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CONSERVAZIONE O DISTURBO? VALUTAZIONE DEL COMPORTAMENTO DEI FOTOGRAFI SUBACQUEI NELLE AREE MARINE PROTETTE ITALIANE

CONSERVATION OR DEGRADATION? ASSESSING THE BEHAVIOUR OF UNDERWATER PHOTOGRAPHERS IN ITALIAN MARINE PROTECTED AREAS

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RIASSUNTO

La fotografia subacquea è un'attività che sta diventando sempre più popolare. Questa pratica può portare a effetti positivi da diversi punti di vista. Le fotografie possono infatti portare l'osservatore a una maggiore consapevolezza ambientale e possono essere utili in attività di citizen science. Spesso, tuttavia, i fotografi trascurano il fattore ambientale e hanno comportamenti potenzialmente dannosi per l'ambiente marino. Le Aree Marine Protette (AMP) hanno spesso al loro interno alcuni dei siti di immersione più ricercati e frequentati da subacquei ricreativi e fotografi. Perciò, questo studio mira a comprendere la percezione dell'ambiente marino da parte dei subacquei ricreativi e dei fotografi subacquei, verificando anche la frequenza delle violazioni dei codici di condotta subacquei delle suddette AMP. Sono stati perciò analizzati tutti i regolamenti e i codici di condotta di tutte le Aree Marina Protette italiane e, attraverso questionari e osservazioni dirette, 84 subacquei sono stati studiati in tre AMP italiane (AMP di Portofino, AMP di Porto Cesareo, e AMP di Punta Campanella) durante l'estate del 2021. Durante le immersioni, sono state contate tutte le infrazioni commesse dai subacquei e sono state catalogate per tipologia, riportando minuto di immersione, posizione nel gruppo del subacqueo, pendenza e tipologia del substrato e gli eventuali

effetti su di esso. Grazie ai questionari, sono stati invece ottenute informazioni socio-demografiche sui subacquei, la loro percezione degli effetti delle loro azioni in immersione, la loro conoscenza dei regolamenti delle AMP, e un'autovalutazione sulle eventuali infrazioni da loro commesse. Le caratteristiche socio-demografiche dei partecipanti rispettavano le aspettative in quanto corrispondevano in media ai dati raccolti nei report annuali delle maggiori didattiche subacquee. Dall'analisi statistica dei risultati, la differenza tra subacquei ricreativi e fotografi subacquei è stata netta, mostrando un numero di infrazioni molto più elevato tra i fotografi più coinvolti. In particolare, la pratica della fotografia subacquea a livello avanzato è stata individuata come unica variabile strettamente legata a un alto numero di infrazioni. Educazione ambientale, esperienza subacquea e conoscenza delle regole non si sono rilevate variabili significativamente correlate con le infrazioni. Infatti, spesso i fotografi più coinvolti nell'attività e di livello più avanzato sono risultati anche quelli con la maggiore esperienza subacquea e la maggiore conoscenza dell'ambiente marino (studi di biologia marina e/o scienze ambientali). La conoscenza degli effetti del loro comportamento sull'ambiente marino non ha mostrato differenze tra le categorie 'subacquei' e 'fotografi', indicando perciò una piena consapevolezza delle proprie azioni da parte dei fotografi. Per rendere la fotografia subacquea meno impattante sui siti

di immersione, contribuendo ad un aumento della capacità di carico e a degli effetti positivi di carattere ambientale ed economico, è importante fare alcune considerazioni sulla gestione dell'attività. Campagne di sensibilizzazione, briefing pre-immersione più dettagliati e redazione di corsi di fotografia subacquea a basso impatto possono aiutare a gestire le prossime generazioni di fotografi subacquei. Inoltre, le didattiche subacquee devono porre maggiore attenzione sulle tecniche di assetto, in quanto un assetto neutro orizzontale senza uso delle mani deve essere una componente tecnica in tutti i corsi di ogni livello. Per quanto concerne, invece, prospettive future di studio, questo studio pone le basi per ulteriori approfondimenti riguardanti eventuali differenze tra aree protette e non protette, oltre alla possibilità di studiare ambienti tropicali dove il turismo fotografico è molto attivo.

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ABSTRACT

Underwater photography is an activity that is increasing in popularity. It has positive effects from different points of view such as conservation awareness and citizen science. Often, however, photographers neglect the environmental factor and engage in potentially damaging behaviours to the marine environment. This study aimed to compare recreational divers' and underwater photographers' perceptions of the marine environment, also verifying the frequency of infringements of underwater codes of conduct. Through questionnaires and direct observations, 84 divers were studied in three Italian MPAs in the summer of 2021. The difference between recreational divers and underwater photographers was stark, showing a much higher number of infractions among the most involved photographers. The knowledge of the effects of their behaviour on the marine environment did not, however, show any differences between the two categories, indicating a full awareness of their actions on the part of photographers. To make underwater photography less impacting on dive sites, contributing to an increase in carrying capacity and positive environmental and economic effects, it is important to make some considerations on the management of the activity. Awareness campaigns, pre-dive briefings and the drafting of low impact underwater photography courses

can help to limit the wrong behaviour of the next generations of underwater photographers.

First Chapter

1. INTRODUCTION

1.1 Marine Protected Areas and scuba diving

A marine protected area – or MPA - is described as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural services" (IUCN, 1994). Inside the borders of these areas, human activities are more strictly regulated than the surrounding waters because the aim of an MPA is mainly to protect natural or historic marine resources (IUCN, 1994). These resources often consist of very good-looking seabeds teeming with marine life, which are very attractive to scuba diving tourism (Green & Donnelly, 2003). Scuba diving is a very popular form of marine leisure pursuit in many areas of the World. Its growth as an economic activity now attracts millions of people to the sea, lakes and rivers, with more than 9 million licenced scuba divers worldwide as of 2019 (Darcy, 2019). In many cases, scuba diving also represents a high constituent of tourism and it contributes to the economy of many nations (Musa & Dimmock, 2013; De Brauwer, Harvey, McIlwain, Hobbs, Jompa, & Burton, 2017.)

Activities practised in the scuba diving industry can affect MPAs both positively and negatively, with an influence on the natural environment, economies and societies (Garrod & Gossling, 2008; Dimmock & Musa, 2015). If we consider the natural environment, the presence of scuba divers could be viewed as a conflict with governance agendas for MPAs as it corresponds to a risk of increasing the amount of stress in organisms and the whole environment (Davis & Tisdell, 1995). This is especially true for divers with a lack of attention and interest in the natural value of the MPA (Hammerton, 2017).

However, underwater activities can also provide a clear and immediate positive income for the funds of an MPA, and raise awareness about the importance of marine conservation (Lucrezi, Milanese, Sarà, Palma, Saayman, & Cerrano, 2018). In addition to receiving environmental education that allows them to understand the functions of a marine reserve (Medio, Ormond, & Pearson, 1997; Hammerton & Bucher, 2015), scuba divers can even be helpful to the scientific community and MPA authorities by sharing information with managers and researchers about the environmental status and possible ecosystem changes in the MPA (Bramanti, Vitelmini, Rossi, Stolfa, & Santangelo, 2011; Cerrano, Milanese, & Ponti, 2017). Participatory research or citizen science activities are a way to generate new scientific or environmental knowledge by engaging the public in science and enable divers to make

themselves useful by actively participating in different phases of the scientific process (Dickinson, Shirk, Bonter, Bonney, Crain, Martin, et al., 2012). Some examples are active data collection for environmental monitoring, giving information to scientists to explore local ecological knowledge and reconstructing historical changes, or even participating by giving ideas, suggestions and opinions during crowdsourcing projects. Thanks to these activities, scuba divers can offer their skills to research and act as real operators in ecosystem monitoring (Branchini et al., 2015; Lucrezi, Milanese, Palma, & Cerrano, 2018; Hermoso, Martin, Stotz, Gelcich, & Thiel, 2019; Hermoso, Martin, Gelcich, Stotz, & Thiel, 2021).

1.2 Underwater photography

One of the activities scuba divers can do is taking pictures underwater. This type of activity saw its beginnings in the middle 19th century with the first experiments of William Thompson and has continued to evolve to equip itself with advanced technologies that facilitate its practice, making underwater photography a viable activity for almost anyone (Martinez, 2014). The spread of this practice has meant that today many scuba divers carry with them a device capable of capturing videos or images to collect memories of the dive they just conducted. These devices can vary in size and range, depending on

the ability and purpose of the carrier; while professionals are limited in numbers, amateurs are widespread (Mojetta, Formis, & Mancuso, 2020).

Underwater photography can give enormous help to the scientific community both if conducted by specialized scientific operators and by recreational divers and amateurs. All the positive aspects given by this activity include marine census and species identification (Borda, Popescu, & El Mahdy, 2014), with the possibility of finding candidate new species or new morphotypes or juveniles of known ones (Manunza, Colombo, & Crocetta, 2020); monitoring the presence of alien species (Poursanidis & Zenetos, 2013); describing relationships between organisms, communities and populations in underwater ecosystems (Jørgensen & Gulliksen, 2001; Öktener, Torcu-Koç, Erdoğan, & Trilles, 2010); and mapping substrates and marine bottoms, with a further possibility of analysing the growth of benthic organisms (Raoult, David, Dupont, Mathewson, O'Neill, Powell, & Williamson, 2016; Rossi, Castagnetti, Capra, Brooks, & Mancini, 2019). Another positive input given by underwater photography consists in social services. Photographs depicting organisms of rare beauty or situations in which an organism or marine environment is in danger due to a direct (i.e. marine litter) or indirect (i.e. climate change) anthropogenic impact can amaze and inspire a considerable category of non-diving people who may be persuaded to learn about functioning and fragility

of ecosystems (Chianese, 2020). In this way, a wider perception of marine environments is promoted, stimulating people to a change aimed at safeguarding and protecting the oceans (Mojetta, Formis, & Mancuso, 2020).

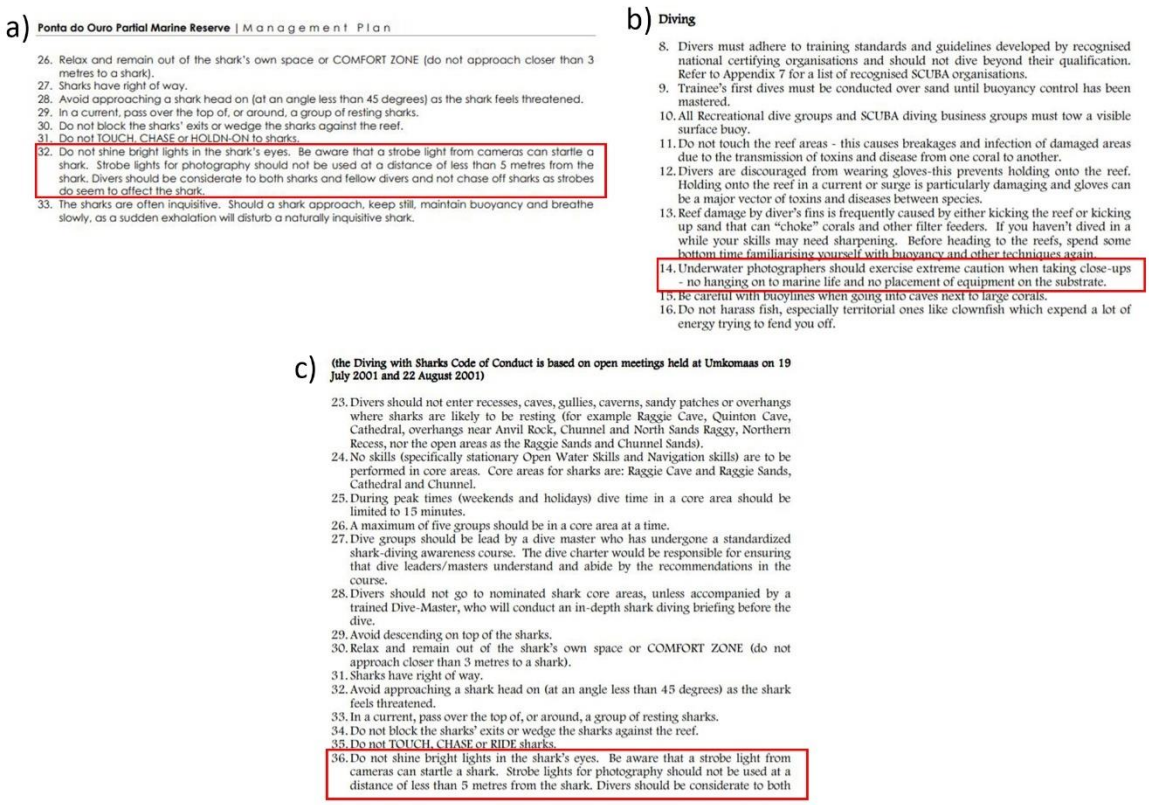
Photography as a visual art form is by far the most widespread among recreational scuba divers, who practise it to have memories of the dive or the travel, share the pictures with friends and on social media, and participate in photographic competitions (Roche, Harvey, Harvey, Kavanagh, & Turner, 2016; Pagel, Orams, & Luck 2020). Always trying to take a better picture can be a determining factor in leading a photographer to behave in a way that can damage the marine environment and put his/her health at risk (Roche, Harvey, Harvey, Kavanagh, & Turner, 2016; Pagel, Orams, & Luck 2020). Moreover, when the subject of the picture is an animal that is considered rare, there is a higher probability that the photographer reduces its compliance with environmental ethics (Uyarra & Côté, 2007). Doing so usually consists of touching, harassing or chasing animals, laying on the bottom and stirring up the sand provoking resuspension. This leads to direct damage to sessile and mobile organisms, impacting the ecosystems with disturbance, degradation, or destruction (Harriott, Davis, & Banks, 1997). Indirect effects mainly concern those related to the changes in the behaviour of animals. Several studies on megafauna (sharks, rays and cetaceans) have shown that interactions with

scuba divers cad reduce animals' mobility and change their feeding behaviour (Shackley, 1998; Clua, Buray, Legendre, Mourier, & Planes, 2010; Pagel, Sheer, & Lück, 2017). Behavioural changes can occur also during interactions with smaller organisms such as cryptobenthic species or small fishes. In fact, in many cases, photographers have been observed using a 'muck stick' or similar objects to move animals to better positions to be photographed (Roche, Harvey, Harvey, Kavanagh, & Turner, 2016). This, added to a very close position and sometimes massive use of underwater flashes can lead to stress in animals, changing their behaviour (Harasti and Gladstone, 2013).

