar in both assessments and tests. However, in their assessment, both groups of respondents significantly moderately overestimated their abilities. This overestimation of underwater swimming skills from a large number of respondents is a consequence of their opinion that they will easily demonstrate this skill, which turned out to be incorrect. The analysis of the real abilities of the respondents shows a somewhat greater ability of males in this skill. In some circumstances, swimming underwater may be a competence required to avoid drowning (Stallman et al., 2017). Moving underwater can be of great benefit to individuals

if they find themselves in a situation where their safety or life depends on crossing a certain distance underwater or on their ability to hold their breath for a while.

When analyzing the perceived and tested surface diving abilities, both groups of respondents are quite different. Both groups of respondents moderately underestimated their surface diving skills. This result may be a consequence of their caution in assessing activities that are somewhat more dangerous for them. By analyzing the tested values, males have significantly better results, which are reflected in a smaller number of respondents who could not dive as well as a larger number of respondents who did very well, while the number of girls who did not surface dive is less than estimated. The skill of surface diving can be very useful in incidents in the water, or to get out if there is an obstacle in the water that they cannot otherwise get around or in a situation to help someone (take him out of the bottom of the pool).

When assessing the risk in the described situations, there is a statistically significant difference in "Capsized canoe 100 meters offshore" (0.046) and "Swept off isolated rocks while fishing, situations" (0.005). In both situations, men estimate that there is no risk at all, while girls are more careful in their assessment. These results confirm the WHO report, which states that men drown more often, and the main risk factors include low awareness of water dangers (World Health Organization., 2014).

The results of this study confirmed gender differences between students' actual and perceived water abilities. The results of this research show that the male and female students had inaccurate perceptions of their own perceived and real water abilities. According to perceived abilities, female students were much better at floating and male students were much better at diving into water and surface dive. In real situations, in the water, female students were much better at distance swimming and floating, and men at diving and surface dive. When assessing the risk, there was gender differences between students. The male students claimed that there was no particular risk when a canoe capsized 100 m offshore and if they are swept off an isolated rock while fishing. It is very important that students are aware of their own abilities in the water so as not to endanger their own lives or the lives of others.

LIMITATIONS OF THE RESEARCH

There are several limitations which must be which must be mentioned. The respondents in this research are students of the faculty of sports and physical education who are much more capable than their peers who are from other faculties. The research was cross-sectional, and such research can be organized and have a longitudinal character. Future research could be conducted for students to assess their own swimming skills in clothing, river, or wave swimming skills.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Novi Sad, Faculty of Sport and Physical Education Ref. No. 47-12-11/2021-1. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

GD and NZ wrote the article. GD, MJ, TK, FS, DŠ, NZ, and ET designed the study, analyzed the data, discussed the results, reviewed, and approved the article. All authors contributed to the article and approved the submitted version.

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Life below water; challenges for tourism partnerships in achieving ocean literacy

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ABSTRACT

Healthy oceans are of great importance in achieving global sustainability, and are thus identified as one of the core Sustainable Development Goals in 'Life below Water' (SDG 14). However, at present, we still face a significant challenge in achieving lay understanding of the influence of the oceans on our lives and the impacts of our behaviour on it. As a key interface, marine ecotourism can support the development of place-based ocean literacy, but this can only be achieved through 'effective partnerships' (SDG 17). This paper examines how stakeholder collaboration can contribute to increased ocean literacy through empirical work on scuba diving in Mallorca, Spain. Ethnographic fieldwork was conducted with divers and other key stakeholders (operators, scientists, government, NGOs, and professional associations). Adopting stakeholder models based on pentahelix opportunities for collaboration we analyse the current challenges. The study identified a sector which currently lacks effective partnerships: there is limited systematic transfer of knowledge; staff are poorly trained in interpretation and communication skills; there is weak industry collaboration; and the sector is neglected in government tourism strategy. Consequently, the current structure fails to connect divers to marine issues in the Mediterranean Sea. Nevertheless, suitable conditions for developing effective partnerships are present: motivated staff and suitable facilities; interested authorities; an active network of knowledge production; and a vigilant society. This paper proposes a multi-stakeholder structure to put place-based ocean literacy into practice in order to contribute to the aspirations of improved global ocean awareness.

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Introduction

Water covers over two thirds of the Earth's surface (NOAA, 2018); oceans are responsible for climate, weather and biodiversity and are thus central to life itself (Fauville et al., 2019). Indeed, according to science, "half of the primary productivity on Earth takes place in the sunlit layers of the ocean" (Ocean Literacy Campaign, 2013, p.8). The ocean is the biggest provider of oxygen on Earth; an integral part of the planet's water cycle; and its characteristics allow the absorption of carbon dioxide from the atmosphere, being the largest reservoir of carbon on the planet. Due to its size, chemistry and strength, the ocean shapes continents through creating coastlines (through wave action) and deposits of land materials (the origin of many tourist beaches for

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example). For these reasons the oceans have a specific core Sustainable Development Goal (SDG), focused on outcomes for *Life Under Water* (SDG14).

However, public understanding of the fundamental importance of our oceans is lacking (Fauville et al., 2019). Yet understanding such issues in the period where humans are the main change agent over the Earth (the Anthropocene) is highly relevant to sustainability debates (Stel, 2016) and thoughtful ocean awareness can be part of the contributions of the tourism industry towards sustainable development (Van der Watt, 2019). This paper suggests that recreational scuba-diving activity has an important role to play in raising knowledge of the ocean (ocean literacy) regarding its current environmental situation. However, such knowledge transfer requires effective partnerships between the multiple stakeholders involved in this increasingly popular tourism product.

As a pioneer of the sand, sun and sea tourism product, the marine component is one of the key drivers for the Spanish island of Mallorca, which (prior to 2020) received over ten million visitors every year (Balearic Islands Tourism Board, 2017). Mass tourism destinations such as these have developed their marine activity offer in recent years, with scuba diving being a good example (Albayrak et al., 2019; Hillmer-Pegram, 2014). In parallel with other Mediterranean tourism sites, Mallorca has an established scuba diving tourism product, with over 30 dive operators on the island. Scuba diving is estimated to make up half of the valuable €1bn nautical tourism sector in Spain (Alcover et al., 2011). As well as the domestic market, scuba diving is very popular with British and German tourists. Indeed it is estimated that each year, 800,000 Europeans make one diving trip (with 10 night-stay on average), spending over €1.4 billion annually (RSTC-Europe, 2020). In Mallorca, the major European markets in 2016, when the study was conducted, were German (38%), British (21%), Spanish (11%) and French (4%) (IBESTAT, 2017).

Beyond this significance to the so called "blue economy", scuba diving tourism activity is also an important interface to increase the public's ocean knowledge. However, as the sector is dominated by small businesses (SMEs) (Mustika et al., 2012; Shaw, 2004), collaboration is a challenge. These small to medium-sized wildlife-tourism enterprises (SMWTEs) described by Higginbottom (2004), often have limited resources to develop their products or to work actively with others to do so. This study examines these challenges in the specific context of scuba diving tourism in Mallorca. We also aim to present options for future collaboration between stakeholders with the goal of using this activity to enhance marine awareness.

In order to address the lack of marine knowledge an educational program based on Ocean Literacy has been developed by educators and scientists (UNESCO, 2018). An ocean-literate person is considered one who understands the importance of the ocean to humankind; can communicate about the ocean in a meaningful way; and is able to make informed and responsible decisions regarding the ocean and its resources (Aqua, 2015). The Ocean Literacy framework summarises basic marine knowledge into seven key ocean principles:

- The Earth has one big ocean with many features (Essential Principles 1).
- The ocean and life in the ocean shape the features of Earth (Essential Principles 2).
- The ocean is a major influence on weather and climate (Essential Principles 3).
- The ocean made Earth habitable (Essential Principles 4).
- The ocean supports a great diversity of life and ecosystems (Essential Principles 5).
- The ocean and humans are inextricably interconnected (Essential Principles 6).
- The ocean is largely unexplored (Essential Principles 7).

At present, this framework has outreach support from high profile organizations on both sides of Atlantic Ocean (e.g.: Smithsonian Sant Ocean Hall and the European Marine Science Educators Association (EMSEA)); and has been adopted by UNESCO in the program "Ocean Literacy for all" (UNESCO, 2018). However considering the current environmental crisis (and climate emergency), knowledge transfer cannot be empty of purpose (Ham, 2013). Thus ocean citizenship is the

broader goal of this literacy effort, in promoting actions that contribute towards a more sustainable relationship with our seas (Fletcher & Potts, 2007). This approach presents an opportunity to involve societies in the achievement of collective social, political, and environmental goals. Global challenges cannot be addressed solely through a governmental approach (Dobson & Valencia Saiz, 2005), especially where a fundamental public good, the ocean, is concerned. The interconnectivity of the ocean requires that the responsibility for its (and our) wellbeing should be shared and international. This requires active partnerships, which are recognised in SDG 17, seeking to "encourage and promote effective public, public- private, and civil society partnerships, building on the experience and resourcing strategies of partnerships" (17.17 (UN, 2020)). However, as this paper demonstrates, these partnerships are particularly challenging in the fluid environment in which marine tourism takes place, particularly as the sector is dominated by a wide range of partners and SMEs.

Marine tourism and scuba diving

Marine tourism is defined as "those recreational activities that involve travel away from one's place of residence and which have as their host or focus the marine environment" (Orams, 1999 cited in Hall, 2001, p.602). This definition puts the value on the "marine realm" which means this ecosystem is both the "setting" and "value" used for tourism. However, disturbance to seascapes and wildlife influences tourist satisfaction, affecting tourism business (Branchini et al., 2015). Consequently, tourism and recreation use of marine environments is one of the most significant interfaces between people and the ocean, and has generated a certain expectation as a contributor to environmental awareness-raising.

One of the most popular underwater activities is Scuba Diving, in which the satisfaction of recreational divers increases with "special" wildlife encounters (Cater et al., 2020; Cater, 2008). Motivations for diving include "experiencing underwater flora and fauna", "exploring new things", "experiencing the adventure of diving", "having stimulating and exciting experience", and "learning about the underwater environment" (Ong & Musa, 2012). The Professional Association of Diving Instructors (PADI), which operates in over 180 countries and territories, have certified 27 million divers globally since their foundation in 1967 (PADI, 2019). At present, the active diver population (recreational and sport) is approximately 15 million, of whom 3 – 4 million are European (RSTC-Europe, 2020). The European Underwater Federation (EUF) & Recreational Scuba Training Council (RSTC) estimates that 70% of European divers dive in the Mediterranean region (particularly areas of Spain, Malta, Cyprus, Turkey and Croatia) (ECORYS, 2013).

Dive tourism is led primarily by certification and safety, and environmental literacy more often takes a secondary position (Hyde, 2015). Yet taking into account the threats to the marine realm, divers become witnesses to ocean trends, for example degradation of the Mediterranean Sea. Its biodiversity is in clear decline with a loss of 41% of its marine mammals and 34% of the total fish population over the past 50 years. The largest reductions happen in the Western Mediterranean Sea and the Adriatic Sea (European Union, 2017). A good example of this are the Mediterranean *Posidonia* meadows, an important endemic plant, which shows similar functions to terrestrial forests. They produce more organic matter than the tropical forests and more than 10 litres of oxygen per m2 per day (RAC/SPA, 2017). However, it is one of the most threatened ecosystems globally, with a reduction rate 5% annually (Montes et al., 2012). Despite this, the Mediterranean diving experience is primarily focused on feeling safe and comfortable in the water instead of discovering and understanding these Posidonia meadows for example.

The dive industry itself has changed in parallel with the experiential turn in tourism more broadly. In its early development scuba divers were often certified in their home country and did much of the activity there. Since 2000, many exotic destinations such as Egypt and Thailand have developed their diving infrastructure, altering the global strategy of the industry to

promote diving trips to the most stunning marine ecosystems on Earth (Dimmock & Cummins, 2013). Today, diving is inevitably bonded to tourism: visiting places underwater. Therefore, diving activity is no longer just a sport (Lemke & Olech, 2011), and over the last decade many Mediterranean destinations have developed a distinct scuba tourism product (Bideci & Cater, 2019). However, the proliferation of such experiences has largely eroded connection to place, with many scuba diving products being globally substitutable.

Nevertheless, as a tourism product within a contemporary experience economyor "exponomy" context (Pine & Gilmore, 2011), the dive could be an active experience incorporating memorable emotions through greater connection to the destination. The process to connect with the environment requires attention towards "what is seen and heard" (sensory impressions); "what is felt" (emotional affinity); the reflective response from the provoked thought; and the actions generated as behavioural responses (Ballantyne et al., 2011). In this way, the industry could foster a greater sense of place connection through developing the storyline of the local seas. The diving destination could be enhanced as a result of a combination of place meaning, place attachment and social norms (Wynveen et al., 2012; Kyle et al., 2003). However in order to achieve this, a strong network of ƀlué stakeholders is needed with effective partnerships between the government, science, private sector, NGOs and society.

Marine tourism governance and partnerships

In a review on ocean and coastal tourism Hall (2001) notes that the multifactorial nature of coastal tourism challenges its understanding by the authorities, and thus the development of effective partnerships. Overlap of competences by governmental bodies has been the norm and the reason for confusion among stakeholders. At present, this situation has not changed significantly, as the study of McKinley & Fletcher (2010) highlights. Consequently, marine planning is handled in a reactive way, instead of implementing active measures and policies (Hall, 2001). Among the latter, improved integration between different knowledge and interests, particularly socioeconomic development (Hammerton, 2014) and environmental protection, is the challenge for policymakers. The scarcity of data pertaining to the marine ecosystem and related economic activities demonstrate that the maritime sector suffers from a lack of updated skills and innovation (Bubbles, 2014). This weakness means a loss of competitiveness, affecting Small Medium Enterprises (SMEs) in particular. Consequently, the European Blue Growth Strategy has been developed (Bubbles, 2014) to "help make the sector more competitive globally". To achieve this, "blue growth" initiatives, of which coastal and maritime tourism is part, are focused on communication and promotional strategies; innovative management; improvement of data availability; and the promotion of ecotourism.

In the context of weak understanding by authorities, scuba diving activity is not an exception. This activity is in transition due to higher accessibility; competitiveness with other water activities; confusing legislation; and governance issues (Lucrezi et al., 2017). A study carried out in the USA (Hillmer-Pegram, 2014) revealed that the resilience of the diving industry depends on understanding that the activity has now been accepted by mass tourism. Indeed, the priority has shifted from a niche activity in a pristine ecosystem to an affordable mass tourism experience (Albayrak et al., 2019). Moreover, resilience of this sector relies on the ability for self-organization. This includes increased recognition of the concept of a blue-green economy, which will demand a mixture of physical, behavioural and institutional change (UNESCO, 2012). The scuba diving tourism system (SDTS) suggested by Hillmer-Pegram (2014) and further developed by Dimmock and Musa (2015), describes the key actors of the activity: the marine environment where the dive takes place; the stakeholders; the divers; the scuba diving industry, and the host community. SDTS requires that this structure works through communication, collaboration and adjustments among all actors (Lucrezi et al., 2017). The self-advocacy structure and active relationship

with stakeholders shows the degree of dynamism required by the industry to face current challenges (Hillmer-Pegram, 2014). The network of stakeholders could develop local management capacity and share lessons learned through outreach and education in order to establish successful ecotourism.

At the same time, the present paper takes into consideration models that encourage cross-sectorial collaboration. Using a structure of the triple helix, academic knowledge has been identified as the driver for profitable relationships with the economic sector through governmental support (Marasco et al., 2018). However, collaboration demands a more active role in the co-management of places as recently revealed in different case studies of tourism such as in smart tourism in Spain (Calzada, 2019) or rural tourism in Indonesia (Putra, 2019). Thus society is a vital part of this collaboration framework towards social entrepreneurship based on place. However, there is a particular challenge regarding our oceans, as the place (ocean) is largely an unknown site for the society; opportunities to access it are limited, therefore, the social construction of place in society is challenging (Mora, 2002). Therefore, the role of citizens in tourism destination management can be enhanced through the support of proactive organized groups who can assist in developing this knowledge from a bottom-up perspective (Björk, 2014). Adding these NGOs to the structure gives the pentahelix model (Figure 1) suggested by some authors (Calzada, 2019; Putra, 2019).

As a result, this paper pursues a stakeholder approach, examining partnerships of government, tourism firms, science (*academia* on the model), citizens (in the form of divers), and NGOs, but with some particularities related to the marine environment under examination. To achieve the goal of ocean literacy, this paper examines the performance of each stakeholder in tourism related to their current support for diving activity in Mallorca. The ultimate aim is to extrapolate these partnerships in order to encourage the resilience of underwater tourism, and to move forward to all stakeholders being in the "same boat", understood as the map of relationships in the pentahelix model. In this way, the foundation for the knowledge based co-management of such public goods could be reinforced, increasing the public profile of the seas.

Methods

The following reflections are part of a wider study carried out in Mallorca, Spain in 2016. This was a detailed investigation of the extent and development of ocean literacy in recreational scuba diving on the island. The partnership interface between the social actors, the study object, and the action context was 'dissected' in detail which required a qualitative approach. To obtain the required level of coherence, the time invested with the social actors is a crucial factor to create an atmosphere of mutual trust, so ethnography was deemed a suitable methodological strategy (Blumer, 1962 in Jennings, 2001). The ethnographic approach seeks to uncover the way in which people interpret social structures in order to develop common activities (De Schutter, 1983), so the institutional and regional context of the object of study was deemed critical.

The multidisciplinary characteristics of the project were crucial in directing the literature review and methodological decisions. The history of diving training, business organisation around the diving activity, and current research related to this leisure activity supported the framework of principal actors (diving centres, certifiers and a professional association). Further work on ocean literacy, the local marine ecosystem, governance and planning were also identified as being important to the study. It became apparent that, according to Mora (2002), the structuring of social representations is based on elements such as context, the communication established and the forms of learning, further justifying a qualitative approach.

Hence, multiple voices are the basis of this paper presenting an insider emic perspective, frequently suggested as being appropriate for qualitative studies (Curtin & Wilkes, 2005; Jennings, 2001, 2015). Therefore, the literature review was followed by participative knowledge gathering

Figure 1. Pentahelix multigovernance model (Source: Pentahelix.eu, 2019).

Table 1. Summary of the research fieldwork.

20 diving trips (structured and participant observations)
85 diver interviews (semi-structured interviews)
48 staff interviews (pre and post season)
17 key stakeholder interviews (unstructured interviews)
6 months of research journals (notes from interviews and observations)

involving six months of ethnographic fieldwork, with (semi-structured and unstructured) interviews (Marshall & Rossman, 2006; Saunders et al., 2009); and (participant and structured) observation (Bryman, 2012; Gill & Johnson, 2002) as the main research techniques. The result was more than one hundred and fifty interviews and extensive research journal notes resulting from intensive social interaction and joint reflexive analysis (Angrosino, 2005). Table 1 outlines the fieldwork completed.

The key stakeholders identified in this paper were covered by seventeen in-depth interviews, typically lasting around two hours. In this sense, the key stakeholders together with the staff interviews facilitated a greater knowledge of the spatial context of the activity. The government sector was approached through two bodies; the tourism industry was explored through seven representatives; science was included via five institutions; and three organizations from the conservation and outreach field were represented in this knowledge gathering exercise. The research developed the exploratory and descripto-explanatory phases (Saunders et al., 2009) in the fieldwork and their subsequent analysis in the framework proposed (emotional, cognitive, and normative ocean literacy based experience). The exploratory phase sought evidence about the combination of diving and marine knowledge towards commitment to ocean literacy. The descripto-explanatory phase was focused on the enabling conditions to bring the ocean literacy approach to diving. The spirit of the project was deliberately participative as these social actors were frequently consulted, as Borda (2000) advocates breaking down the subject/object binary in fieldwork.

The social actors of the study were analysed from an interpretative perspective (following thematic coding of Braun & Clarke, 2006): exploring the roles, responsibilities, information content and abilities. The network of social actors was described and analysed according to a number of factors, including: their connection with the marine realm; their knowledge about the ocean; and their commitment to ocean citizenship. The resulting codes were gathered according to the

three main areas: tourism; education; and environment. As a result, the coding process gave a system based on six themes subject to one supra theme grouped into 55 codes. The last step was to link and organise the groups of codes in mind maps, as divergent views and perspectives can be represented in order to reach common understandings (Meier, 2007). This situation is common in work with multiple stakeholders, so these mind maps guided the narrative analysis. All this scrutiny was the baseline for the collaborative knowledge related to emotional, cognitive and normative domains inside the diving structure. In addition, a goal of the study was to develop the partnership structure that is reported in this paper, so the participation of stakeholders mentioned above was deemed a significant cornerstone in identifying structures that would facilitate ocean literacy (Fletcher & Potts, 2007). This paper uncovers the map of relationships and the partnership challenges that exist in order to implement the framework of place-based ocean literacy in underwater marine ecotourism.

Results

The recreational diving landscape in Mallorca is particularly defined by the following features: the type of tourists (walk-in rather than prior booking); marine biodiversity (encounters with big groups of fish) and seascape (active such as karst); sea conditions (good visibility and warm temperature of waters); and the quality of services (staff). As was explained previously, the diving activity in these regions is presently going through a transitional period, leaving behind its foundations as a niche sport and becoming a major tourism activity. However, the current design of the touristic offer in Mallorca is still largely based on a recreation/sports approach, with a strong reliance on international certifiers. We examine the partnership challenges in relation to the different stakeholder groups but do so in a mixed narrative from all the stakeholder perspectives that reflect the issues around collaboration.

Governmental partnership challenges

As scuba diving activity is conducted in public space, the government must be the central stakeholder for the entire industry (as illustrated in the pentahelix model in Figure 1). However, a public good like the ocean is beyond the sole governance capacity of governments (Dobson & Valencia Saiz, 2005). Consequently, cooperative management needs to be considered, although the ultimate responsibility for marine issues should still lie in governmental hands (McKinley & Fletcher, 2010). However, there was a shared opinion across the diving operators in Mallorca that the activity is misunderstood by the government. The current governmental structure has not kept pace with the tourism dynamic in which diving activity is currently involved (as identified by Hillmer-Pegram, 2014). During the interviews with managers, elements such as being in an inappropriate category in the labour framework; and the constant change of the regional department in charge, were identified as the main challenges (as other studies confirmed such as Lucrezi et al., 2017). As a result, a local manager concluded, "no department wants to host the diving activity".

During 2016, diving came under the jurisdiction of the General Director of Port and Airport. This oversight can be explained due to the fact that, for a long time, the ocean has been mostly considered as a means of transport. In this regulatory context, the interviewed managers stated that tourism had limited relevance and this added more barriers to recreational diving. Furthermore the Department of Tourism was a regional responsibility (of the Balearic Islands) until 2018, when that competence was transferred to each island. Mallorca did not have its own tourism department and strategy when this study took place, so coherent planning and marketing of scuba diving tourism was absent.

