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Cultural Ecosystem Services Provided by Coralligenous Assemblages and *Posidonia oceanica* in the Italian Seas

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Posidonia oceanica meadows and coralligenous reefs are two Mediterranean ecosystems that are recognized as suppliers of valuable ecosystem services (ESs), including cultural services. However, valuation studies on these ecosystems are scarce; rather, studies have mainly focused on provisioning and regulating services. Here we focus on the cultural services provided by *P. oceanica* and coralligenous assemblages by addressing a specific group of users. Through an online survey submitted to Italian scuba divers, we assess their willingness to pay for a dive in the two ecosystems and how their preferences will change under different degradation scenarios. Diving preferences are assessed using a discrete choice experiment. The results confirmed that ecological knowledge is associated with higher ecosystem values. Moreover, the results confirm and assess how a high degradation of coralligenous and *P. oceanica* habitats would reduce the value of the underwater environment, by decreasing scuba diver satisfaction and their rate of return visits. Considering a 50% reduction in the coverage of keystone species, the marginal willingness to pay decreased by approximately €56 and €18 for coralligenous reefs and *P. oceanica,* respectively, while the willingness to pay decreased by approximately €108 and €34, respectively, when there was a total reduction in coverage. Our results can be used to support marine ecosystem-based management and the non-destructive use of Mediterranean *Posidonia oceanica* meadows and coralligenous reefs.

Keywords: coralligenous, *Posidonia oceanica*, scuba divers, willingness to pay, cultural services, ocean literacy

INTRODUCTION

Coralligenous reefs and *Posidonia oceanica* meadows are two Mediterranean ecosystems that are important suppliers of highly valuable ecosystem services (ESs) and benefits and have a fundamental role in supporting human wellbeing (Salomidi et al., 2012; Campagne et al., 2015). Following ES theory (CICES V4.3, 2012), coralligenous reefs and *P. oceanica* meadows provide humans with several services belonging to provisional (i.e., food, raw materials, pharmaceutical molecules), regulating (i.e., carbon sequestration, nutrient recycling), and cultural ecosystem services (CESs), including numerous services (i.e., high biodiversity, fish abundance, complex habitats to explore, and water clarity) that enhance the quality and the enjoyment of underwater recreation activities (Campagne et al., 2015; Thierry de Ville d'Avray et al., 2019). However, coralligenous reefs and *P. oceanica* meadows are particularly vulnerable to several anthropogenic pressures that are increasingly threatening coastal waters worldwide, including those in the Mediterranean Sea. Indeed, the Mediterranean Sea is currently facing multiple anthropic pressures, which affect the ecological, economic, and social spheres (de Groot et al., 2012). Mediterranean marine ecosystems, including coralligenous reefs and *P. oceanica* meadows, are highly threatened by local and global stressors, which often interact with one another. These stressors include intensive coastal development, pollution, invasive alien species, unsustainable fishing practices, poorly planned tourism (Coll et al., 2012; Katsanevakis et al., 2014; Randone et al., 2017), and global drivers of climate change (Jordà et al., 2012; Marbà et al., 2014; Martin et al., 2014; Gaylord et al., 2015; Zunino et al., 2017). Indeed, in the business-as-usual scenario of anthropogenic emissions (IPCC, 2014), the observed and projected levels of ocean acidification (OA) and global warming may highly threaten *P. oceanica* and coralligenous ecosystems (Jordà et al., 2012; Gattuso et al., 2015; Chefaoui et al., 2018; Zunino et al., 2019).

Over the past two decades, the scientific community has developed and adopted the ES framework, aiming to highlight the complex relationship between human ecosystems and ecosystem functioning. The power of this framework lies in the integration of the ecological dimension into the economic and social dimensions by applying a common system of values. The goal is to improve environmental decision making by providing information regarding the benefits of nature conservation, the costs of degradation, and the consequences of ecosystem changes in terms of human wellbeing. Mapping and assessing ESs is considered to be a key action for environmental governance in support of biodiversity objectives and ecosystem-based planning (Maes et al., 2016). Moreover, monetary valuation tools can be used to raise awareness among users and provide information for managers and policy-makers (Wright et al., 2017). Although our understanding of the ways in which ESs support human wellbeing has increased over the last two decades, the available data on marine ecosystems and the methods used to assess them are much more limited when compared to those pertaining to terrestrial ecosystems (Liquete et al., 2013). In addition, assessing and valuing marine ESs is still a challenging task despite the recent methodological and operational advances (Hattam et al., 2015; Garcia Rodrigues et al., 2017; Newton et al., 2018). Indeed, Mediterranean marine ESs, particularly CESs, are often overlooked due to their limited visibility and accessibility (Liquete et al., 2013; Garcia Rodrigues et al., 2017) and due to the difficulties in valuing non-material benefits (Chan et al., 2012).

To a large extent, the economies of countries bordering the Mediterranean Sea rely on cultural activities including both coastal and marine tourism. Marine tourism in the Mediterranean Sea generates US$110 billion annually (∼€90 billion), representing, together with coastal tourism, 92% of the annual economic output of all sectors related to the sea (Randone et al., 2017). Coastal natural destinations are of particular interest to scuba divers, whose recreational activities have become one of the most important factors in the marine tourism sectors globally (PADI, 2017; Lucrezi et al., 2018a). Uncontrolled coastal tourism, including unregulated scuba diving, can negatively impact marine ecosystems (United Nations Environment Programme [UNEP], 2015; Habibullah et al., 2016), and as the number of scuba divers is currently increasing, concern related to environmental deterioration has also increased (Flores-de la Hoya et al., 2018). However, because high-value nature-based tourism largely relies on the maintenance of a good environmental status and on the preservation of all ecosystem functions (Drius et al., 2018), the sustainable management of this activity can represent a viable alternative to more destructive uses of the environment (De Brauwer and Burton, 2018). Hence, there is an urgent need to analyze, estimate, evaluate and communicate all these values, including the cultural values, provided by threatened marine ecosystems, such as coralligenous reefs and *P. oceanica* meadows; this information can be used to facilitate their inclusion in ecosystem-based management policies, which are also directed to improve and maintain sustainable blue jobs (EU Commission, 2017).