Previous studies have shown how, among all divers, those belonging to the category of photographers are those who most commit actions of contact with the seabed, with breakages and crushing of structures, resuspension (Trainito, 2007), and excessively close interactions (including contacts) with marine organisms (De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018). In particular, the most experienced photographers are those who, to obtain a good photograph, neglect most safety and environmental directives and best practices during interactions with marine organisms (De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018; Pagel, Orams, and Lück, 2020). Paradoxically, most experienced underwater photographers are expected to have a greater mastery of equipment and buoyancy and a better

knowledge of the environment, thus resulting in less impact in terms of disturbance of the seabed and wildlife (Roche, Harvey, Harvey, Kavanagh, & Turner, 2016). Studies have shown that, during the phases of the dive in which they do not approach the subjects to photograph them, most experienced underwater photographers are those who pay more attention to contacts with the seabed or other organisms (De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018). The reason for this contradiction is still partially unexplained. One of the causes could be found in the self-perception of photographers: many of them, especially the most active, serious and professional (or even semi-professional), view themselves as conservationists and ambassadors of the sea on social media as if this justified their inappropriate photography behaviour underwater (Pagel, Orams, and Lück, 2020).

To overcome the problem of behaviour, some MPAs and countries in which underwater tourism has considerable value have introduced directives concerning the practice of photography in their scuba diving regulations. Some examples can be found in the codes of conduct for scuba divers and shark diving in the MPAs of Aliwal Shoal (South Africa) and Ponta do Ouro (Mozambique), where there are provisions on the distance to be kept from the subject if using underwater lights or strobes (Figure 1).



a) **Ponta do Ouro Partial Marine Reserve** | Management Plan

26. Relax and remain out of the shark's own space or COMFORT ZONE (do not approach closer than 3 metres to a shark).
27. Sharks have right of way.
28. Avoid approaching a shark head on (at an angle less than 45 degrees) as the shark feels threatened.
29. In a current, pass over the top of, or around, a group of resting sharks.
30. Do not block the sharks' exits or wedge the sharks against the reef.
31. Do not TOUCH, CHASE or HOLD-ON to sharks.
32. Do not shine bright lights in the shark's eyes. Be aware that a strobe light from cameras can startle a shark. Strobe lights for photography should not be used at a distance of less than 5 metres from the shark. Divers should be considerate to both sharks and fellow divers and not chase off sharks as strobes do seem to affect the shark.
33. The sharks are often inquisitive. Should a shark approach, keep still, maintain buoyancy and breathe slowly, as a sudden exhalation will disturb a naturally inquisitive shark.

b) **Diving**

8. Divers must adhere to training standards and guidelines developed by recognised national certifying organisations and should not dive beyond their qualification. Refer to Appendix 7 for a list of recognised SCUBA organisations.
9. Trainee's first dives must be conducted over sand until buoyancy control has been mastered.
10. All Recreational dive groups and SCUBA diving business groups must tow a visible surface buoy.
11. Do not touch the reef areas - this causes breakages and infection of damaged areas due to the transmission of toxins and disease from one coral to another.
12. Divers are discouraged from wearing gloves-this prevents holding onto the reef. Holding onto the reef in a current or surge is particularly damaging and gloves can be a major vector of toxins and diseases between species.
13. Reef damage by diver's fins is frequently caused by either kicking the reef or kicking up sand that can "choke" corals and other filter feeders. If you haven't dived in a while your skills may need sharpening. Before heading to the reefs, spend some bottom time familiarising yourself with buoyancy and other techniques again.
14. Underwater photographers should exercise extreme caution when taking close-ups - no hanging on to marine life and no placement of equipment on the substrate.
15. Be careful with buoylines when going into caves next to large corals.
16. Do not harass fish, especially territorial ones like clownfish which expend a lot of energy trying to fend you off.

c) **(the Diving with Sharks Code of Conduct is based on open meetings held at Umkomaas on 19 July 2001 and 22 August 2001)**

23. Divers should not enter recesses, caves, gullies, caverns, sandy patches or overhangs where sharks are likely to be resting (for example Raggie Cave, Quinton Cave, Cathedral, overhangs near Anvil Rock, Chunnel and North Sands Raggy, Northern Recess, nor the open areas as the Raggie Sands and Chunnel Sands).
24. No skills (specifically stationary Open Water Skills and Navigation skills) are to be performed in core areas. Core areas for sharks are: Raggie Cave and Raggie Sands, Cathedral and Chunnel.
25. During peak times (weekends and holidays) dive time in a core area should be limited to 15 minutes.
26. A maximum of five groups should be in a core area at a time.
27. Dive groups should be lead by a dive master who has undergone a standardized shark-diving awareness course. The dive charter would be responsible for ensuring that dive leaders/masters understand and abide by the recommendations in the course.
28. Divers should not go to nominated shark core areas, unless accompanied by a trained Dive-Master, who will conduct an in-depth shark diving briefing before the dive.
29. Avoid descending on top of the sharks.
30. Relax and remain out of the shark's own space or COMFORT ZONE (do not approach closer than 3 metres to a shark).
31. Sharks have right of way.
32. Avoid approaching a shark head on (at an angle less than 45 degrees) as the shark feels threatened.
33. In a current, pass over the top of, or around, a group of resting sharks.
34. Do not block the sharks' exits or wedge the sharks against the reef.
35. Do not TOUCH, CHASE or RIDE sharks.
36. Do not shine bright lights in the shark's eyes. Be aware that a strobe light from cameras can startle a shark. Strobe lights for photography should not be used at a distance of less than 5 metres from the shark. Divers should be considerate to both

Figure 1. Codes of conduct for diving and shark diving in Ponta do Ouro (Mozambique) (a) and Aliwal Shoal (South Africa) (b-c). Points 32 (a) and 36 (c) identify the regulation on the use of flashes. Point 14 (b) identifies general regulations for underwater photographers (Aliwal Shoal Marine Protected Area, 2006; Ponta do Ouro Partial Marine Reserve, 2009).

Another example is found in Green Fins: an internationally recognized program containing an environmental code of conduct for diving and snorkelling adopted by 11 different countries. In the guidelines of this code of conduct, it is expressly written "Do not place cameras on reefs or move marine life to capture a better shot" (Figure 2).

Figure 2. Green Fins infographic about scuba diving code of conduct in Egypt - CDWS (www.greenfins.net)

However, these regulations require controls in divers' compliance and it is a complicated operation, especially in areas of mass tourism.

1.3 Aim of the study

This study aimed to assess existing scuba diving codes of conduct in Italian MPAs and the compliance showed by recreative scuba divers with such codes of conduct. Since admiring photographs and diving in MPAs stimulate the interest of divers in the health of marine ecosystems, the study investigated the level of divers' knowledge of anthropogenic impacts on dive sites. Furthermore, as photographers are recognized as divers who frequently violate

the codes of conduct, the study aimed to understand if this is related to a lower perception of environmental health and knowledge of the rules. Therefore, this study gave special consideration to underwater photographers by analysing their behaviour and self-perception of compliance with the rules. To reach the aims of the study, the following research questions were formulated:

1) What is the current regulation in terms of the scuba diving code of conduct and are there rules concerning underwater photography in Italian MPAs?
2) How much do scuba divers and underwater photographers know about existing codes of conduct?
3) How do scuba divers and underwater photographers perceive the health of a dive site or, more generally, of a marine environment?
4) What is the self-reported compliance with MPAs' scuba diving rules and does it differ from observed compliance?
5) What are the relations between data obtained from recreational scuba divers and underwater photographers?

Answering these questions can be useful to better understand the level of knowledge of and compliance with underwater codes of conduct among different groups of divers. This will represent a starting point to move towards a greater comprehension of the perception that divers and photographers have

of their behaviour and the underwater environment. This can also contribute to possible future sensibilization and regulation strategies in Italian MPAs, to enhance their environmental health and economic value.

1.4 Sites of study

Three sites of study were selected for the in-situ observations and data collection. They were chosen to represent different types of diving locations in Italy and they all share the following features:

- They are SPAMI (Specially Protected Areas of Mediterranean Importance);
- They are important scuba diving and underwater photography tourism destinations;
- They have a similar code of conduct for scuba diving activities.

1.4.1 Portofino MPA

Portofino is a small Italian MPA in the Liguria region. It has a surface area of 3.74 km^2 and it borders the Southern coastline of the Promontory of Portofino (Figure 3). It was established in 1999 and became effective in 2001 (Salmona & Verardi, 2001). In nearly 20 years the presence of the MPA has led to numerous positive ecological effects such as the increasing of fish biomass and the protection and recovery of important and endangered local species (i.e.

Epinephelus marginatus and *Corallium rubrum*) (Bavestrello, Bo, Bertolino, Betti & Cattaneo-Vietti, 2014; Guidetti et al., 2014).

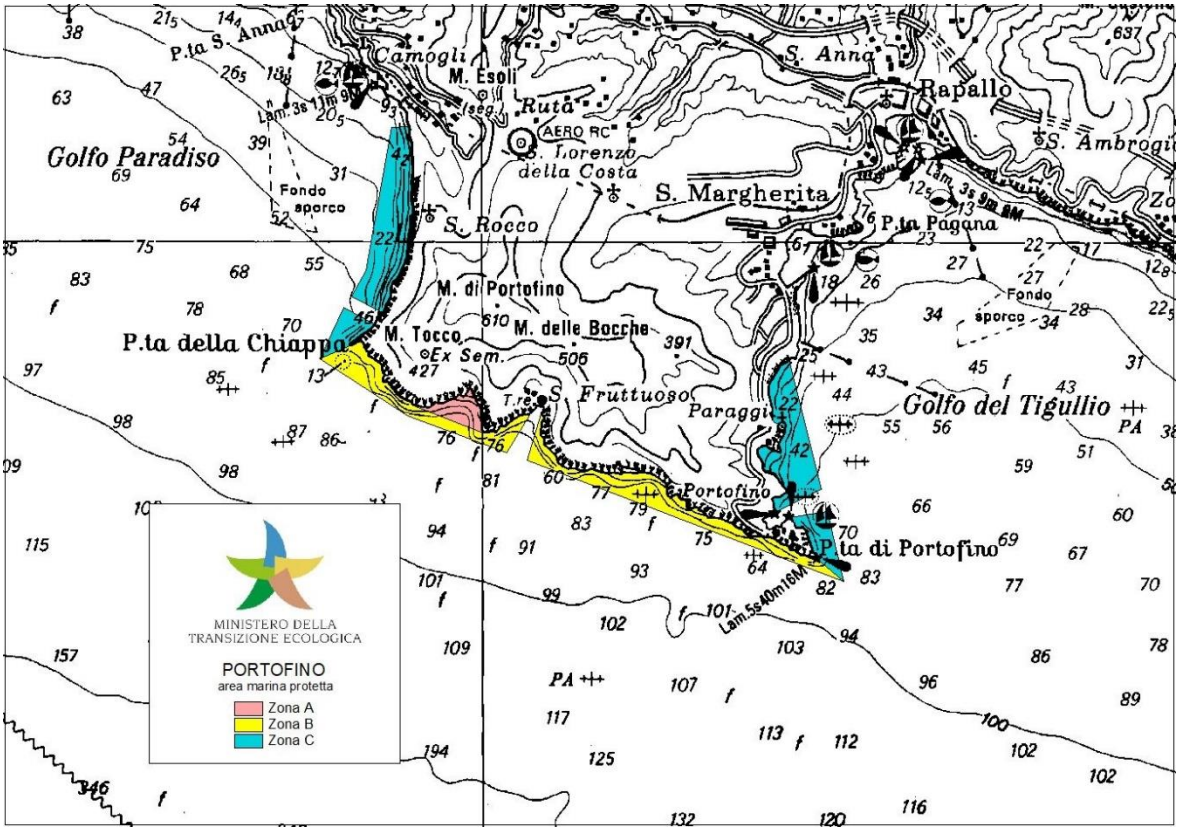


Figure 3. Map of the study area at the Portofino MPA, Italy. Latitude: 44°18'12" N. Longitude: 9°12'33" E. Zone A = no-take zone or integral reserve; only research diving activities are allowed within this zone under a permit. Zone B = general reserve; scuba diving, boating, bathing, and fishing activities are allowed at designated areas and under specific regulations. It is the area where most recreational scuba diving activities are conducted. Zone C = partial reserve; scuba diving (night diving and training activities included), boating, fishing, and anchoring are allowed. (Ministero della transizione Ecologica, 2021).