At the local level, the fieldwork noted that the structure was disjointed, particularly when talking to council officers about marine ecotourism. The council has responsibilities divided between

the environment department for land issues; and the harbour department for marine issues. As a result, everything related to diving logistics, such as paperwork for the mooring of the boat and other technical requirements, is managed by officers focused on the shore. Meanwhile, the health of the marine ecosystem was not covered, as marine reserves are managed in the regional or national government. Operators also felt that government was largely indifferent; "We feel orphans in regard of government. When we go to the international events we are alone", claimed a manager of a network of diving centres. Diving operators explained that the international tourism trade fairs are one of the main sources of clients; however, Mallorca is primarily marketed at these as a sun and sea destination. Authorities argued that this official position came from the understanding that diving had reached a mature stage; therefore, the diving was not a priority in the marketing agenda.

The economic argument was also suggested as another reason for the low government support for the diving industry. "Diving is not a profitable activity. We survive but not earning a lot of money" confessed a local manager and president of one of diving associations. "In Mallorca, the season is short, only three months, so only two or three centres can keep open the entire year", according to the managers. However, in contrast, several other Mediterranean destinations have successfully developed scuba diving as an off-season activity, for example Malta, with strong official promotion and infrastructure investment (Bideci & Cater, 2019). This was based on awareness that the multipliers from dive tourism can be considerable across other parts of the tourism industry.

In addition, the study identified another reason that could explain the lack of official support, the nearly unique categorisation of the activity. The government officers stated that diving activity was considered as active and adventure tourism within the government tourism strategy. This means that the "active" characteristic of water sport was the only approach taken to its management. According to the classification based on Recreation Experience References scale (Manfredo et al., 1996), this group expects to obtain excitement, develop new skills or abilities (Factor 1 – novelty-self-development). However, taking into account the type of walk-in tourist divers common within the "sun and sand" destination of Mallorca, the spectrum of motivations to dive was much wider, yet this categorisation ignores this potential (see also Albayrak et al., 2019). In summary, the communication channel between government and the diving centres was a challenge often reiterated by staff (noted by the analysis of Lucrezi et al., 2017). All managers highlighted that they only heard from government for regulations and standards (with the exception of some personal contacts with the marine reserves employees).

Certifier partnership challenges

In contrast dive centres have a much closer relationship to international certification agencies such as PADI and SSI (Scuba Schools International), who design the teaching and training services for scuba diving. Increasing specialisation allows for the basic courses to progress to training in particular techniques. This framework is common globally and was no different in Mallorca. Certified divers could enjoy the experience in single or double dive trips, receiving a briefing about the site, itinerary, equipment and the guiding of a crew member (instructor or master guide). The diving product was mainly based on wildlife encounters and their distinguishing seascape (karst). However, taking into account the oligotrophic (low nutrient) characteristic of the Mediterranean and the growing loss of marine biodiversity globally, the design of the product is not sustainable (Stewart, 2015).

To understand the diver's comprehension the basic training manuals provided by the certifiers were analysed through the seven principles of ocean literacy in order to evaluate the marine literacy in the diving product. The results were that all of these were covered to a limited degree, with priority on those which can impact on the diving performance, such as principle 2 and 3

related to the physical characteristics of the ocean. However, the impact of this marine literacy on the diving product itself was limited, with an inconsistent message and is more likely to be focused on the spectacular ecosystems like corals or key species like sharks (Dobson, 2011; SSI, 2020, 2017), neither of which are easy to see in the Western Mediterranean.

This situation can be explained by the dominant international marketing strategy of trips to tropical diving destinations (PADI, 2020). However, it is important to highlight that the main ecosystem in Mallorca, the Posidonia meadows, is not included in that material. The diving experience illustrated poor knowledge about this key ecosystem: 'the seabed is covered by that green grass; it's so annoying because we don't see anything", was a common comment among new divers. Frustration amongst divers and practitioners was evident due to the lack of connection to the place. The study confirmed that the staff often received limited training in communication/interpretation techniques to facilitate the comprehension of the local elements. Hence, the experience could be classified as nature tourism but not as ecotourism because of the absence of the environmental awareness and place commitment in its structure (Luo & Deng, 2008; Weaver, 2005).

The structure was safe and comfortable for the diver but realising a fun, active and informed dive depended dramatically on the instructor. Local knowledge relied on a veteran or local member of staff, turning the *in situ* experience into the main source of knowledge. Yet the knowledge provided by dive guides tended to be basic, unstructured, and was often neither scientifically validated nor up to date. This unstructured knowledge transfer impacted on the training of staff and the knowledge gained by dive tourists. For that reason, it was not a surprise that the divers (including the staff) confessed that their knowledge about the local sea usually came from other sources, such as relatives, the internet, or documentaries.

The training material of certifiers did encourage diving centres to share the local marine knowledge which is available in universities or NGO's (PADI, 2010). However, there is not currently an offer related to local wildlife embedded in the certifiers' education frameworks. To that end, marine literacy should have greater influence in the certifiers' evaluation, as noted by a member of staff:

> If you want all of us to know about the Ocean Literacy & Citizenship approach, this knowledge has to be part of certifier's tests (local instructor).

However, the certifier'sofficersdisagreedabouttheresponsibilitiesforlocalknowledgetransfer. A manager recognised that this would be possible and even benefit the sustainability of the activity, making the design of the experience more associated with the dive spots. But the international certifiers highlighted the logistical barriers, particularly "As the tests are standardised, I don't see its feasibility in short term". To incorporate this would mean a change in the evaluation system, which cannot be developed under conditions of standardization. However, the certifier interviewed suggested that they could use their multiple campaigns (e.g., Blue Mission and Project Aware) to "personalize" the messages of local issues related to global challenges such as plastic pollution in the Sea (for example the *Dive Against Debris* speciality of PADI). However, some divers noted that they were seldom used because of lack of local connection. Another solution explored was to give this responsibility to the local Balearic Federation of Subaquatic Activities (FBDAS), but their lack of focus on tourism discouraged this option. The diver tourists, who are not already certified, usually prefer an education scheme with international recognition.

In conclusion, the industry worked together but did not explore innovative partnership approaches in order to improve the standardized position in the market. As a certifier's officer reflected, '*there are not many enthusiastic people and dreamers in this industry*'. The experience is delivered through unchanging narratives without carefully considering the emotional, cognitive and normative domains (Ballantyne et al., 2011), turning it into what was humorously described as "tea-bag diving", with ashort immersion in the water and no long term connection. As such, the activity shows a poor implementation of ocean literacy with a near absence of "sense of the

place" during the experience (Kyle et al., 2003). The particularities of the ocean (Principle 1 of Ocean Literacy: *The Earth has one big ocean with many features*) are not being revealed. British research respondents taking an open water course reflected this very well;

- What did you learn about marine literacy? – *Many things about corals*
- And about the Mediterranean Sea? – *Umm not really anything*

As a consequence, the memory of place (Mora, 2002) is not promoted towards the design of ocean literacy for divers in the current tourism product. The industry conditions of Mallorca and partnerships with certifiers were not favourable to design their own training and marketing strategy reflecting the island particularities.

Industry partnership challenges

The dive industry was not united in Mallorca. The general perception of the sector was that its professional association was nearly inactive, defined by individual issues and private interests. Overall, it was noted that the association did not contribute to the integration of the sector, to the development of the shared marketing strategies to overseas markets (their main target markets), nor to a joint voice. Although it was recognized for its importance amongst managers, membership was considered mainly for access to hyperbaric facilities. Consequently, respondents agreed that the passive role of the main professional association needed to be developed to a more active one (Hillmer-Pegram, 2014).

A key issue was that official figures about diving in the island were lacking. The president of the main professional association confirmed that no institution collects these figures, and they are only available for entry to marine reserves. As a consequence, the significance of the activity and its economic contribution cannot be demonstrated to key stakeholders (as shown above). This condemns diving to a weak role in any conflict with other sectors (Green Bubbles, 2014), for example:

> There are a lot of problems with rental boats because they usually don't know the diving signs and don't respect the security space. But we know that if we try to claim with the authorities, we'll lose, protested a local manager.

Another critical example of the weak position of the sector was inside the marine reserves where fishing and scientific research were seen as more important than diving. In these special zones; the benefits of the dive industry were seen as just a 'side effect', rather than an important economic contribution itself. Therefore the diving sector in Mallorca was lacking recognition of their place in the blue economy because of the absence of a united sector.

NGO partnership challenges

Like many coastal tourism destinations, Mallorca is struggling with increased plastic pollution. As the divers are direct users of the sea, they can be considered as informal eyewitnesses of the environmental crisis. However, despite this, environmental NGOs had not developed a solid relationship with diving activity. The insular organisations mostly focus their marine activism on environmental issues related to the over-exploited coast; the cleaning of beaches (Figure 2); and overfishing campaigns. A significant exception were the actions observed related to the situation of Posidonia, a key ecosystem for diving activity on the island described above, with social activities (Figure 3) and educational campaigns developed by some NGO groups.

In addition organisations such as the Mallorca Aquarium are also important for informal marine education and development of Ocean Literacy. Although under private ownership, outreach is a major part of their activities, and aquariums worldwide use education as a justification for capture and display of wildlife (Cater, 2010). We therefore include them under the NGO umbrella

Figure 2. Coastal cleaning organized by Ondine (environmental organization). Mallorca, 2016.

Figure 3. Posidonia Festival, Mallorca, 2016.

as they are an important influencer as a bridge between experts and the public, but are not allied to existing government or industry objectives. As well as hosting large numbers of tourists, the Mallorca Aquarium targeted programs at local schools to facilitate marine education in the formal system. However, the diving sector was not considered a strategic sector for their programs. This is again in contrast to other destinations which have developed aquarium and dive training facilities in tandem, for example in Qawra, Malta (Bideci & Cater, 2019). In Mallorca, the Aquarium felt that, "the knowledge from the diving sector is not rigorous enough to be considered a reliable source". In addition, the lack of an active professional association described above made it more difficult to develop a beneficial relationship. "It is difficult to work with the sector when there is not a unique voice", the aquarium confessed. The mixed profile of staff in the dive centres, being multicultural and with high mobility as result of the seasonality, were other barriers pointed out by organisations. However, their relationship had potential to evolve in more

sustainable way (as the scuba diving tourism system suggests), as they confirmed that they had the institutional structure and staff to train the diving sector in knowledge about the Mediterranean Sea (Lucrezi et al., 2017).

Scientific organisations partnership challenges

Mallorca hosts a diverse multiplatform of scientific and technical infrastructure (Spanish National Research Council-CSIC). It is home to the Balearic Oceanography Centre (COB-IEO); the Balearic Islands Coastal Observing and Forecasting System (SOCIB); the Mediterranean Institute for Advanced Studies (IMEDEA); and the local governmental department (Conselleria), so significant regional marine science research is undertaken. IMEDEA is focused on biological and ecological studies; the long established COB-IEO, conducts foundational studies of the ocean; and SOCIB is the operational branch of this research triangle. Their main role is to explain the physical, chemical and biological parameters of the ocean.

However, this study found that these efforts did not reach the diving sector. The diving script showed a lack of scientific rigour and currency. This was reflected in an interview with a trainee instructor in a diving centre of the study,

- 'How do you know that?

Because other instructor -who are here longer than me- told me. We usually ask the veterans.

And don't you prefer to check it in scientific websites?

no, what for? I trust them, they dive here, they know it'.

The scientific institutions consulted in Mallorca were aware of the importance of dissemination of scientific knowledge. Yet publishing in scientific journals and communication in social media were still the main means employed to do so. All of them had staff designated to outreach with special attention to educational programs for the general public (particularly with a family education focus on teachers, children, and parents). However, the only collaboration observed with the diving sectors were citizen science experiences (Figure 4). The 'Observadores del Mar' (SeaWatchers)

Figure 4. SeaWatchers Posters in a diving centre, Mallorca, 2016.

is a program in the region; managed by the Institute of Marine Science (ICM) in Barcelona and The Spanish National Research Council (CSIC) (Observadores del Mar, 2020).

Some diving centres tried to be involved through the design of citizen science diving trips for customers who want to be part of the monitoring network, for example to collect information about the quality of Posidonia meadows. However, there were some criticisms of this type of scientific network because of its complex logistics. In the past, a lack of consistency and regular communications with the scientists were the main reasons to abandon the initiative according to some managers. Whilst communication issues have been highlighted as a partnership issue previously (Spenceley et al., 2016), the diving centres still saw these programs as added value for their performance as noted by some previous studies (Branchini et al., 2015; Hyde, 2015).

Overall it is clear from this discussion that the partnerships to achieve sustainable marine knowledge transfer and action required by SDG 14 are not present. The scuba diving activity manifested an unstructured management approach resulting from the lack of knowledge regarding the dynamics of tourism, generic training materials and weak collaboration amongst actors. Figure 5 shows the initial observations from the study which define the diving experience and the shortcomings of each stakeholder group building on the helix partnership model (Calzada, 2019) described above. However, the study did also observe that the experience had potential to develop insight-seekers with a commitment to ocean literacy. To meet this challenge, the research also revealed the significant role of stakeholders in development of recreational diving on the island. Moving forward, the roles of these stakeholders in further developing the partnerships supported by SDG 17 deserves to be discussed.

Discussion – a partnership map for knowledge transfer

The influence of *exponomy* (experience economy) and hedonism in the leisure of this century engenders demand for personal experiences that are unique, varied and constantly changing (Bordas, 2003). Within the increased standardization of the diving industry, place-based ocean literacy can support experiences that could compete with other diving destinations in the Mediterranean region (for example Malta or Turkey). To that end, the study suggests that diving can facilitate a transition from passive to active observant diver, with a special focus towards the insight-seekers over the species-seekers. As a result, the "sense of place" (local sea) through *place meaning* and *place attachment* is promoted (Wynveen et al., 2012). The goal is that, once returning ashore, there is a shift from spectators to actors, making decisions that include the marine realm in their personal norms, as required by SDG14. Yet, as has been shown, the industry is not currently prepared to implement the Ocean Literacy approach. Therefore, the entire structure has to be involved, creating cross-sectorial collaboration through the connections, partnerships and mutually beneficial business identified in the scuba diving tourism system (Dimmock & Musa, 2015). The development and transfer of this knowledge is the joint task of the entire structure. Consequently this challenge requires the proactive role of the stakeholder groups identified and the individual responsibilities of the partners are described below.

Dive industry: facilitator

The dive centre should be the focus for innovation, becoming the local knowledge centre for divers. To achieve this aim, knowledge providers have to make an extra effort to incorporate local insights (Robinson & Picard, 2011). Towards this task, the international certifiers have a responsibility to represent the diversity of the ocean in their narratives. The development of regional material (The Mediterranean; the Red Sea; or North Atlantic, as examples) could be jointly developed in order to highlight the cultural, historical and ecological richness of the regional marine realms. For example, a local manager interested in scientific diving highlighted

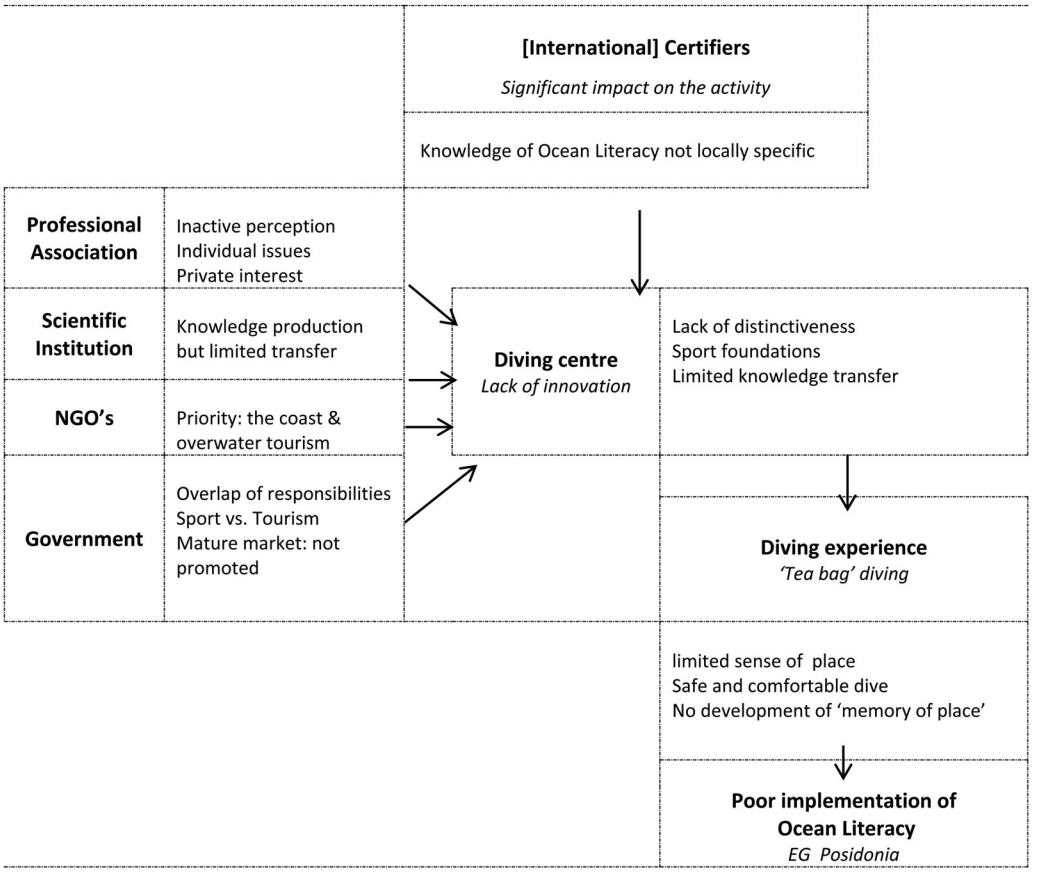

Figure 5. Analysis of diving partnership challenges in Mallorca.

archaeological heritage as having a significant role in this new narrative, as well as the existing scientific awareness of Mediterranean ecology present in Mallorca. In this way, the diver will not focus on coral reefs when the course is carried out in the Western Mediterranean. This role could be assumed by the professional association to bring together the local ocean literacy and incorporate it within the certification schemes. Skills to share the stories of local seas need improvement in the staff training and these could be developed in collaboration with a more effective local professional association. However, the greatest requirement of the professional association is to better consolidate the diving activity within the tourism framework of the island (Hillmer-Pegram, 2014). Greater knowledge regarding the importance of the dive activity itself would be a good starting point to foster stronger partnerships with other stakeholders (Bubbles, 2014).

Government: supervisor

The umbrella function of government requires improved understanding about the extent and nature of this scuba diving activity. The notion of a blue society requires a holistic view in order to include the multiple users and interests of the marine realm (Hammerton, 2014). To start with, the official designation of the activity could evolve from its active/adventure focus to a broader ecotourism lens where the blue humanities (e.g: history, literature, art) are included. At the same time, the domestic and international marketing of Mallorca has room to improve. Being part of the official marketing agenda could provide a boost for the diving activity in competition with other diving destinations in the Western Mediterranean. However, it is important to note that

the overlap of competences and regulations is currently a barrier to improving action (Lucrezi et.al, 2017). It has been noted that, for proper marine stewardship (Dobson & Valencia Saiz, 2005), regulations have to be well-known and every user group would benefit from developing their own code of conduct to maintain ocean health. The recent change towards island based tourism administration is a positive step to improve tangled official responsibilities, and should allow for more holistic partnerships.

Science: decoder

The development of a working relationship among the diving sector and scientific field is another critical factor. In this regard, Mallorca showed some promising efforts, represented by the citizen science projects. An individual responsible for these suggested that the reproduction season of Posidonia in May was a good example, where divers (particularly locals) could re-discover a diving resource which has become "boring" for them. Placing value on these eco-systems and species through citizen science partnerships could reinvigorate connections to place (Hyde, 2015). At the same time, this diver generated information could help update the data about the state of the marine environment. The interlinked nature of this ecosystem means that scientific projects often cover a vast territory, so the importance of this is not overlooked;

> we need all of the eyes which we can find in order to register what it is going on underwater. (Sea Watchers Programme officer of ICM)

This example demonstrates the potential incursion of knowledge into diving which increases the probability of feeling interested. Scientific partners could adopt the challenge to develop material for the other users of this shared environment and consider diving activity as a target for their institutional dissemination objectives. With this scientific grounding, the diving sector, in turn, has to promote the appreciation of those scientific discoveries in their products.

Additionally, the relationship with other stakeholders has to be reinforced and extended. For example, the design of socio-environmental messages could be strengthened and delivered to marine officers and staff on the ground. In common with the established relationship between fishing industry and science, the diving sector could design a set of best practice or code of conduct incorporating rigorous scientific knowledge. It can be helpful to routinely engage these experts under a regular knowledge transfer group to maintain a dialogue with scientific partners (Branchini et al., 2015). To that end, the scientific institutions have to reinforce their outreach department to decode and facilitate the goal of marine literacy to a wider spectrum of users.

NGOs: translator

NGOs are another translator of ocean literacy, but their emphasis is on the relationship with society, encouraging actions in an eco-friendly direction. The challenge in Mallorca was that these groups included the wider meaning of the ocean in their environmental commitments to engage more sectors. The interviews confirmed their sources of information are usually universities or other research institutions. The role of NGOs to bridge between experts and the general public has the power to translate that raw information into relevant material for different target groups. As a result of this scientific dialogue they could provide the diving activity; a set of marine-friendly messages and practices for the diving script; a contribution to the code of conduct; and enhanced training systems (Bubbles, 2014). The involvement of diving activity in the protection of Posidonia meadows, is a recent example of the potential for that sort of multi-stakeholder collaboration. Equally, NGOs' lobbying role was important for this new partnership between sectors, as they are often already represented on various policy groups; "we could be the speaker of the diving activity in the environmental boards in some councils" (the main environmental organization, personal comment).