Here, we collected all the information on the existing valuation studies of cultural ecosystem services related to the Mediterranean marine ecosystem. Then, we performed an explorative evaluation study aimed at highlighting the societal implications of the degradation of coralligenous and *P. oceanica* meadow ecosystems, with a particular focus on the Italian diving sector. We apply non-market analysis techniques to assess underwater recreational services provided by coralligenous reefs and *P. oceanica* meadows using an online questionnaire (MEA, 2005; de Groot et al., 2010; Chan et al., 2012; Daniel et al., 2012).

MATERIALS AND METHODS

Study Area

Italy is a country with 8309 km of coastline that essentially separates the Mediterranean Sea into Western and Eastern sub-basins. Coralligenous assemblages are widespread along the Italian coast, with the exception of the sandy-muddy seabed between the Po river delta and the Gargano peninsula (Ingrosso et al., 2018). *P. oceanica* is present along most of the West Mediterranean and in the western Adriatic Sea. Coralligenous assemblages and *P. oceanica* meadows are considered to be the most important hotspots of species diversity in the Mediterranean (Ballesteros, 2006) (**Figure 1**).

The Mediterranean seagrass *P. oceanica* creates the "climax community" of soft sublittoral habitats covering a known area of 1,224,707 ha in the Mediterranean Sea (Giakoumi et al., 2013; Telesca et al., 2015). In addition, coralligenous reefs have been described as mesophotic biogenic structures produced by the growth and accumulation of calcareous encrusting algae (Ballesteros, 2006). Bioconstructors, such as coralligenous species, can be very common from 18–20 to 100 m depth and more. Because a wide variety of human activities threaten *P. oceanica* and coralligenous ecosystems, they are both under protection. *P. oceanica* is included on both the Red List of marine threatened species of the Mediterranean (Boudouresque et al., 1990) and the list of priority natural habitats in Annex I of

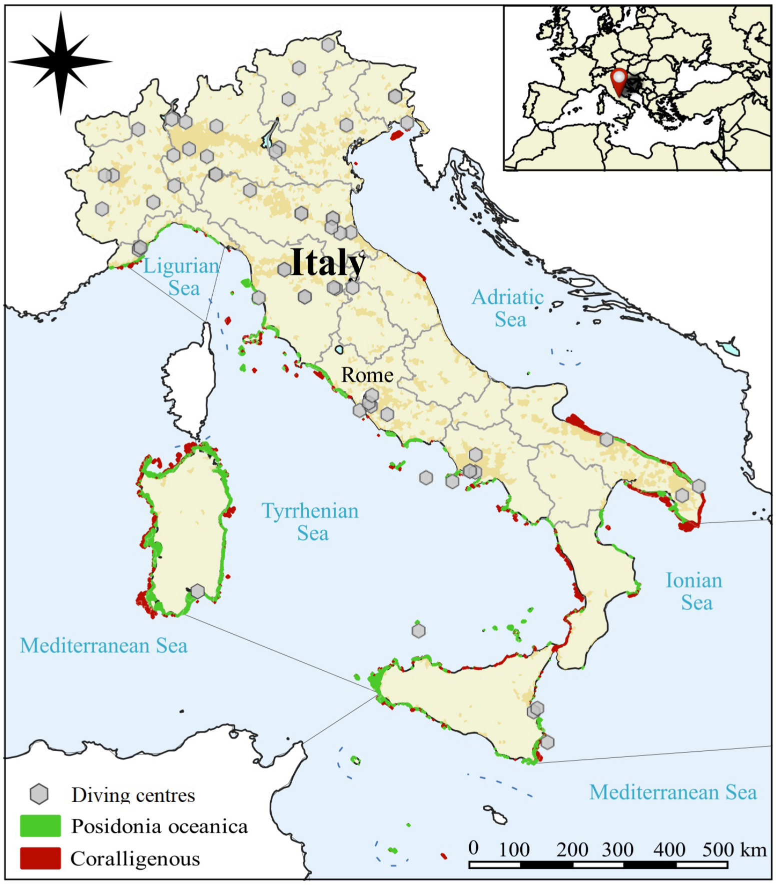


FIGURE 1 | Location of the study site and distribution of *P. oceanica* meadows and coralligenous assemblages along the Italian peninsula Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats project (http://www.emodnet-seabedhabitats.eu/), funded by the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE). Gray dots represent the diving centers that have received the questionnaire.

the EC Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (EEC, 1992), while coralligenous reefs were incorporated as habitats that require protection into the Protocol for Special Protected Areas (SPA/BD, 1995) of the Barcelona Convention for the Conservation of Mediterranean Biodiversity.

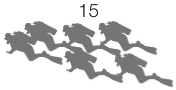
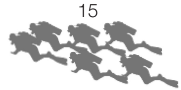
ES Framework

We performed a literature review to understand the state of the knowledge related to the identification and/or assessment of the marine CES in the Mediterranean Sea. The review was performed in June 2019 through a search of the SCOPUS database for the following relevant keywords: cultural OR "cultural ecosystem service" OR tourism OR recreat* OR social AND "ecosystem service" AND "marine" OR "sea" AND Mediterranean. Subsequently, the abstracts that specifically targeted our research focus were selected.

Valuation of CES: The Questionnaire

An online questionnaire was distributed among Italian marine divers to assess their diving habits, environmental attitude, and preferences for different diving experiences following marginal changes to ecosystems due to degradation. This work expands the analysis conducted by Rodrigues et al. (2015), which assessed the extent of the negative preference for the degradation of coralligenous reefs in the Medes Islands Marine Protected Area (MPA) in Spain, to a different Mediterranean context of the Italian divers diving in the Italian Sea and with an analysis not limited only to MPAs. Moreover, this analysis addresses *P. oceanica* meadows, for which, despite their uncontroversial ecological relevance and contribution to the preservation of Mediterranean biodiversity, few cultural valuation studies exist (Dewsbury et al., 2016). Among the general public, the level of knowledge about seagrass ecosystems and their associated services is low (i.e., Unsworth et al., 2019), for this reason we addressed the valuation of seagrass cultural services among divers. Divers, as other stakeholders that directly interact with the sea, better understand the functioning of different marine ecosystems, including *P. oceanica,* and their associated services (Ruiz-Frau et al., 2018). The *P. oceanica* ecosystem is not a preferred diving location (Lucrezi et al., 2018b), and its inclusion in our study

TABLE 1 | Example of choice set.