The area covered by the Portifino MPA encompasses several types of marine environments. A characteristic environment present in the area is vertical walls, which are made up of Oligocenic puddingstone. The MPA also includes seagrass meadows (*Posidonia oceanica* and *Cymodocea nodosa*), coralligenous biocenoses, boulders and stones, small caves and caverns, sandy

substrates, and the pelagic zone (Lucrezi, Milanese, Sarà, Palma, Saayman, & Cerrano, 2018).

The MPA is divided into 19 management units, which are assigned to a zonation system, each one for the control of various uses. There is one integral reserve (Zone A) used as a sanctuary no-enter and no-take zone, followed by two general reserves (Zone B), and two partial reserves (Zone C) (Figure 3).

Scuba diving was practised in the area way before the establishment of the MPA and today it is mainly conducted with licences in the area where diving activities are most regulated: the Zone B of the MPA. The regulation of the MPA does not allow boat anchoring inside general reserve areas, so 21 fixed mooring buoys are positioned along the coastline. In Zone B scuba diving training activities are also forbidden. On the contrary, in Zone C anchoring is allowed, as well as dive training. Night diving is allowed, but only in some designated dive sites of the general reserve.

1.4.2 Porto Cesareo MPA

Porto Cesareo is the third largest Italian MPA (ISPRA, 2021) and is situated in the Italian region of Puglia. It has a surface area of 166.5 km^2 and it rises in the eastern side of the Taranto Gulf, which constitutes the northernmost area of the Ionian Sea (Figure 4).

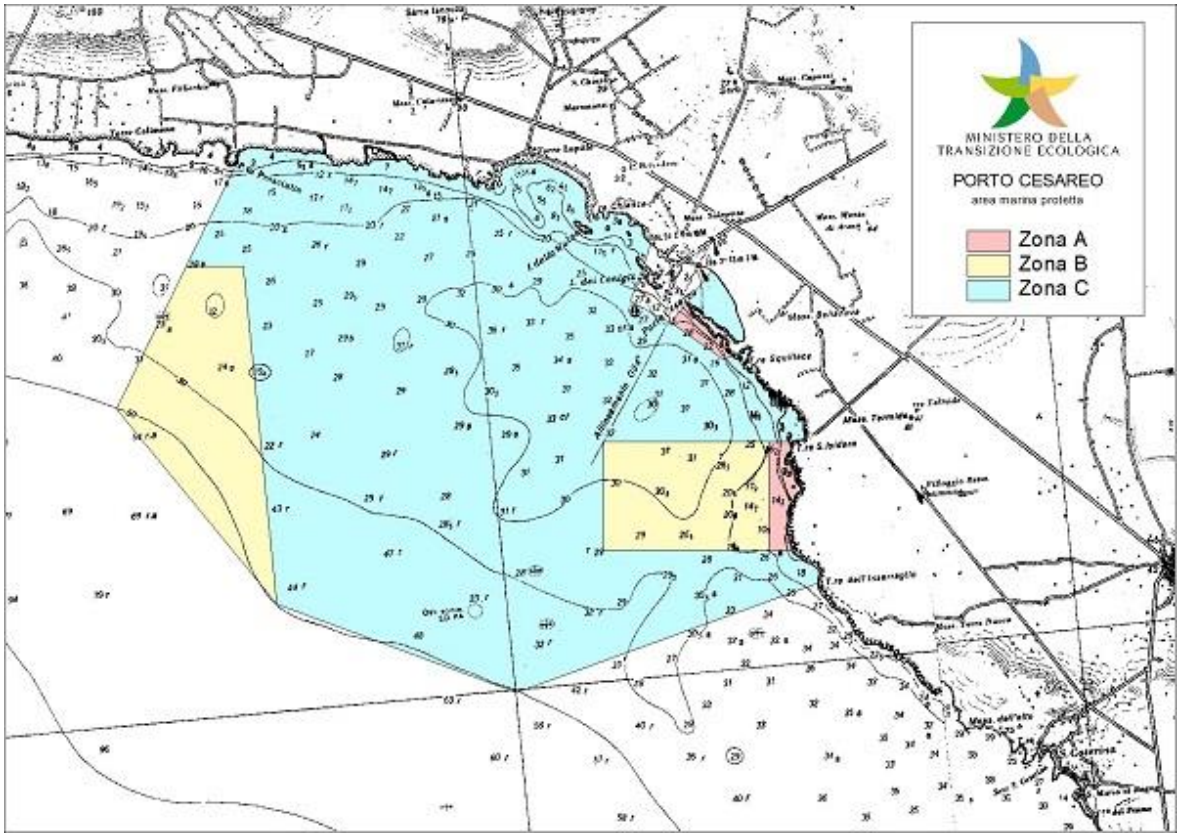


Figure 4. Map of the study area at the Porto Cesareo MPA, Italy. Latitude: 40°15'27" N. Longitude: 17°53'37" E. Zone A = no-take zone or integral reserve; only research diving activities are allowed within this zone under a permit. Zone B = general reserve; scuba diving, boating, bathing, and fishing activities are allowed at designated areas and under specific regulations. Zone C = partial reserve; scuba diving, boating, fishing, and anchoring are allowed. Most of the scuba diving activity is conducted in partial reserve areas privately and without the help of dive centres. (Ministero della Transizione Ecologica, 2021).

It was established in 1997, but during the first years of its existence, it has shown a lower demographic increase in coastal fish populations than the Portofino MPA. The explanation for this weaker ecological positive effect has to be attributed to the lesser ability to control illegal fishing in large areas (Guidetti, Bussotti, Molinari, Tunesi & Cattaneo-Vietti, 2006). The management of the MPA has nevertheless obtained positive results in terms of

the protection of coastal fish populations, with an increase in the economic value of the area (Visintin, Tomasincig, Marangon, et al., 2021).

The underwater environments of Porto Cesareo MPA include biocenoses of mixed coarse sands and fine gravels, seagrass meadows (mainly *Posidonia oceanica* and only in a small area *Cymodocea nodosa*), coralligenous platforms, overgrazed facies with encrusting algae and sea urchins, infralittoral algae biocenoses and semi-dark caves.

The zonation of the MPA includes three different levels of protection: two no-enter and no-take integral reserves (Zone A), two general reserves (Zone B), and a large partial reserve (Zone C) covering the largest area of the MPA (Figure 4).

Scuba diving is permitted commercially and privately (without a licenced guide) within the partial reserve area (Zone C) with the permission of the managing body of the MPA. Diving in Zone B and the submerged caves is only permitted in the form of guided tours authorized through scuba diving operation licences. Since anchoring is prohibited in MPA, mooring buoys have been fixed for exclusive use by scuba diving operators (in Zone B) and different uses (divers, boaters, etc.) in Zone C. Night diving is only allowed for guided tours with permission.

1.4.3 Punta Campanella MPA

Punta Campanella MPA is based in the Italian region of Campania. It is extended for 15.39 km^2 and covers about 40 km of coastline in the area of the Promontory of Punta Campanella, in the Sorrento Peninsula (Figure 5).

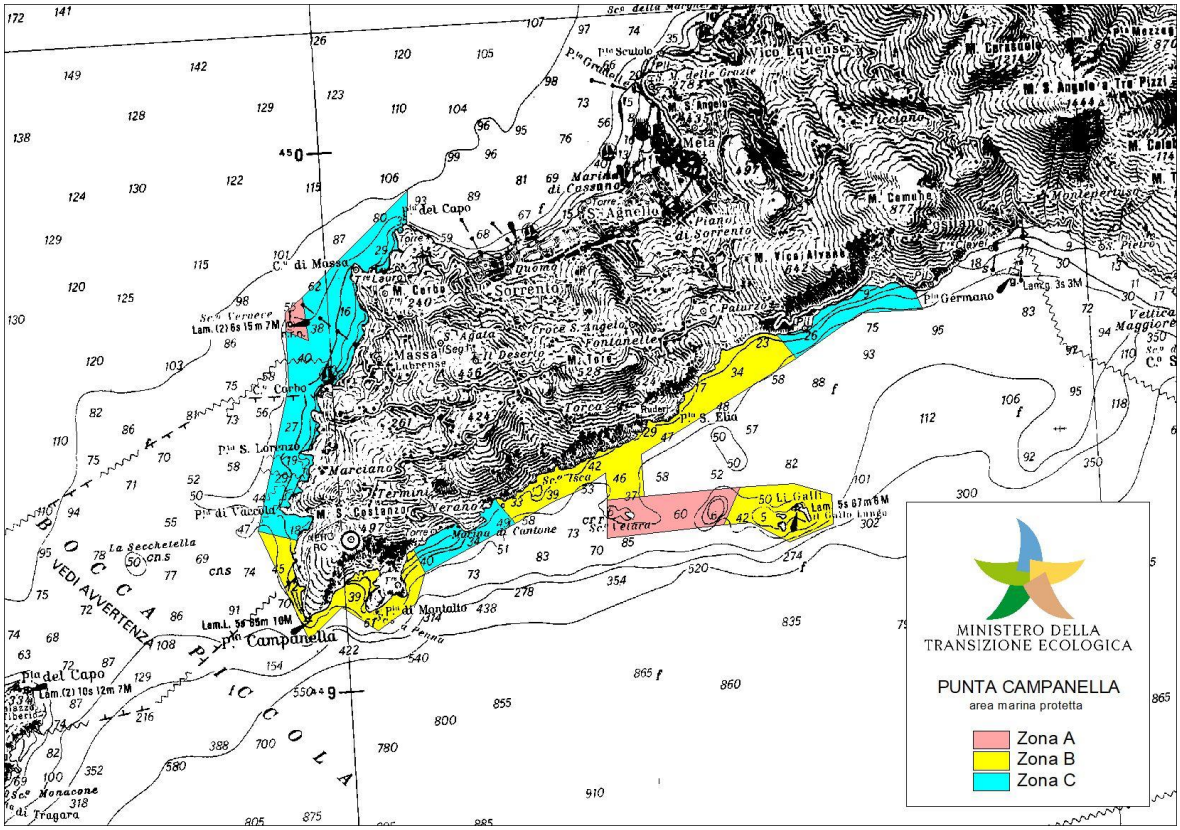


Figure 5. Map of the study area at the Punta Campanella MPA, Italy. Latitude: 40°33'32" N. Longitude: 14°19'19" E. Zone A = no-take zone or integral reserve; diving activities are permitted only as guided tours with licenced dive centres with limited admissions. Zone B = general reserve; scuba diving, boating, bathing, and fishing activities are allowed at designated areas and under specific regulations. Zone C = partial reserve; scuba diving, boating, fishing, and anchoring are allowed. (Ministero della Transizione Ecologica, 2021).

It was established in 1997 to protect and recover important local species (Sgambati, Moura, Said, Rueda, et al., 2020). Special importance was given to the recovery of the fish population, which showed a sensible demographic

increase. This has happened especially within the areas of the integral reserve, generating a spillover effect with increasing populations also in adjacent areas, which have lower protection (Apolloni, Sbrescia, & Russo, 2013).

The underwater environment is highly diversified and includes vertical walls, coralligenous biocenoses, seagrass meadows (*Posidonia oceanica*), biocenoses of coarse sand and mixed gravel, submerged caves, the pelagic environment, and, at the base of the calcareous rocky walls, muddy pelite bottoms (puntacampanella.org, 2021).

There is a zonation system with three levels of protection. This highlights the intent to ensure both the integral protection of nature (integral reserve – Zone A) and the correct management of the territory for eco-friendly tourism use (general reserve – Zone B; and partial reserve – Zone C), combining the conservation of environmental values with the sustainable use of the marine environment. There are two integral reserves (*Scoglio del Vervece* and *Vetara*), three general reserves and three partial reserve areas (Figure 5).