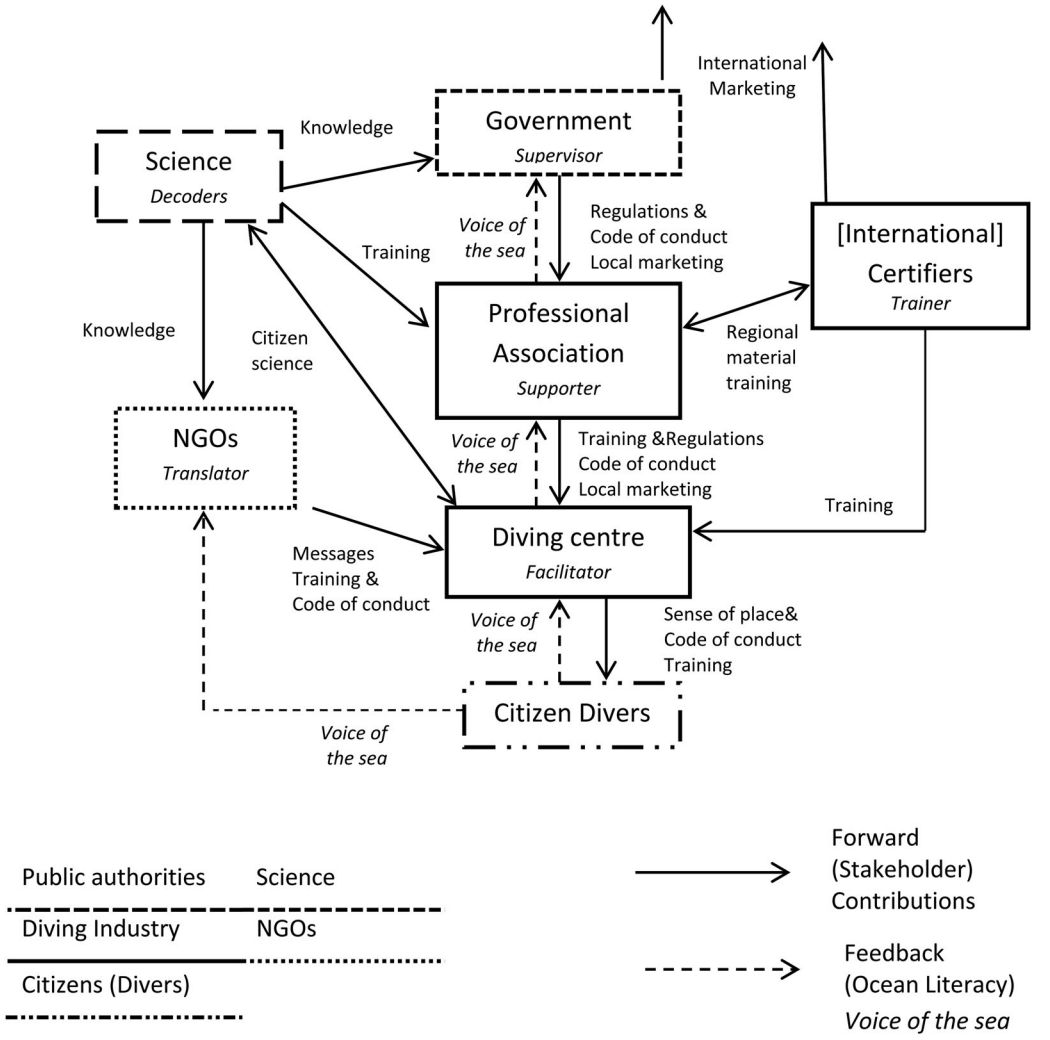

Figure 6. Partnerships for ocean literacy in the diving sector.

The final Figure 6 illustrates the map of the partnerships required to carry out this collaborative approach towards ocean literacy.

The grid of this structure is the pentahelix approach (Pentahelix.eu, 2019; Calzada, 2019) with a more complex hierarchy due to the fact that the relationships happen in the ocean: one of the largest and most unknown common goods. Government is the main guarantor and facilitator; Science acts as the decoder of the sea; NGOs work as socially vigilant translators of the knowledge; and diving centres (with the support of international certifiers and their professional association) are the receptacle of that ocean literacy and the facilitators of the emotional [re]connection to the sea. Hence, the divers can play an active role as ocean citizens, but are guided by the entire structure because of the limited knowledge about the marine realm. Indeed, if this structure could be implemented more effectively, divers could be considered as advocates for ocean literacy (*voice of the sea*) in society more broadly.

Conclusions

Overall, scuba diving activity in Mallorca demonstrates a lack of partnership approaches arising from the lack of knowledge regarding the dynamics of tourism, leading to the challenges described in this paper. The diving activity was still conceptualised as a sport, with low priority given to local marine knowledge within the diving frameworks, resulting in a limited, repetitive and unsustainable offer. However, Mallorca does demonstrate potential to promote ocean literacy in recreational diving by adopting a cross-cutting approach for the entire sector. In promoting first-hand experiences of the ocean, the diving experience is based on "what you see", so with the required support, it has the potential to help in understanding what is seen towards increased ocean literacy in order to develop "what you feel" and "what you think". To that end, the activity has to be designed to attract divers with biospheric and social-altruist values whose motivation is related to insight-seeking, and where they feel comfortable in an ecotourism framework reinforced by the sense of place. Whilst this may not initially seem possible in a mass tourism setting, the popularisation of environmental issues such as plastics and climate change, combined with an experiential shift does offer significant possibilities. However in order to achieve this, the activity needs a change of mind-set amongst all of the partnership stakeholders.

Drawing on the aspirations of SDG 17 this paper has illustrated a partnership model whereby the tourism activity is the vehicle to develop social change and sustainability in the achievement of the Sustainable Development Goals. In this case, the ocean literacy narrative is the channel to intertwine all the elements in generating a product that is unique and innovative as a result of its local foundations. Therefore, the general framework based on place could be extrapolated from this case study to be implemented in other diving destinations and even in other marine tourism activities focused on life underwater (SDG14). However, it will be important to note the following limitations. Firstly this study has taken place in a western cultural context, and so attempts to define a place-based narrative need to pay attention to the respective socio-cultural context. Secondly, the profile of the divers here was lay visitors engaging in mass tourism, and did not show any significant knowledge about the marine realm. Lastly and perhaps controversially given our arguments, as the Western Mediterranean marine ecosystem lacks the appealing biodiversity of other areas, the role of the staff becomes more significant in the diver's satisfaction because it cannot offer iconic species promoted by the media and the standardized marketing of diving. Sadly, taking into account the increased loss of biodiversity, these seascapes are becoming common over the world, so this will become ever more important. In conclusion, the design of the ocean literacy framework acquires relevance as a pathway for the identified stakeholders to connect to the local seas. Establishing this foundation and developing resilient partnerships (SDG17) for future marine-based ecotourism can contribute towards genuinely sustainable life below water (SDG 14) and ultimate achievement of the goals.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Rule-directed and discovery learning in SCUBA-diving

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Abstract

Time efficiency is crucial when teaching SCUBA-diving with limited practice time. Safety skills must be learned with sufficient quality and still be mastered after long breaks and in critical situations. We hypothesized a rule-directed learning approach (RL), which provides the learners with information on the best way to perform a skill, to show good initial results but less stability over time. Discovery learning (DL), which enables learners to experience more variability and to find individual solutions, might support greater stability over time and higher robustness to stress and fatigue.

25 beginners (age:22.5 ± 2.7; 5 females) were randomly assigned to RL (N = 13) or DL (N = 12) and received the same general criteria for successful deployment of a surface marker buoy. Only RL got additional visual presentation and explicit instructions. Six acquisition trials were conducted. Three evaluation trials were performed, video-recorded, and independently rated for water-position/trim, time, and safety-aspects (Pre). Another three rated trials were performed after 45 (±5) days without further practice (Retention).

Safety performance was rated higher for RL both during Pre ($P < 0.001$) and Retention ($P < 0.001$), but RL took significantly more time during Pre ($P < 0.001$) and Retention ($P < 0.001$) and reported a significantly higher perceived performance quality during Retention ($P = 0.014$) compared to DL. Trim performance improved for RL and deteriorated for DL from Pre to Retention.

Performance quality in unique aspects of the new skill seems to benefit more from explicit instructions with a detriment for speed. The suspected higher learning for DL and robust performance in the Retention test could not be observed.

Keywords

Didactics, explicit instruction, implicit learning, underwater movement

Highlights

- The methods of rule-directed and discovery learning were investigated in an applied underwater setting for the complex movement-skill sequence of surface-marker-buoy deployment
- Rule-directed learners showed better performance for safety-related aspects of the skill with a detriment for overall speed
- Performance of fundamental aspects like buoyancy and trim control deteriorated from Pre to Retention (+45 days) for the discovery-learning group but improved for the rule-directed group

Introduction

Learning new skills in recreational SCUBA-diving is relevant for certification and overall safety in the unique underwater environment. Teaching in the context of recreational diving is especially challenging: Practicing skills underwater requires the attendance of a diving instructor, specialized SCUBA equipment, access to open or confined water, and is further limited by gas supply, water

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temperature, and overall logistics, including costs. When beginners learn to dive, the time available for practice is often severely limited (i.e. minimum requirements are five dives at 20 min each, which are only in part used for learning skills).[1] Another problem is the long periods between learning safety-relevant movement skills in a course and the later application without an instructor in open water dives when movement skill performance might have decreased. This is especially true when a beginner's certificate (e.g. according to standards such as European standard ISO 24801-02, which describes contents for the lifetime-valid "open water diver" or "Confédération Mondiale des Activités Subaquatiques*") is achieved locally in preparation for future diving trips abroad (e.g. during a holiday). Therefore, it is necessary to teach skills with regard to time efficiency, quality, and consistency over longer periods and explore the possible benefits of different didactic methods to ensure sufficient performance and prevent accidents.[2] Standard practice in SCUBA-diving courses is a very structured, standardized, and rule-directed approach. So far, only very little work exists on different teaching methods for this specific sport (see limitations for the role of trait-anxiety on overall performance).[3–5]

Common explicit and rule-directed methods in sports education have been extended with more implicit approaches over the last decades.[6–8] Explicit instructions, which are essential during rule-directed learning, are known for fast increases in performance but high dependence on the learners working memory capacity.[9] Learning complex movement sequences such as diving skills (e.g. dance routines[10]) post even higher demands on working memory capacity, thus making explicit teaching approaches disadvantageous for individuals with low[11] or even compromised working memory capacity.[12] In addition, performance might deteriorate after longer breaks when being highly reliant on working memory. Because working memory capacity is rarely assessed and heterogeneously developed in the general population, it might be a modulating factor for learning outcome.[13] Explicit instructions are prominent in sport-specific learning settings and can positively impact performance after the initial acquisition, but the results might be less stable over time or in transfer and dual-task scenarios.[13,14] Explicit verbal instructions paralleling the learning process might be beneficial for many sports but restricted during underwater scenarios with limited communication.

Alternative approaches might both extend the repertoire for diving instructors (i.e. and thus respond to their individual preferences) and positively influence learning outcome and movement skill performance in the unique underwater environment. Good results have been reported for the implicit method of analogy learning, although performance seems to depend on verbal preference[8], and for different variations of discovery learning.[15,16] The latter is often described as making repeated attempts to perform a specific skill based on a working hypothesis (i.e. an intended goal) and modifying the technique based on interim results.[17] The higher degree of flexibility was described to allow learners to experience more variability of task solutions,[18] which might be beneficial for the application of skills within highly variable underwater contexts. Both guided (i.e. information on the goal of the learning process) and unguided discovery learning seem to enhance movement skill performance when compared to rule-directed methods,[19,20] although early acquisition (i.e. beginners) might benefit from some degree of guidance.[21] It was shown that, compared to rule-directed learning, declarative knowledge was reduced in guided discovery learning,[20] which might be beneficial for complex sequences of movement-skills and learners with a reduced working memory capacity.[12,16]

While many studies consider discovery learning to be mostly explicit based on the build-up of declarative knowledge during hypothesis-testing,[22–24] others described the method or aspects (i.e. perceptual discovery learning[16]) as implicit.[15,25] Many authors agree that a dichotomous distinction is not possible in applied sports settings, and both implicit and explicit aspects are present during discovery learning.[26–28] Possible implicit shares during discovery learning might imply additional benefits for teaching SCUBA-diving, as rather implicitly learned movement-skills become more automated, are less reliant on explicit knowledge, and therefore more robust over time, and are executed more consistently in highly demanding scenarios and environments.[13,16,22,29–31] More stable and consistent performance over time could be considered a higher learning outcome and be more important than the initial performance directly following acquisition, especially in the unique context of SCUBA-diving education. Considering the challenging and complex underwater environment, implicitly learned diving skills might be executed with a high-performance level even after long periods without practice (e.g. between the initial learning phase and a diving holiday) and especially during highly demanding situations (e.g. during emergencies). It should also be noted that diving skills could be considered as dual-task scenarios because the execution of the main movement-skill is paralleled by the constant monitoring and adjustment of water position, trim, and buoyancy, which might alter previous findings. Improved performance of movement skills after implicit compared to explicit learning, possibly due to automation,[13] may be even more marked in dual-task scenarios.[32]

On a side-note, providing instructions for learners either to supply information on the objective of the learning process (i.e. discovery learning) or to provide explicit instructions for the acquisition phase (explicit rule-directed learning) might result in a different setting of emphasis on various parts of the movement skill: Beneficial effects have been reported for performance and for learning (i.e. more permanent changes) when advice and cues are

focused externally (i.e. on the effect of the movement), like it is common in discovery-based learning, rather than internally[33,34] (i.e. on specific body movements; see Wulf et al. for a review).[6] Because focus setting might impact the results of our main research question, we integrated a short questionnaire to investigate the extent to which participants focused on several aspects of the skill. We assumed rule-instructed learners to have focused more internally and to a higher extent on single items of the movement skill.

A wide variety also exists in studies investigating the time-span between the initial learning phase and the retention test (i.e. between a few hours and up to 7 days), but > 24 h are generally considered beneficial for movement performance.[35] However, this time span might vary and should be considered longer in sports diving, thus altering results.

Teaching movement skills in SCUBA diving demands adapted methods that consider the restricted possibility for verbal cues, a demanding environment with possible dual-tasks, such as monitoring depth and trim, the limited time for practice, and possibly long retention times between learning and application in autonomous open-water scenarios. Discovery learning might be an alternative method with a variety of beneficial effects that have not yet been applied in the underwater context. Therefore, rule-directed learning (RL) and discovery learning (DL) were investigated concerning movement-skill performance for several diving-specific aspects, both after an initial learning phase and after approximately six weeks without further practice. We hypothesized that when teaching a safety-related movement skill, like the complex deployment of a surface marker buoy (SMB), (I) the rule-directed learning group (RL) would initially achieve similar movement performance compared to the discovery-learning group (DL); however, (II) that the learning-outcome might be higher for DL, thus resulting in more stable performance over time and a lower deterioration after longer breaks, when compared to RL.

Methods

Participants

An a priori sample size calculation (G*Power 3.1.9.2) demanded a total sample size of 24 participants to obtain a moderate effect size $f = 0.4$ and power of $1\text{-}\beta = 0.95$ with a mixed design and a significance level of $\alpha < 0.05$. This effect size was considered appropriate to reveal effects with practical relevance. In total, 28 healthy and medically fit diving beginners were recruited for the study; however, only 25 completed both tests and, thus, were included in the analysis (age: 22.5 years (2.7); 5 females). This group should be considered highly homogeneous in fitness, as all participants were active sport students, approximately the same age, and had very similar SCUBA-diving experience in the pool. All participants in this randomized study performed two dives, each with a time interval of 45 ± 5 days. Inclusion criteria were a completed university's indoor diving course (i.e. one term length) and no further open-water diving experience. Participants received information about the purpose and procedure of the study and gave written consent before involvement. The study was approved by the university's ethics committee, following the Declaration of Helsinki rules.

Materials

The diving equipment consisted of a 12-liter (L) steel tank, a buoyancy control device (BCD), a breathing regulator, fins, a personal mask, and no wetsuit. All conditions were conducted in the swimming facilities of the German Sport University Cologne ($20 \times 20 \times 5$ meter (m)) with a constant water temperature of 28° C. For practice trials, participants were not restricted to any part of the pool. Video-recorded test trials were performed starting above a marker on the pool bottom and recorded by frontal and lateral cameras (approx. area: $6 \times 6 \times 6$ m). The SMB ($140\text{cm} \times 15\text{cm}$) had an open bottom without any sealings or valves and was pre-attached to 15 m of line on a standard reel. The complete SMB kit consisted of the buoy and reel which were connected with a double-ender carabiner.

Experimental conditions

SMB deployment must be considered an important skill that requires a complex sequence of movements. Because of its role for SCUBA-diving safety, it recently became a mandatory skill within the beginners' certification in Germany (German Divers License-1 / CMAS-1), thus making the topic very relevant for beginners' education. During the first test, each participant received a short introduction about the relevance of SMB deployment in sports diving. Pilot-testing showed this goal-directed information to be necessary, as most participants had no prior knowledge about the equipment or its purpose (i.e. opposed to sports that are more medially present). These constraints towards a prescribed goal might be considered as guidance during discovery learning, although no further information was offered during the learning process.

In addition, all participants received the criteria used for later evaluation by experts. These criteria included a horizontal and stable position in the water (i.e. *positioning and trim*), no risk of entanglement, and a fully-inflated and upright buoy on the surface (i.e. *safety*). Concerning all those criteria, the movement performance was to be conducted as swiftly as possible (i.e. *time*). These general criteria supported an external focus on desired effects but provided no information on how to achieve good movement-skill performance (see Table 1 for a summary of all criteria). The information above was provided to all

participants in a standardized video without any visual presentation of the skill or clues for successful practice.

Only then were participants randomly assigned to either the discovery-learning group (DL; N = 12) or the pre-practice information, rule-directed-learning group (RL; N = 13). All participants were asked to refrain from communication with one another, and no parallel testing was conducted.

Before entering the water, the RL group watched an additional tutorial video including visual instructions, explicit guidance, and cues: general tips (e.g. take breaks to check your buoyancy and position; use visual references) and specific solutions for segments of the performed movement-skill were provided (e.g. how to: hold the buoy, spool, and regulator; best inflate a buoy using a regulator; roll up the spool; ensure and check a fully-inflated and upright buoy). These specific instructions can be considered to evoke an internal focus of attention.[6] RL should follow these instructions while DL received no additional information (see Table 1 for details).

Acquisition: After submerging with a safety diver and 5 min of underwater familiarization, participants performed six practice trials with the SMB. Total practice time was approximately 15 min. After each trial, the safety diver took over the deployed buoy and provided a new, originally assembled kit. Note: Acquisition was conducted *before* the Pre-test because the movement skill was entirely new to all participants. Thus, an initial baseline test was not possible without any explanatory information (see above). Pre-test: At a pre-arranged signal, the participant moved into position for three consecutive video-recorded trials. During the interval between the Pre- and Retention-test (45 ± 5 days), participants were asked to refrain from any practical (i.e. diving) or mental (i.e. watching videos or instructions about the skill) training. Retention: Participants received no further information or training but conducted 5 min of mandatory underwater familiarization (i.e. without the SMB). Then, three consecutive trials were performed and video-recorded (see Figure 1).

Table 1. Left: General criteria were provided by video for both the rule-directed (RL) and discovery-learning group (DL). Right: Additional instructions and cues on the movement skill were provided with an additional video for RL only.

Criteria for movement skill (All participants)	Additional video instructions and cues (RL only)
►Remain in a horizontal and stable position	►Cues for water positioning
►Prevent any safety risks (e.g. entanglement)	►Cues for prevention of entanglement
►Aim for a fully inflated and upright SMB on the surface	►Cues for hand-positioning & self-review
►Perform the skill as swift as possible	► Visual presentation of the skill

Video recording and evaluation

All test trials were recorded with an underwater camera both from a frontal and lateral position simultaneously. Three experienced experts rated the participants' performance on a scale from 1 (poor) to 5 (excellent). All experts were external SCUBA dive instructors ISO 24802-2 or higher and not involved within planning or conduction of the study. Performance was evaluated for eight sub-criteria to the main criteria *positioning and trim, safety*, and *time*. Overall scores for these main criteria were then calculated as summated values from the sub-criteria (see Table 3 in the results section).

Each expert rated all test trials from all participants in a randomized order, using both frontal and lateral video material. Inter-rater reliability (IRR) was assessed using a two-way mixed, consistency, average-measures intra-class correlation (ICC).[36] The degree that experts assessed provided consistency in their ratings of criteria across all subjects. ICC cut-offs were determined following,[37] with poor ICC values being <.40, fair values between.40 and.59, good values between.60 and.74, and excellent for values >.75.

Questionnaires

Participants gave general information about their age, self-assessed general fitness level, and self-assessed level of expertise in sports-diving based on their prior beginners' training in the pool. Before every test, they stated their current mood from −5 (very bad) to + 5 (very good)[38] and their perceived level of activation (i.e. arousal) from 1 (low activation) to 6 (high activation; see Table 2),[39] which has previously been applied in similar ways for diving studies.[3,4] After every test, participants self-assessed both their perceived movement-performance (1 = poor to 5 = excellent) and their emphasis (i.e. focus) on a variety of sub-criteria to *positioning and trim*, *safety*, and *time* on a scale from 1 (not relevant) to 5 (very relevant). These criteria were the very same later rated by the evaluators and involved the body-positioning in the water (i.e. head up, head down, neutral), vertical or horizontal movement, the amount of air in and the position of the buoy on the surface, the amount of slack in the reel line, safety issues of any kind (e.g. entanglement), and overall time (see Table 3 in the results section). It was assumed that RL might focus on different items of the movement skill to a higher extent than DL, which might be interpreted as a more internal focus and point towards a higher amount of declarative knowledge.

Data processing and statistics

Resulting ICCs from the experts' ratings were all fair (three aspects) or higher, indicating a high degree of agreement

Table 2. Participants stated their self-assed general fitness level (i.e. in hours per week of physical training) and diving-specific expertise level (i.e. with respect to the content of their beginners diving course).

	Age [years]	physical activity [h per week]	fitness level [self stated]	expertise level [self stated]	Mood [Pre]	Activation level [Pre]	Mood [Retention]	Activation level [Retention]
DL	22.4 ± 2.9	7.0 ± 3.9	3.7 ± 0.7	3.2 ± 0.6	3.3 ± 1.4	3.8 ± 0.8	2.7 ± 2.1	3.6 ± 1.2
RL	22.6 ± 2.5	6.6 ± 2.5	3.8 ± 0.7	3.4 ± 0.7	3.9 ± 2.5	3.3 ± 1.2	3.2 ± 1.3	3.3 ± 1.0
ALL	22.5 ± 2.7	6.8 ± 3.2	3.7 ± 0.7	3.3 ± 0.6	3.6 ± 1.1	3.6 ± 1.0	3.0 ± 1.7	3.4 ± 1.1

Activation and mood scores were assessed before each test All data is shown as mean ± standard deviation for all participants and separate for the rule-directed (RL) and discovery-learning group (DL).

and suggesting that criteria were rated similarly across experts (see Table 3 in the results section). The high ICCs suggest that a minimal amount of measurement error was introduced by the independent experts. Therefore statistical analysis is not substantially biased. Ratings were therefore deemed to be suitable for use in the hypothesis tests of the present study. (Table 3)

For all evaluated criteria, medians (MED) with 25% and 75% quartiles were calculated over the three recorded trials and the three independent scores by the evaluators. Since ordinal data were analyzed, only non-parametric test procedures were applied. Calculating Mann-Whitney-U-tests, performance ratings were analyzed for group differences within each test day. In addition, the differences in ratings between Pre and Retention values were analyzed concerning the within-subject factor group (i.e. DL, RL). Spearman bivariate correlations were computed for the effects of mood, activation, fitness level, and diving-specific fitness on the evaluated criteria and self-reported emphasis (see Table 2). The alpha level was set to 0.05. Effect sizes for significant results were then stated as r, where $r > 0.1$ indicates a small effect, $r > 0.3$ indicates a medium effect, and $r > 0.5$ indicates a large effect.[40]

Results

Overall *safety* performance was higher for RL compared to DL both during Pre ($P < 0.001$, $r = 0.79$) and Retention ($P < 0.001$, $r = 0.84$), but participants from the RL group needed significantly more time to complete the skill both during Pre ($P < 0.001$, $r = 0.75$) and Retention ($P < 0.001$, $r = 0.74$). Nevertheless, RL reported a significantly higher perceived quality of execution during Retention ($P = 0.014$, $r = 0.54$) compared to DL. No significant differences emerged for the factor *trim* (Pre: $P = 0.849$, Retention: $P = 0.191$).