Characteristic of the dive	Site 1	Site2	Neither
Number of divers found on a diving trip	15 	15 	Choose not to take a dive
Expected state of gorgonian (red coral, black gorgonian, yellow gorgonian)	50% cover of corals 	50% cover of corals 	
Expected state of seagrass meadows (P. oceanica)	100% cover of Posidonia oceanica 	0% cover of Posidonia oceanica 	
Price of the dive (includes boat trip, air tank and dive insurance)	€ 40	€ 20	

was made to provide insight into the general cultural benefits provided by seagrass to divers.

From August 2016 to August 2017, an online survey was e-mailed to 18 diving centeres and clubs distributed along the Italian peninsula. The link was also spread through the OGS (Italian Institute of Oceanography and Applied Geophysics) webpage and the FIAS (Italian Underwater Activities Federation) official webpage and to all of their clubs (**Figure 1** and **Supplementary Appendix Figure A1**). The questionnaire was structured with two sections that addressed diver preferences for different levels of ecosystem quality. The first section collected personal and demographic data, such as gender, age, level of education, and diving certification, to identify factors that could be related to their responses. Additional questions explored the type of benefits that the scuba diving experience provided to them. The second section was a choice experiment (CE) which was used to model the preferences for different typologies of the diving experience using a choice modeling approach (CM) (Hanley et al., 2001). This methodology is a preference-based method; such methods are currently the most commonly used approaches to assess the economic value of ESs (Kumar, 2010). The power of the CE relies on not asking respondents directly for their willingness to pay (WTP) or to accept compensation (WTA) for a certain environmental change. In our CE, the divers were asked 6 times to choose the most preferred alternative between two choices. The alternatives differed in terms of the quality and type of attributes (technically called attribute levels) characterizing the diving experience and the state of the ecosystem.

Choice Experiment Design

We reviewed the literature to identify the attributes that maximized the divers' utility and that would likely be impacted by climate change. In particular, following Wielgus et al. (2003), Gill et al. (2015), and Rodrigues et al. (2015), we tested the consistency of the selected attributes and of their respective levels administering the questionnaires to a pre-sample of divers selected from five Italian sites (Ischia, Ventotene, Ustica, Cyclops Island, and Siracusa). Thus, the selected attributes were the "Number of divers" (per dive trip), "Coral cover," "Seagrass cover," and "Price" (per dive) (**Table 1**), while the chosen levels represented a spectrum of environmental conditions from good conservation status to heavily damaged, as detailed below:

(1) *Number of divers* found on a diving trip: The crowding level is an important consideration when valuing the quality of a dive, as suggested by several studies (e.g., Wielgus et al., 2003; Gill et al., 2015; Rodrigues et al., 2015). We selected 25, 15, and 5 as the levels of this attribute.
(2) *Coral cover* (the expected status of corals): We used the term corals as a proxy for the coralligenous environments since the latter is mostly known in the academic context (Tonin and Lucaroni, 2017). Indeed, corals are considered to be attractive features of coralligenous ecosystems in Italian diving destinations that are highly threatened by multiple anthropogenic pressures exacerbated by the drivers of climate change (Ingrosso et al., 2018 and the literature therein). Scientific literature suggests that coralligenous reefs could disappear or shift to deeper sites (Ingrosso et al., 2018) which are not suitable for recreational divers. Three levels were defined for this attribute: (a) 100% of the corals are in good condition; (b) 50% of the corals are degraded; and (c) 0% of the coral cover.
(3) *Seagrass cover* (the expected status of *P. oceanica*): Although we are aware that this ecosystem is not among the favorites of divers, the presence and status of *P. oceanica* meadows were included in the questionnaires since this ecosystem is undergoing degradation as a result of anthropogenic activities (Short et al., 2011) declining by 34% in the last 50 years (Telesca et al., 2015) and possibly becoming functionally extinct by 2100 in the worst-case emission scenario (Chefaoui et al., 2018). Three levels were defined for this attribute: (a) 100% of the seagrass meadow is in good condition; (b) 50% of the seagrass meadow is degraded; and (c) 0% seagrass meadow cover.
(4) *Price* of the dive: This attribute indicates the price of a single 50-min dive and includes the cost of the boat trip, air

TABLE 2 | Review of the marine CES in the Mediterranean Sea.

Ecosystem service		Description	ES Valuation	Site	References
Mediterranean Sea					
Cultural	Symbolic and aesthetic value (Cultural identity, Sense of place, Existence value)	Aesthetic cultural services of coralligenous	YES; quantitative	France	Tribot et al., 2016
		Deep sea perception	YES, quantitative (Q valuation)	Mediterranean deep-sea	Zanoli et al., 2015
		Sense of place (degraded habitat and jellyfish outbreaks)	YES; quantitative (WTP)	France, Gulf of Lion	Kontogianni and Emmanouilides, 2014
		Existence values (Mediterranean monk seal)	YES; quantitative (CVM)	Greece, Lesvos	Kontogianni et al., 2012
		Coastal landscape, aesthetic	YES; quantitative; monetary (market analysis)	Mediterranean Sea	Fleischer, 2012
	Recreation, leisure and tourism	Recreational value of coralligenous	YES; quantitative_monetary	Italy, Apulia region	Chimienti et al., 2017
		Recreational fisheries valuation	YES; quantitative; monetary (market analysis)	Mediterranean sea	Jackson et al., 2015
		Tourism scuba divers-coralligenous	YES; quantitative; monetary (CM)	Spain, Medes Islands	Rodrigues et al., 2013
	Cognitive effects; (Environmental education and ecological knowledge; Scientific knowledge)	Report of citizen science activities	NO	Italy, Gulf of Taranto (Ionian Sea)	Carlucci et al., 2017
		Knowledge contribution of *Posidonia oceanica (*estimated through the cost of research projects)	YES; quantitative; monetary (market analysis)	France	Campagne et al., 2015
	General overview	Marine ecosystem: aesthetics, lifestyle, and cultural identity	YES; quantitative	Italy, North Adriatic Sea	Tonin and Lucaroni, 2017
		Identification of coralligenous ecosystem services via expert valuation	YES; qualitative (expert assessment)	France	Thierry de Ville d'Avray et al., 2019
		Mapping of cultural ecosystem services	YES, Cumulative effects assessment	Italy, Northern Adriatic Sea	Menegon et al., 2018

Following Liquete et al. (2013) we categorized the results into 3 groups: recreation and tourism, symbolic and aesthetic values, and cognitive effects. General studies were categorized as general overview (WTP, willingness to pay; CVM, contingent valuation method; CM, choice modeling).

and tank for diving, and dive insurance. The average price is €40 during the high tourism season. For the CE, the price levels were set at €20, €50, €70 and €90. An opt-out option was offered in all cases.