Scuba diving activities are always allowed in Zone C, allowed with previous permission or in the form of guided tours in Zone B, and allowed only as licenced guided tours for three days per week from 1st May to 31st October and two days per week during the rest of the year in Zone A. Every year, on the first Sunday of September, diving activities are allowed for everyone at *Scoglio del*

Vervece (Zone A) due to local holidays, but still with the permission of the MPA. Dives in submerged caves are only possible during licenced guided tours from 1st May to 31st October and only during the day. In Zone A, mooring is only allowed on special mooring buoys and only for licenced dive centres for the strictly necessary time of the dive. In Zones A and B, anchoring is prohibited. In Zones B and C mooring buoys near dive sites are reserved to licenced dive centres.

Second Chapter

2. METHODS

2.1 Research design and data collection

The research for this study followed a quantitative, descriptive, and nonexperimental design. The first phase of the study involved the research of all the regulations concerning underwater codes of conduct in all Italian MPAs, with a subsequent comparison between them. Then, compliance with these regulations by recreational scuba divers and underwater photographers at the study locations was verified using two methods: *in situ* observations during the dives and a questionnaire survey. The questionnaire also included sections aimed to investigate the divers' perception of environmental health and features of dive sites at the study locations.

All data were collected during the Summer of 2021 with the contribution of the main dive centres operating inside the MPAs, which allowed the researcher to join and follow their customers during guided scuba dives. To have a wider heterogeneity of customers, types of divers and data, different diving centres were visited in each MPA. In particular, 3 dive centres were accessed for the Portofino, 3 for Porto Cesareo, but only one in Punta Campanella. The decision regarding this last site of study was taken as there is only one large dive centre

that operates daily within the MPA, while the other dive centres are very small or focus their activities outside the MPA.

2.1.1 Codes of conduct for scuba diving activity

To find official data regarding diving regulations in the 27 MPAs present in Italian territorial waters, a search operation was carried out on the official website of the Italian Ministry of the Environment (https://www.minambiente.it/pagina/aree-marine-istituite). All the implementing decrees and official regulations of MPAs were found on the website. The decrees were downloaded and the codes of conduct for scuba diving were extracted. The data obtained were inserted into a Microsoft Office Excel table (APPENDIX 1) to allow comparison, check for similarities and differences, and search for information concerning the discipline of underwater photography.

2.1.2 In situ observations

The method by which the divers were observed underwater was based on previous similar studies (Trainito, 2007; De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018) and adapted to the requirements of the research. Underwater observations were carried out by following groups of divers from the first to the last minute of the dive, to obtain for each of the study

sites several observations sufficient for statistical analysis. The dive centres, which were asked for prior authorization to conduct the research (same as the MPA management boards), knew of the performance of monitoring activity in a generic sense, but not in its specific contents. This is so that they would not influence the behaviour of their clients, causing potential behavioural bias. For privacy-related reasons, the divers subjected to monitoring were also notified of the presence of a scientific operator who would follow them during the dive. However, the details of the research were not disclosed in full, and none of the divers knew that the observations were related to their behaviour. Also in this case, the precaution was taken to reduce the chance of behavioural bias. Furthermore, they were followed at the maximum distance to allow an unbiased evaluation of behaviour (generally between 2-5 m, never more than 6 m, with a water clearance that always allowed visibility further than 10 m).

Data on divers' behaviour were collected by reporting every single infringement of the underwater code of conduct on a waterproof slate. The slate contained the following information: the name of the dive site, the most present type of substrate at the dive site, dive time and maximum depth, and a table on which the infringements were reported. Each row of the table represented an infringement of the code of conduct, while the columns represented the rules themselves (APPENDIX 2). The rules shown on the slate were the first three

rules of the code of conduct and were the same in all three MPAs. Reasons for other rules not being contained in the slate are provided below.

The first rule prohibits contact with the bottom, as well as the removal of and damage to any material and/or marine organism. For this rule, any voluntary or involuntary contact made with a part of the body or its extension (e.g. fins) on the substrate or benthic animals or plants was considered an infringement. The second rule does not allow feeding marine organisms, introducing or abandoning any material and, in general, having behaviours that disturb the organisms. In this case, feeding marine organisms, abandoning litter or any other material, close voluntary interactions (contacts or strong behavioural alterations) with motile marine fauna, whether benthic or pelagic, were considered as infringements. The third rule obliges scuba divers to keep the equipment as close as possible to the body, in order not to disturb or accidentally damage organisms. The infringements for this rule included any involuntary contact with the seabed by components of the scuba equipment, not adherent to the body (e.g. air gauge, alternative air source, diving torch, etc.).

The fourth rule was not considered as it concerns the unauthorized use of underwater propulsion equipment and is not related to recreational diving practised at dive centres. The fifth rule was also not considered: this rule obliges scuba divers to report to the authorities the presence of waste, dangerous

materials and illegal or abandoned fishing gear on the seabed of the MPA. The sixth rule obliges scuba divers to inform themselves in advance about the environmental characteristics and regulations of the MPA, and, in particular, of the specific dive site. This rule is present only in the regulations of the MPAs of Porto Cesare and Punta Campanella, and its compliance was verified through the questionnaire, while in the Portofino MPA the responsibility for informing divers about the regulation is passed to scuba diving operators (guides and diving centres). In the Portofino MPA, there is another rule. This one obliges divers to pass through natural caves only in the ways and times necessary for carrying out the submerged path. In case of infringements, these were reported in the column dedicated to the researcher's notes.

For each infringement, the researcher identified: the dive time, the alphanumeric code of the diver who committed the infraction, its position in the group, the type of substrate, the effects on the seabed and/or on the sessile organisms that covered the substrate, the inclination of the substrate, and whether the infringement was due to the use of a photographic device. For rule 2, only the dive time, the alphanumeric code of the diver, the position in the group and the use of a camera were indicated. Effects on the substrate and/or sessile organisms were not indicated as infringements in rule 2 are mainly related to interactions with motile organisms. For each infringement, the

operator had the opportunity to add descriptive notes in the last column (e.g. the species concerned, the action of the diver, the part of the body or the equipment that touched the seabed, etc.).

The moment of the dive in which the infringement was committed was indicated with a number: '1' if it occurred in the first 10 minutes of the dive, '2' if it occurred between 11 and 20 minutes, '3' between 21 and 30, and so on until the end of the dive. The position of the diver was defined as the 'head', 'centre', or 'tail' of the group, dividing the number of divers by 3 and ordering them according to the distance from the guide. The type of seabed on which the infringement occurred was defined as 'hard' (naked or slightly encrusted rock), 'soft' (sand or gravel), or living organism (seagrass, macroalgae, corals, and so on). The effects on the seabed were defined as: 'contact' in case of simple contact without further damage, 'detachment' in case of lifting and/or uprooting of an organism from the substrate, 'breaking' in case of damage to an organism or a rock to the point of breaking a piece of it, and 'resuspension' in case of the lifting of sediment in the water column. The slope of the seabed was then referred to as 'horizontal', 'oblique', or 'vertical'. For the measurement of this last factor, no instrument other than sight was used and the categorization was made by observing if the inclination of the seabed was respectively: between 0° and 30°, between 30° and 60°, and between 60° and

90° on the horizontal axis. The reefs with an inclination greater than 90° (shaded environments) were considered for the study purposes as vertical walls.

Each table compiled on the slate was finally photographed and copied on a Microsoft Office Excel worksheet.

2.1.3 Questionnaire

The questionnaire was developed based on previous studies (Ong & Musa, 2012; Lucrezi, Saayman, van der Merwe, 2013; Lucrezi, Milanese, Sarà, Palma, Saayman, & Cerrano, 2018), and adapted to the needs of the study. Each section and question of the questionnaire was carefully studied so as not to violate any rule of the ethical code established by the Polytechnic University of Marche.

The questionnaire was administered to agreeing scuba divers immediately after the dive in which they were observed. All participating divers had to sign an informed consent form. The participation was anonymous and voluntary and divers could withdraw at any time.

The questionnaire was structured in four sections. The first section contained socio-demographic questions including gender, age, scuba diving experience and certification. The second section contained questions about knowledge of and compliance with the rules of the scuba diving code of conduct in each

MPA. Divers were asked to list the rules they were aware of and self-report compliance with these rules. The third section included a question on the perceived environmental health of the MPA. The question had a series of items to be evaluated using a Likert scale (from 1 = 'it is actually beneficial' to 5 = 'very damaging' and 6 = 'I am not sure'). In particular, scuba divers were asked to express their opinion about the potential ecological damage caused by: scuba diving and underwater photography; non-diving activities such as fishing and boating; environmental factors (i.e. climate change, species invasion, etc.); and situations that actually could represent beneficial factors for the underwater environment. The fourth and last section asked if the diver used a photographic device during the dive just conducted, and its level of involvement in underwater photography practices. Most of the questionnaires were printed in Italian, but also English and French versions were administered to divers coming from abroad.

2.2 Data Analysis

The data were analyzed for descriptive patterns and trends. All analyses were performed using the software TIBCO Statistica (Version 13.3, 2017). Graphs were created using Microsoft Office Excel (Version 16.0.14326.20164). The profile of the participants in this study was analysed using descriptive statistics (mean, standard error, minimum and maximum value), breakdown statistics

(mean, standard error, minimum and maximum value according to categories of independent variables), and frequency tables (percentage according to categories of independent variables). Any significant differences between study sites were tested through cross-tabulations, using Pearson Chi-square (χ^2) and Kruskal-Wallis tests. The relationships between variables from scuba diving observations and variables from the questionnaire were investigated through Spearman rank-order correlations (r_s).

Third Chapter

3. RESULTS

3.1 Codes of conduct for scuba diving activity

Data obtained from the official regulations of the 27 Italian MPAs showed that all of them have a code of conduct concerning scuba diving activities. The codes of conduct are similar, only differing in the way rules are written and in some topics which are specific to the environment of the single MPA (APPENDIX 1).

All MPAs have two rules in common. The first one prohibits any kind of contact with the seabed, as well as partial removal and damage to any material and/or organism of both geological, biological or archaeological nature. The other one requires keeping the equipment as close to the body as possible, so as not to disturb or accidentally damage organisms. Two other very common rules include one that does not allow to feed marine organisms, to introduce or abandon any material and, in general, to have behaviours that disturb the organisms; and one where it is mandatory to report the presence on the seabed of the MPA of trash or hazardous materials and abandoned fishing gear to the managing body or the local maritime authority. These two rules are present in all codes of conduct except that of the Isole Pelagie MPA. The latter MPA also

lacks another rule, not allowing the use of underwater propulsion systems, except for those possibly used by disabled people, subject to the authorization of the managing body. This rule is also absent in the code of conduct of the Miramare MPA.

Another rule present in most codes of conduct concerns the divers' obligation to inform themselves in advance about the environmental characteristics and regulations of the MPA, in particular the specific diving sites. This rule is lacking only in four MPAs: Isola di Bergeggi, Isole Pelagie, Miramare, and Portofino (site of study). However, the responsibility for informing divers about regulations in MPAs is often passed to the diving operators. The remaining rules are mainly specific to the environments of every single MPA. In the Capo Rizzuto and Portofino (site of study) MPAs, transit in natural caves must take place in the ways and times strictly necessary for carrying out the submerged path. In the Cinque Terre and Isole Pelagie MPAs, access to the submerged caves is allowed only with the use of a closed or semi-closed circuit breathing system, with air discharge outside the caves. In the Isola dell'Asinara MPA it is not allowed, unless specifically authorized by the managing body, to land ashore. Finally, in the Isole Ciclopi MPA, diving must be carried out in compliance with the rules indicated by the certifying agencies, and in each site, scuba and freediving must take place within a radius of 50 meters from a

mooring buoy, or the float that signals the presence of scuba and/or freedivers (Table 1).

Table 1: Percentage of the presence of the single rules in the codes of conduct of the Italian MPAs. The number of each rule refers to the table in APPENDIX 1.

Rule 1	Rule 2	Rule 3	Rule 4	Rule 5	Rule 6	Rule 7	Rule 8	Rule 9	Rule 10	Rule 11
100.0%	95.8%	100.0%	95.8%	91.6%	83.3%	8.3%	4.2%	4.2%	4.2%	8.3%

3.2 Descriptive analysis – Environmental features

The behaviour of 84 divers in a total of 23 dives was observed throughout the study period. More precisely, 6 dives were carried out in the Portofino MPA, with data on 25 divers; 8 dives with data on 31 divers in the Porto Cesareo MPA, and 9 dives with data on 28 divers in the Punta Campanella MPA. The number of divers observed is therefore divided into 30% for Portofino, 37% for Porto Cesareo, and 33% for Punta Campanella (Figure 6). Overall, 7 divers were observed within Zone A, 37 within Zone B, and 40 within Zone C.