The analysis over time between Pre and Retention revealed significant differences between groups for *positioning and trim* ($P = 0.034$, $r = 0.4$) and its sub-criteria. *Trim* performance for DL deteriorated from Pre to Retention, while *trim* performance for RL improved (see Table 2 and Figure 2).

The self-reported emphasis on specific aspects of the movement differed between groups during Pre for vertical movement ($P = 0.046$; $r = 0.41$; higher emphasis for RL) and SMB inflation ($P = 0.008$; $r = 0.53$, higher emphasis for DL), and during Retention for SMB inflation ($P = 0.060$; $r = 0.40$, higher emphasis for DL) and an upright SMB ($P = 0.046$; $r = 0.42$, higher emphasis for RL).

During Pre, the participants self-reported general fitness level correlated positively with their performance in the sub-criteria *trim* ($P = 0.023$, $r = 0.44$) and *vertical movement* ($P = 0.021$, $r = 0.46$) of *positioning & trim*. During Retention, this correlation remained for *vertical movement* ($P = 0.050$, $r = 0.40$). The self-reported diving-specific expertise level positively correlated with *perceived quality of movement performance*. Concerning group differences, a correlation between the self-reported fitness level and the main criteria *safety* emerged during Pre ($P = 0.026$, $r = 0.60$) and Retention ($P = 0.050$, $r = 0.54$) for RL only (see Table 2 and Figure 2). The self-stated mood and activation levels did not correlate with overall performance in the movement skill or group assignment.

Discussion

Our results showed that the rule-directed learning group (RL), in comparison to the discovery-learning group (DL), achieved significantly better ratings for *safety performance* during both Pre and Retention. Still, RL took more *time* to complete the movement skill during both tests. From Pre to Retention, changes in *trim performance* were significantly different between groups with improvements for RL, but deteriorations for DL. On this basis, our hypotheses are only partly confirmed. It can be assumed that (I) rule-directed teaching results in initially better performance compared to discovery-learning, at least concerning safety aspects. (II) The assumption that the possibly more implicit method of discovery learning results in a more stable performance over time must be rejected.

Rule-directed teaching showed overall beneficial effects for safety performance which might be attributed to several aspects: While positioning and trim can be considered as basic skills in diving (i.e. and have been practiced in the beginners' indoor course), specific safety-related aspects, like the handling of the SMB, the danger of entanglement, and the amount of air in and the orientation of the SMB on the surface were new to all participants. Therefore, it can be

Table 3. Pre and retention data is depicted as ratings from the experts (upper part) and self-reported focus assessed by the participants after each test (lower part) as medians (MED) with 25% and 75% quartiles for the criteria position/trim, safety, time, and their sub-criteria.

				Position/Trim				Safety					Time	Perception
				trim[b]	vertical movement	horizontal movement	Overall Score Position/ Trim	SMB inflation (surface)	SMB upright (surface)	taut line (underwater)	danger of entanglement	Overall Score Safety	time [s]	quality of movement skill
Rated by evaluators	Pre	DL	MED	3.11	2.94	3.44	9.28	4.33	1.00[a]	2.28[a]	3.56	11.06[a]	54.44[a]	
			25%	1.44	2.17	2.81	6.53	4.00	1.00	1.97	2.83	10.47	47.25	
			75%	3.92	3.50	3.86	10.89	4.92	1.92	2.86	3.86	13.06	71.86	
		RL	MED	2.89	3.11	3.22	8.78	5.00	5.00[a]	4.56[a]	3.78	17.67[ac]	96.00[a]	
			25%	1.67	2.33	2.39	6.72	4.33	4.33	4.11	3.00	15.83	77.78	
			75%	3.44	3.28	3.78	10.44	5.00	5.00	4.78	3.89	18.44	104.83	
		ALL	MED	2.89[c]	3.11 [c]	3.33	8.89[b]	4.67	3.67	3.44	3.67	14.44	74.11	
			25%	1.44	2.28	2.61	6.61	4.00	1.00	2.28	3.00	11.06	54.44	
			75%	3.61	3.33	3.78	10.83	5.00	5.00	4.56	3.89	17.67	96.44	
		ICC		*0.724*	*0.581*	*0.647*				*0.649*	*0.568*		*0.741*	
	Retention	DL	MED	2.61	2.72	3.39	8.67	4.67	1.00[a]	2.44[a]	3.28	12.06[a]	60.5[a]	
			25%	1.61	1.69	1.89	5.33	4.33	1.00	2.33	3.14	11.61	54.89	
			75%	3.61	3.39	3.64	10.42	4.92	2.08	3.28	3.89	12.31	66.31	
		RL	MED	2.89	3.22	3.22	9.00	4.67	5.00[a]	4.33[a]	3.67	17.11[ac]	87.67[a]	
			25%	2.61	2.39	3.06	8.11	4.33	4.00	4.11	3.33	16.56	76.83	
			75%	3.56	3.44	3.78	10.33	5.00	5.00	4.72	4.11	18.00	108.94	
		ALL	MED	2.78	3 [c]	3.33	8.78[b]	4.67	2.67	4.00	3.67	13.44	73.33	
			25%	2.39	2.22	2.94	7.61	4.33	1.00	2.44	3.22	12.06	60.50	
			75%	3.50	3.44	3.67	10.33	5.00	5.00	4.39	3.89	17.22	93.67	
		ICC		*0.748*	*0.713*	*0.754*				*0.635*	*0.449*		*0.897*	
Self-reported focus	Pre	DL	MED	2.5	3.5[a]			5.0[a]	4.0		2.0		2.0	2.0
			25%	2.0	3.0			4.0	3.0		2.0		2.0	2.0
			75%	4.0	4.0			5.0	5.0		4.5		3.0	2.0
		RL	MED	4.0	4.0[a]			3.0[a]	3.0		2.0		3.0	2.0
			25%	2.0	3.5			2.0	2.0		1.0		2.0	1.5
			75%	4.0	5.0			4.5	4.5		2.0		3.0	4.0
		ALL	MED	3.0	4.0			4.0	4.0		2.0		2.0	2[d]
			25%	2.0	3.0			3.0	2.0		1.0		2.0	2.0
			75%	4.0	5.0			5.0	5.0		3.0		3.0	2.5
	Retention	DL	MED	2.0	3.5			5.0[a]	3.0[a]		2.0		2.5	2.0[a]
			25%	1.3	2.0			3.3	2.0		2.0		1.0	2.0

(continued)

Table 3. (continued).

		Position/Trim				Safety					Time	Perception
		trim[b]	vertical movement	horizontal movement	Overall Score Position/ Trim	SMB inflation (surface)	SMB upright (surface)	taut line (underwater)	danger of entanglement	Overall Score Safety	time [s]	quality of movement skill
	75%	3.8	4.0			5.0	4.0		3.8		3.0	3.0
RL	MED	3.0	4.0			4.0[a]	4.0[a]		2.0		2.0	3.0[a]
	25%	1.5	3.0			2.0	4.0		1.0		2.0	3.0
	75%	3.5	4.0			4.5	5.0		2.5		3.5	3.0
ALL	MED	2.0	4.0			4.0	4.0		2.0		2.0	3.0
	25%	1.5	2.5			3.0	3.0		1.0		2.0	2.0
	75%	3.5	4.0			5.0	5.0		3.0		3.0	3.0

The perceived quality of the movement skill was rated by participants only. Rows are arranged to show data as medians for all participants (ALL) and assigned to the rule-directed (RL) and discovery-learning group (DL). Intra-class correlation (ICC) is stated for all values assessed via video by the experts. Significant differences between RL and DL are marked with [a]. Differences in movement performance between groups from Pre to Retention are marked with [b]. Significant positive correlations of values with participants' self-reported general fitness level ([c]) and diving-specific expertise level ([d]) are also marked.

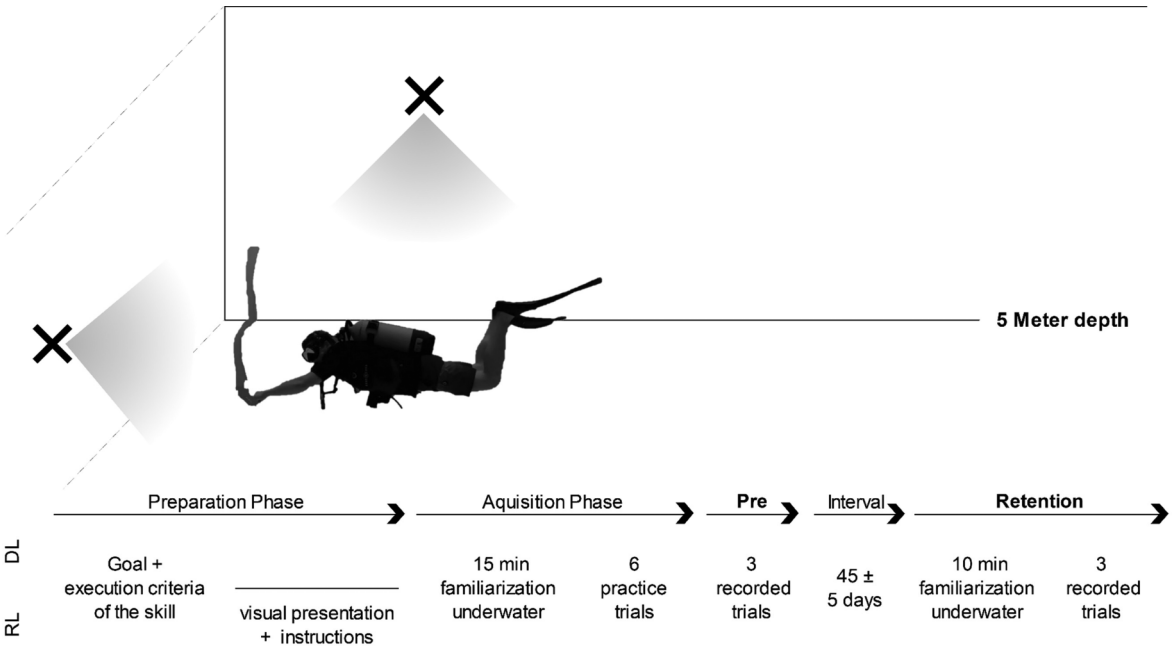

Figure 1. The underwater setup consisted of a marked area on the bottom of the pool as an orientation for the participants' positioning for performing the movement skill and both frontal and lateral cameras. The time-course of the study for the rule-directed (RL) and discovery-learning group (DL) is shown in the lower section of the figure.

speculated that performance in these new movements profited by explicit instructions with advantages over discovery learning, at least within the available time for practice. Nevertheless, longer practice times are reported to be beneficial for DL and might alter these results.[7] In addition, it can be speculated that DL took longer to find the best-working solution to perform the skill, as no feedback on potential errors was received.[30] Long-term effects of the different teaching methods, which can be interpreted as learning outcome, showed group differences for trim performance only with an increase for RL and a decrease for DL. In line with that, participants of RL reported a significantly higher perceived quality of their movement-skill performance compared to DL in the retention test (i.e. they were more satisfied with their performance). It might be that these participants were already more familiar with the basic aspects of positioning and trim from their beginners' course, thus enabling positive embodied feedback processes for these aspects,[34] although this is not backed-up by data. This might be true for RL only because DL was more engaged with improving the performance of the new movement-skill, due to their lack of additional explicit instructions. This diversion of resources might also explain the decrease of trim performance for DL opposed to RL. Although the implicit and explicit shares for discovery learning could not be determined within this study, we suspected a higher amount in line of possible automation for DL and resulting higher robustness when repeating the movement in the retention test This was already reported for highly demanding[22,41] and dual-task scenarios,[23,32] although opposing results have also been reported with better decision-making in highly complex situations during a basketball-shooting task.[42]

A positive correlation was found between the self-reported general fitness of RL with safety performance which could be carefully interpreted in such a way that those who practice sports ambitiously in everyday scenarios have also been more ambitious when learning how to dive both in their beginners' diving course (i.e. which was mandatory for participation) and within this study. Therefore, they might have entered the study with higher initial performance and put more effort into improving learning outcome and performance.

Wulf et al. reported positive effects on performance with external-focus instructions, like the general criteria provided for all participants, compared to the additional more internally-focused instructions for RL.[6] Although this might indicate improved movement-skill performance for DL, the absence could be explained by the mixture with the above-mentioned benefits of rule-directed learning or even general differences in working memory capacity between participants,[14] which, however, were not systematically investigated in this study. Differences between groups in their emphasis on aspects of the movement skill could only be observed for some variables: DL focused more on the safety aspect of SMB inflation both during Pre and Retention when compared to RL, while RL was

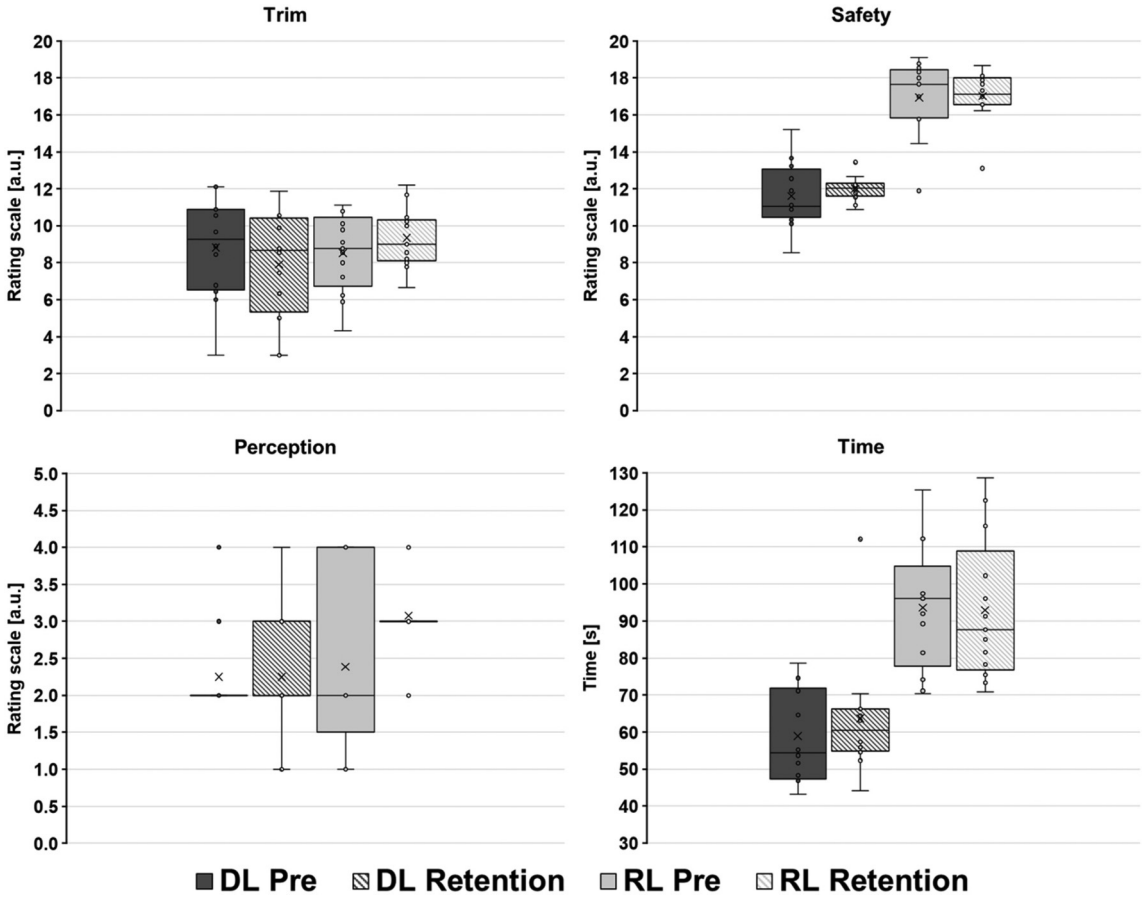

Figure 2. The main criteria trim, safety, time, as well as the self-reported perceived quality of movement execution are depicted as medians with 25% and 75% quartiles for Pre and Retention and the rule-directed (RL) and discovery-learning group (DL). Horizontal line: Median; X: Mean value; Dots: Individual values. Significant differences between groups or over time (i.e. from Pre to Retention) are marked with *.

focused more on vertical movement during Pre and an upright SMB during Retention. SMB inflation, which received a higher emphasis by DL, might be linked to an external focus (i.e. on the movement effect), while vertical movement (i.e. buoyancy) might be rather internal (i.e. focus on the body movement). This might suggest the effort of DL to develop efficient strategies to improve performance, while RL potentially remembered the instructions and followed step-by-step. However, while this supports better performance ratings for RL during Pre, it does not support differences during retention, where significant group differences emerged for potential externally focused safety-aspects for both groups (i.e. RL focused more on an upright SMB, while DL focused more on SMB inflation).

Conclusions

This study provides one of the first applied approaches to investigate the effects of different teaching methods on movement-skill performance in SCUBA-diving. New and complex movement-skills seem to benefit from explicit instructions, which resulted in better performance for safety-related aspects but to the detriment of speed. Long-term learning outcome was initially suspected to be higher for discovery learning, but only trim performance differed between groups during retention and was reduced for DL. More research is necessary to determine clear advantages concerning the long-term effects on movement skill performance. So far, the influences of environmental factors, implicit and explicit amounts during learning, and internal and external focus settings have been noted but require further investigation. Future studies might work on possible ways to communicate guidance or explicit instructions during the learning process[19,21] in underwater settings and consider additional movement skills from SCUBA-diving to determine optimally and applied ways for didactics.

Limitations

This study investigated different teaching methods for movement-skills in an applied underwater setting and within the established standards in SCUBA-diving

education (e.g. limited time, restricted underwater communication). On this basis, data analysis is affected by a number of limitations: (I) Movement-skills in diving are, in most cases, combinations of single movements paired with environmental stressors and accompanied by tasks like buoyancy and trim control. Thus, the distinction between different aspects of the movement-skill poses a challenge. Also, these skills require the provision of some general criteria to guide the acquisition for both groups. Most movement skills in diving have never before been seen by beginners because it is complicated to watch SCUBA-divers during their sport, and media presence is minor. However, future studies might conduct a Pre-test to assess general SCUBA-diving performance prior to teaching novel movement skills. Because RL is provided with mostly internally and DL with mostly externally focused instructions, these aspects are discussed for data interpretation, but should be considered explorative. (II) Both movement-skill performance and actual learning outcome are relevant for sports education, but learning outcome was only estimated from the stability of performance over time (i.e. Pre-Retention-comparison). (III) Rule-directed and discovery-learning have varying amounts of explicit and implicit information, which complicates the clear distinction between those methods and the analysis of the application in complex movement-skill sequences.[23,25,27] (IV) While discovery-learning is often suspected to increase learning outcome and create a high degree of automation, this is mostly described for experts and only after extensive practice time. (V) In emergency situations, performance might be additionally affected by the level of trait-anxiety in beginners and panic behavior, which has been investigated by other studies.[3–5]

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The authors report there are no competing interests to declare.

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ARTICLES FOR FACULTY MEMBERS

DIVE GUIDES AND COMPETENCY SKILL

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Scuba diving operators' perspective of scuba diving tourism business in Nusa Penida, Indonesia

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ABSTRACT

Nusa Penida is not only the leading diving destination in Indonesia but also one of the most famous diving points in Southeast Asia. However, it is not a mature tourist area due to its unsustainable tourism development. Furthermore, the problems experienced by diving tourism businesses in this area have rarely been studied. Therefore, this study aims to explore the challenges that affect tourism sustainability in the scuba diving tourism industry in Nusa Penida, from the perspective of dive operators. Drawing on qualitative data collected through 10 semi-structured interviews with diving operators, seven themes emerged from the study (i.e. environmental issues, lack of trained staff and guides, water sport activity, lack of enforcement, lack of government support, unhealthy competition, and irresponsible operators). These findings are expected to provide substantial theoretical and practical implications for researchers, diving business managers, and local governments in sustainable business management.

Management implications:

- It provides policymakers with insights as to how to revise development plans and reinforce regulations for future tourism sustainability.
- It aids managers of diving tourism businesses in gaining awareness and understanding the potential challenges in small diving business operations as well.
- This helps prepare future diving entrepreneurs for the marketing and management aspects of their business.
- This research could be applied by similar destinations to craft an effective business strategy that meets their desired outcomes.

1. Introduction

Despite being a niche sector, scuba diving is a form of adventure tourism that has high economic value (Fossgard & Fredman, 2019; Musa & Dimmock, 2013; Zimmerhackel et al., 2019), contributing at least USD4 billion non-market values annually to the Southeast Asia region (Pascoe et al., 2014). Particularly, muck dive tourism is worth over USD 150 million, contributing significant income generation and employment to many island and coastal communities in Southeast Asian countries (De Brauwer et al., 2017). Scuba diving is an outdoor leisure sport activity that has become increasingly popular (Bentz et al., 2016; Emang et al., 2017; Szuster et al., 2011). It has become a source of income for many marine destinations, offering significant economic impacts for the local people (Dimmock & Musa, 2015; Tapsuwan and Rongrongmuang, 2015). Scuba diving offers positive ways to experience the underwater world and brings physical and psychological benefits to divers (Dimmock, 2009; Gregory & Dimmock, 2019; Kovacs & Walter, 2015). The psychosocial benefits of scuba diving are especially valuable to disabled individuals (Carin-Levy & Jones, 2007). It further motivates social interaction among divers by encouraging a scuba 'buddy' for safety purposes (Kovacs & Walter, 2015). Since scuba divers are willing to pay significant amounts of money to experience the underwater world (De Brauwer et al., 2017), diving guarantees a promising income to both business operators as well as local communities. Thus, if appropriately

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managed, scuba diving can improve locals' income and livelihood, conservation efforts, as well as divers' underwater experience (Albayrak et al., 2019; Emang et al., 2019; Lucrezi et al., 2017). Consequently, many potential destinations have been established as diving destinations. Dimmock and Musa (2015) highlighted that the scuba diving tourism system encompasses four essential elements, namely the marine environment, divers, the host community and the scuba diving tourism industry. The diving business community is an essential stakeholder because without diving businesses, diving tourism would not be able to develop and grow. All these four elements interact to ensure the sustainability of the entire scuba diving system. This research was triggered by evidence that the diving business industry in Nusa Penida faces various challenges, thus providing a need to fully understand these challenges. Based on the author's personal observation and informal interviews with local authorities, most small and medium dive operators experience difficulties due to unsustainable tourism practices and external challenges.

Dive operators are one of the stakeholders who are responsible for sustainable tourism. Upon reviewing studies in the hospitality and tourism field, it was found that published research work on the business aspect of diving is, as of yet, limited. This is because most research on scuba diving has mainly focused on divers (Emang et al., 2019; Lucrezi et al., 2019). Though diving has been extensively researched from the tourism perspective, virtually nothing is known about the diving business in Nusa Penida since it has been limited by a paucity of primary and secondary data. As previously stated, the literature on scuba diving businesses is still scarce, while extant literature on diving tourism has mostly concentrated on quantitative approaches (Haddock-Fraser & Hampton, 2012). Therefore, to develop a better understanding of the problems faced by scuba diving businesses, a qualitative approach was deemed more suitable than a quantitative approach. Furthermore, limited research attention has been given to the perspectives of dive operators concerning sustainable development (Lucrezi & Saayman, 2017). Therefore, this study is timely in its attempt to fill this gap.