Starting from the attributes list -with their relative levels- we created a total choice set using ALgDesign package for R software (Wheeler, 2004). A full factorial design with three three-level factors (*"Numbers of divers," "Corals cover," "Seagrass cover"*) and one four-level factor (*"Price"* -per-dive attribute) was created. The full factorial design comprised 135 combinations of the levels of each attribute ($3^3 \times 5$). In order to make the questionnaire more manageable, we generated a fractional factorial design from the full factorial design with the function optFederov (Wheeler, 2004). Following the procedure described by Aizaki and Nishimura (2008) we obtained 24 alternatives that were considered to be cognitively manageable. The alternatives were then blocked into two sets of six paired choices, each with a "neither" alternative for consistency with market decisions and were presented to divers. The presence of this latter choice option mimicked real market situations in which the diver is not forced to make a choice but can opt-out (Rodrigues et al., 2015).

Multinomial Logit Model

The CE technique is an application of the theory of value (Lancaster, 1966) combined with the random utility theory (Thurstone, 1927; Manski, 1977). According to Lancaster theory of value (Lancaster, 1966), individuals (i) obtain utility (U) not from goods themselves but from the attributes that describe these goods (Hanley et al., 1998). This theory assumes that individuals are perfectly able to discriminate between sites, basing the choice of the site j on a systematic, and observable, component, vij, which is based on the site attributes, and an additive random component ε_{ij} which is not observable. The utility function for the model used in this work is specified in Equation 1:

$$
\begin{aligned}
U_{ij} = {} & \beta_{optout} * \mathit{Opt\text{-}out}_i + \beta_{25\ divers} * \mathit{25\ divers}_i + \beta_{15\ divers} \\
& * 15\ \text{divers}_i + \beta_{\mathit{Coral}\ 50\%} * \mathit{Coral\ 50\%}_i + \beta_{\mathit{Coral}\ 0\%} \\
& * \text{Coral}\ 0\%_i + \beta_{\mathit{Seagrass}\ 50\%} * \mathit{Seagrass\ 50\%}_i + \beta_{\mathit{Seagrass}\ 0\%} \\
& * \text{Seagrass}\ 0\%_i + \beta_{price} * \mathit{PRICE}_i + \varepsilon_{ij} \qquad (1)
\end{aligned}
$$

Where *Opt-out* is a dummy variable that assumes a value of 1 for the no-choice option and 0 otherwise; *25 divers* is a dummy variable that indicates a highly crowded diving experience, and *15 divers* indicates a less crowded excursion; *Coral 50%* and *Seagrass 50%* represent dummy variables taking a value of 1 if the respondent chose the alternative including an environment that is 50% degraded and 0 otherwise; *Coral 0%* and *Seagrass 0%* are dummy variables taking a value of 1 if the respondent chose the alternative including a completely degraded environment and 0 otherwise, and, finally, *PRICE* is the price variable. The probabilistic odds that one alternative is selected over another can be estimated using a standard multinomial logit model (MNL), also called a conditional logit model (see **Supplementary Appendix A1**). The CE model analysis was conducted using the "survival" package (Therneau and Grambsch, 2000; Therneau, 2015) in the R statistical environment (R Core Team, 2015) using the clogit function (Aizaki, 2012).

Latent Class Model

As stated by Greene and Hensher (2003), the basic assumptions of the Latent Class Model (LCM) affirm that individual behavior is determined both by the attributes of the alternatives and by certain latent heterogeneity that is not observed by the researcher. Therefore, one of the main strengths of the model is its ability to capture the heterogeneity of preferences (Boxall and Adamowicz, 2002). This model assumes that the population consists of a number of latent classes that is exogenously determined and permits to overcome the limits of MNL model, which considers the utility coefficient as fixed among respondents. The unobserved heterogeneity is captured by these classes through the estimation of a parameter vector.

In this study, the LCM was used as an instrument to identify groups of divers interested in counteracting the degradation of coralligenous and *P. oceanica* meadow habitats, with a particular focus on the implications to the Italian dive sector. The LCM analysis was conducted using the program NLogit4®. Both the MNL and the LCM models shared the same linear utility function (see Equation 1 above).

Willingness to Pay

The parameters estimated by the MNL and LCM models were used to identify the diver's willingness to pay. The WTP for each attribute was derived from the models using the coefficients from each attribute level and the coefficients for price. The estimated coefficients represent the marginal utilities that are increments of utility. When the coefficients are compared with reference levels they reveal the relative importance of attributes and their levels and reflect respondents' willingness to trade one attribute level for another.

The addition of the price attribute in the utility expression is essential in order to derive implicit price for marginal changes in attribute levels (Rodrigues et al., 2015), called the marginal WTP.

The marginal WTP for attributes/levels (non-monetary variable) is calculated as $-\beta_{nm}/\beta_{price}$ (Equation 2); where β_{nm} is an estimated coefficient of the non-monetary variable and β_{price} is an estimated coefficient of the monetary variable:

$$WTP = -\frac{\beta_{nm}}{\beta_{price}} \quad (2)$$

From the parameter estimates it is possible to derive welfare changes in monetary terms. These values are associated with changes in the level of an attribute compared with its reference level, provided that the remaining parameters are held constant. WTP measures reflect utility increases when the value is positive. This can be interpreted as WTP for a change in a certain attribute level. However, a negative value indicates a decrease in utility. This result suggests that individuals require compensation through lower prices (Train and Weeks, 2005) to have the same level of utility as that in the reference dive. We calculated the negative ratios of the parameters associated with each attribute level and price.

RESULTS

ES Framework

The SCOPUS search listed 48 articles targeting CES in the Mediterranean Sea, which were further reduced to 14 after an analysis of the abstracts. The results were grouped into three categories, recreation and tourism, symbolic and aesthetic values, and cognitive effects, according to Liquete et al. (2013) (**Table 2**).