The main substrates on which divers were observed differed depending on the dive site. In the Portofino MPA, 14 divers (56%) were observed on vertical walls, 5 (20%) on gravel slopy bottoms, 4 (16%) on walls alternating with gravel bottoms, and 2 (8%) on walls alternating with *Posidonia oceanica* meadows. The dives carried out in the Porto Cesareo MPA mainly featured bottoms formed by caves and canyons (12 divers – 39%), followed by cave and gravel bottoms (9 divers – 29%), rock and gravel bottoms (7 divers – 22%) and

sandy bottoms with *Cymodocea nodosa* meadows (3 divers – 10%). The seabed on which the observations were carried out in the Punta Campanella MPA were represented almost entirely by vertical walls (26 divers – 93%), and only minimally by cave environments (2 divers – 7%).

The mean dive time during the observations was 53 minutes. The means in the three MPAs differed in a significant way (ANOVA with p = 8.1E-08), with shorter dive times in the Punta Campanella MPA (mean = 47 minutes) and longer ones in Portofino and Porto Cesareo MPAs (respectively 54 and 57 minutes). The maximum depth depended on the morphology of the seabeds; there were higher mean depths in Portofino and Punta Campanella MPAs, where the bottoms are mainly formed by vertical walls (33.6 m and 30.5 m), while in Porto Cesareo the maximum depths were shallower (18 m).

3.3 Socio-demographic information

Over half (57%) of divers identified themselves as male, 29% as female, while 14% did not specify. Pearson χ^2 analysis on the three MPAs frequencies showed a borderline significance value (p = 0.054). In fact, while Portofino and Punta Campanella MPAs had the most male divers, in Porto Cesareo MPA female divers and male divers were present in the same percentage (Figure 6). The age of the divers also significantly differed between the MPAs (Kruskal-Wallis, p = 0.0415): divers in Porto Cesareo and Punta Campanella MPAs showed a

similar mean age (37 and 39 years old), while divers in Portofino MPA were on average older (46 years old) (Figure 6). The origin of the divers was mainly Italian (51%), but in the Punta Campanella MPA, only 21.5% of the divers were Italian and the rest came from abroad, creating a significant difference (Pearson χ^2, p = 0,0000) (Figure 7). Most divers (51.1%) had at least one college degree (28.5% degree and 22.6% postgraduate degree), while 33.3% had high school as their highest level of education; 15% of the sample did not answer the question on education. Pearson χ^2 analysis indicated a significant education difference between the MPAs (p = 0.036). In Punta Campanella MPA the highest percentage was covered by postgraduate divers (39%), in Portofino MPA by graduated divers (40%), and in Porto Cesareo MPA 45% of the divers had school as highest education level. Most divers (75%) declared they did not receive any education in marine biology or environmental sciences. This data was found to be constant across the three sites of study (Figure 8).

The level of divers was categorized as Open Water Diver, Advanced and Professional. In Porto Cesareo and Punta Campanella MPAs the advanced divers were the most (51.6% and 46.4%), while in Portofino MPA the largest percentage of divers were professionals (45.2%). In all study sites, the least represented category was first level divers (Figure 7). The scuba divers belong to up to 10 different certifying agencies. The most frequent was PADI

(Professional Association of Diving Instructors, 42.8%), followed by CMAS (Confédération Mondiale des Activités Subaquatiques, 13.1%), FIPSAS (Federazione Italiana Pesca Sportiva ed Attività Subacquee, 9.5%), and SSI (Scuba Schools International, 8.3%) (Figure 7).

The number of lifetime dives was divided into three categories: 0-50 dives, 51-200 dives, and more than 200 dives. Considering the whole sample, 28.6% had done less than 50 dives in their lifetime, 28.6% had done 51-200 dives, 29.7% had done more than 200 dives, and 13.1% did not specify. Results were significantly different between the three MPAs (Pearson χ^2, $p = 0.004$). In Portofino MPA 44% of divers had done more than 200 dives, in Porto Cesareo people with less than 200 dives were the most (71%), while in Punta Campanella MPA 42.9% had done less than 50 dives, followed by 28.6% with more than 200 dives.

A third of the divers (34.5%) declared to do more than 20 dives per year, 26.2% did 10-20 divers per year, and 22.6% did less than 10 dives per year, while 16.7% did not specify. There was a significant difference among the three MPAs, with a Pearson χ^2 $p = 0.00002$. All divers in Portofino MPA did more than 10 dives per year, while in Punta Campanella MPA 42.9% did less than 10 dives per year. In the Porto Cesareo MPA, 45.2% of divers did 10-20 dives per year. The Kruskal-Wallis test confirmed a significant difference between

MPAs ($p = 0.0012$) with a mean of 48.6 dives per year in Portofino, 32.2 in Porto Cesareo, and 27 in Punta Campanella.

Most of the divers were not using a camera during the dives (55.9%), while the rest of the sample was mainly represented by people using action cams (29.8%), followed by compact cameras and DSLR or mirrorless interchangeable lenses cameras (both at 7.1%). Differences between the MPAs were not significant based on Pearson χ^2 ($p = 0.73$). Half of the divers (51.2%) identified themselves as occasional/amateur underwater photographers. The second most frequent category was 'heavily involved' photographers (13.1%), while only 11.9% of the sample were moderately involved in underwater photography. Some 23.8% did not specify; these people were not using a camera during the dive at the time of the study (Figure 8). There were no significant differences in the type of photographers between the study sites (Pearson χ^2, $p = 0.44$).

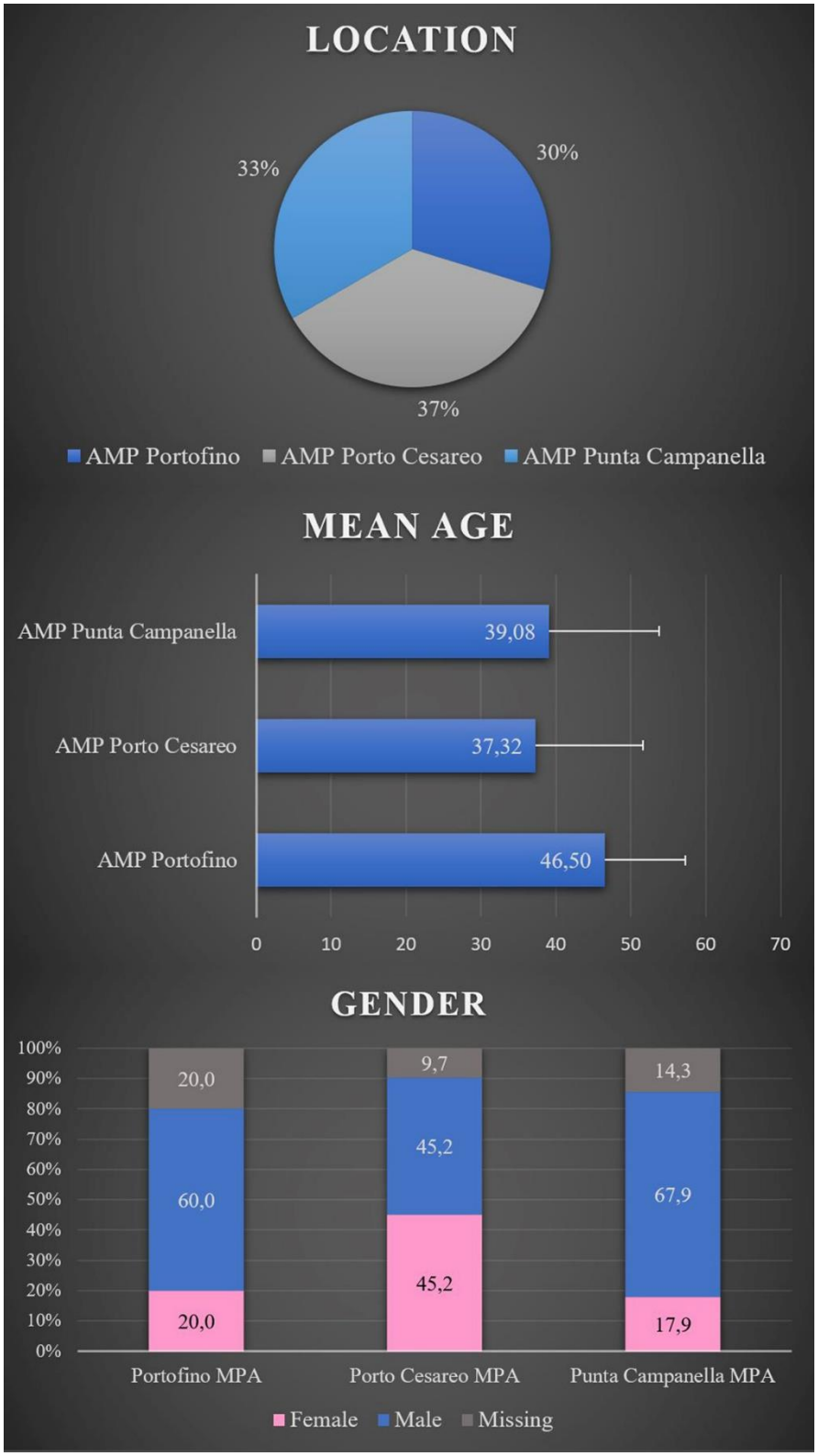


Figure 6: Infographic representing socio-demographic information of the participants of the study. There are represented: percentage of divers per site of study, their gender, and their age (N = 84).

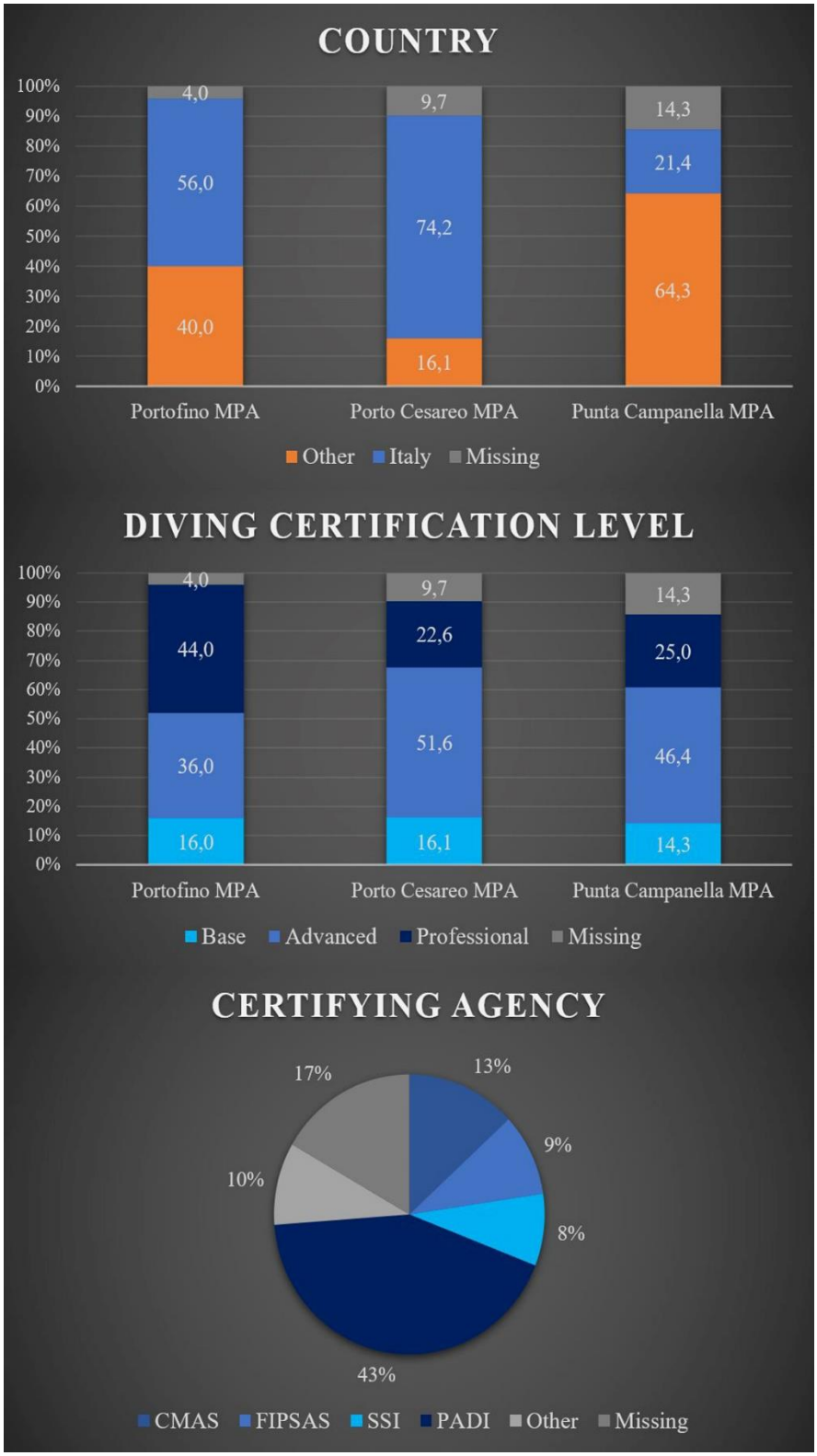


Figure 7: Infographic representing socio-demographic information of the participants of the study. There are represented: the country of origin of the divers, their diving certification level, and the cerifying agency (N = 84).