2. Literature review

2.1. Scuba diving tourism in Nusa Penida

The district of Nusa Penida, located on the southeast coast of Bali, is among the best-known tourist destinations in Indonesia and had a resident population of 59,196 at the end of 2018 (Pemerintah Kabupaten Klungkung, 2018). The region is part of the Klungkung regency and comprises three islands (e.g. Nusa Penida Island, Nusa Lembongan Island and Nusa Ceningan Island) covering a total land area of 20,284 ha (see Fig. 1). Located within the coral triangle (Coral Triangle Centre, 2020; Ruchimat et al., 2013), a 200 km^2 Marine Protected Area (MPA) was gazetted in Nusa Penida in 2010 to protect marine biodiversity (Eriksson et al., 2019). There are five entrances to the island of Nusa Penida and one ferry harbour. Some dive sites, such as Manta Point, are named after famous marine megafauna. These sites attract substantial dive and boat traffic, which in turn raises concerns about coral reef health and dive safety due to overcrowding.

The primary source of income for Nusa Penida's locals was originally in the agriculture and fisheries sector. Due to geographical and topographical conditions, the district of Nusa Penida is one of the poorest districts in the Klungkung regency (Wayan Yogi Swara et al., 2018). Thus, some fishermen in Nusa Penida work in tourism for additional income by guiding tourists' snorkelling activities (Eriksson et al., 2019). Therefore, tourism is an alternative source of livelihood for local people to improve their living standards. Now, over half of the population works in the service sector, which includes tourism. Realizing the importance of tourism development in Nusa Penida, local authorities were given the power to develop the island. In fact, based on Butler's Tourism Area Life Cycle, Nusa Penida is currently in the development stage. The island has high quality marine resources and offers a variety

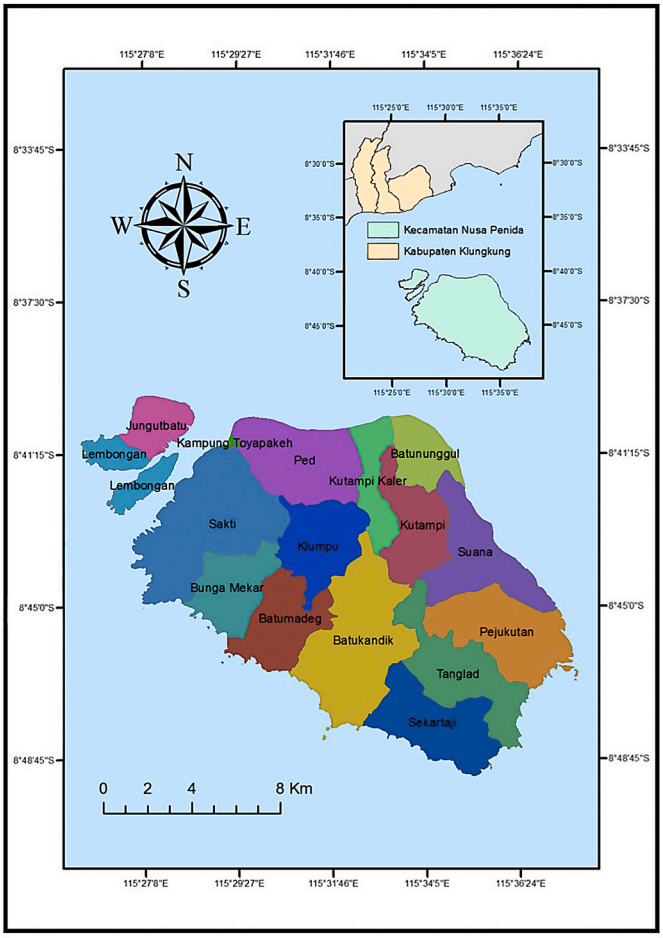

Fig. 1. Map of nusa penida. Adapted from Badan Pusat Statistik Kabupaten Klungkung (2019).

of marine tourism products and services. The main reason tourists visit Nusa Penida is for its diving activity and ocean sunfishes, i.e. molidae and manta (Thys et al., 2016). As the island is a stopover for divers or visitors coming from Bali, most visitors choose not to stay on the island, resulting in economic losses to the local economy.

The influx of tourists to Nusa Penida has resulted in a myriad of problems economically, socially and environmentally. Thus, like other islands in the world, tourism sustainability is currently the main problem in Nusa Penida. Several tourism studies have been undertaken in Nusa Penida on various issues including tourism development (Nyoman et al., 2019), marine ecotourism (Thys et al., 2016) and marine conservation area governance (Eriksson et al., 2019; Yunitawati & Clifton, 2019). These studies have revealed that the island's tourism development is a point of criticism as it is not in line with current economic development. For example, most development is focused on the West region of the island which has more tourism activities while other regions remain neglected. Likewise, the public facilities in Nusa Penida are generally inadequate or under maintenance. Transportation between Nusa Penida islands largely relies on traditional motorboats, while mobile signals are weak because of the lack of a telecommunications tower on the island (Ekbis, 2019). Fibre optic coverage is limited in most areas as well. This has affected tourism businesses' operations for some time. Apart from that, the road conditions in some areas are poor (e.g. narrow, cracked, potholes), which affects resorts located near the cliff point as there are only muddy roads instead of tar road access. The roads to access less popular tourist destinations such as Seganing waterfall, Manta Point cliff and Banah cliff point are also of poor quality. This is similar to the case of Tioman Island in Malaysia (Chia et al., 2018) where

road accessibility is one of the problems on the island.

2.2. Scuba diving business in Nusa Penida

The history of the diving business in Nusa Penida dates back to 2009 when the first diving business launched on the island. Dive spots in Nusa Penida were actually discovered when Bali dive pioneers started an expedition back in 1978. More divers in Bali then started diving businesses around Sanur, the closest harbour to Nusa Penida. However, not a single dive operator attempted to open a business on the Nusa Penida island itself until "MM Dive" became the first one in 2009. The island now has 22 registered scuba diving businesses with more planning to open. Of the 22, eight are owned by locals, 12 are owned by foreign investors and two have mixed ownership. The diving business in Nusa Penida is mainly operated by non-local businesses from the mainland of Bali (Yunitawati & Clifton, 2019). Most dive shops are found in the West region of the island where most of its businesses and tourism activities are located. Diving businesses generally operate at a small scale, offering limited services such as sightseeing and snorkelling activities. Nevertheless, the growth of scuba diving has altered the nature of interactions between people and tourism businesses, which has encouraged these businesses to re-think and change their business model (Leung & Bai, 2013). All diving businesses in Nusa Penida partner with either PADI or SSI, which are international diving agencies. These organizations act to monitor and regulate operating standards for the diving businesses (PADI, 2019). Besides, Nusa Penida has associations such as PUWSI (Indonesia Recreational Diving Business Association), whose members include diving business owners, and P3B (Bali Professional Divers Association), whose members are professional local divers. Besides scuba diving operators, water sports companies also offer scuba diving packages; however, they are not affiliated with professional diving agencies. Overall, the scuba diving business culture in Nusa Penida is unique compared to other regions because it is primarily based on trust. Many scuba diving businesses face significant challenges to maintain service quality and satisfy divers' experience.

2.3. Scuba diving tourism and tourism sustainability

Greater competitiveness within the scuba diving industry, poor legislation, governance issues, poor road networks and divers' lack of understanding of the marine environment (Dimmock et al., 2013; Dimopoulos et al., 2019; Haddock-Fraser & Hampton, 2012; Jentoft et al., 2012; Naidoo et al., 2018) are causing sustainability challenges for the scuba diving industry. The scuba diving literature has also emphasized the irresponsible behaviour of scuba divers and snorkelers (Hunt et al., 2013; Musa et al., 2011; Wongthong & Harvey, 2014). As a result, many small dive operators experience challenges in developing a sustainable business plan. This is exacerbated by the fact that managerial and senior positions in larger dive shops are mostly filled by outsiders instead of local villagers. Therefore, the rapid growth of diving tourism without proper planning has caused negative impacts for the industry. Today, one of the main considerations for divers in selecting a diving destination is the sustainability practices of the destination (Iniesta-Bonillo et al., 2016; Naidoo et al., 2018), since tourism sustainability can shape a diver's experience. Musa and Dimmock (2013) contended that the sustainability of scuba diving comprises three crucial elements: (1) conservation of the environment, (2) roles of scuba diving operators and (3) the satisfaction of divers. Therefore, there is a need to balance these three components to ensure sustainability. From the divers' perspective, sustainability can be achieved through responsible diving behaviour (Anderson & Loomis, 2011) which includes various behavioral obligations and sanctions that refrain divers from destroying the marine ecosystem. For diving operators, business costs have been shown to affect the sustainability of dive operations (Dimopoulos et al., 2019). Finally, from the conservation aspect, environmental impacts have been cited to influence tourism sustainability (Haddock-Fraser & Hampton, 2012).

3. Methodology

In this study, an exploratory approach permitted the researchers to gain new insights into a relatively undiscovered research area (Dimopoulos et al., 2019), i.e. diving businesses in Nusa Penida. This study was carried out in two phases (1) informal interviews with industry players (e.g. Indonesian Recreational Diving Business Association): and local authorities (vice sub-district head); and (2) in-depth semi-structured interviews with 10 interviewees. A two-section interview guide was prepared for this purpose. The first section covered background information about the interviewee's profile and business operations. In the second section, the interviewees were asked about the challenges faced by scuba diving businesses.

The first phase of the investigation took place between 18 and August 28, 2019 with the aims of fully understanding the diving industry and building rapport with key diving business players. An informal meeting was arranged with industry players and government officials via the researcher's personal network. During the meeting, the researcher introduced the attendees to the purpose of the study and attempted to understand the daily operations of dive operators in Nusa Penida. To identify potential interviewees for the next phase of the study, a snowball sampling technique was used whereby the industry players were asked to recommend potential respondents. The researcher then conducted field observations in Nusa Penida to ascertain the eligibility of potential interviewees. Confirming the eligibility of interviewees was a challenge as it was difficult to reach potential respondents during the peak tourist season. In order to qualify as a respondent, the interviewee had to be from a scuba diving business's top management, i.e. manager, owner or chief executive officer. This was paramount because these individuals are generally more experienced in the marketing, operations and overall businesses in the diving industry.

Following the first phase, the second phase commenced from 30 October to November 15, 2019 after the key informants helped provide a better picture of the diving industry. Before the actual interviews, the researcher requested potential interviewees to participate in the interview via telephone and email based on recommendations from the industry players. However, only a few responded and were willing to participate. Therefore, the researcher decided to visit the remaining dive operators in person to set an interview date and time. Finally, ten interviews were secured. Potential interviewees were informed of the aims of the study and the use of the information to increase data credibility, as suggested by Björk and Kauppinen-Räisänen (2019). Interviewees were also requested to select a suitable venue and time for the interviews. The majority of the interviews took place in the afternoon or evening due to busy working hours between 7.00 a.m. and 2.00 p.m. All the interviews were conducted at the interviewees' dive shops where the interviewees felt most comfortable with the interview process. Interviewees were guaranteed full confidentiality and anonymity and were given the choice to end the interview at any point. They were also encouraged to narrate their views without intervention. The interview procedure was terminated when no new info was attained or when the interviewee decided to end the interview. However, no interviewee chose to end the interview early. The findings emerged exclusively from Phase Two interviews.

3.1. Data analysis

Among the ten interviewees, six were local villagers and four were expatriates from Europe. Six interviews were conducted in the English language while the remaining four were conducted in Bahasa Indonesia, the language that interviewees were familiar with. All interviews were audio-recorded with the permission of the interviewees and were transcribed verbatim as soon as possible after the interviews. These transcriptions were supplemented by field notes taken during interviews.

Translation into English was completed by the researcher and co-researcher who took turns reading the Bahasa Indonesia and English manuscripts to cross-check inter-rater reliability. The 'DO' code was assigned as the abbreviation of 'Dive Operator' to protect the anonymity of respondents. The transcribed interview scripts were read independently by the researchers several times and were deliberated in combination with researchers' field notes and observations to determine the validity of the findings.

Classical coding techniques and thematic analysis were used to sort, organize and interpret data from the transcribed manuscripts. These techniques offered a flexible method to connect data to concepts, identify broad themes and advance generalizations (Neuman, 2014). Following Lincoln and Guba's (1985) suggestion, this study employed validation procedures to enrich the trustworthiness of the data. First, member checks were used to ensure that the description truly represented the underlying concepts (Buchbinder, 2011). Each transcript was then sent to the corresponding interviewee for confirmation and was corrected accordingly. Second, triangulation of the responses was achieved to confirm the findings. Meanwhile, the reliability of the study was enhanced by the use of a standardized interview guide and tape-recorded interviews (Appleton, 1995). There is also an ethical aspect that needs to be mentioned. To safeguard the anonymity of interviewees, no identifying information was revealed in their quotes. Further, interviewees' names and tour operators' names appearing in other interviewees' narratives were substituted with pseudonyms. Saturation was achieved with 10 participants' narratives; no further interview was conducted thereafter.

4. Findings

In total, data from ten interviews was obtained and analyzed in the second phase of interviews. The findings indicate that most of the respondents were males while most of the diving businesses they represented were under foreign ownership. Thematic codes which examine dive operators' marketing and operations can be found in Table 1 alongside the themes and examples of respondents' responses related to the codes. The following sections describe the challenges faced by scuba diving businesses in Nusa Penida as divulged by the interviews.

4.1. Environmental issues

All the interviewees agreed that environmental issues, mainly trash issues, have the greatest immediate impact on the island. One interviewee (DO6) expressed his viewpoint this way:

> "Nusa Penida is seriously affected by trash issues. I mean, there is trash everywhere, right? Many islands do not have trash collection points and most of the trash will not even go off the island. The trash problem will not be solved until there is government action."

Another interviewee (DO2) addressed the increasingly serious trash issue by offering a solution. He suggested:

> "If I have to choose, I would rather burn it than throw it into the ocean. It is not ideal but it is what it is. It would be nice to have a solution."

A majority of the interviewees believe that waste and the marine environment are not well managed, leading to the degradation of healthy coral reefs. One interviewee (DO3) commented:

> "The coverage of coral reefs is impacted, in that it has reduced. Scientifically, I cannot say the percentage of reduction but we can visually see the difference during dives. Coral reef species are decreasing and will soon be destroyed."

A common comment from the interviewees was that the negative environmental impact is due to human activities. They blame irresponsible human activities for causing deterioration of the natural environment. Below are some interview quotes that illustrate this:

> "They (divers) dive in shallow waters and make contact with the coral reefs … the worst is the 'sea walker' diver." – DO3

> "Environmental problems start when people apply sunblock or sun cream. It has a huge negative impact on the coral reefs. Besides, non-divers often swim without proper finning, which leads to direct contact like stepping on coral reefs and destroying them." - DO1

4.2. Lack of trained staff and guides

The second most critical problem in the scuba diving business, according to the interviewees, is the lack of trained staff and guides. Most of the time, the diving business owner is also responsible for other jobs since it is tough to hire local staff. For example, one interviewee (DO10) explained:

> "Yes, my staff are barely enough to make up the diving crew. I need back-up people to work in reception, to prepare food in the kitchen and to fill up compressor tanks."

Some interviewees agreed that trained staff and guides are essential, especially for the duties of dive master and dive instructor. One respondent shared her views in this manner:

> "I think it is a good opportunity for dive businesses to train locals to become dive guides, snorkel guides or boat crew. They can provide more specialized training too, such as to work with diving equipment. It is good to have people who are experienced or qualified." - DO9

Respondents also linked the lack of trained staff to safety concerns as untrained staff may not follow standard operating procedures. The interviewees elaborated:

> "Many guides are not familiar with the currents. Two people went missing recently! So many accidents happen while business owners just focus on money." - DO4

> "Two guides went as deep as 50 m and only one came up. It's just absurd. I feel bad for the victim who did not follow procedures." - DO2

> "You can ask how many dive operators have guides of good standard. You can even ask dive companies if they educate their guides. Do you know that many local people do not even have a divemaster license?" - DO5

Locals' lack of skills is not a new phenomenon in the scuba diving industry (Mograbi & Rogerson, 2007). In fact, diving tourism in Malaysia suffers from a severe shortage of trained local diving personnel (Daldeniz & Hampton 2012). Due to the high cost of training for dive masters and dive instructors, many dive operators cannot afford to

Table 1
Respondents' demographic profile.

Code	Gender	Designation	Business ownership
DO1	Male	Director	Local
DO2	Male	Operation Manager	Foreign
DO3	Male	Operation Manager	Local
DO4	Male	Operation Manager	Foreign
DO5	Female	Operation Manager	Foreign
DO6	Female	Director	Foreign
DO7	Male	Director	Local
DO8	Male	Operation Manager	Foreign
DO9	Female	Director	Foreign
DO10	Male	Marketing Manager	Foreign

provide such training for their local staff.

4.3. Water sport activities

One of the controversial interview findings in this study is dive operators' dislike of water sport activities. These activities, such as a pontoon, damage and affect the health of coral reefs (DO1, DO3, DO6, and DO9). Moreover, water sport activity is dangerous in the eyes of the interviewees. One interviewee expressed his concern by stating the following:

> "There are jet skis and boats that go very fast. Tourists have no idea that the surface marker buoy is just a few meters from them when their boats are passing by - it is crazy! It may cause you to lose your head. This is why lots of accidents happen and people die as well. Also, I do not see the necessity for a pontoon in Nusa Penida. The buoys and moorings are everywhere and destroy the corals." -DO2

This was further supported by two interviewees who explained:

> "I hate water sports. I'm sure many diving professionals also hate them. They are dangerous and they are not good for the environment! Look at the damage they have caused in Buyuk. There are anchor chains and concrete everywhere. It is breaking the reefs and it is disgusting. The corals used to be amazing but now it is a pile of nothing." - DO6

> "It's a huge problem. They generate a lot of money so permits are given to them, but I don't know how much reassessment is done on their environmental impact. You can see the damage they have done. The anchors have damaged the corals and people walk on the seabed. That's against the rules of the MPA and should not be allowed. They don't care for the environment. Furthermore, the sewage discharged from the pontoon goes straight into the sea and kills corals. This needs to be stopped!" - DO9

4.4. Lack of enforcement

Another problem uncovered in this study's analysis is the lack of enforcement. Two interviewees claimed:

> "As far as I know there's almost no enforcement whatsoever, so it's a bit of a joke." - DO2

> "Even though there are regulations in MPA, there is no enforcement or patrol." – DO9

Another interviewee (DO8) added that the government puts more emphasis on tourism development in Bali and will only pay attention to Nusa Penida if something happens. He reiterated:

> "At the moment, the government mostly focuses on Bali. I think the government has not regulated that much. Right now, they have temporarily closed their eyes. They will start paying attention if something happens."

The findings also revealed that fishing is an issue in Nusa Penida; however, there is a lack of enforcement in this matter. Below are some interview excerpts that illustrate this issue:

> "In Nusa Penida, fish bombing was prohibited long ago. It is illegal, yet some fishermen from nearby islands bomb Nusa Penida waters. Some come quietly with compressors, long hoses and potassium chemicals to fish. However, no action is taken." -DO3

> "There are still fishing issues which are difficult to solve. Though there are regulations, no one is enforcing them." -DO6

4.5. Lack of support from the government

The role of the government, particularly the local government, is significant as a facilitator, coordinator and regulator of tourism planning and development (Churugsa et al., 2007). Most interviewees realized that there is a lack of support from the government. Comments regarding this issue included:

> "The government doesn't care about the diving industry." – DO10

> "There is not much communication that I see from the government." – DO6

> "The government has played a minimal role in developing the diving industry. I refer to the government in broad terms. Supposedly, the ones who take care of development should understand tourism, environmental and spatial aspects because they are linked to each other. When tourism is developed but the spatial aspect is not considered, it is a mess. There has been no control, or if there is, it has been minimal – probably just once a year - in monitoring diving businesses." – DO3

However, some interviewees recognize the efforts of the government in promoting the destination, as one interviewee said:

> "There are many government promotions in this area.'' – DO9

4.6. Unhealthy competition

The findings indicate potential conflict that has led to unhealthy competition among diving business operators in Nusa Penida. This was revealed by the following quotes:

> "I have heard and seen operators compete in a way that is not fair to everyone. Hopefully, there's not going to be something like 'price-fighting' one day." - DO2

> "With the establishment of so many dive centres, we have to survive. We have to enter and compete in the diving industry." – DO3

> "I would say the competition is not very healthy." – DO4

> "There is growing competition." – DO5

> "We did not have too much competition before. I mean, if you go somewhere and you want to dive, you see us. Now, customers have started to compare and have other options to choose from." – DO8

4.7. Irresponsible operators

The interview findings suggest a negative depiction of diving operators as irresponsible due to certain practices. This was mentioned by one of the interviewees:

> "Some companies know the necessary distance when diving while some companies don't know or don't care and go too close. We have been discussing with other dive shops as well that it would be good to have buoys to indicate areas that are safe for boats. Otherwise, for those who are not divers, if they pop up and there's a boat there … I mean, accidents happen." – DO2

The findings also imply that some irresponsible dive operators hire unprofessional staff who lack important skills. These staff are often not given proper safety training, which causes accidents. The respondent dive operators shared their own experiences:

> "They cause many problems with the 'sea-walker' activity. It is insane! The whole thing is totally wrong - they are just doing it for the money. Some operators hire new guides that have not learned proper diving skills. They do not care about the coral reefs because

they work for money as guides in the water sports business. The bad thing is when water sport business owners try to sell cheap packages and hire people that are not professionals." – DO4

"I have witnessed many dive centres hire unprofessional staff who lack education. Most of the staff don't know how to dive safely. These businesses want to satisfy the people who come to the island, which is why they lower their safety standards and do not make these activities safe anymore. Accidents happened, unfortunately." – DO5

A similar sentiment was expressed by another interviewee:

"There are always 10 to 20 per cent of dive shops that do not teach or train their divers properly. They just let them do whatever they want in the water; that's the problem." – DO6

Additional findings are included in the discussion section.

5. Discussion

Scuba diving is a popular recreational activity in Nusa Penida, but human activities and business practices have impacted its sustainability. Therefore, actions must be taken for the destination to be developed in sustainable ways. As Lucrezi et al. (2017) pointed out, it is difficult to declare sustainability goals unless the interaction of the three pillars (i.e. economic, social and environmental) is understood. Hillmer-Pegram (2014) highlighted that there are several concerns in diving tourism and applied a resilience framework to understand social–ecological dive tourism systems. This study was undertaken to obtain a deeper understanding of the challenges faced by scuba diving businesses in Nusa Penida. Based on in-depth interviews with dive operators, seven key challenges were found in the scuba diving business. Environmental challenges are expected to have the most significant impact on scuba diving businesses (Dimopoulos et al., 2019) due to poor trash disposal mechanisms and continuous coral reef degradation. The trash issue is a severe problem on the island as there is a lack of sewage and garbage treatment (Kossmann, 2015). This is in line with previous studies (Chia et al., 2018; Chong, 2020; Jitpakdee & Thapa, 2012) that found a lack of marine waste management on islands. The trash in the ocean can entangle, entrap or be eaten by marine species. This degradation of marine environments would result in financial losses for businesses since divers would not be interested in diving in such environments. Other studies have reinforced that if a scuba diving business is managed correctly, it will benefit the environment (Gier et al., 2017; Lucrezi et al., 2017). Thus, diving business operators play an important role in educating their staff and guests to act responsibly (Anderson & Loomis, 2011; Dimopoulos, 2019). For example, some dive operators organize beach clean-up programs or join local organizations (e.g. Trash Hero) to collect trash.