Notably, only a few studies have focused on coralligenous and *P. oceanica* ecosystems. Among the others, Tonin and Lucaroni (2017) found that the general public is not generally aware of the existence and/or the value of coralligenous ecosystems; however, the authors highlight the important role of public education and communication to enhance awareness of endangered ecosystems.

Valuation of CES: The Questionnaire

The online survey was completed by 221 Italian scuba divers; of a total of 229 respondents, the surveys submitted by 8 were discarded due to incompleteness.

The respondents were Italian, with an average age of 43 years, and 71% were male ($\chi^2 = 37.88$, df = 1, $p < 0.001$). The mean number of years of diving experience per diver was 13 years, ranging from 1 to 50 years, and the divers mainly held superior dive licenses from divemaster to technical licenses ($\chi^2 = 135.67$, df = 2, $p < 0.001$). The mean number of dive trips per recreational diver (open, advanced) was 15 per year, ranging from 1 to 40 dives per year. Divers holding a superior dive license reported a mean of 53 dives per year, ranging from 5 to 250. Over half of the surveyed divers were employed full time (73%; $\chi^2 = 383.77$, df = 4, $p < 0.001$), with an average annual gross income of between €30,001 and €40,000 (51%) (**Supplementary Appendix Table A1**).

The respondents were asked about the importance of some features determining the choice of a dive experience location (**Figure 2**). The most important factors that the respondents selected were the beauty of the underwater landscape (important for 91% of the divers; $\chi^2 = 77$, df = 1, $p < 0.001$; **Figure 2**), the abundance of marine fauna (90%; $\chi^2 = 73$, df = 1, $p < 0.001$; **Figure 2**), the wellbeing that they derived from

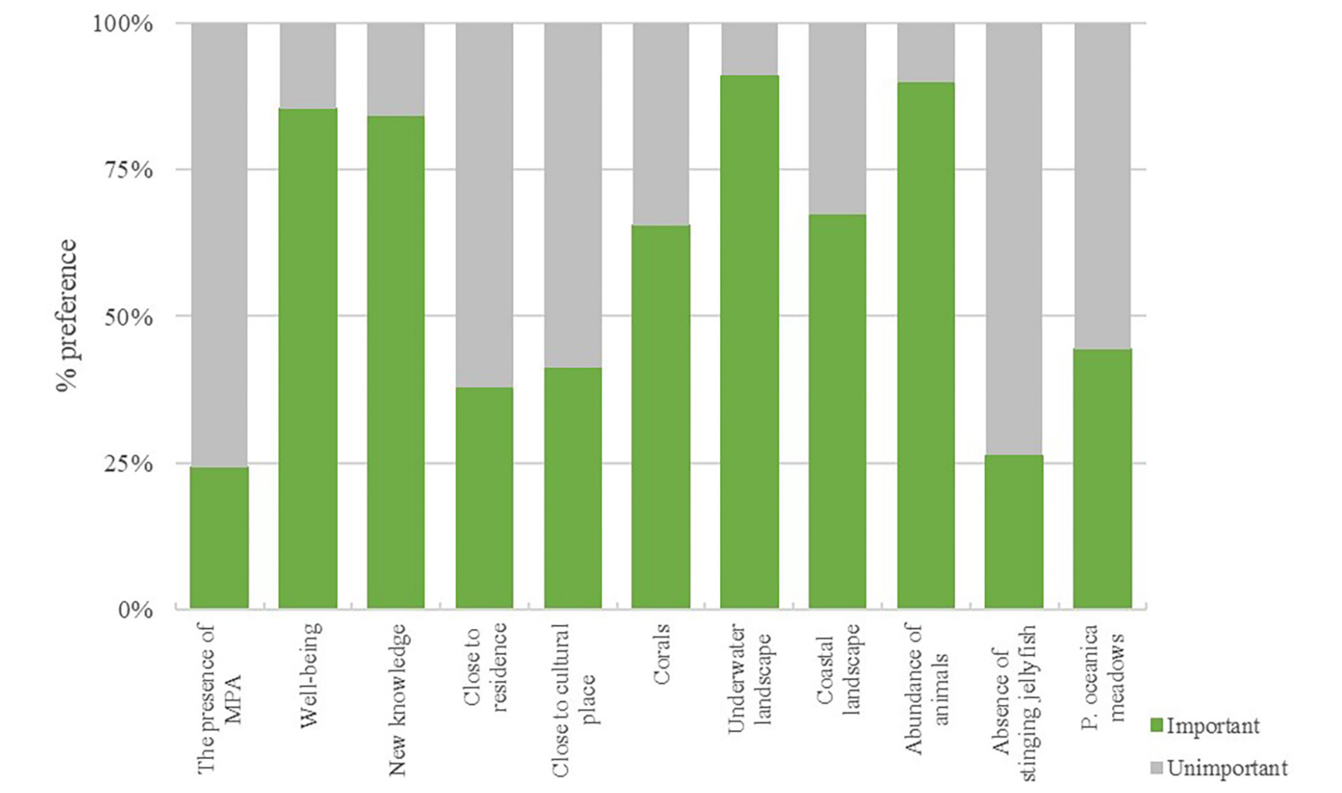


FIGURE 2 | Percentages of diver preferences among different features determining the choice of a dive experience location. The green bars represent the responses classified as important and very important, while the gray bars represent the responses classified as unimportant and very unimportant.

the dive experience (85%; $\chi^2 = 58$, df = 1, $p < 0.001$; **Figure 2**), and the acquisition of new knowledge (84%; $\chi^2 = 77$, df = 1, $p < 0.001$; **Figure 2**), confirming the relevant role of the marine environment as a provider of important CESs. Significant preferences were also related to the presence of corals (66%; $\chi^2 = 11$, df = 1, $p = 0.001$; **Figure 2**) and to the coastal landscape (67%; $\chi^2 = 14$, df = 1, $p < 0.001$; **Figure 2**), while no significant preference for the *P. oceanica* meadows was found (44%; $\chi^2 = 1$, df = 1, $p = 0.25$; **Figure 2**).