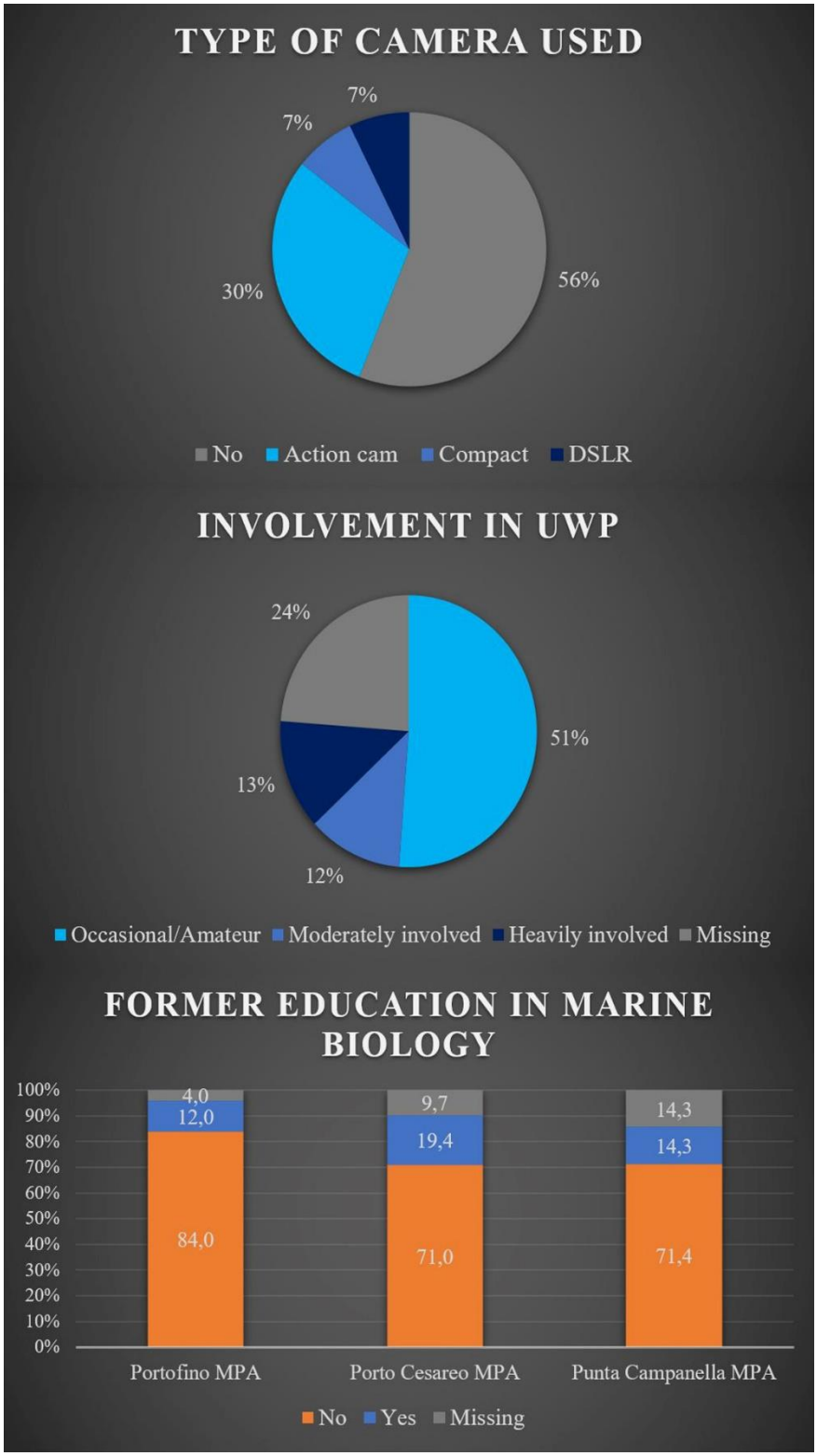


Figure 8: Infographic representing socio-demographic information of the participants of the study. There are represented: the type of camera used at the time of the study by divers, their grade of involvement in underwater photography, and former education in marine biology and/or environmental studies (N = 84).

3.4 Correlations between the main variables

Two main steps of this study included a comparison between actually committed and declared infractions, as well as a comparison between the behaviours and the responses to the questionnaire by recreational divers and underwater photographers. This paragraph reports the results of all these comparisons.

3.4.1 Underwater photography

The parameters deriving from the diving observations were correlated with those deriving from the questionnaire (Table 2). Positive and significant correlations were found concerning the type of camera used. The more complex and professional the system used by the diver, the more likely the diver was to have a background of studies in marine biology or environmental sciences, to have a high level of diving experience (professional certification, many lifetime dives and many dives per year), to appreciate more macro subjects such as nudibranchs or seahorses, and to commit violations of rules 1 and 2 of the code of conduct of the MPA. Likewise, just using a camera underwater was a factor correlated with having a background in marine or environmental sciences, and infringing rules 1 and 2.

The divers most involved in underwater photography were predominantly Italian, appreciated macro subjects more, had more diving experience, had better knowledge of rule 2 of the code of conduct, and had a high number of infractions of rule 1. These infractions occurred mainly in the back of the group of divers (away from the dive guide) and consisted mainly of contacts and breakages of sessile organisms.

3.4.2 Other correlations

Female divers demonstrated greater knowledge of rules 1, 2, and 3 of the code of conduct, while males made more contact with the seabed. Divers who declared to be older mostly performed deep dives, were most experienced, and committed more infractions of rule 3, with many contacts with the seabed and breakages.

Italian divers (who were more involved in underwater photography) self-reported committing fewer infractions. The highest number of self-reported violations of the code of conduct was instead encountered in divers with the highest level of education. Divers who had a background in marine biology or environmental sciences (who were more likely to have a camera and did more dives per year) self-reported a high number of infractions.

Those who declared to have a higher diving certification level were found to be older, more involved in underwater photography, with a more frequent knowledge of rule 3, mainly diving at the end of the group. In the same way, divers who made the most dives were older, more involved in underwater photography, and diving mainly at the end of the group. However, they showed a better knowledge of rule number four, instead of rule number 3. Divers who indicated a preference in macro subjects almost always had photographic equipment and were more involved in underwater photography, they did more dives per year, were responsible for a high number of total infractions and infractions for rule 1, with a high percentage of contacts with the seabed and resuspension of sediment, especially on bottoms with a horizontal and semi-horizontal inclination (Table 2).

Table 2: D = Maximum depth; Eq = Type of photographic equipment used; Cam = Camera used at the time of the study or not; Inv = Involvement of the diver in underwater photography practice; G = Gender; A = Age; C = Country; ED = Highest level of education; MB = Education background in Marine Biology or Environmental Studies; DL = Highest level of scuba diving certification; YD = number of years diving; TD = Total number of dives logged; DY = mean number of dives logged per year; CoC = Code of conduct; M = Interest in marine Macro subjects; SBO = Interest in sessile benthic organisms; RMO = Interest in reef motile organisms; BPO = Interest in big pelagic organisms; S = Interest in shearks; R1 = infractions of rule 1 per 10 minutes; R2 = infractions of rule 2 per 10 minutes; R3 = infractions of rule 3 per 10 minutes; PH = Position, head of the group; PC = Position, center of the group; PB = position, back of the group; EC = effect, contact; ED = effect, detachment; EB = effect, breakage; ER = effect, resuspension; H = Horizontal slope; O = oblique slope; V = vertical slope; SH = hard substrate; SS = soft substrate; ML = marine life. Correlation coefficients in bold indicate significance at p < 0,05 (N=84).

	Eq	Cam	Inv	G	A	C	Ed	MB	DL	YD	TD	DY	M
						Divers profile							
D	0.04	-0.03	**0.31**	**0.24**	**0.38**	0.05	0.10	-0.06	**0.35**	**0.32**	**0.47**	**0.49**	0.13
Eq		**0.96**	**0.55**	0.15	0.20	0.13	0.00	**0.33**	0.00	0.06	0.10	**0.24**	**0.28**
Cam	**0.96**		**0.38**	0.14	0.15	0.09	-0.01	**0.29**	-0.05	-0.01	0.02	0.16	0.21
Inv	**0.55**	**0.38**		0.14	0.21	**0.28**	0.13	0.08	**0.25**	0.23	**0.36**	**0.53**	**0.34**
G	0.15	0.14	0.14		0.11	-0.08	-0.18	-0.13	-0.15	0.15	-0.08	-0.11	-0.04
A	0.20	0.15	0.21	0.11		0.14	0.16	0.14	**0.52**	**0.71**	**0.68**	**0.55**	0.15
C	0.13	0.09	**0.28**	-0.08	0.14		-0.17	0.05	0.12	0.13	0.22	**0.39**	0.20
Ed	0.00	-0.01	0.13	-0.18	0.16	-0.17		0.09	0.18	0.06	0.10	0.01	-0.10
MB	**0.33**	**0.29**	0.08	-0.13	0.14	0.05	0.09		0.10	0.12	0.22	0.18	0.14
DL	0.00	-0.05	**0.25**	-0.15	**0.52**	0.12	0.18	0.10		**0.47**	**0.72**	**0.63**	0.18
YD	0.06	-0.01	0.23	0.15	**0.71**	0.13	0.06	0.12	**0.47**		**0.72**	**0.42**	-0.12
TD	0.10	0.02	**0.36**	-0.08	**0.68**	0.22	0.10	0.22	**0.72**	**0.72**		**0.78**	0.15
DY	**0.24**	0.16	**0.53**	-0.11	**0.55**	**0.39**	0.01	0.18	**0.63**	**0.42**	**0.78**		**0.25**
						Favourite marine life encounters							
M	**0.28**	0.21	**0.34**	-0.04	0.15	0.20	-0.10	0.14	0.18	-0.12	0.15	**0.25**	
SBO	0.09	0.05	0.17	0.09	-0.13	0.00	0.13	0.11	-0.12	**-0.25**	-0.17	-0.16	0.15
RMO	0.11	0.18	-0.11	0.04	-0.16	0.00	-0.16	-0.09	-0.19	-0.13	**-0.28**	-0.23	0.05
BPO	-0.13	-0.18	0.10	0.12	0.00	-0.17	0.01	0.00	0.18	0.14	0.12	0.10	-0.20

S	-0.13	-0.18	-0.01	0.12	0.05	**-0.23**	0.17	0.04	0.12	0.08	-0.05	-0.16	-0.21
Other	0.13	0.18	0.04	0.12	-0.05	-0.19	0.23	0.14	-0.05	-0.07	-0.11	-0.23	-0.09
Code of conduct knowledge and self-reported compliance													
CoC	-0.01	-0.04	0.06	-0.20	0.06	0.05	0.05	-0.03	0.19	0.10	0.10	**0.26**	0.04
Rule 1	0.04	0.00	0.12	-0.06	0.00	-0.03	0.06	0.07	0.17	0.08	0.15	0.10	0.20
Rule 2	-0.06	-0.14	**0.25**	**-0.26**	-0.15	-0.05	0.16	-0.02	0.12	-0.08	-0.01	0.08	0.17
Rule 3	-0.10	-0.13	-0.09	**-0.27**	-0.06	0.13	-0.02	0.16	**0.25**	-0.03	0.06	0.09	-0.03
Rule 4	-0.18	-0.18	-0.02	**-0.29**	0.00	0.18	0.03	-0.09	0.15	0.07	**0.25**	0.23	-0.12
Rule 5	-0.05	-0.05	0.04	-0.03	0.09	-0.22	-0.11	-0.16	0.04	-0.15	-0.06	0.07	0.10
Rule 6	-0.10	-0.10	-0.09	-0.17	-0.07	0.10	-0.13	-0.05	0.15	0.00	0.14	0.13	-0.07
Self-report	0.07	0.10	-0.09	0.03	0.10	**-0.34**	**0.24**	**0.28**	-0.22	0.17	0.02	-0.11	-0.09
Code of conduct infractions													
R1	**0.66**	**0.61**	**0.43**	**0.30**	0.19	0.03	-0.04	0.19	0.02	0.11	0.09	0.07	**0.26**
R2	**0.36**	**0.32**	0.24	0.05	0.13	-0.05	0.20	0.19	0.05	0.08	0.13	0.22	0.01
R3	0.14	0.20	-0.06	0.08	**0.23**	0.01	-0.19	0.00	0.16	0.11	0.08	0.15	0.16
PH	**0.40**	**0.39**	0.23	0.03	-0.04	-0.11	0.00	0.20	0.00	-0.05	-0.07	-0.08	0.15
PC	**0.23**	**0.25**	0.00	**0.25**	0.14	0.12	-0.20	-0.10	-0.04	0.04	-0.03	0.12	0.13
PB	**0.49**	**0.39**	**0.42**	**0.29**	**0.29**	0.10	0.02	0.01	0.12	**0.23**	**0.25**	**0.28**	0.16
EC	**0.69**	**0.65**	**0.48**	**0.25**	**0.29**	0.11	0.10	0.17	0.16	0.20	0.19	0.18	**0.30**
ED	**0.44**	**0.42**	0.20	**0.24**	0.14	0.03	-0.08	**0.26**	-0.05	-0.02	-0.03	-0.01	0.15
ER	**0.37**	**0.36**	0.16	0.00	0.06	0.21	**-0.24**	0.14	-0.10	0.02	-0.09	0.04	**0.27**
EB	**0.32**	**0.25**	**0.45**	0.21	**0.39**	0.00	0.06	0.09	0.21	**0.34**	**0.26**	0.21	0.14
H	**0.57**	**0.56**	**0.25**	0.14	0.15	0.18	-0.07	0.06	0.00	0.01	0.07	0.11	**0.32**
O	**0.48**	**0.44**	**0.42**	**0.25**	0.20	-0.10	0.00	0.13	0.08	0.13	0.14	0.13	0.14
V	**0.23**	0.19	0.10	0.02	**0.27**	-0.13	0.03	0.09	0.13	0.16	0.20	0.20	0.01
SH	**0.70**	**0.65**	**0.40**	0.21	**0.28**	0.15	0.05	0.20	0.08	0.12	0.16	0.12	**0.34**
SS	**0.37**	**0.36**	0.18	0.01	0.07	**0.23**	-0.23	0.15	-0.09	0.03	-0.08	0.05	**0.28**
ML	**0.52**	**0.49**	**0.38**	0.21	**0.23**	0.04	-0.11	0.21	0.14	0.21	0.17	0.22	0.13