Staff members comprise vital human capital for small and medium enterprises and consequently require human capital development. It is suggested that staff skill building contributes to sustainable and responsible development (Koutra & Edwards, 2012). Indeed, well-trained staff (i.e. dive instructors) are crucial in the scuba diving business (Andy et al., 2014; Giglio et al., 2018). However, in this study, there appeared to be limited training opportunities for staff to improve their dive operation knowledge and skills (i.e. product, service and formal diving knowledge). Giglo et al. (2018) highlighted that a lack of staff training is one of the main barriers to pre-dive briefings. Our findings also reveal that some dive operators do not have proper planning and knowledge improvement programs for their staff and dive marshals due to high costs. Besides, small dive operators generally do not have access to enough dive professionals to train their local staff. The lack of formal education and language barriers are also common challenges for local staff. Failing to provide proper training to dive staff puts inexperienced scuba learners in danger; thus, internationals or expatriates are often recruited to fill vacancies for dive professionals.

Our interviews with scuba diving operators advocate that the unsustainability of diving operations relate explicitly to water sport activities. The number of tourists engaging in surfing, snorkelling, diving, sailing and water sports is increasing (Kossmann, 2015). The majority of the interviewees felt that the availability of water sport activities poses a significant threat to their dive operations while directly and indirectly impacting the marine ecosystem. These water sport companies have giant pontoons or jetties for cruises and big boats to berth near the shore. A pontoon is a big platform up to 100 m in length, constructed for boats to berth and for tourists to enjoy recreational activities in the middle of the sea. A big pontoon can accommodate a maximum of 1000 visitors and has several facilities (e.g. restaurant, slides and kids' pool) on board. Typically located 200–300 m from the shore, a pontoon is attached to the sea bed with mooring lines mounted to concrete for stabilization. During low tides, there is a high tendency for the pontoon to destroy coral reefs in shallow areas. Although the government regulates zoning to an extent, some water sport activities are carried out in the wrong zone (Darma et al., 2010). Consistent with this, our interview findings show that there is a lack of planning and monitoring of water sport activities by the authorities. Therefore, when water sports are conducted at large scales and in the wrong zone, they jeopardize diving businesses.

Constant engagement and long-term commitment between community groups, NGOs and the government are crucial for marine protected areas' sustainability (Mills et al., 2010); however, the government is said to lack strong political will (Yunitawati & Clifton, 2019). The interviewees in this study felt that the government has overlooked the development of the diving industry. For example, due to unnecessary bureaucracy in the local government, the permissions process takes much longer than initially expected. While waiting for license approval, some diving operators operate their businesses without a valid business license. Additionally, the competition among island tourism businesses influences the economic development of island economies (Stauvermann & Kumar, 2016). Interviewees admitted that there is unhealthy competition on the island due to unstandardized service prices. The situation becomes worse when small dive operators lower their service quality and price to compete with bigger dive operators. As a result, the benefits (e.g. commission) of dive instructors reduce.

Similar to previous studies (Cheablam & Shrestha, 2015; D'Anna et al., 2016; Arias et al., 2016), lack of enforcement is another problem found in this study that results in difficulties spotting illegal activity. Ban et al. (2011) highlighted that the cost of enforcement in a marine setting, especially in marine protected areas, is always on the high side and is logistically difficult due to 'borderless' waters. However, enforcement can be optimized if the authorities take serious action (D'Anna et al., 2016). Nevertheless, the interviewees agreed that limited government officials monitor the area, to the extent that some locals still fish in restricted areas. The findings also reveal complaints about the lack of environmental education for visitors, particularly from dive operators either from Bali or Lembongan. These irresponsible operators do not inform their guests to follow the 'dos' and 'don'ts' while snorkelling or diving, allowing them to engage in unethical activities (i.e. touching corals and fish). Several interviewees pointed out that there are other unsustainable practices in diving operations such as lower safety standards and the hiring of unprofessional staff. Therefore, there is still the challenge of dive operators who do not care about the destination's sustainability. Overall, all interviewees agreed on the issues facing the Nusa Penida island and call for more cooperation between all the parties involved.

5.1. Implications

This study makes valuable contributions to both academia and the industry. The findings reveal useful information from the diving businesses' perspective that is under-researched in the scuba diving tourism literature. These findings are meaningful and promising for future

research in the scuba diving tourism field. The following sections discuss the implications of the study and potential directions for future research.

5.2. Theoretical implications

From a theoretical perspective, research on sustainability in the diving industry is minimal. Thus, this study extends the knowledge on sustainability in the diving tourism context that has been neglected in the literature. This is one of the first attempts to explore business challenges from the perspective of dive operators in Nusa Penida. To this end, this study employed a qualitative approach to examine the challenges faced by diving businesses in sustainability. Our research broadens the literature on sustainable diving tourism by revealing two unique challenges faced by diving businesses, namely water sport activities and irresponsible operators. Its results not only enrich existing theoretical research but also provide further inspiration for managers and owners in the diving tourism industry. The findings of the present research are expected to improve our understanding of diving business operations and its challenges. As such, it not only has pertinent value for scholars in the development tourism sustainability research but also provides a reference point for future sustainability studies.

5.3. Limitations and suggestion for future study

Several limitations of this study should be highlighted to improve research findings in the future. First, the study site was in Nusa Penida only; thus, the findings may not be generalizable to other tourism destinations. Second, this study was solely based on scuba diving operators' opinions; as such, bias might be present in the findings owing to the lack of representativeness of the sample. Finally, as the data collection period was during the peak tourist season, the scope of this study was limited to a smaller sample. Hence, generalizability to the whole population of business operators may be restricted. Future research should replicate this study in other scuba diving destinations and maximize sample sizes by collecting data during off-peak or shoulder seasons. Since the data source was limited to a single stakeholder group, future studies should verify the findings among different stakeholder groups such as the government, tourists and local communities. By doing so, a broader and more precise picture of sustainability challenges in diving tourism can be obtained.

CRediT authorship contribution statement

Azalia Gerungan: Data curation, Methodology, Writing - original draft. **Kei Wei Chia:** Conceptualization, Supervision, Investigation, Writing - review & editing.

Declaration of competing interest

No potential conflict of interest was reported by the authors.

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Sinking deeper: The most significant risks impacting the dive tourism industry in the East African Marine Ecoregion

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ABSTRACT

Scuba diving continues to be one of the most popular recreational activities in marine tourism, but its sustainability is currently threatened due to environmental, social, political, and economic risks. The East African Marine Ecoregion is renowned for its richness in marine fauna and flora, including some of the Indian Ocean's most diverse and abundant coral reef ecosystems, making it a popular destination for scuba divers. However, empirical evidence suggests that external risks (international and domestic) are impacting on dive operators in the region, creating the need to better understand these impacts. This research was therefore aimed at identifying the most significant of these external risks from the perspective of dive operators, via an explorative and descriptive study. The qualitative and quantitative primary data collected revealed that domestic and international economic and political risks have the greatest impact on dive operators in the East African Marine Ecoregion, and this trend is expected to continue. Environmental degradation of coral reefs, while not seen as a threat to dive operators at present, constitutes a key threat within the near future. In terms of the variation in perceived risk across the region, Kenya suffers most from social and political risks, Tanzania from environmental risks, Mozambique from political risks, and South Africa from economic risks. The research contributes to Africa's Blue Economy, which aims to guide African countries in sustainable use of the marine environment while harnessing its social and economic benefits. The findings create awareness of the impact of external risks on regional dive operators and their significance. Furthermore, they create an opportunity for decision makers and stakeholders in the region to craft solutions to improve the sustainability of the scuba diving industry.

1. Introduction

Scuba diving tourism is a form of marine tourism (Orams, 1999) and is considered an economically important industry, as evidenced by the number of locations striving to become scuba diving destinations (Dimmock and Musa, 2015:52) and dive tourism hotspots (Dimopoulos, 2018). This is specifically evident in the coastal tropical and sub-tropical regions of developing countries, which are largely dependent on foreign investment through tourism activities (Burke et al., 2011; Spalding et al., 2017). When choosing a dive destination, divers generally seek high-quality coral reef habitats, rich coral and fish diversity, an ocean with high visibility free of pollution and sediment, and resort style retreats (Dimmock, 2003).

In the East African Marine Ecoregion (EAME), scuba diving tourism is one of the key components of marine and coral reef tourism (ASCLME, 2012; Orams and Lück, 2014; Spalding et al., 2017). The EAME extends for over 4600 km (Fig. 1) and supports a rich diversity of plant and animal life, including some of the Indian Ocean's most diverse coral reefs and globally significant marine and coastal habitats (Guerreiro et al., 2011; Obura, 2001; Oglethorpe, 2009; WWF, 2015). The geographical scope of this study includes all countries with dive operators that fall within the EAME, namely, the territorial waters of Kenya, Tanzania, Mozambique, and Sodwana Bay in South Africa (Obura, 2005).

While scuba diving continues to be one of the most popular marine recreational activities in marine and coral reef tourism, its future is being threatened as a result of environmental, social, political and economic impacts (Burgoyne et al., 2018; Burke et al., 2011; Canty, 2007; Richmond, 2011). These are referred to as external (exogenous) risks and are divided into domestic and international external risks (Cabrini, 2013).

The Blue Economy in the African context includes aquatic and marine spaces, such as oceans, coasts, lakes and rivers. It is an integral part of the African Agenda 2063, aiming at guiding African countries to better mainstream the marine environment into national development plans, policies, strategies and laws (United Nations Economic

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Fig. 1. Map of the EAME.
Source: Adapted from Crochelet (2015); Burke et al. (2011); EAME, 2004; Guerreiro et al. (2011); Obura (2005); Oglethorpe (2009).

Commission for Africa, 2016).

The Blue Economy focusses on improving human wellbeing and social equity; reducing environmental risks and ecological scarcities; and identifying focus areas for growth given present risks in the region (African Union, 2012; Smith-Godfrey, 2016; United Nations Economic Commission for Africa, 2016; Van Wyk, 2015; World Bank and UN, 2017). One of its key sectors is marine tourism, which provides a wealth of value and potential, of which the scuba diving industry plays an integral part (United Nations Economic Commission for Africa, 2016). To contribute to research on the Blue Economy, this article delves deeper into the risks prevalent in the EAME, which stakeholders need to be aware of.

2. External risks impacting on the scuba diving industry

External risks are those that are beyond the control of management, and can be attributed to natural and political disasters, and socio-economic and macro-economic shifts. They affect not only individual businesses but can impact the region and its entire tourism industry (Kaplan and Mikes, 2012; Shaw et al., 2012). These external risks are further divided into domestic and international external risks (Cabrini, 2013). **International risks** refer to risks occurring indirectly or outside a country's borders, which still affect the host country (Shaw, 2010), and ultimately the scuba diving industry. Regional examples include terrorism, rising oil prices, depressed economic activity, and the recent 2015/2016 El Niño phenomenon (AIMS, 2016; Booth, 2015; PGI, 2015; PWC, 2013; 2015; Song, 2011; Tourism Update, 2015; Wexler, 2015). Similarly, tourism in the region has been plagued by **domestic risks**, which impact directly or occur within the borders of the host country and impact on scuba diving businesses (Shaw et al., 2012). These include crime and safety, political instability, health, over-utilisation of marine resources and environmental degradation (Business Daily, 2015; Floros et al., 2013; Groenewald, 2013; Kutengule, 2015; Manning, 2016; Morisset, 2015; O'Leary and McClanahan, 2011; Silva, 2006; Times Live, 2015; World Bank, 2016).

This research considered a wide range of environmental, economic, social and political social risks that undermine tourism growth in African countries and could potentially affect the scuba diving industry

as a component of the tourism industry (Mayaka and Prasad, 2012).

In this section, current literature provides a brief overview of the four external risk groups that were considered in this research.

2.1. Environmental risks

Direct human-induced impacts on coastal ecosystems, specifically on or around coral reefs, have a negative effect on these marine environments. In East Africa, the most documented damage to coastal habitats occurs near major towns and cities, due to sewage discharge, over-exploitation of marine resources and marine pollution (Richmond, 2011). Destructive fishing and agricultural runoff also pose significant threats (Bryant et al., 1998). According to Burke et al. (2011), 65% of reefs in the Indian Ocean are at risk from locally induced threats. Any change to the environment may affect the destination image and threaten future tourism opportunities for scuba diving operators (Paterson et al., 2012), seriously undermining local tourist revenues which are a vital source of foreign exchange for African countries (UNODC, 2013).

2.2. Economic risks

Tourism has long-term economic benefits for countries, especially those whose main source of revenue is derived from tourism (Brau et al., 2003; Dritsakis, 2004; Durbarry, 2004; Oh, 2005; Skerritt and Huybers, 2005, World Travel and Tourism Council (WTTC), 2017). However, any negative economic disturbances will impact tourism and its associated sectors, such as transport (Lejarraja and Walkenhorst, 2007). The effects of the 2008 financial crisis led to a slowdown in economic growth in the EAME countries, manifesting itself in falling commodity prices, inflation, unemployment, and a decline in income (Lunogelo et al., 2009). Currency depreciations have continued to add inflationary pressures, impacting on regional economic growth.

2.3. Social risks

Social risks emanate as a result of economic migration, population growth, disease epidemics and different types of crime (Baker, 2014; Richmond, 2011; Tairo, 2015; WHO, 2016); and then impact on the sustainability of the tourism industry. Developing countries such as those in the EAME may not have the capacity to deal with social changes as readily as advanced economies. With the onset of globalisation and internationalisation of markets, as well as uncertain political and economic environments, governments and regulators struggle to determine how to effectively manage such socio-economic and geo-political disturbances (WTO and ILO, 2013).

2.4. Political risks

Tourism may decline when conditions in a country or region appear to be unsettled. Scuba diving businesses operating in historically tumultuous and unstable political environments are highly susceptible to these crises (Musa and Dimmock, 2013). Commercial Risk Africa (Booth, 2015) concludes that 91% of risk managers in Africa perceive that domestic political risks are increasing, with corruption and political instability being most pertinent (Booth, 2015). Moreover, institutions employed to govern and regulate the tourism industry can also hamper tourism growth through restrictive policies and regulations (Henderson, 2007; Seddighi et al., 2001). Consequently, tourists tend to choose alternative destinations if they feel that travel to the destination is too complex or unsafe (Cyceon, 2015; Gössling et al., 2012).

Based on the literature above, regional knowledge gaps need to be addressed. Most research on scuba diving tourism focuses on the environmental effects on tourism destinations, and these have been well documented in literature (Dimmock and Musa, 2015; Garrod and Gössling, 2008; Lemke and Olech, 2011; Musa and Dimmock, 2013). However, researchers are proposing a wider range of factors (economic, social and political) to consider when assessing the tourism industry (Akan et al., 2007); and Burke et al. (2011), focussing on the scuba diving industry, assert that there is a need to better understand these external risks impacting on businesses. Furthermore, several studies focus on the demand side of the tourism industry, but "very few researchers have investigated risk from the point of view of the supply side" of tourism (Shaw et al., 2012:193). These indicate gaps and an under-researched domain. As a result, to address these knowledge gaps, this research aimed **to identify the most significant external risks impacting on dive operators in the EAME from the perspective of the supply side of tourism (dive operators).**

3. Materials and methods

The research follows a post-positivist paradigm and comprises an exploratory and descriptive research design. The exploratory approach allowed new insights into a relatively unknown research area. The descriptive research design used current literature to provide detailed descriptions of external risks; and details regarding dive operators, Marine Protected Areas (MPAs), and events relevant to this study (Babbie et al., 2007).

3.1. Study sites

The geographical area covered in this study is the EAME, as shown in Fig. 1. It includes the territorial waters from Somalia (10° North latitude), extending south along the East African coastline to north-eastern South Africa (28° South latitude); and the international waters within the 200-mile Economic Exclusion Zone (EAME, 2004; Muthiga et al., 2008; Oglethorpe, 2009). Kenya, Tanzania, Mozambique, and the north eastern coast of South Africa fall within the EAME and are the countries of focus for this research. The distribution coverage of dive operators within these countries is limited to their proximity to coral reefs, since most dive operators operate from within or close to MPAs and marine reserves (Oglethorpe, 2009; Wilkinson, 2008).

3.2. Research instruments, sampling and data collection

The data presented in this article were obtained through two phases. For **Phase 1**, qualitative structured face-to-face interviews were conducted with one dive operator in each of the four EAME countries (between July and October 2015), regarding the external risks they perceived to be relevant. As key stakeholders of the dive tourism industry, in operation for at least 20 years, these four dive operators were deemed as experts in managing their dive businesses and the most suitable to participate in Phase 1. This constituted purposive sampling. From these results, the individual external risks were classified into risk groups and then further into risk categories (Table 1), which were used as the basis for the research instrument in Phase 2.

For **Phase 2**, knowledge gained from Phase 1, as well as existing literature, informed the design of a quantitative structured online survey, which was validated by a pilot test with four dive operators who

Table 1
External risk groups and categories.

Risk group	Risk category
Environmental	Direct environmental risks (DER)
	Indirect environmental risks (IER)
Economic	Domestic economic risks (DEcR)
	International economic risks (IEcR)
Social	Domestic social risks (DSR)
	International social risks (ISR)
Political	Domestic political risks (DPR)
	International political risks (IPR)

Table 2
Dive operators in the East African Marine Ecoregion.

Dive operators in East Africa		Total number of respondents	
Country	Region	All respondents (n)	Percentage of population
Kenya	Mombasa	3	3.89
	Ukunda and Diani Beach	4	5.19
	Wasini	1	1.30
	Watamu	1	1.30
Sub-total		9	11.69
Tanzania	Dar es Salaam	1	1.30
	Mafia Island	5	6.49
	Mtwara and surrounding areas	1	1.30
	Pemba Island	2	2.60
	Tanga and surrounding areas	1	1.30
	Zanzibar Island	19	24.67
Sub-total		30	38.96
Mozambique	Bazaruto islands and Vilanculos	5	6.49
	Inhaca Island	1	1.30
	Inhambane	7	9.09
	Memba, Nacala and surrounding areas	3	3.89
	Ponta do Ouro and Ponta Malongane	4	5.19
	Ponta Mamoli	1	1.30
	Quirimbas Archipelago and Pemba	3	3.89
Sub-total		24	31.17
South Africa	iSimangaliso Wetland Park – North reef complex	2	2.60
	iSimangaliso Wetland Park – Central reef complex	12	15.58
Sub-total		14	18.18
Total		**77**	**100**

had good knowledge of the EAME dive industry. The population for Phase 2 consisted of all dive operators with dive tourism businesses in the EAME operating within or nearby MPAs or marine reserves; and who are affiliated with a professional scuba diving organisation. These operators are located in specific areas of the East African coastline characterised as dive tourism hotspots (Dimopoulos, 2018). Research of websites and other secondary sources revealed that there were 77 such dive operators (Table 2).

All 77 were contacted and purposefully invited to participate between July and September 2016. Using Survey Monkey© as the online platform, the survey was emailed as a web link to the 77 dive operators. E-mail reminders were sent, followed by telephone contact. Twenty-two (22) surveys were returned via the online approach. Nulty (2008) suggests that in order to present data that maximises the probability of needing the lowest response rates, liberal conditions can be set. Using this approach, a response rate of over 25% can be considered satisfactory. Hence 22 surveys would have been sufficient. However, to further increase statistical significance, follow up was done in person to administer the surveys to non-respondents in Kenya (Diani, Mombasa and Kisite), Tanzania (Zanzibar), Mozambique (Ponta do Ouro and Ponta Malongane) and South Africa (Sodwana Bay). These were printed in the same format as the web survey and completed manually by respondents. This resulted in 12 additional surveys, achieving a total of 34, i.e. a 44% response rate.

3.3. Data analysis

Data processing for Phase 2 involved capturing, editing and checking the data to ensure it was free of inconsistencies. IBM SPSS© was used to support the analysis. Content validity was demonstrated because questions originated from literature. Furthermore, peer review was used as an external check, while piloting was undertaken to ensure valid constructs prior to survey dissemination. To enhance validity and reliability, descriptive statistics (means) were used to describe the outcomes of this study. To express the variable levels of impact, a Likert scale was used, ranging from very high impact (5), high impact (4), moderate impact (3), low impact (2) to no impact (1). This scale provided a rating of the respondents' perceptions on the level of impact (Table 3).

Table 3
Impact level of external risks.

Level of impact	Likert scale	Cumulative Likert scale results (Mean)
No impact	1	1.00–1.80
Low impact	2	1.81–2.60
Moderate impact	3	2.61–3.40
High impact	4	3.41–4.20
Very high impact	5	4.21–5.00

Eight external risk categories were assessed (Table 1), each of which contained its own set of individual risks. These individual risks were ranked from lowest to highest by a mean score derived from the Likert scale. The total mean score of individual external risks with means that fall on or above the Very High impact level (M = 4.21) are considered to have the highest significance and form the focus of this article.

4. Results

The results presented and discussed next relate to Phase 2. In terms of **dive operator profile**, ten (29.41%) respondents had been in business for over 20 years. Seven (20.59%) had been in operation between 16 and 20 years, nine (26.47%) between 11 and 15 years, and eight (17.64%) for 10 years or less. Collectively, the majority of dive operators had been in business for ten years or more, constituting 82.35% of the survey responses. This affirms their extensive knowledge and experience in the scuba diving industry, confirming their suitability as expert respondents. Most indicated that 100% of their scuba diving activities occur on coral reefs, and that above 90% of these dives occur within MPAs. For over 70% of dive operators, most of their income was derived from scuba diving activities. The majority of **dive tourists** who visit the EAME are from Europe (28.07%), while 20.18% are local divers who travel to dive sites within the borders of their own country (domestic tourists), such as South Africans going to Sodwana Bay. North America accounts for 17.54% of dive tourists, followed by 16.67% originating from other parts of Africa. The latter are predominantly South Africans travelling to dive tourism hotspots in Mozambique and Zanzibar in Tanzania.