The divers with more than 10 years of experience were asked to indicate their perception of the status of the underwater environments. 70% of the respondents agreed that the underwater habitat conditions had worsened since they began diving ($\chi^2 = 209.08$, df = 4, $p < 0.001$). The main reasons were decreases in the numbers and size of the fish and corals (33%), increases in plastic litter, ghost nets and pollution (29%), and the increased abundance of stinging jellyfish, alien species and algae (9%).

However, almost 12% of the respondents with more than 10 years of diving experience acknowledged that the MPAs have significantly improved the environmental status through an increase in the presence of marine biodiversity within the MPAs. Most of the respondents (74%; $\chi^2 = 51.88$, df = 1, $p < 0.001$) visited at least one MPA during their lifetime, and among them, more than 91% evaluated the experience as good or excellent ($\chi^2 = 152.67$, df = 1, $p < 0.001$).

The respondents were also asked to choose among three species the one that they would like to see during a dive trip (**Figure 3**). The respondents were grouped by their level of expertise (i.e., beginners vs. experts). No difference was found between beginners and experts in the choice of emblematic species (χ^2 test, df = 1, $p > 0.05$; **Figure 3**), except for scorpionfishes and moray eels, which appear to be more appreciated by beginners (χ^2 test, df = 1, $p < 0.05$; **Figure 3**). Overall, more than half of the participants selected red corals (51%), groupers (42%), and seahorses (51%) (**Figure 3**).

The results of the CE showed that the decision to take a dive was chosen by 81% of the respondents in the choice simulation. All coefficient estimates with the MNL were significant at the 99% level, except for the attribute level "*Seagrass cover 50%,*" which showed 90% significance (**Table 3**).

The coefficient of the variable "*Price*" was negative and significant, indicating the respondents' preference for a cheaper option. The attribute levels "*Coral cover 50%*" and "*Coral cover 0%*" had significantly negative coefficients (p-value < 0.05), indicating that respondents highly prefer habitats with good coral coverage for their diving rather than those with partial or total degradation of the coral cover (**Table 3**).

The seagrass parameters indicate a slight preference of the divers ($p = 0.02$) for habitat with seagrass meadows in good condition ("*Seagrass cover 100%*") and that they significantly rejected degraded habitat ("*Seagrass cover 0%*") (**Table 3**). We

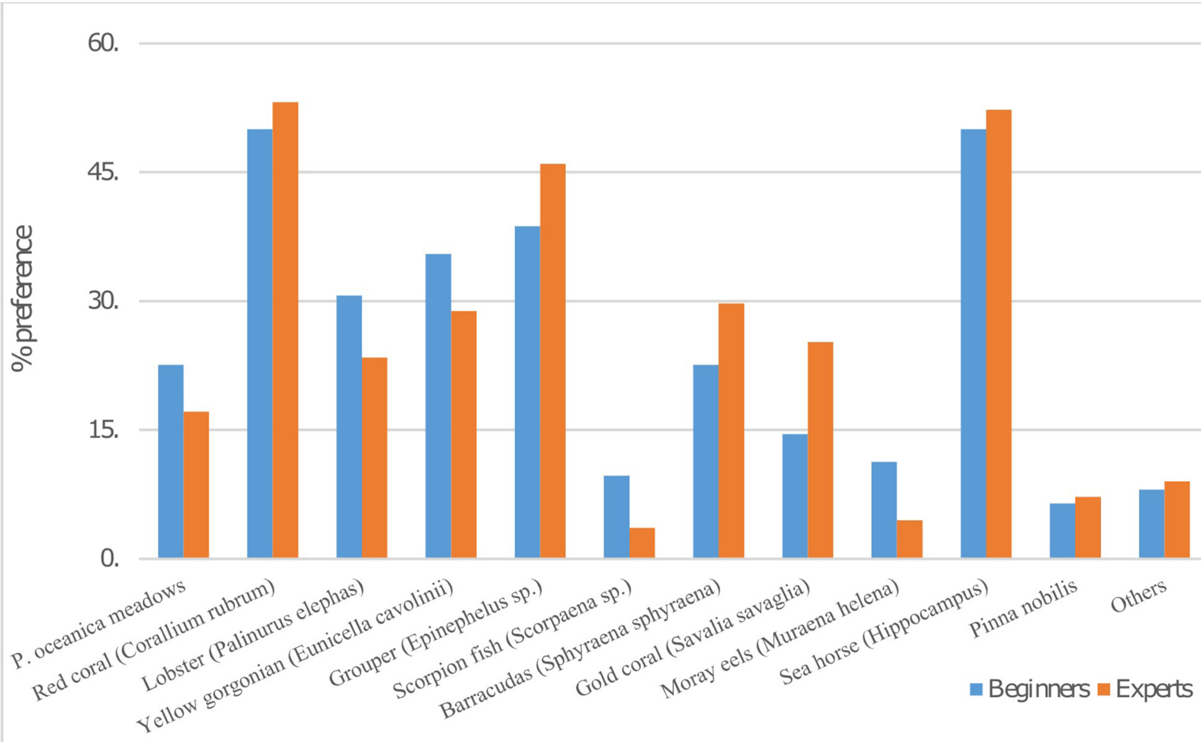


FIGURE 3 | Percentages of diver preferences regarding emblematic Mediterranean marine species. The blue bars represent the responses of beginner divers (open and advanced licenses, *N* = 79), and the orange bars represent the responses of expert divers (superior dive license, *N* = 142).

TABLE 3 | MNL and LCM results.