Total infractions	**0.70**	**0.67**	**0.41**	**0.28**	0.21	0.04	-0.03	0.20	0.02	0.09	0.07	0.09	**0.26**

3.5 Environmental perception

Concerning environmental perceptions, correlations did not indicate significant differences between the responses given by photographers and other divers. Most of the divers recognized the presence of apex predators and citizen science activities as beneficial features for the environment. All the impacts deriving from anthropic and non-diving (e.g. boating) elements were mainly considered very damaging, with the only exception of anchors laying on the bottom. This action was considered less damaging than the others. Lower values, but still damaging, resulted from the answers about diver behaviour impacts, considered between 'slightly damaging' and 'damaging' by most of the divers. As for the perceptions of climate change and alien species, opinions were very diversified in the analysed sample, with a high percentage of blank or 'I am not sure' answers, highlighting poor knowledge of the topic (Figure 7).

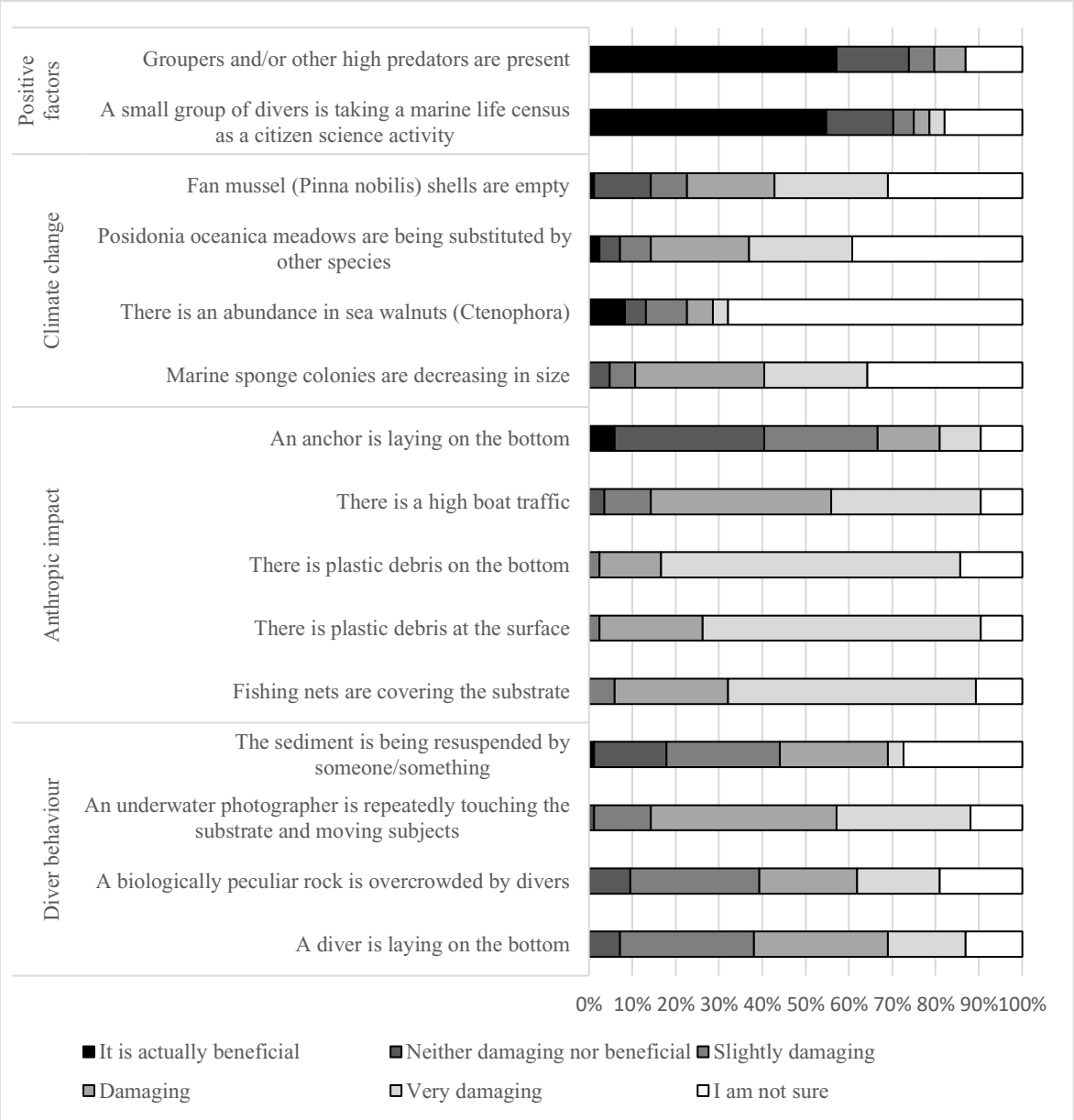


Figure 9: Divers opinions about ecological damages derived from scuba diving behaviour, anthropic impacts not-diving related, climate changes and alien species related, and positive factors (N=84).

Fourth Chapter

4. DISCUSSION

The divers that participated in this study faithfully represented the mean type of user of the investigated MPAs. The three sites of study did not show a relevant difference from each other. Age, certification level, diving experience and gender of divers reflected the data collected by the world's leading scuba diver organization in its reports (PADI, 2021) (Figure 7, 8), with the only differences in age in the Portofino MPA, and the percentage of women in the Porto Cesareo MPA.

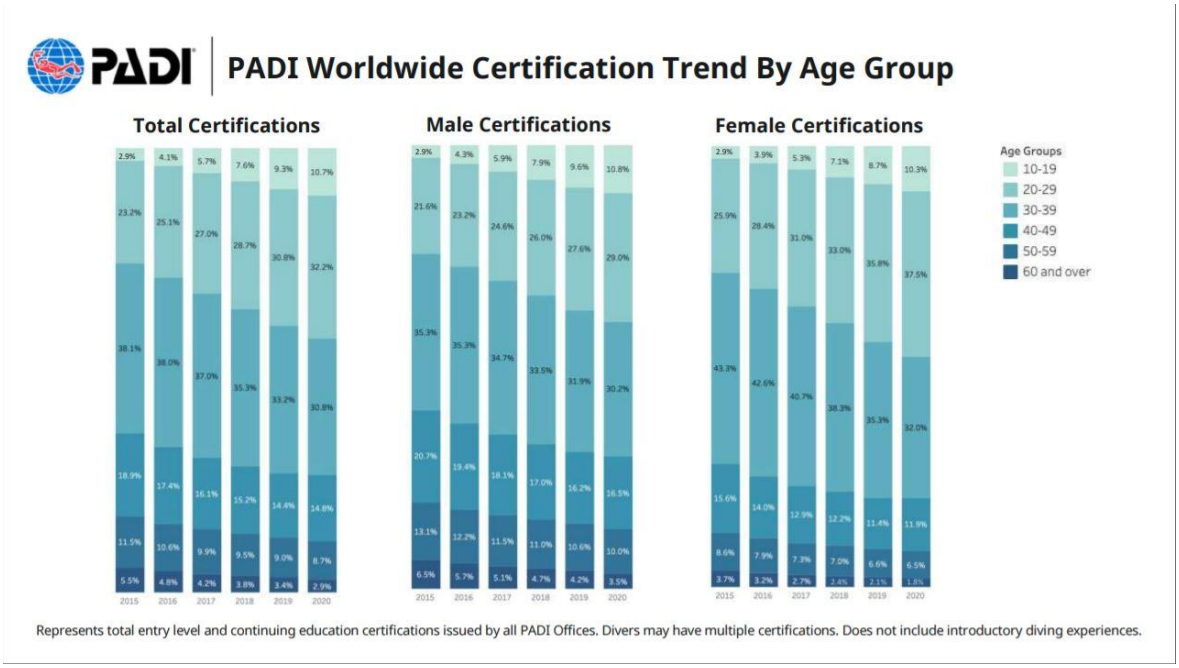


Figure 10: Age distribution of new PADI certified divers from 2015 to 2020, with age distribution in males and females (Padi, 2021).

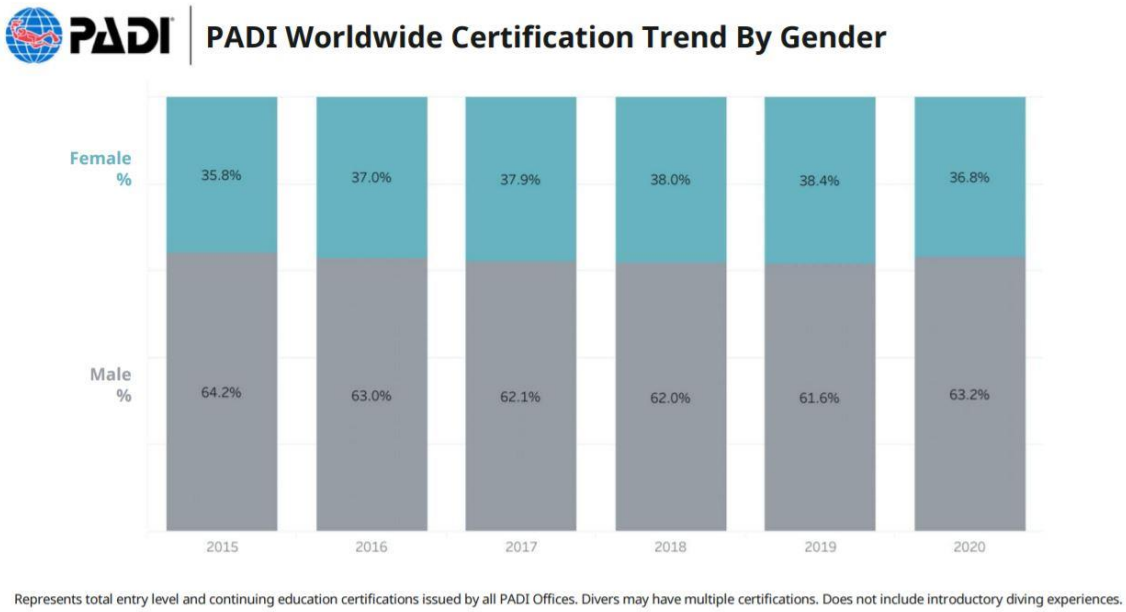


Figure 11: Distribution by gender of new PADI certified divers from 2015 to 2020 (PADI, 2021)

Most divers did not use photographic equipment, many used amateur equipment, and only a small percentage had professional equipment. However, the results showed that the use of photographic equipment was the only real discriminating factor in committing a large number of infractions. Considering the results of this study, it can be said that most divers have a very slight impact on marine environments, while most situations involving damage to the seabed are attributable to a small percentage of individuals: the most involved underwater photographers. Previous studies (Musa, Seng, Thirumoorthi, & Abessi, 2011; Ong & Musa, 2012b) have shown that the diver's experience and level of certification are of paramount importance in determining the number

of contacts with the bottom (the main type of infringement found in this study). Inexperienced divers are more likely to have bottom contacts.