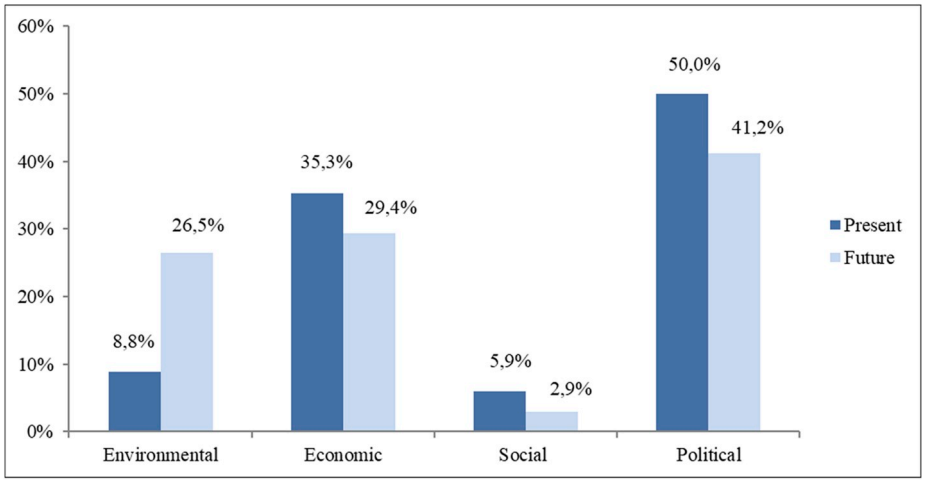

Fig. 2. Perceived present and future impacts.

In terms of **environmental risks**, 50% of dive operators expressed concern that coral reef degradation would occur more frequently in future, 35.3% believed it is likely to continue at the same pace and 14.7% were unsure. Dive operators were also asked whether coral reef degradation would impact on their businesses, and how long they could continue to operate given the extent of this degradation. In response, 11.35% of respondents felt that they would close their operations within five years, 14.65% said their businesses could survive if there was no further degradation and 34.75% were unsure. The largest percentage of respondents (39.28%) believed that they could continue to operate indefinitely.

Overall, dive operators felt that political risks had the greatest impact on their dive operation **at present**, followed by economic risks. Environmental and social risks were not deemed to have a high impact at present (Fig. 2). Perceptions regarding **future** impacts, however, differed notably from the present risks, with political and economic risks decreasing in perceived impact by 8.8% and 5.9% respectively, and environmental risks increasing by 17.7% (Fig. 2).

Of the eight risk categories, IER and DSR did not present any significant risks. Therefore, only six risk categories (DER, DEcR, IEcR, ISR, DPR and IPR) are presented for further interpretation, with the focus being on the most significant individual risks (shaded in red in Table 4), namely those with a mean impact of between 4.21 and 5.00 (according to the Likert rating).

5. Discussion

5.1. Direct environmental risks

Dive operators perceived that continued degradation of coral reefs and their surrounding ecosystems will affect the dive tourists' image of the destination and risk future tourism opportunities for scuba diving operators. The most significant risks here were overfishing and destructive fishing.

5.1.1. Overfishing (on or near to coral reefs)

Dive operators in **Tanzania** viewed overfishing to have a very high impact on their businesses, with most of these operators being from Zanzibar Island. Although many parts of the island are classified as marine conservation areas, regulation and enforcement of environmental protection is not sufficiently implemented. Inshore reef fisheries utilise a variety of traditional fishing vessels (sailing canoes, dhows and

Table 4
Most significant risks (means) per risk category (based on cumulative Likert scale).

Risk Category	Abbrv.	External risk (4.21-5.00)	Kenya	Tanzania	Mozambique	South Africa	Overall mean per risk (all countries)	Overall mean (risk categories)
1. Direct environmental risks	**DER**	Overfishing	2.00	**4.30**	3.38	1.56	**2.88**	**2.15**
		Destructive fishing	1.43	**4.30**	3.13	1.22	**2.62**	
2. Domestic economic risks	**DEcR**	Price inflation	3.57	3.70	3.88	**4.56**	**3.94**	**3.24**
		Depressed local economic activity	2.86	3.00	4.00	**4.22**	**3.53**	
		High fuel prices	2.71	2.80	4.00	**4.22**	**3.44**	
3. International economic risks	**IEcR**	Dive tourist accessibility	1.71	3.00	4.00	**4.33**	**3.26**	**3.34**
4. International social risks	**ISR**	International crime	**4.29**	3.50	2.63	2.56	**3.21**	**2.87**
5. Domestic political risks	**DPR**	Political instability	**4.43**	3.80	3.63	3.67	**3.85**	**3.24**
6. International political risks	**IPR**	Strict Visa regulations	3.43	3.20	**4.38**	3.78	**3.68**	**2.92**
		Travel restrictions	**4.86**	3.50	3.38	2.56	**3.50**	

small motorised vessels) and fishing gear (baited fish traps, nets and lines). These fishermen are mainly artisanal and small-scale fishermen who catch a range of fish species on or nearby coral reefs. Since scuba diving tourism is largely dependent on healthy marine environments and high diversity richness, overfished coral reefs reduce the appeal for scuba divers to visit these areas (Burke et al., 2011). Dive operators in Mozambique reported that in certain parts along its coastline, unregulated fishing on or nearby coral reefs is increasing. However, those in **Kenya and South Africa** did not perceive this as an issue since these countries have very strict MPA regulations in place.

5.1.2. Destructive fishing (on or nearby coral reefs)

Destructive fishing practices have resulted in the loss of large areas of formerly productive coral reef ecosystems (Richmond, 2011). **Tanzania** reported a very high impact from destructive fishing techniques, resulting in the devastation of coral reef ecosystems. Previous studies confirm these findings, indicating that this risk is continuing due to unregulated fishing (Burke et al., 2011; Obura, 2005; Richmond, 2011). Zanzibar Island has experienced major problems with destructive fishing, which is of great concern to dive operators as reefs are continuously being harmed. While there has been an effort to promote more modern and sustainable fishing techniques, these are not readily enforced by authorities. Dive operators in northern **Mozambique's** Primeiras and Segundas Archipelago and Quirimbas Archipelago reported a high to very high impact, although dive operators further south reported that destructive fishing was not pervasive. Environmental degradation is therefore of increasing concern to dive operators in Mozambique, and emphasises the need for stricter protection of coral reef environments which bring high-value dive tourism to the region. However, **South Africa** and **Kenya** reported no impact due to strict governance of and law enforcement within its MPAs.

5.2. Domestic economic risks

Economic risks had the greatest impact on the region, with the most significant being price inflation, depressed local economic activity and high fuel prices.

5.2.1. Price inflation

While both domestic and foreign factors drive inflation in EAC countries, global and regional shocks appear to contribute more to inflation (Dridi and Nguyen, 2017). Dive operators in **South Africa** perceived rising prices to constitute a key determinant of the sustainability of their dive operations. One respondent reported that rising prices are primary causes of dive operators in the area closing their businesses recently. This challenge has been compounded by value-added tax (VAT) increasing from 14% to 15% for most products and services in South Africa as from April 2018 (SARS, 2018). **Price inflation scored as the highest overall mean for the region,** indicating its significance for the sustainability of dive tourism businesses. **Kenya, Tanzania** and **Mozambique** perceived the increased cost of running their businesses to be a major issue.

5.2.2. Depressed local economic activity

For some countries in the EAME, the effects of the 2008 global financial crisis initially went largely unnoticed owing to the traditionally low levels of integration with international financial markets. However, economic decline in the region soon followed (WTTC, 2017; WTO and ILO, 2013). This resulted in the decreased purchasing power of developing economies, which manifested as falling commodity prices, unemployment, decline in incomes, and decreased demand for commodities (Lunogelo et al., 2009). Tourism was one of the most negatively affected industries (Lunogelo et al., 2009). Results from this study align. Depressed local economic activity as an impact was highest in **South Africa**. Moreover, **South Africa** fell into recession in 2016 and again in 2018 (Head, 2018), and is experiencing low growth (World Bank, 2016). South Africa's economy has been undermined following a slump in commodity prices, weakening demand, credit-rating downgrades, uncertainty over land expropriation, on-going corruption scandals, and the worst drought in more than a century (Van Zyl, 2018; Zahid Jadwat, 2018). For **Mozambique,** dive operators perceived that the southern region is experiencing slow economic growth and decreased economic stability. In **Tanzania** and **Kenya**, operators felt that the current depressed local economic activity has a moderate impact on their dive operations. This could be due to the fact that they are well positioned and receive a steady stream of tourists throughout the year, especially in Mombasa and parts of Zanzibar Island.

5.2.3. High fuel prices

High fuel prices impact highly on dive operators' businesses in the region. Developing countries tend to feel the cost of high fuel prices even more, since, to maintain the high standards that tourists expect, they need to buy products that may be unavailable in the home country. These products need to be transported. For the dive tourism industry, this may relate to service parts, equipment for dive boats and scuba gear, accommodation and storage facilities. Dive operators in **South Africa rated** this domestic economic risk as having a very high impact. To take out a group of divers to a nearby reef requires a minimum number of divers to cover fuel costs. With the stiff competition between the many dive operators in the area, passing these costs onto dive tourists is not always easy. Similarly, **Mozambique** rated high fuel prices as a high impact. **Kenya** and **Tanzania** also felt the significance of high fuel prices as they rely on supplementing their income with other water sports.

5.3. International economic risks

A key international economic risk was the ease of accessibility to dive sites by dive tourists.

5.3.1. Dive tourism accessibility

Tourists perceive access to tourist sites in remote areas (particularly in developing countries) as major obstacles to travelling to these sites (Griffin and Edwards, 2012). Dive tourism accessibility ranked as having a significant impact on business for some countries. In **South Africa,** lengthy road travel and poor road conditions are a reality. The remote iSimangaliso Wetland Park is located in the north-eastern corner of South Africa with minimal public infrastructure. International travellers are forced to arrange transport themselves or through travel agencies. Many roads are pot-holed, with gravel roads being the only access. In **Mozambique**, the need to cross borders by vehicle causes long delays, and dive operators see the lack of government support for infrastructure planning as a major limitation to improving access. On the contrary, **Kenya and Tanzania**, cater quite well in terms of dive tourist accessibility for international tourists.

5.4. International social risks

Social changes are brought about by human movement to coastal regions and increasing populations, along with their ancillary effects (such as crime and global disease epidemics). The most significant risk emerging here was international crime.

5.4.1. International crime

Africa is one of the most conflict-ridden and poorly governed regions of the world. Terrorists based in Somalia pose a security threat to the region, while piracy off the Somalian coast affects regional economic interests. The challenge of tackling poor governance has been at the forefront within East African countries dealing with on-going efforts to bring stability to the region (Bryden, 2014; CSIS, 2016). Terrorism is a high priority concern in **Kenya**. Dive operator businesses in **Tanzania** suffered from reduced tourism due to their proximity to Kenya (Brown,

2017; CSIS, 2016). Further south, in Mozambique and South Africa, international crime is not perceived to be of significance.

5.5. Domestic political risks

Domestic political risks are considered to have a high to very high impact in the region, with political instability emerging strongly.

5.5.1. Political instability

Political instability was ranked as a very significant risk for **Kenya.** Recent political violence ignited fears of a resurgence of past political instability (News 24, 2017). For the other EAME countries, this risk was rated as having a high impact, the knock-on effects of which are felt by the tourism industry, and by default, the dive tourism industry. As **Tanzania** was in the process of local elections in 2015, dive operators anticipated negative implications for businesses as Zanzibar Island was seeking independence from the mainland (WPR, 2016). This ignited uncertainty, which operators feared could negatively affect dive tourist arrivals. **South Africa** has also been reeling from political turmoil for several years. Dive operators rated political instability as a significant impact in northern **Mozambique due to** regional political violence a few years back, but this is not perceived to be an issue further south (OSAC, 2015).

5.6. International political risks

These risks affect all the countries in this research. Strict visa regulations along with travel restrictions imposed on countries, severely limit dive operators' ability to generate tourism income.

5.6.1. Strict visa regulations

Visa regulations are a major obstacle to tourism growth in Africa. Dive operators in **Mozambique** felt this to have a very high impact on their businesses. With most divers who visit Mozambique coming from South Africa, bureaucracy at border crossings and lengthy delays can restrict access for these tourists (AVOR, 2016). At the time of the study, **South Africa** had been affected by the 'birth certificates for minors' debacle (Booysen, 2015; Traveller 24, 2015). However, as most dive tourists are local, the effects were not as great, although the issue did impact on international tourist arrivals. Additionally, **Kenya** and **Tanzania** indicated that strict visa regulations were detrimental to business.

5.6.2. Travel restrictions

Travel advisories against countries are fiercely resisted by governments owing to the serious repercussions on economies, communities, tourism businesses and neighbouring countries (Henderson, 2007). Travel alerts have had a very high impact on **Kenya** and constitute the **highest of all external risks in the EAME**. The terrorist acts carried out over the past few years by al-Shabaab, including the hijacking of foreign nationals, have prompted governments to impose strong warnings against travelling to areas in and around Kenya (News 24, 2017). Owing to its geographical proximity to Kenya, **Tanzania** also experienced a high impact in this regard. **Mozambique** indicated a moderate impact, while **South Africa** reflected a low impact.

5.7. Current versus future impacts

Respondents rated political risks as having the greatest **present impact**. Regarding the greatest **future impact** perceived, political and economic risks decrease, while environmental risks increase (Fig. 2). This is an important finding given that, while economic and political risks are expected to continue to have a considerable impact, in future this will be compounded by a significant increase in environmental impacts on dive tourism businesses.

6. Conclusion

Scuba diving is one of the more popular marine recreational activities in marine and coral reef tourism, but its future is being threatened due to environmental, social, political and economic impacts. This research was undertaken to acquire a deeper understanding of the impact that external risks may have on managing scuba diving tourism businesses in the EAME. From the perspective of the dive operator, there are both internal and external risks. The latter are harder to control, but awareness is an important first step in dealing with such risks.

In terms of risk groups, **environmental risks** are expected to have a greater impact on dive operators' businesses in future. This is due to the expectation that coral reef degradation will continue, as well as the effects of climate change. Over 85% of dive operators in the region felt that presently, economic and political risks pose a significant threat to their dive operations. **Economic risks** constitute the greatest impact on the region, with the price inflation risk scoring the highest overall mean across all four countries. Similarly, dive operators deem **political risks** to pose a very serious threat to them at present. In particular, political instability has a significant impact across all four countries.

In terms of risks per country, **Kenya** suffers significantly from international social risks with terrorism as a form of international crime, political instability as a form of domestic political risk, and international political risks in the form of travel restrictions. The latter was the highest of all external risks identified in the EAME. **Tanzania** scored highest on the direct environmental risks of overfishing and destructive fishing. For **Mozambique**, strict visa regulations as an international political risk had the most critical impact. **South Africa** had the greatest impact in terms of domestic economic risks with depressed local economic activity and high fuel prices, as well as price inflation having an extreme impact – causing some operators to close down. With respect to international economic risks, dive tourism accessibility had a very high impact for South Africa.

This research **identified the most significant external risks impacting on dive operators in the EAME from the perspective of the supply side of tourism (dive operators).** Dive operators are at risk. Decision makers in the EAME thus need to take note of these significant risks and grasp the challenges to craft solutions to prevent dive operators from sinking deeper. While certain factors are well beyond the control of dive operators, awareness of these risks is essential to the future of the dive tourism industry and the Blue Economy; and can help to prevent them from sinking deeper into the unsustainability of these risks. The ability to make comparisons between various risks in different parts of the EAME can assist the decision-making processes of dive operators. Digital and risk transformation is essential in enabling dive operators to develop into more resilient organisations and gain greater access to insights for performance improvement. By developing resilient lines of defence to current and emerging external risks, greater collaboration can exist between dive tourists, communities, governments and dive operators to enhance the dive tourism value chain. As tourism revenue is a vital component of local and regional gross domestic product, better governance and carefully considered regulations by policy makers need to be implemented, not only within countries, but for the region as a whole. It is only through a committed development strategy between all stakeholders of the marine tourism industry, along the entire length of the tourism value chain, that external risks such as those identified in this research can be combatted and their severity reduced. This will be to the benefit of both dive operations as well as the communities who depend on this industry.

Future research could replicate the study in the context of the Western Indian Ocean (WIO) islands, as well as other coral reef regions where scuba diving is a key tourism attraction. In addition, The Blue Economy stated the need to identify areas for growth, and the results of this study could be used to assess the impact of external risks on the growth of the Blue Economy in the African region. The research holds value for all dive tourism operators and other stakeholders involved in

the marine tourism value chain. Moreover, the results of this study could provide a reference point for future risk studies by providing a baseline of data.

Declaration of interest

None.

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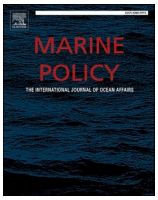

Work Below Water: The role of scuba industry in realising sustainable development goals in small island developing states

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ABSTRACT

The scuba diving industry is vital to economies of Small Island Developing States (SIDS), providing a pivotal opportunity to realise their blue economy aspirations. This industry is fundamentally dependent on both the health of the marine environment coupled with a skilled and safe underwater labour force. This article explores the interlinkages between the United Nations Sustainable Development Goals 8 (Decent Work) and 14 (Life Below Water) in particular through the lens of workers below water and contends that the scuba diving industry can be a crucial enabler for SIDS blue economy. The SDG target 14.7, explicitly developed for SIDS, provides a direct linkage in this context. Mapping functional interlinkages between decent work and ocean sustainability policy through the lens of the diving sector offers opportunities to enhance the development of scuba industry-based skills training while simultaneously addressing the healthy ocean aspirations of SDG 14.

1. Introduction

Scuba that is, Self-Contained Underwater Breathing Apparatus along with other compressed air diving systems forms a multibillion-dollar global industry [1,2]. The scuba industry is essential to marine tourism, fisheries and aquaculture, shipping, oil and gas, marine science, navy and other maritime law enforcement authorities and requires a highly skilled below water workforce [3–5]. It is estimated that the dive tourism industry alone is worth over US$36 billion globally and is anticipated to play a critical role in realising blue economic growth for Small Island Developing States (SIDS) [6–8]. However, the foundation for blue economic growth policies and associated jobs is fundamentally dependent on the health of the oceans in the SIDS, where tourism and fisheries are the predominant sectors [8–11]. The critical importance of the conservation and sustainable use of the oceans and its marine resources was accorded international political weight through the oceans, becoming a distinct goal among the 17 United Nations Sustainable Development Goals under Agenda 2030 [12,13]. Sustainable Development Goal 14: Life Below Water (SDG 14) seeks to integrate with other SDGs and balance social, economic, and environmental sustainability in the ocean economy, which is particularly relevant to SIDS [12,14–16].

SDG 14 is categorised as an “environmental goal” [17,18] that focuses on mitigating ocean environmental threats such as marine pollution, unsustainable fishing practices, loss of coastal and ocean habitat, and the effects of climate change [15]. SDG 14, therefore, alone does little to address the socio-economic issues, which are instead dealt with under other SDGs [9,15,19]. There is, however, increasing recognition that SDG14 needs to take into account social consideration [20–22]. This, in turn, illustrates the need for interlinkages between SDGs, for example, to develop a highly skilled labour force to ’work below water’ is necessary for realising SDG 14, something that should be a strategic priority for SIDS. An exception in this context is that one of SDG 14 target (14.7), which was explicitly developed for SIDS and least developed countries, and envisions increased economic benefits through the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism [12,23]. Therefore innovative strategies are required to reinforce sustainability aspirations between these distinct sectors alongside decent work and job creation policies [9,11]. Considering synergies between industry-specific skills requirements and labour policies across fisheries, aquaculture, tourism [24] and the scuba diving sectors is critical in addressing deficits in decent work and well-being of the coastal communities [24–26]. For example, conservation strategies are likely to constrain options for job creation in specific marine sectors such as fisheries. However, sectoral

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cooperation mechanisms on industry-based skills can help generate jobs in other areas such as marine tourism [9,24,27].

Recognising and promoting the interlinkages of SDG 14 is vital in achieving the 2030 Agenda, as emphasised by Le Blanc et al. [14,28] Ntona and Morgera. [15] Singh et al. [29] Nash et al.[30] Obura [31]. The work by Elder et al. [32], Tosun et al. [33] subsequently highlights the importance and the impact of SDG interlinkages on institutional reforms and policy integration outcomes at the national level. Here we identify important interdependencies between SDG 14 and SDG 8 pertaining to decent work as per the principles of the UN's International Labour Organisation program of work. The fundamental focus of SDG 8 is on social responsibility, the future of work, an inclusive labour market with adherence to occupational safety alongside environmental sustainability and economic growth [34–36]. The scuba diving industry within a number of blue economy sectors has a vital role to play in this context. It can be anticipated that scuba's 'work below water' labour force will substantially contribute to achieving target 14.7 pertaining to the sustainable use of coral reefs and the marine environment in SIDS. Our objective is to demonstrate how the scuba diving industry is uniquely positioned as a means to highlight and understand the interlinkage that SDG target 14.7 creates between SDG 8 and SDG 14.

This article first discusses the scuba diving industry's economic contributions and its recognition by island policymakers in advancing SDG 14 progress. It then provides a conceptual reinforcement of the direct interlinkage that target 14.7 creates between SDG 8 and SDG 14 through the lens of the 'work below water' workforce (see Fig. 1). The article draws attention to the policy needs of dive tourism, dive fisheries and public sector diving labour force within the 2030 Agenda for SDG framework, in particular SDG 14 and the blue economy of SIDS. The article, therefore, addresses issues of direct and urgent concern for SIDS policymakers. We conclude by offering perspectives for future research in the context of SIDS.

2. The economic value of the scuba diving industry

The scuba diving industry is a crucial component of island states blue economy sectors. Scuba diving, notably on coral reefs and to view iconic marine species, represents a lucrative business attraction. It underpins the tourism sector in many SIDS, helping to generate 20–50% of gross domestic product (GDP) and over 30% of employment in the Cook Islands, Fiji, Palau, Maldives, Barbados Grenada, and Bahamas [37]. Across the Caribbean islands, for instance, scuba diving is estimated to contribute more than US$7.9 billion per annum to local economies [38]. More specifically, in the Bahamas, the scuba dive industry, mainly through shark tourism diving, contributes approximately USD 113.8 million annually to the Bahamian economy [39].

Alongside the SDG 14 commitments to mitigate the environmental threats faced by oceans, SIDS leaders, notably those of Fiji, Grenada and Palau, have recognised the sector interlinkages envisioned in SDG 14.7 target under the Coral Reef Life Declaration, a follow up political step for strengthening SDG 14 progress [40]. The declaration notes the profit side of the global coral reef tourism industry, acknowledging annual revenues of US$36 billion, of which $19 billion is directly derived from the scuba dive tourism industry, and the remainder coming from reef-linked seafood and other reef-associated activities [2,7,8]. Moreover, the declaration highlights the economic benefits of the high-value dive tourism industry and its interlinkages with reef linked seafood.