			Latent class model (LCM)					
n 221	**Conditional logit (MNL)**		**Class 1**		**Class 2**		**Class 3**	
Attributes	**Coef (*SE*)**	**WTP (€/trip)**	**Coef (*SE*)**	**WTP (€/trip)**	**Coef (*SE*)**	**WTP (€/trip)**	**Coef (*SE*)**	**WTP (€/trip)**
Opt-out	−4.33 (0.25)***	/	−1.47 (0.30)***	/	−1. 27 (0.72)	/	−4.46 (0.82)***	/
Price	−0.02 (0.00)***	/	−0.01 (0.00)***	/	−0.05 (0.01)***	/	−0.17 (0.02)***	/
25 divers	−2.24 (0.13)***	−114.55	−1.87 (0.23)***	−187	−14.24 (99.95)	/	0.50 (0.51)	/
15 divers	−0.9 (0.17)***	−45.87	−0.56 (0.18)***	−56	−2.64 (0.44)***	−52	−2.66 (0.45)***	−15.7
Coral 50%	−1.09 (0.15)***	−55.84	−1.22 (0.22)***	−122	−0.09 (0.48)	/	−6.87 (0.67)***	−40.4
Coral 0%	−2.11 (0.14)***	−108.01	−2.49 (0.25)***	−249	−0.43 (0.44)	/	−8.56 (0.78)***	−50.3
Seagrass 50%	−0.35 (0.14)*	−18.12	0.34 (0.20)	/	−0.59 (0.57)	/	−10.40 (1.01)***	−61.2
Seagrass 0%	−0.68 (0.13)***	−34.71	−0.77 (0.15)***	−77	−2.09 (0.48)***	−41.8	−4.16 (0.45)***	−24.47
Adj *R*-squared	0.18		Average probability	0.66	0.13		0.21	
Likelihood ratio test	902.3				Theta in class probability model			
AIC	4138.15		Higher educational level		1.00 (0.50)**		0.22 (0.79)	Fixed Parameter
BIC	4179.67		Experience (≥15 years)		2.15 (0.89)***		2.71 (1.06)***	Fixed Parameter
Log-likelihood	−2512.25		Superior dive license		0.49 (0.46)		1.56 (0.84)	Fixed Parameter

****Significant at a 99% confidence level; **Significant at a 95% confidence level; *Significant at a 90% confidence level.*

found that the respondents significantly preferred less crowded dives instead of more crowded ones ($p < 0.05$; **Table 3**). Moreover, they also assigned a low preference to the intermediate level of crowdedness, the "*15 divers*" level ($p < 0.05$; **Table 3**), which differs from Rodrigues et al. (2015), who did not find a significant response in terms of the "*15 divers*" dive attribute level. The approximation of the mean WTP for the different levels of the attributes suggest that the divers were willing to pay approximately €56 less if the coral coverage decreased by 50% and €108 less if corals disappeared entirely. The same occurred for the *P. oceanica* coverage, for which the respondents were willing to pay approximately €18 and €34 less in the case of a partial or total

TABLE 4 | Latent class model statistics.

	LCM-2	LCM-3	LCM-4	LCM-5
LL	−1023.699	−975.951	−950.390	−939.141
AIC	1.574	1.520	1.500	1.501
BIC	1.652	1.645	1.672	1.720
HQIC	1.603	1.567	1.564	1.583
McFadden pseudo R^2	0.30	0.33	0.35	0.35

The model with three classes minimizes the BIC value. In addition, the AIC and R^2 values indicate that this model is suitable for the aim of our study.

loss, respectively. The results also suggest that the scuba divers were willing to pay less for highly crowded dive trips (25 divers).

The number of classes for the LCM analyses was identified before the evaluation of the parameters that was performed using the Bayesian information criterion (BIC) and Akaike information criterion (AIC) (Boxall and Adamowicz, 2002) (**Table 4**).

The three-class LCM (LCM-3) indicated that the sample showed heterogeneous preferences and that the respondents could be divided into three classes, representing 66, 13, and 21% of the divers, respectively.

It is interesting that the coefficients for class two were not significant ($p > 0.05$) except for *"Price,"* an intermediate number of divers and no seagrass cover. The members of this class when choosing the most preferred alternatives considered only the number of divers found during a diving trip ("*15 divers,*" $p < 0.05$) and seemed to be independent of the other attributes considered in our experiment. However, they showed also a negative WTP for the absence of seagrass cover. Each of the other two classes was characterized by a different structure of preferences. In detail, members of class one were more concerned about having a good quality of coral cover ("*Coral cover 50%,*" $p < 0.05$, and "*Coral cover 0%,*" $p < 0.05$), the level of seagrass cover ("*Seagrass cover 0%,*" $p < 0.05$) and a low crowding level of divers on a trip ("*25 divers,*" $p < 0.05$; *15 divers,*" $p < 0.05$), while members of class three preferred a high coral cover ("*Coral cover 50%,*" $p < 0.05$, and "*Coral cover 0%,*" $p < 0.05$) and a high seagrass cover (*Seagrass cover 0%,*" $p < 0.05$; *Seagrass cover 50%,*" $p < 0.05$) and did not have a clear preference regarding the number of divers on a trip ("*25 divers,*" $p > 0.05$). We will refer to members of class two as "dive-alone divers" and members of classes one and three as "pro-habitat conservation divers," although class one had a positive but insignificant low seagrass cover attribute value, meaning a low preference for a high abundance of these meadows.

Furthermore, members of class one had a lower (negative value) WTP for degraded coral cover on average (−€186) than the other classes. In addition, considering their WTP value for the highest level of the number of divers attribute, class one strongly preferred to avoid crowded trips (WTP −€187), while members of class three had a lower but negative WTP (€-15.7). The interactions between the attribute and socio-economic variables show that class one is composed of more experienced divers (in terms of years of experience) and those with a higher level of education (master's degree), while there was no correlation with the license level. Regarding class two (also called the "dive alone divers"), the results show a correlation only with the more experienced divers. The *Opt-out* coefficients capture the degree to which respondents tend to choose no scuba diving experiences. The *Opt-out* coefficient was negative and significant ($p < 0.05$) for classes one and three, indicating that respondents were more likely to choose one of the alternatives.

DISCUSSION

The results of the analysis of the data from the online questionnaire administered to Italian divers provide new insights into their attitudes toward coralligenous and *P. oceanica* meadow ecosystems and furthermore contribute to the valuation of the marine CESs they provide.