However, the results of this study indicated that, when the diver was engaged in taking photographs, any relationship with his/her experience and level of certification lost significance. Newly licensed first level divers and professionals with thousands of logged dives behave in the same way when in possession of an underwater camera, that is, they tended to commit infractions. This was particularly the case if the photographic equipment was of a professional type. The greater the complexity of the equipment, the greater the number of infractions committed by the diver. The same was true for the degree of involvement in the practice of underwater photography, with a higher number of infractions in the most involved photographers.

The fact that the photographers most involved were also those fondest of macro photography may be part of the reason why the number of infractions was so high. When small subjects are photographed, it is more difficult for the photographer to maintain the stability necessary to obtain the shot and often the diver leans against the seabed (De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018). This practice can be more or less invasive on the substrate depending on the way the diver leans. This can have a minimal impact if contact is minimized to a finger or a tripod/monopod, or high if the diver lies

down in negative buoyancy, in some cases causing damage to the substrate with detachment or breakage of sessile benthic organisms (Roche, Harvey, Harvey, Kavanagh, McDonald, Stein-Rostaing., & Turner, 2016). Substrate contact is not the only way an underwater photographer can damage the marine environment. Interactions with organisms, be it contact or just repeated stress from continuous flash shots, can lead to short-term behavioural changes (Harasti & Gladstone, 2013).

Although the percentage of underwater photographers is very small compared to the total number of divers, the constant increase of people approaching this discipline (Roche, Harvey, Harvey, Kavanagh, & Turner, 2016; De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018) can greatly reduce the carrying capacity of a dive site. If we consider sites where the pressure of underwater tourism is very high, the continuous manipulation of slow-moving animals could cause chronic stress in them, reducing their nutritional and reproductive capacity and increasing the risk of predation (De Brauwer, Saunders, Ambo-Rappe, Jompa, McIlwain, & Harvey, 2018).

The results of the study showed that photographers had environmental perceptions similar to those of other divers. Photographers knew that lying on the substrate and moving organisms can lead to environmental problems. Likewise, most of them were aware that the MPAs' regulations with the related

codes of conduct prohibit this type of behaviour. However, these behaviours were exhibited regularly and with high intensity by those who were very involved in underwater photography. This may lead to think that many photographers, considering themselves conservationists and advocates of the sea, feel justified in their actions to obtain the perfect shot that communicates the beauty of marine environments and their fragility, without realizing that they are part of the problem (Pagel, Orams, & Lück, 2020). In favour of this hypothesis, most of the photographers who participated in this study declared that they knew they were committing infringements, albeit with much less frequency than that verified by the observer. Therefore, although the use of bulky equipment and concentration in photographing small subjects can lead to involuntary (but equally harmful) contact with the seabed (pers. observation), the self-assessment given by underwater photographers indicated that the way to reduce the impact of underwater photography does not lie only with learning techniques, but also with the mentality of the diver.

An important factor from this point of view concerns the regulations of MPAs. While in other MPAs (i.e. Ponta do Ouro, Mozambique; and Aliwal Shoal, South Africa; mentioned in the introduction) there are points dedicated exclusively to the ethics of underwater photography, in the Italian MPAs these points cannot be found and the codes of conduct concern divers in a generic

sense. The rules that a good underwater photographer should respect are the same ones that a good diver should respect. However, the presence of specific rules dedicated to this practice could discourage wrong behaviours. Just as written regulations can act as a deterrent, diving industry professionals and certified guides have to take additional steps with detailed briefings that include environmental awareness (Medio, Ormond, & Pearson, 1997; Giglio, Chadwick, & Ferreira, 2018).

Fifth Chapter

5. CONCLUSIONS

5.1 Management guidelines

To complete the study, it is necessary to reiterate that the practice of underwater photography is not an activity that brings only negative sides. Indeed, the positive effects deriving from this activity, if carried out following a suitable ethical profile, are of fundamental importance concerning scientific research, knowledge, dissemination and environmental awareness. Being the number of highly involved underwater photographers very low compared to the total, the impact they have on the marine environment is likely to remain lower than that by other categories of divers as a whole. However, by taking precautions on the behaviour of underwater photographers, it is possible to further reduce the impact of the diving industry on marine environments. In this way, it will be possible to increase the carrying capacity of diving sites and MPAs, increasing their naturalistic value and the economic potential of the commercial activities that use them. To achieve these improvements, there are several possibilities, which can be summarized in the following guidelines.

1. Promote a greater level of education and knowledge of the regulations in MPAs, involving stakeholders such as dive centres in the drafting and

application of new codes of conduct. This can be done through dissemination campaigns and greater precision during pre-dive briefings and debriefings.

2. Raise awareness with information campaigns on diving ethics. For example, in the regulations of underwater photography competitions, there could be a paragraph dedicated to ethics, and organizers should not accept images implying an obvious manipulation of the subject or any behaviour that could harm marine life. Similarly, the manufacturers of underwater photography equipment (i.e. housings, strobes, etc.), could include in the instructions for use a leaflet in which all the aforementioned behaviours are discouraged.
3. Given the constant growth of underwater photography even among the youngest and most newly licensed divers, there is the possibility of stipulating a 'Low-Impact Underwater Photography' course that imposes general standards and procedures valid all over the world. In this case, the involvement of scuba diving certifying agencies and diving schools would become essential to promote such a course to anyone who approaches the practice of underwater photography or even just wants to improve their techniques. Also, more attention is needed on trim techniques. In fact, the horizontal trim in neutral buoyancy, without

leaning or using the hands, must become a technical component in all training courses.

5.2 Future research perspectives

This study aimed to understand diving codes of conduct in Italian MPAs and compliance thereof, with observations and questionnaires dedicated exclusively to divers at three case study MPAs and a focus on underwater photographers. A future perspective may consist of verifying whether the results obtained with this study are the same as those obtained outside the MPAs. The possibility is that the awareness of diving into a protected site can ensure that divers and photographers behave more respectfully of the environment and that the number of contacts with the seabed and harmful interactions with organisms is greater in unprotected sites. Furthermore, as this study was conducted in temperate environments and a single country, it reflects only a partial view. For example, the situation may be different in tropical environments, where the pressure from the underwater activity is much higher, especially when considering destinations known to attract underwater photographers from around the world.

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un approccio di contabilità ambientale. *XIII Conferenza nazionale sulla Biodiversità,* 1-19.

APPENDIX

Appendix 1. Table of MPAs' codes of conduct for scuba diving

Codes of Conduct Italian MPAs											
	Contact with the seabed, even partial removal and damage of any material and / or organism of a geological, biological and archaeological nature is not allowed	It is not allowed to feed marine organisms, to introduce or abandon any material and, in general, to have behaviors that disturb the organisms	It is mandatory to keep the equipment as close to the body as possible, so as not to disturb or accidentally damage the organisms	It is mandatory to report to the managing body or to the local maritime authority the presence on the seabed of the protected marine area of waste or hazardous materials and abandoned fishing gear	The use of auxiliary means of underwater propulsion is not allowed, with the exception of those that may be used by disabled people, subject to the authorization of the managing body	It is mandatory to inform oneself in advance about the environmental characteristics and regulations of the marine protected area, in particular the specific diving site	Transit in natural caves must take place in the ways and times strictly necessary for the purpose of carrying out the submerged path	It is not allowed, unless specifically authorized by the managing body, to land ashore	The dive must be carried out in compliance with the rules laid down by the teaching of your license	In each site, scuba diving and freediving must take place within a radius of 50 meters, calculated from the vertical of the mooring point, or from the scuba buoy, or from the float that signals the presence of scuba divers and / or freedivers in immersion	Access to the submerged caves is allowed only with the use of closed or semi-closed circuit breathing apparatus, with air discharge outside the caves.
Capo Carbonara	1	1	1	1	1	1	0	0	0	0	0
Capo Rizzuto	1	1	1	1	1	1	1	0	0	0	0
Cinque Terre	1	1	1	1	1	1	0	0	0	0	1
Asinara	1	1	1	1	1	1	0	1	0	0	0
Bergeggi	1	1	1	1	1	0	0	0	0	0	0
Ustica	1	1	1	1	1	1	0	0	0	0	0
Isole Ciclopi	1	1	1	1	1	1	0	0	1	1	0
Ventotene e Santo Stefano	1	1	1	1	1	1	0	0	0	0	0
Isole Egadi	1	1	1	1	1	1	0	0	0	0	0
Isole Pelagie	1	0	1	0	0	0	0	0	0	0	1
Isole Tremiti	1	1	1	1	1	1	0	0	0	0	0
Miramare	1	1	1	1	0	0	0	0	0	0	0
Penisola di Sinis	1	1	1	1	1	1	0	0	0	0	0
Plemmirio	1	1	1	1	1	1	0	0	0	0	0
Porto Cesareo	1	1	1	1	1	1	0	0	0	0	0
Portofino	1	1	1	1	1	0	1	0	0	0	0
Punta Campanella	1	1	1	1	1	1	0	0	0	0	0
Regno di Nettuno	1	1	1	1	1	1	0	0	0	0	0
Santa Maria di Castellabbate	1	1	1	1	1	1	0	0	0	0	0
Secche della Meloria	1	1	1	1	1	1	0	0	0	0	0
Tavolara	1	1	1	1	1	1	0	0	0	0	0
Tor Paterno	1	1	1	1	1	1	0	0	0	0	0
Torre del Cerrano	1	1	1	1	1	1	0	0	0	0	0
Torre Guaceto	1	1	1	1	1	1	0	0	0	0	0

Appendix 2. In situ observation table

Diving observations

Date_____

Dive site_____

Main substrate_____

Maximum depth_____

Dive time_____

	Rule 1	Rule 2	Rule 3	Notes – Rule 7
1				
2				
3				
4				
5				
6				
7				
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23				

Appendix 3. Questionnaire

SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

This information will only be used to describe the composition of the sample and will not be used to make any inferences about the individuals.

1. What gender do you identify with? _____
2. What is your age? _____
3. What is your country of origin and residence? _____
4. What is your highest level of education? _____
5. Do you have a study background in marine biology and/or environmental sciences? _____
6. What is your primary occupation/profession? _____
7. What is your highest level of scuba diving certification? And which agency? (PADI, SSI, SNSI, FIAS, FIPSAS, etc.) _____
8. How many years have you been diving? _____ years
9. How many lifetime dives have you logged? _____ dives
10. How many dives do you log, on average, in a year? ____ dives
11. What wildlife subjects would you like to see and/or photograph at the location you are diving in? (Maximum 3)

_____

SECTION B: RULES KNOWLEDGE AND COMPLIANCE

12. Do you know of the existence of a code of conduct for scuba divers regarding the environment and/or wildlife in the location you are in? If yes, can you name some rules?
    - o Yes
    - o No

_____
_____
_____

13. Based on your self-evaluation, have you breached any rules of the code of conduct and/or diving safety rules? If yes, which ones? (i.e. touching the bottom and/or animals, stressing and chasing animals, leaving litter underwater, diving beyond your certification levels, etc.)
    - o No, never
    - o Yes, but rarely
    - o Yes, sometimes
    - o Yes, often
    - o Yes, always
    - o I don't know

_____
_____
_____

14. Have you ever observed operators and divemasters breaching any rules of the code of conduct?
    - o Yes
    - o No
    - o I am not sure

SECTION 3: ENVIRONMENTAL HEALTH PERCEPTION

15. How damaging for the dive site do you think the following factors would be?

	It is actually beneficial	Neither damaging nor beneficial	Slightly damaging	Damaging	Very damaging	I am not sure
a. Fishing nets are covering the substrate	1	2	3	4	5	6
b. A diver is laying on the bottom	1	2	3	4	5	6
c. Marine sponge colonies are decreasing in size	1	2	3	4	5	6
d. There is an abundance in sea walnuts (Ctenophora)	1	2	3	4	5	6
e. A biologically peculiar rock is overcrowded by divers	1	2	3	4	5	6
f. A small group of divers is taking a marine life census as a citizen science activity	1	2	3	4	5	6
g. There is plastic debris at the surface	1	2	3	4	5	6
h. There is plastic debris on the bottom	1	2	3	4	5	6
i. There is a high boat traffic	1	2	3	4	5	6
j. *Posidonia oceanica* meadows are being substituted by other species	1	2	3	4	5	6
k. An anchor is laying on the bottom	1	2	3	4	5	6
l. Groupers and/or other high predators are present	1	2	3	4	5	6
m. The sediment is being resuspended by someone/something	1	2	3	4	5	6
n. Fan mussel (*Pinna nobilis)* shells are empty	1	2	3	4	5	6
o. An underwater photographer is repeatedly touching the substrate and moving subjects	1	2	3	4	5	6

SECTION 4: UNDERWATER PHOTOGRAPHY

16. What camera were you using during the dive you just finished?
    - o I did not use a camera
    - o Yes: Action cam (GoPro or similar)
    - o Yes: Compact camera
    - o Yes: Mirrorless or DSLR camera
    - o Yes: other
17. What type of photographer would you consider yourself to be?
    - o Occasional/amateur
    - o Moderately involved
    - o Heavily involved
    - o Professional