The scuba diving industry also creates strong multiplier effects through

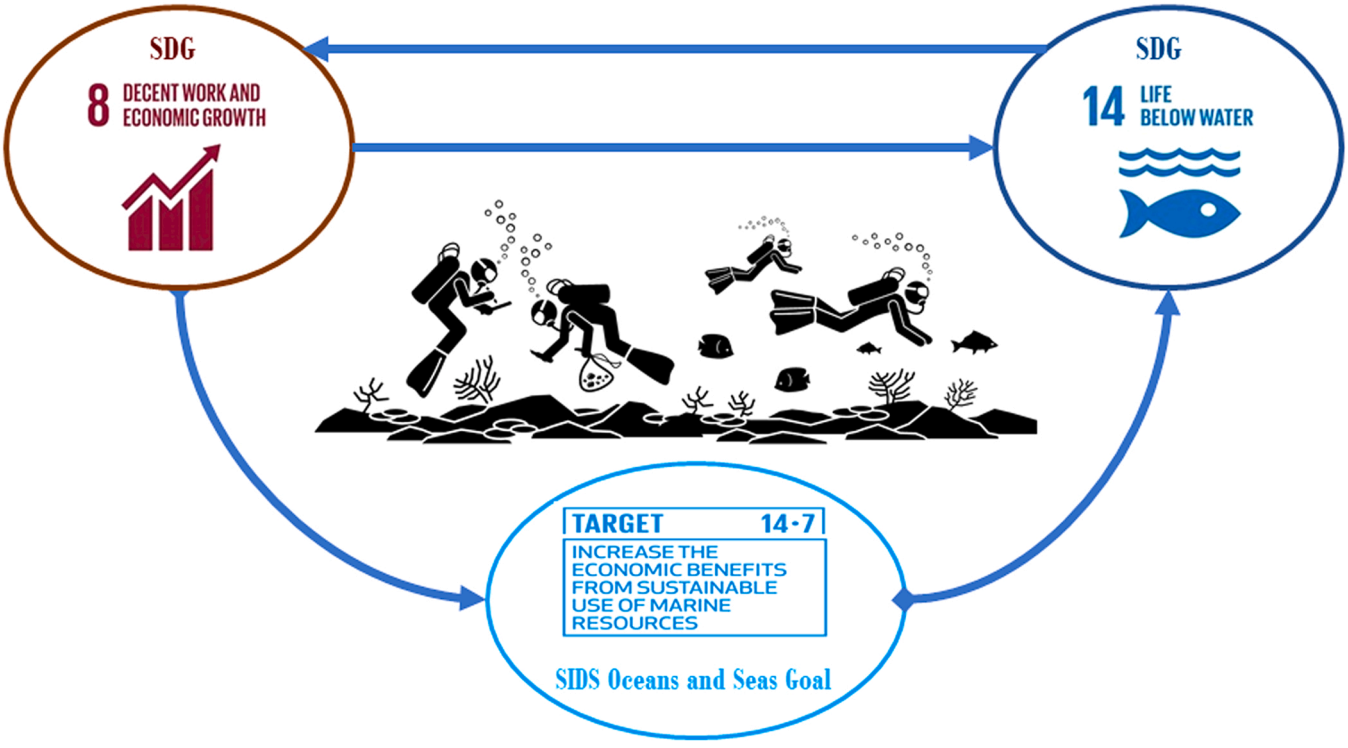

Fig. 1. A conceptual interlinkage that target SDG 14.7[1] creates in the SIDS context between SDG 14[2] and 8[3] and through the work below water workforce and scuba diving industry in integrating the three dimensions of sustainability for future policy outcomes.

[1] SDG 14.7: "By 2030 increase the economic benefits to SIDS and LCDs from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism, coherently linked to SAMOA pathway- SIDS Oceans and Seas Goal para 58 a-b [84]

[2] SDG 14: "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" [12]

[3] SDG 8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" [12].

linkages with the local economy resulting in a substantial number of jobs being created indirectly or in other sectors. A study by Nash et al.[30], mapping SDG 14 interlinkages to SDG 1 concerning poverty reduction, acknowledged diving as an essential source of economic revenue for SIDS such as Fiji, where the marine tourism sector is the largest employer and contributor to the national GDP. Additionally, the small-scale dive fisheries workforce is essential in meeting the seafood industry demands, but its economic contributions are generally unrepresented in government GDP reporting [24,41]. Scuba dive industry contributions via dive fisheries are essential in seafood exports and often strongly aligned with the tourism sector, which is the destination of much of the reef-linked catch. In the Bahamas alone, the spiny lobster harvested by dive fishers is worth US $75–90 million, accounting for 40% of total exports and 60% of all the islands' fisheries landings [42]. The Bahamian lobster industry employs about 9000 dive fishers at the community level; however, the overall economic contribution of dive fisheries to the national GDP is poorly understood [42]. While the Bahamian lobster fishing industry is one of the first SIDS fisheries to become eco-labelled, the assessment for this distinction is unrelated to aspects such as the diving gear and labour used or the health and safety of the workforce [43].

The actual national economic contribution of the dive industry is likely far higher than the estimates highlighted above, especially with considerations of its interdependent and interlinked elements. Such as investments relating to dive safety management, gear, skills, and training and certification value. While the vital role of the scuba diving industry in realising both the blue economy and SDG14 has gained some political recognition by SIDS, there has been little attempt to explicitly align relevant skills and training of the labour force to secure decent work creation. Acknowledging the multiple, complex inter-relationships between SDGs (e.g. Ref.[28,29]), we highlight SDG target 14.7 particularly as a catalyst for SDGs 8 and 14 in the context of SIDS diving industry. A conceptual framework (Fig. 1) in this context aims to enhance engagement of policymakers from domains of employment, labour, decent work, blue economy, scuba diving industry and ocean sustainability (for SDG interactions and policy use see Refs. [32,44,45]).

3. Positioning Health and Safety for diving occupations within SDGs

Scuba diving can be a high-risk occupation as divers are dependent on compressed air breathing systems [46,47]. SDG target 8.8 focuses on achieving policy outcomes that promote the demand for a safe and decent work environment, especially those in hazardous sectors and are highly vulnerable to occupational injuries[48]. Divers work under increased pressure (hyperbaric conditions) and in an open ocean environment, often remote from medical facilities. Consequently, drowning, physiological injury and fatality rates can be high under these conditions [47,49]. One of the occupational injuries that divers are at greater risk of is decompression sickness (also called the bends) [50]. When not treated urgently with emergency oxygen and hyperbaric oxygen therapy, the consequences can lead to paralysis and fatalities in the workplace [51,52]. Compressed-air diving is unforgiving to anyone ignoring established diving practices and safety procedures [25,53,54].

In light of the risks involved, occupational divers require industry-specific skills and training strategies and cooperation with a network of sectors, social partners, training centres, enterprises, and specialists related to safety [47,55]. For example, dive safety strategies require sectoral cooperation mechanisms with health ministries to support divers with recompression chamber infrastructure and hyperbaric medical expertise. Other national strategies to support the dive workers require sectoral cooperation mechanisms for safety at sea and rescue services. In developed countries diving for military, government, commercial, and scientific work are subjected to state labour and skills policies supported with laws and safety protocols [54]. No matter how diving work activity is classified, no one should engage in diving work unless properly trained and certified to meet the accreditation requirements by training agencies [47,53,54].

The enabling factors for the economic growth of the scuba diving industry are the investments placed in advancing skills and training for safe diving, coupled with ensuring the availability of reliable diving equipment alongside an attractive ocean environment [56–58]. At the national level, operationalising international industry-specific skill training standards depends on governance mechanisms and the capacity of national policymaking bodies such as labour authorities. Small island states are often geographically isolated and therefore far removed from diving industry training agencies, including specialised agencies on safety and engineering, creating added barriers to reaching critical safety measures for its labour force [59].

The Divers Alert Network (DAN), based in Europe, is the scuba diving industry's largest association globally invested to diving safety, serving divers with safety resources, emergency assistance, and medical research [60]. SIDS are primarily affiliated with the American agency, Professional Association of Dive Instructors (PADI) and DAN regional centres as their industry sector organisations. Dive safety training and certification governed by industry training bodies help build national capacity in modernising safety and preventing or reducing the risk of dive-related injuries. In developed countries, dive industry safety and the technical demands of scuba diving have led to national-level industry-based skills development strategies. For example, in association with Divers Alert Network Europe, Malta's tourism and hospitality educational centre in 2014 announced the first Bachelor of Science in Dive Safety Management programme to meet Malta's dive industry skill demands for economic development[61]. Analogously, the Australian Diver Accreditation Scheme (ADAS) has established safety and hyperbaric specific training for medical technicians, police diver and dive safety officers to support supervisory and safety enforcement roles [3]. The international Association of Scuba Services Engineers and Technicians (ASSET) supports the engineering skills development and diver's safety equipment quality check and safe work programmes [62].

A further challenge for SIDS policymakers is that the scuba training agencies international governance architecture are fragmented [54,63–65]. In this context, government and industry cooperation mechanisms for monitoring labour skill supply, safety demand and market competition are critical. However, the scuba industry is self-regulating and such information is not readily accessible for SIDS governments and associated ocean forums to help inform the policymaking process [1]. In such circumstances, policymakers are not fully aware of the diving industry's contribution to the national labour force, and where data is available, it tends to face challenges in terms of reliability [66]. The worldwide proliferation of multiple dive training organisations with different governing frameworks and marketing strategies has become a confusing and highly competitive area to navigate [54,64,65]. Such gaps and complexities hinder island governments' knowledge on the supply and demand of industry-specific skills related to safety, decent work creation strategies, and policies. The following subsections highlight policy deficiencies in three diving sectors of island operations dive tourism, fisheries, and the public sector dive workforce, which requires a holistic national approach for future of diving work.

3.1. Dive Tourism labour force

The advancements in diving safety procedures, mass participation and high value have led the World Trade Organization to recognise the scuba diving industry as one of the fastest-growing international tourism sectors [1]. In all jurisdictions and sectors, international diving training certifications and standards, including dive tourism and fisheries, require occupational and recreational divers to be safe from injury and unnecessary risks [54,60]. In addition, demand for the general duty of care calls for policies supporting workers to adhere to diving safety responsibilities and have professional acknowledgement in the national systems that provides for litigation supports following diving accidents or incidents [47,49,67]. Where policies for monitoring quality assurance in dive

industry-based skills and procedures for safety operations are not regulated and bridged with the right infrastructure support, mitigating dive accidents will continue to face problems. In noting the scuba diving industry's overall national safety protocols using the European context, Lucrezi et al. [59] found that very few dive centres supporting dive tourism were actively involved in safety campaigns or placed emphasises on diver safety procedures. While 60% of dive accidents in dive tourism were related to decompression sickness, most often, dive centres workforce and scuba diving clients were not within immediate reach of a hyperbaric chamber for oxygen therapy and immediate treatment[59]. Many cases go unreported as reporting accidents and fatalities has been voluntary, and this type of informal safety culture is often apparent in SIDS [59,60].

The national-level dive tourism sector faces other deficits in safety standards in the global south. Chronic tensions and conflicts over uneven education and dive skill certification level, language barriers, intensive safety and risk management responsibility due to the nature of the work environment, salary allocations, and lack of job security are common barriers to applying additional international standards [64,68]. While international dive training agencies govern dive safety, the national level mechanism and labour force for enforcing safety and quality control are not given priority in the SIDS by the industry. In addition, other decent work conditions hinder safety. Local island entrepreneur-led small and medium-sized dive operators find it hard to compete and cooperate with foreign-owned diving enterprises associated with chain hotels, cheap labour and corporate marketing strategies [69]. Multiple barriers indicate that the scuba dive industry requires several national policies to be coherently aligned to support the workforce and industry clients with dive safety.

3.2. Dive fisheries labour force

SIDS live fish and coral aquarium trade together with aquaculture production for the global supply chain is estimated to be worth USD 200 million per year [70], where the dive fishing workforce operate in unsafe conditions. Dive safety management is undermined in the case of commercial fisheries operations where the diving gear market predominantly lacks adequate safety checks and standards in the use of diving apparatus [57,71]. In many island fisheries, diving without proper training in the use of the diving apparatus or inadequate safety practices and adherence to standards causes hundreds of decompression accidents, resulting in death, partial and complete paralysis, and permanent neurological disability [71–74]. Studies by Forman [75], Winkler [76] and Bassett [73] in island countries, such as the Grenadian dive fisheries primarily for lobsters in the Caribbean, have reported high rates of decompression injuries, with 81% of divers in the sector experiencing decompression sickness at least once, with many experiencing the issue multiple times. Further, Sloan and Tuivanualevu [77] highlight the legal case where 12 fatalities are reported in one year in the Fiji Islands, with three times the fatality rate concerning divers in the sea cucumber industry[77]. Similarly, Marschke et al. [71] highlight the case of commercial dive fishers not being protected from improper dive gear use and unacceptable forms of labour exploitation in the case of Jamaica's high value reef fisheries.

Death and disability resulting from hazardous commercial dive fishing occupations in islands global supply chains of fisheries trade face ethical and human rights concerns [71,74,77]. The UN voluntary guidelines for securing sustainable small scale fisheries have accorded island states to address decent work deficits, occupational health and safety, and unfair working conditions [78]. A transformative policy outcome is needed in protecting the dive fishing workforce in SIDS, who are placing great hopes on their blue economy and, by extension, their underwater workforce pertaining to SDG target 14.7.

3.3. Public sector diving labour force

As governments invest in interrelated SDG 14 targets, such as target 14.1 on marine pollution, 14.2 on healthy oceans, 14.4 on sustainable fisheries, 14.5 on marine protected areas, there is an increasing demand for training policies and systems supporting professional environmental divers. Efforts to establish marine protected areas, coral restoration initiatives, and invasive species removal under SDG targets further create the need for a decent underwater workforce consistent with SDG 8. Appropriate work standards for such, as it were, scientific/environmental diving activities are not necessarily available to those seeking work in the public sector, marine park operations, or within marine science in developing states [67,79]. Lack of formal recognition of diving for work occupations highlights a pressing need for national employment strategies to support islands blue economy sectors. In particular, quality assurance for skills training, occupational health and safety for hyperbaric workers, and appropriate insurance schemes would be consistent with SDG 8.

4. SDG 14.7 interlinkages for SIDS blue economy

SIDS have traditionally faced shortages in terms of skilled labour force, and their heavy reliance on expatriate labour for new industries led island leaders to make decent work and economic growth a high priority agenda [37,80]. As exemplified by the International Labour Organisation (ILO), Decent Work Country Programs in the Pacific SIDS reflects the commitment to achieving the SDGs [35]. However, the scuba diving industry is not part of this dialogue on the future of work. There is a need for policy-level interventions with labour agencies and industry concerning skill investments strategies, workforce safety and health, engineering and infrastructure [1,7,59,68,81]. A key policy gap relates to where information concerning the diving industry labour force is generally unavailable for policymakers at both the international and developing states country levels [65]. It is suggested that SIDS policymakers lack this evidence from the scuba diving industry domain in order to build future mechanisms for industry-based skill and safety for its work below the water labour force.

The SIDS Accelerated Modalities for Action (SAMOA) Pathway that provides policy guidance specific to island governments is the starting point for establishing interlinkage between blue economic sectors, industries, decent work principles and ocean sustainability [23,82,83]. Of particular note in this context, SDG target 14.7 explicitly calls for the international community to increase the economic benefits to SIDS by reducing the separation between blue economy sectors and provide support for industries within the context in which they are operating so that they can better support healthy job creation [14]. Those tasked with implementing SDG 8 recognise that decent work and healthy job creation are central for the global south to transition towards sustainable use of oceans [23,34,84,85]. However, there is arguably a lack of awareness concerning the case of the scuba diving industry and its role in the current and future blue economies of islands. These challenges give rise to an increasingly urgent need for the development of national and international level strategies on decent work to foster the future of work for SDG 14 and target 14.7 specific for SIDS.

Pioneered by SIDS, the blue economy concept offers the potential to implement policy reforms needed for the scuba diving industry. The blue economy encompasses all ocean-related economic activities which are dependent on marine education training and maritime safety agencies [86,87]. Via Fig. 1, a key initial step emerges in the case of islands dive fishers work conditions, which is accorded within SDG 8.7 target where governments need to take immediate and effective means to abolish, control and limit unsafe working conditions (e.g. Ref.[77]) pertaining to the blue economy. In this regard, other interdependencies need to be explored to help abolish unsafe and unhealthy work concerning SDG 14, using functional and high priority SDG interlinkages as argued by Elder et al. [32]. Developing countries can align SDG interlinkages that support the pooling of financial and infrastructure resources [32]. It is also important in this context to highlight target SDG 8 (a) that urges wealthier nations to increase aid for trade-related technical assistance. SDG target 8.2 that

supports technological upgrading for high value-added and labour-intensive sectors [48] and target SDG 14. b pertaining to the small-scale fisheries, global supply chains, and economic productivity [85]. SDG 8 and 14 interlinkages, directly connected via target 14.7 (i.e., Fig. 1), encourages policymakers to position the scuba diving industry in the blue economy policies of islands governments and alongside international standards of decent work. These SDG targets further island governments engagements to seek assistance with industry, academia, the ILO concerning the high-value future of work below water labour force needs. However, further research is needed to understand the context and interpretation of SDG targets in a holistic manner to further support the impact of the interactions for policy process.

5. International Organisations and the scuba diving industry

The ILO is the specialised UN agency that oversees the decent work creation and the progress of SDG 8 at the country level. [34]. Previous studies have identified the need for ILO's decent work creation programs to be linked with divers work [71,88]. To understand whether, under SDG 14, the scuba diving industry and the need for decent work creation for work below water labour force are on the political radar of the ILO and related UN agencies, an assessment was made of an SDG 14 policy-level discussions held at the 2017 UN Ocean Conference (UNOC). The ILO and UNDP led the discussions on decent work (SDG 8), and blue economy were assessed using content analysis.

The ILO flagged to member states that there are significant decent work deficits for many ocean workers in high-risk occupations and these deficits persist where violations of human and labour rights, increased frequency of accidents, and fatality rates are fundamental concerns [89]. The ILO urged member states to implement their responsibilities under the Work in Fishing Convention 2007 (No.188) pertaining to commercial fishing and standards governing working conditions on fishing vessel where ILO has accorded fishing as a hazardous occupation, consistent with key SDG target 8.8 addressing labour protection and safety. However, no explicit recognition of the particular circumstances of scuba diving for work was made. In addition, no mention of the scuba diving industry, decent work creation for divers, or provisions for dive safety was made after the ILO statement delivery, followed by the high panel debate and consensus-building for future work. Consequently, it appears that decent work deficits in island small-scale dive fisheries and small-scale diving enterprises under tourism sectors were very much "out of sight, out of mind" during the UNOC and were essentially ignored. The policy agenda setting and process of the week-long UNOC aimed to build momentum on the implementation of SDG 14. Consequently, discussions were heavily focused on protecting the ocean, with less attention to workers who are the agents to help transition towards a sustainable blue economy [89]. For instance, six out of seven UNOC partnerships or political streams focused on restoring near-shore marine ecosystems to enhance climate security for SIDS, linking environmental SDGs only covering the climate, oceans, and land [90].

Following the UNOC, UN agencies recognised the dive industry's essential and growing role-specific to the tourism and business sectors [91,92]. Consequently, the 2017 UN international year of sustainable tourism forecasted that the dive-tourism industry could stimulate economic growth and create decent jobs, as illustrated by the certification of one million newly qualified divers each year [93]. The recognition of the economic growth of the dive tourism industry led UN Environment Programme to flagship coral reef ecosystems via the Green Fins initiative [91]. This initiative, spearheaded by international NGOs in partnership with PADI, a private sector entity, developed environment certification schemes with a view to greening the scuba diving industry [91,94]. In advancing the UNOC outcomes, PADI introduced a decade of ocean action platform to achieve the conservation goals of SDG 14, supporting the UN Decade of Ocean Science for Sustainable Development [94]. SIDS policymakers may see the UNEP initiative and funding for greening schemes as a welcome step from PADI. However, the likelihood for such investments to bridge decent work deficits in islands underwater workforce that can help transition to environmental sustainability is low. Due to a lack of skilled workers in SIDS, many past green projects have not been implemented successfully [35]. Baum et al. [95] argue that UN World Tourism Organisation has proved negligent on work and labour and highlighted that decent work creation continues to be unmet in many aspects of the tourism sector. The work of Cisneros-Montemayor et al. [96] further explores equity and sustainability guidelines concerning blue economy sectors, including the UN ecotourism resolution. Further research is needed to understand how intergovernmental organisations working on oceans position themselves on the attainment of SDG interlinkages that directly impact the SIDS national policy process.

6. Conclusion: Work below water to deliver blue economy outcomes

The scuba diving industry is an increasingly important part of the blue economy [67,97] which necessitates safe diving for work conditions under technical, legal and social obligations of decent work and economic prosperity. SIDS have multiple policy deficits concerning scuba diving industry-based skills and safety underpinning decent work, future job creation and employability. The scuba diving industry is dependent on a highly skilled and safe workforce to help successfully deliver SIDS blue economy aspirations. This paper makes the case that SDG target 14.7 provides the basis for interlinkages between SDG 8 pertaining to decent work as per the principles of the ILO program of work and SDG 14 in the case of the scuba diving industry. We highlight the potential use of Fig. 1, in providing a relatively simple conceptual framework offering clarity for SIDS policy makers and their development partners in visualising the interlinkages among functional and foundational SDGs.

A failure for SIDS to make headway on bringing SDG 8 and 14 interlinkages at the forefront for their work below water labour force under their emerging blue economy plans impedes their progress on both decent work creation and ocean sustainability. Neglecting the relationship between these foundational SDGs (i.e., Fig. 1) limits governments in maximising their aid for trade partnerships and SDG 14 investments in creating necessary conditions to prevent unhealthy and unsafe work conditions. Such as resources for modernising the work below water labour force and needs concerning occupational dive safety and risk mitigation systems. Following which the SDG 14 labour force in islands will continue to face precarious conditions hindering to meet progress in other SDGs such as decreasing inequalities (SDG 10), improving education (SDG 4), health and well-being (SDG 3), and overall progress envision under Agenda 2030.

In moving forward SIDS leaders urgently need to prioritise the interlinkages that SDG 14.7 target creates in stimulating engagements for policies needed in supporting the governance of labour matters with ILO and UN agencies to ensure blue economy pathways are truly sustainable, both environmentally and socially. SDG 8 and 14 interlinkages, via target 14.7 helps brings clarity on the importance of ensuring national-level policy integration between all different sectors the interlinkages represent, to avoid the additional social burdens on island communities' wellbeing. Additionally, the interlinkages widen the scope for scuba diving training agencies, industry partners, UN agencies to engage and account for social sustainability within islands blue economy development plans.

Islands work below water labour force across all the sectors pertaining to SDG 14 are a natural fit for accelerating engagement across stakeholders. A coalition of island stakeholders, including interdisciplinary marine scientists, labour practitioners, scuba dive professionals, artisanal dive leaders, dive fishers, dive training agencies, and technical authorities collectively can support governments in building national decent work programmes such as blue apprenticeship training schemes. In addition, island scuba diving educators, technical experts such as hyperbaric medical, engineers, and dive safety officers can map SDG14 occupational skills strategy for islands work safety programmes under

their blue economy sectors. SDG 14.7 brings a sense of urgency for further inter and transdisciplinary research agendas to be prioritised by island governments to advance strategies for their future work below water labour force. Ultimately, using SDG target 14.7 as a bridge between SDG 8 and SDG 14 policy domains highlights the value for creating synergies and partnerships between the three dimensions of sustainability: people, planet, and profit.

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