As can be inferred from the results, a diving experience is rated not only in terms of the quantity and quality of the charismatic environments or species (as indicated by the rates of preferences for the *presence of corals*, the *abundance of animals* or the *underwater landscape* features) but also for *knowledge-related* and *environmental-related* features, as expressed by the choices for *new knowledge* and the presence of *P. oceanica meadows.* The last choice, in particular, reveals a positive environmental attitude because the meadows themselves are not very attractive in terms of the diving experience. Therefore, the choice of a diving site, including those with *P. oceanica,* could indicate the respondent's knowledge regarding the indirect functions that the *P. oceanica* meadows provide to the ecosystem (i.e., protection of juveniles from predators and allowing the aggregation of individuals and their reproductive success). The divers' "pro-habitat" conservation attitudes were also confirmed by the LCM for the two most numerous classes (class one and class three), grouping 66 and 21% of the divers, respectively. This, in the end, supports the importance of "knowledge" as an important element which increases the "value" of the ecosystems and confirms that "understanding the ocean is essential to comprehending and protecting this planet on which we live," as quoted from the Ocean Literacy Framework[1]. A secondary benefit of ES valuation exercises lies in fostering the relationship with the environment, acting "as a tool of self-reflection that helps people rethink their relationships with the natural environment and increase their knowledge about the consequences of consumption, choices and behavior" (Brondìzio et al., 2010). Thus, the scientifically sound assessment of ESs can support local managers as well as marine governance bodies in the complex process of valuation aimed at supporting both ecosystem-based management and knowledge on ecosystem functions and values.

Coralligenous and *P. oceanica* meadow ecosystems provide a variety of ESs whose valuation requires a combination of different approaches to assess all the different types of benefits. Our study focused on a subset of these services, CESs, which are classified as non-consumptive benefits that are related to wellbeing, aesthetic inspiration, cultural identity, and spiritual experience.

The WTP estimates obtained from the MNL and LCM confirm the importance of structured and complex ecosystems

[1] http://oceanliteracy.wp2.coexploration.org/ocean-literacy-framework/

as providers of benefits for scuba divers. In the present study, as expected and in agreement with Rodrigues et al. (2015), we found that scuba divers have a strong predilection for coralligenous habitats but are also sensitive to the loss of *P. oceanica* meadows. Declines in the coverage of both corals and *P. oceanica* would result in significant economic losses to the recreational dive industry in the Italian peninsula. Conversely, proper management that promotes habitat conservation will likely have a positive economic impact on diving tourism and significantly influence the choice of a dive site destination.

However, when considering the present valuation study, we must note that our results are based on the responses of people who voluntarily participated. This could mean that our sample was potentially biased toward scuba divers who were likely more interested and committed to environmental issues, as confirmed by the high percentage (74%) of respondents who had visited at least one MPA during their lifetime.

Another important point to be taken into account is that the number and origin of the sample of 221 Italian divers, despite providing statistically significant results, should be treated and interpreted in the proper context. As for any other local valuation study, the extrapolation of these results requires the application of a benefit transfer analysis that allows scaling up and transposing the values obtained in an original study to a different policy context (Smith et al., 2002). WTP is strongly related to the socio-economic context in which the valuation takes place, and the generalization of the results should only be conducted by adjusting the results to the different contexts. This could allow us to extend these results to members of the entire international community who dive in Italy and to the coralligenous and *P. oceanica* ecosystems across the Mediterranean Sea. This valuation, however, as for any other valuation of ES, should not serve as a substitute for other scientific or ethical reflections and systems of values related to biodiversity conservation. Instead, valuation should be used to complement them and to provide information that can guide policymaking (Turner and Daily, 2008).

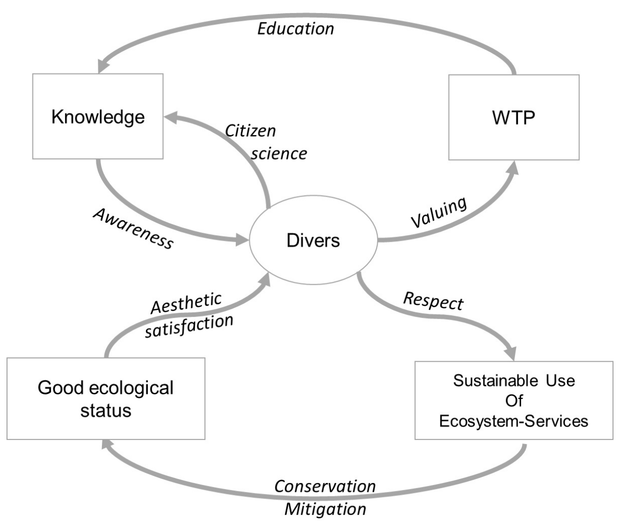


FIGURE 4 | Ocean and Ecological literacy can promote the sustainable use of marine ecosystems and contribute to both ecological conservation and blue growth. In fact, even if divers value (and are willing to pay for) pristine and well-preserved ecosystems mainly for aesthetic reasons, they appreciate, respect, and value them even more, when they are aware of the ecological importance of those systems. Positive feedback arises when extra-value is used to sustain education, conservation and mitigation.

CONCLUSION

This study contributes to the valuation of Italian marine benthic ecosystems and estimates how their disappearance could lead to economic losses. The coastal underwater landscape attracts millions of scuba divers yearly and depends on the presence of healthy environments. The current threats imposed by human pressures on the marine environment, which are exacerbated by climate change, are degrading these ecosystems and the flow of their ESs. The potential loss of economic value may, in turn, negatively impact other economic activities directly or indirectly related to scuba diving tourism. By highlighting the losses that could be caused by habitat destruction, our estimates can be used to support sustainable and non-disruptive diving tourism activities and the implementation of local conservation policies. However, the consideration of an interest in coralligenous and seagrass should be treated with caution, as excessive scuba diving activities in these ecosystems may ultimately cause ecological damage. Balanced uses of diving sites must be considered by mitigating the negative effect of human presence pressures with the positive effects derived from increasing people's awareness of these ecosystems, especially for the *P. oceanica* meadows (Lucrezi et al., 2018b), see **Figure 4**.

Different activities should be spread and routinely implemented, such as ecological guided tours and citizen-science projects that actively involve citizens in the data collection, using pictures, videos and dive computer data. Improving divers environmental awareness might be seen as a tool to support viable local-scale management solutions to dampen the degradation of coastal ecosystems. By highlighting a change in the WTP, our results indicate that the Italian diving sector might be willing to invest and implement sustainable actions for the protection of the marine ecosystems, thus fostering the development of sustainable jobs, as suggested by the EU Blue Growth initiative (EU Commission, 2017).

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SZ and DM developed the initial idea, designed and analyzed the questionnaire. SZ performed the statistical, MNL and WTP analysis. ST and FM performed the LCL and WTP analysis. SZ and DM wrote the manuscript with contributions from all coauthors, discussed the results, and revised the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2019.00823/full#supplementary-material

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